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Proceedings

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Forward & Executive Report

The organizers of the International Conference on Systematic Innovation (ICSI) are pleased to present the proceedings of the conference. There are 47 English papers and 10 Chinese Papers are accepted for presentation at the conference. Author and non-author participants from more than 13 countries will interact in the conference.

This conference is co-organized by The Society of Systematic Innovation (SSI), the Hong Kong University of Science and Technology-IELM Dept., the Hong Kong Institute of Systematic Innovation, The Hong Kong Institute of Industrial Engineers – Manufacturing & Industrial Division, and the Journal of Systematic Innovation (IJoSI) which is an affiliation of the SSI. Whether the papers included in the proceedings are work-in-progress or finished products, the conference and proceedings offer the authors an opportunity to disseminate the results of their research and receive early feedback from colleagues, without the long wait associated with publication in peer-reviewed journals. On the other hand, the presentations and the proceedings do not preclude the option of submitting the work in an extended and finished form for publication in a special or general issue of the IJoSI, or another peer-reviewed journal.

The organizers are indebted to a number of people who gave their time to make the conference a reality. The list of organizations and working team who have contributed tremendous amount of time and efforts to create this conference are acknowledged at the end of this program brochure. There are more contributors who are beyond the list.

The conference is one of the leading SI/TRIZ international conferences in the world and typically publish the most papers in the field. The next ICSI conference will be in the Lisbon during July 20-22, 2016. We welcome proposals for locations of future conferences in various countries. Please submit your proposal us. In addition, you are cordially invited to submit scholarly papers to the IJoSI at www.IJoSI.org. The conference and the journal are synergetic and closely related. The journal is intended to be with academic rigor while addressing real-world problems and opportunities. The conference provides platform for papers to be reviewed and feedback collected.

We are confident that you will find the participation in this conference rewarding. If there is anything needing assistance, please feel free to let the attendant(s) at the service desk know.
We are here to serve you.

With best regards,

D. Daniel Sheu, Ph.D., MBA, CMfgE
General Chair & Chair of Organizing Committee
President, the Society of Systematic Innovation
Editor-in-Chief, the International Journal of Systematic Innovation
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Director, Education & Training, the Society of Manufacturing Engineers, Taipei Chapter
Editorial Board, Computers & Industrial Engineering, an SCI indexed international journal
2015.07.15

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Paper ID: E-06

Questionnaire Investigation on Jewelry / Accessory Internet Shopping and its Analysis Utilizing Bayesian Network

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Abstract

Recently, the numbers of jewelry/accessories buying via the Internet are increasing, especially for young people. They often have difficulty deciding what kinds of jewelry/accessories, because there are many kinds of jewelry/accessories to choose from. Consulting service to support decisions is required for these matters. In this paper, a questionnaire investigation is executed for the purchasing on-line network, used for jewelry/accessory purchasing in order to get instructions for an on-line network consulting service. Nearly 500 sample data are collected. In this research, we construct the model utilizing Bayesian Network and causal relationship is sequentially chained by the characteristic of customer, the purchase budget and the accessory type. We analyzed them by sensitivity analysis and odds ratio was also calculated. One of the TRIZ methods is extended and applied. Some useful results were obtained. These are utilized for constructing a much more effective and useful on-line network consulting service.

Keywords: jewelry, questionnaire investigation, Bayesian Network, Odds ratio

1. Introduction

Owing to the prevailing Internet, new businesses such as jewelry selling via Internet with on-line consultation, what kind of jewelry/accessory for gift purchasers would be better to choose, is becoming a big trend. Purchasers via Internet have various purchasing patterns and they may have significant relationship with their characteristics and the circumstances they are in. Therefore, if we can make clear the relationship between these, we would be able to make a much more effective marketing plan and execute efficient sales promotion for each of them.

For these purposes, we created a questionnaire investigation of jewelry/accessory purchasing. In recent years, Bayesian Network is highlighted because it has the following good characteristics (Neapolitan, R.E., 2004).

• Structural Equation Modeling requires normal distribution to the data in the analysis. Therefore it has a limitation in making analysis. But Bayesian Network does not require specific distribution type to the data. It can handle any distribution type.

• It can handle the data which include partial data.

• Expert's know-how can be reflected in building Bayesian Network model.

• Sensitivity analysis can be easily executed by settling evidence. We can estimate and predict the prospective purchaser by that analysis.

• It is a probability model having network structure. Related items are connected with directional link. Therefore understanding becomes easy by its visual chart.

In this research, it is suitable to utilize Bayesian Network to analyze jewelry / accessory purchasing because each variable does not necessarily have normal distribution. Reviewing past researches, there are some related researches as follows. Takahashi et al. (2008) made analysis for the future home energy utilizing Bayesian Network. Tsuji et al. (2008) made analysis concerning preference mining on future home energy consumption. There are some papers concerning purchase behavior in the shop (Tatsuoka et al.,2008-a, Tatsuoka et al., 2008-b). But we can hardly see the analysis concerning jewelry / accessory purchasing utilizing Bayesian Network.

In this paper, a questionnaire investigation is executed for on-line network jewelry/accessory purchasing in order to get instructions for an on-line network consulting service. These are analyzed by using Bayesian Network. One of the TRIZ methods is extended and applied.

The analysis utilizing Bayesian Network enabled us to visualize the causal relationship among items. Furthermore, sensitivity analysis combined with odds ratio analysis brought us estimating and predicting the prospective purchaser. Hypothesis testing is executed before Bayesian Network analysis in order to confirm the effectiveness of this new approach.

Some interesting and instructive results are obtained. These are utilized for constructing a much more effective and useful on-line network consulting service.

The rest of the paper is organized as follows. Extended analysis method is stated in section 2. Outline of questionnaire research is stated in section 3. In section 4, Hypothesis testing is executed. In section 5, Bayesian Network analysis is executed which is followed by the sensitivity analysis in section 6. Section 7 is a conclusion.

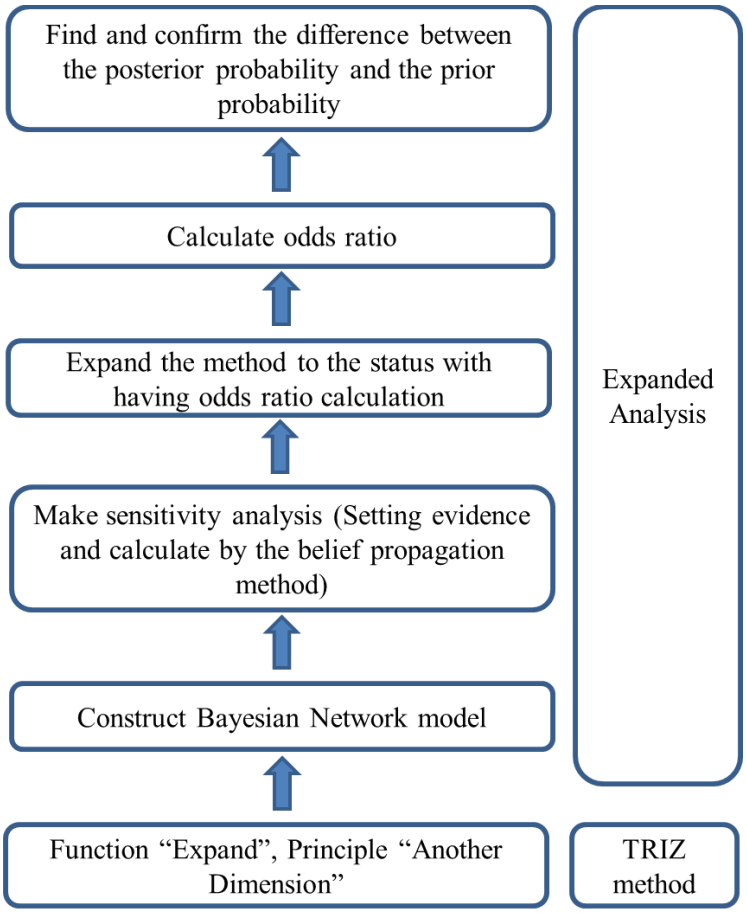
2. Extended Analysis Method

In making sensitivity analysis, the value becomes small when the node becomes far from the evidence setting node. Therefore some device is needed to obtain clear result. In this paper, odds ratio is used to make the difference much clearer. This may be the "Another Dimension" viewpoint.

The function "Extend" is a fundamental function of TRIZ (www.creax.com),(Mann.D, 2004). We can further develop this concept as shown in Figure 1. Based on the TRIZ method, extended analysis is developed. Applying Principle "Another Dimension"(Jun Zhang et al. 2003), the odds ratio calculation is executed.

These are the process of "Extended Analysis" based upon TRIZ "Extend" and/or Principle "Another Dimension" method. Detailed inspection is executed in section 6.

Figure1. Extended Analysis Method



3. Outline of Questionnaire Research and Examinees

3.1. Outline of Questionnaire Research

Outline of questionnaire research is as follows.

Scope of investigation: Young Persons, Japan

Period : May 2008～June 2009

Method : Mail and self writing

Collection : Number of distribution 1,500, Number of collection 421 (collection rate 28.1%)

Analysis methods are as follows.

Questionnaire results are analyzed in three methods. First, analysis by Cross Tabulation is executed in 3 in order to confirm hypotheses. Second, analysis by Bayesian Network is executed in 4 in order to clarify and visualize the causal relationship among the items. Third, analysis by sensitivity analysis is executed in 5 in order to predict the prospective purchaser as is shown in Table 1.

Table 1. Analysis Procedure

Step	Aim of analysis	Used Method
①	Confirm hypotheses	Cross Tabulation
②	Build Bayesian Network in order to clarify and visualize the causal relationship among items	Bayesian Network Analysis
③	Predict the prospective purchaser	Sensitivity Analysis

3.2. Outline of Examinees

(1) Sex (Q45)

- Male : 67%
- Female : 33%

(2) Age (Q46)

- Under 18 : 1%
- 18～22 : 36%
- 23～27 : 15%
- 28～32 : 12%
- 33～37 : 14%
- 38～42 : 10%
- 43～47 : 4%
- More than 48 : 8%

(3) Occupation (Q47)

- Student : 39%
- Officer : 2%
- Company Employee : 46%

- Clerk of Organization : 1%
- Independents : 6%
- Miscellaneous : 6%

(4)Address (Q48)

- Osaka : 57%
- Hyogo : 7%
- Kagawa : 6%
- Wakayama : 5%
- Fukui : 5%
- Nara : 4%
- Others : 16%

4. Hypothesis Testing

4.1 Fundamental ideas for hypotheses

We set 15 Themes as follows. These are extracted from the experience of the professionals.

Theme 1	Female would esteem coupon much better than male does.
Theme 2	Those who make stress upon material or quality have rather high budget amount.
Theme 3	There is not so much utilization of Internet shopping for the people who like sports and shopping.
Theme 4	Those who like indoor lifestyle use Internet frequently.
Theme 5	Company employee uses Internet Shopping much more frequently than student or housewife.
Theme 6	Those who like shopping esteem brand, trend and design.
Theme 7	Budget amount is large when he / she has someone to consult with in making present.
Theme 8	Those who like shopping do not hesitate to consult with sales clerk.
Theme 9	Those who often use Internet shopping live far from urban.
Theme 10	Those who like shopping also like Internet shopping.
Theme 11	Presents from male to female consist of mainly Ring and Necklace, while Pierced Earring and Bracelet from female to female.

Theme 12	Fewer becomes the presenting frequency, as age grows up.
Theme 13	Anxiety about net shopping grows larger as ages become young.
Theme 14	Frequent utilization of Internet does not have direct correlation with the usage of Internet shopping.
Theme 15	Average purchasing amount of money for Internet shopping by mobile is gradually increasing.

4.2 The results of statistical hypothesis testing

The results of statistical hypothesis testing are as follows.

Theme1. Female esteems coupon much better than male does.

Null hypothesis: Female esteems coupon as male does.

Table 2. Cross Tabulation result 1

		Q35 (%)					
		Very important	Slightly important	Ordinary level	Not so important	Not important	Total
Q45	Male	0.208	0.384	0.220	0.107	0.082	1.000
	Female	0.321	0.346	0.233	0.057	0.044	1.000
Sum		0.245	0.371	0.224	0.090	0.069	1.000

Real number	Important	Not important	Sum
Male	188	60	248
Female	106	16	122
Sum	249	76	370

Expectation	Important	Not imprtant	Sum
Male	197.0594595	50.94054	248
Femal	96.94054054	25.05946	122

Statistic	6.149465
Rejection region	3.84146

The hypothesis is rejected with 5% significance level.

Therefore it can be said that “Female esteems coupon much better than male does”.

Shop owner has an impression that many women respond to the promotion or campaign of coupon.

It is only women to inquire about campaign of coupon. Women seek the best timing to buy, while men often buy the goods when they need, whether the campaign is held or not.

Theme2・Those who do not make stress upon material or quality have rather low budget amount.

Null hypothesis: There is not so much difference in esteeming material or quality whether the budget is high or not.

Table 3. Cross Tabulation result 2

		Q12 (%)							
		～5000	～10000	～15000	～20000	～25000	～30000	more	Total
Q5	Very important	0.123	0.262	0.139	0.197	0.033	0.172	0.074	1.000
	Slightly important	0.145	0.271	0.187	0.182	0.019	0.131	0.065	1.000
	Ordinary level	0.149	0.175	0.193	0.228	0.009	0.123	0.123	1.000
	Not so important	0.214	0.143	0.143	0.286	0.107	0.071	0.036	1.000
	Not important	0.000	0.333	0.000	0.167	0.000	0.333	0.167	1.000
Sum		0.143	0.240	0.171	0.202	0.025	0.138	0.081	1.000

Real number	0 ～ 20,000 （Cheap）	20,000 ～ （High）	Sum
Important	256	80	336
Not Important	25	9	34
Sum	281	89	370

Expectation	0 ～ 20,000 （Cheap）	20,000 ～ （High）	Sum
Important	255.18	80.8216	336
Not Important	25.822	8.17838	34
Sum	281	89	370

Statistic	0.1197
Rejection region	3.8415

The hypothesis is not rejected.

It cannot be said that budget is not necessarily high even though consumers esteem material or quality. In particular, consumers cannot confirm the goods holding at their hands, therefore they confirm the explanation of material or quality at the site.
We often hear from many shop owners that they have experience of what consumers who buy only price deducted goods are severe in selecting goods. It can be said that those who are severe for price are also severe for quality.

Theme3・There is not so much utilization of Internet shopping for the people who like sports and shopping.

Null hypothesis: There is little difference in the frequency of utilization of Internet shopping among those who like sports/shopping and those who do not.

Table 4.1 Cross Tabulation result 3

		Q38 (Internet Shopping) (%)				
		Very often	Sometimes	Rarely	Never	Total
Q21 (Sports)	Very important	0.139	0.376	0.171	0.314	1.000
	Slightly important	0.071	0.473	0.161	0.295	1.000
	Ordinary level	0.125	0.458	0.139	0.278	1.000
	Not so important	0.250	0.438	0.094	0.219	1.000
	Not important	0.286	0.286	0.000	0.429	1.000
Sum		0.130	0.415	0.156	0.299	1.000

Real number	Use	Not use	Sum
Like	187	170	357
Dislike	26	13	39
Sum	213	183	396

Expectation	Use	Not use	Sum
Like	192.023	164.9773	357
Dislike	20.977	18.02273	39
Sum	213	183	396

Statistic	2.886697
Rejection region	2.874374

The hypothesis is rejected with 1% significance level.

Table 4.2 Cross Tabulation result 3

		Q38 (Internet Shopping) (%)				
		Very often	Sometimes	Rarely	Never	Total
Q23 (Shopping)	Very important	0.167	0.395	0.111	0.327	1.000
	Slightly important	0.124	0.513	0.133	0.23	1.000
	Ordinary level	0.119	0.396	0.208	0.277	1.000
	Not so important	0.081	0.243	0.27	0.405	1.000
	Not important	0	0	0	1.000	1.000
Sum		0.133	0.41	0.161	0.296	1.000

Real number	Use	Not use	Sum
Like	163	112	275
Dislike	12	27	39
Sum	175	139	314

Expectation	Use	Not use	Sum
Like	153.264	121.7357	275
Dislike	21.736	17.26433	39
Sum	175	139	314

Statistic	11.24787
Rejection region	6.634897

The hypothesis is rejected with 9% significance level.

It can be said that there are not so much utilization of Internet shopping for the people who like sports and shopping.

There who like sports and shopping would easily go out and search goods at real shop. It may be considered that they do not think highly of net shop.

Theme4・Those who like indoor lifestyle use Internet frequently.

Null hypothesis: There is not so much difference in the frequency of using Internet whether those who like indoor lifestyle or not.

Table 5. Cross Tabulation result 4

		Q37 (%)				
Q30	Outdoor	0.571	0.276	0.100	0.053	1.000
	Indoor	0.755	0.123	0.065	0.058	1.000
	Either	0.597	0.264	0.069	0.069	1.000
Sum		0.638	0.223	0.079	0.060	1.000

Real number	Use	Not use	Sum
Outdoor	144	26	170
Indoor	136	19	155
Sum	280	45	325

Expectation	Use	Not use	Sum
Outdoor	146.462	23.53846	170
Indoor	133.538	21.46154	155
Sum	280	45	325

Statistic	0.626487

Rejection region	3.84146

The hypothesis is not rejected.

There is not so much difference in the frequency of using Internet whether those who like indoor lifestyle or not.

Once, there was an image that indoor typed people often use Internet. But nowadays, it became common to use Internet whenever and wherever.

Theme5・Company employee uses Internet Shopping much more frequently than student or housewife.
Null hypothesis: There is not so much difference in the frequency of using Internet whether they are company workers or not.

Table 6. Cross Tabulation result 5

		Q47 (Occupation) (%)						
		Student	Officer	Company Employee	Clerk of Organization	Independents	Miscellaneous	Total
Q38	Very often	0.238	0.016	0.540	0.000	0.127	0.079	1.000
	Sometimes	0.293	0.005	0.571	0.005	0.066	0.061	1.000
	Rarely	0.446	0.036	0.422	0.012	0.024	0.060	1.000
	Never	0.559	0.021	0.301	0.000	0.049	0.070	1.000
Sum		0.390	0.016	0.462	0.004	0.062	0.066	1.000

Real number	Student	Worker	Sum
Use	90	171	261
Not use	132	94	226
Sum	222	265	487

Expectation	Student	Worker	Sum
Use	118.977	142.0226	261
Not use	103.023	122.9774	226

Sum	222	265	487

Statistic	27.948
Rejection region	6.6349

The hypothesis is rejected with 1% significance level.

It can generally be said that company employee uses Internet shopping much more frequently than student or housewife.
Company employees are accustomed to use Internet and they have hard time to go out shopping while in week days.

Therefore they may use Internet for shopping. Actually, the most frequent access times to Cherish Co. Ltd. are around 21 o'clock. They may be making Internet shopping at home after work.

Theme6. Those who like shopping esteem brand, trend and design.
Null hypothesis: There is not so much difference in esteeming brand, trend and design whether those who like shopping or not.

Table 7. Cross Tabulation result 6

		Q4 (Fad) (%)					
		Very imprtant	Slightly important	Ordinary level	Not so important	Not important	Total
Q23 (Shopping)	Very important	0.588	0.267	0.097	0.036	0.012	1.000
	Slightly important	0.318	0.473	0.118	0.091	0.000	1.000
	Ordinary level	0.297	0.506	0.127	0.063	0.006	1.000
	Not so important	0.270	0.378	0.216	0.135	0.000	1.000
	Not important	0.500	0.000	0.500	0.000	0.000	1.000
Sum		0.403	0.403	0.123	0.066	0.006	1.000

Real number	important	Not important	Sum
Like	228	18	246
Not Dislike	25	5	30

Sum	253	23	276

Expectation	important	Not important	Sum
Like	225.5	20.5	246
Not Dislike	27.5	2.5	30
Sum	253	23	276

Statistic	3.0599
Rejection region	2.8744

The hypothesis is rejected with 9% significance level.

It can generally be said that those who like shopping esteem brand, trend and design. Those who like shopping are accustomed to go shopping and generally have information about brand, trend and design therefore thy have own standard what to buy.

Theme7. Budget amount is large when he / she has someone to consult with in making present. Null hypothesis: There is not so much difference for the budget amount whether they have someone to consult with or not in making present.

Table 8. Cross Tabulation result 7

		Q12 (%)							
		～5000	～10000	～15000	～20000	～25000	～30000	more	Total
Q15	Boy(Girl)friend	0.061	0.210	0.144	0.238	0.022	0.193	0.133	1.000
	friend	0.196	0.346	0.215	0.121	0.028	0.075	0.019	1.000
	clerk	0.141	0.250	0.156	0.266	0.047	0.141	0.000	1.000
	Do not consult with anybody	0.205	0.197	0.189	0.220	0.016	0.102	0.071	1.000
	Miscellaneous	0.200	0.000	0.000	0.000	0.000	0.200	0.600	1.000
Sum		0.140	0.240	0.171	0.209	0.025	0.136	0.079	1.000

	～5000	～10000	～15000	～20000	～25000	～30000	more	Total
Consult with somebody	0.118	0.255	0.165	0.204	0.028	0.148	0.081	1.000

Do not consult with anybody	0.214	0.136	0.175	0.243	0.019	0.126	0.087	1.000
Sum	0.139	0.228	0.167	0.213	0.026	0.143	0.083	1.000

Real number	0~20000(Cheap)	20000~(High)	Sum
Important	265	92	357
Not important	79	24	103
Sum	344	116	460

Expectation	0~20000(Cheap)	20000~(High)	Sum
Important	266.97391	90.026087	357
Not important	77.026087	25.973913	103
Sum	344	116	460

Statistic	0.25847
Rejection region	3.84146

The hypothesis is not rejected.
It cannot be said that the budget is high for those who have someone to consult with in making present compared with those who do not have.

Theme8. Those who like shopping do not hesitate to consult with sales clerk.
Null hypothesis: There is not so much difference whether they like shopping or not, for those who do not hesitate to consult with sales clerk.

Table 9. Cross Tabulation result 8

		Q45 (%)					
		Boy(Girl)friend	Friend	Clerk	Do not consult with anybody	Miscellaneous	Total
Q23	Very important	0.315	0.321	0.117	0.241	0.006	1.000

(Shopping)	Slightly important	0.330	0.259	0.098	0.313	0.000	1.000
	Ordinary level	0.433	0.121	0.172	0.255	0.019	1.000
	Not so important	0.371	0.171	0.143	0.286	0.029	1.000
	Not important	1.000	0.000	0.000	0.000	0.000	1.000
Sum		0.365	0.226	0.132	0.265	0.011	1.000

Real number	Consult	Not consult	Sum
Like	30	74	104
Not Dislike	5	10	15
Sum	35	84	119

Expectation	Consult	Not consult	Sum
Like	30.58824	73.41176	104
Not Dislike	4.411765	10.58824	15
Sum	35	84	119

Statistic	0.127137
Rejection region	6.634897

The hypothesis is not rejected.

Generally, there are few people to consult with sales clerk while shopping. It may be because they hear the request before making present. Sales talk of sales clerk may be backed away at any rate.

Theme9. Those who often use Internet shopping live far from urban.
Null hypothesis: There is not so much difference among those who live urban and those who do not live, in the use of Internet shopping.

Table 10. Cross Tabulation result 9

		Q48 (Address) (%)							
		Aichi	Ibaragi	Kyoto	Kagawa	Kouchi	Saitama	Yamaguchi	Shiga
	Very oftem	0.016	0.032	0.016	0.129	0.016			0.016

	Sometimes		0.010	0.026	0.052		0.010	0.005	0.005
	Rarely		0.026	0.039					
	Never		0.044	0.007	0.015		0.007		
Sum		0.002	0.026	0.021	0.043	0.002	0.006	0.002	0.004

		Akita	Chiba	Nara	Shizuoka	Osaka	Tokyo	Kanagawa	Fukui
	Very oftem		0.048	0.032	0.016	0.403	0.032	0.016	0.065
	Sometimes		0.021	0.073	0.021	0.578	0.005	0.010	0.031
	Rarely	0.013				0.701			0.039
	Never		0.007	0.030	0.007	0.659	0.007		0.030
Sum		0.002	0.017	0.043	0.013	0.599	0.009	0.006	0.036

		Oita	Hyougo	Mie	Fukuoka	Nagano	Hirosima	Wakayama	Total
	Very oftem		0.081		0.016			0.065	1.000
	Sometimes		0.094	0.005	0.016	0.021		0.036	1.000
	Rarely	0.013	0.078		0.026	0.021		0.065	1.000
	Never		0.074	0.007	0.030	0.021	0.007	0.059	1.000
Sum		0.002	0.084	0.004	0.021	0.021	0.002	0.052	1.000

Real number	urban	far	Sum
Use	139	115	254
Not use	144	68	212
Sum	283	183	466

Expectation	urban	far	Sum
Use	154.2532	99.74678	254
Not use	128.7468	83.25322	212
Sum	283	183	466

Statistic	8.44255
Rejection region	6.634897

The hypothesis is rejected with 1% significance level.

It is generally assumed that residents in urban area have less need to use Internet because shops are near.

But the actual order number is many for the residents in urban area. It does not depend upon the place where they live but lifestyle and/or hobby may have correlation for the utilization of Internet for shopping.

Theme10. Those who like shopping also like Internet shopping.

Null hypothesis: There is not so much difference whether those who like shopping also like Internet shopping or not.

Table 11. Cross Tabulation result 10

		Q38 (%)				
		Very often	Sometimes	Rarely	Never	Total
Q23 (Shopping)	Very important	0.167	0.395	0.111	0.327	1.000
	Slightly important	0.124	0.513	0.133	0.230	1.000
	Ordinary level	0.119	0.396	0.208	0.277	1.000
	Not so important	0.081	0.243	0.270	0.405	1.000
	Not important	0	0	0	1.000	1.000
Sum		0.133	0.41	0.161	0.296	1.000

Real number	Use	Not use	Sum
Like	163	112	275
Dislike	12	27	39
Sum	175	139	314

Expectation	Use	Not use	Sum
Like	153.264	121.7357	275
Dislike	21.736	17.26433	39
Sum	175	139	314

Statistic	11.24787
Rejection region	6.634897

The hypothesis is rejected with 1% significance level.

It can generally be said that those who like shopping also like Internet shopping. Internet shopping became popular and it is one of the style of shopping in general.

In particular, those who like shopping may feel convenient in selecting goods as there are so many goods sold in Internet shop.

Theme11. Presents from male to female consist of mainly Ring and Necklace, while Pierced Earring and Bracelet from female to female.

Null hypothesis: It cannot be said that present from male to female consist of mainly Ring and Necklace, while Pierced earring and Bracelet from female to female.

Table 12. Cross Tabulation result 11

	Ring & Necklace	Pierced earrings & Bracelet/Bungle
Male to Female	367	110
Female to Female	65	43

Real number	Ring	Pierced earrings	Sum
Male	367	110	477
Female	65	43	108
Sum	432	153	585

Expectation	Ring	Pierced earrings	Sum
Male	352.2462	124.7538	477
Female	79.75385	28.24615	108
Sum	432	153	585

Statistic	12.79855
Rejection region	6.634897

The hypothesis is rejected with 1% significance level.
It can generally be said that present from male to female consist of mainly Ring and Necklace, while

Pierced earring and Bracelet from female to female.
Necklace is easiest to select when male makes present to female. It is because the strict size information is not required and the feeling of likes and dislikes are not so prominent.
As for Ring, pair ring is often selected by male. Female may buy ring for herself but it is rare to make present to her girlfriend. Pierced earring and Bracelet is not so high therefore it is easy to make present to her girlfriend.

Theme12. Fewer becomes the presenting frequency, as age grows up.

Null hypothesis: There is not so much difference whether presenting frequency decreases or not, as age grows up.

Table 13. Cross Tabulation result 12

Q46	0	Once	Twice	3 times	4 times	More	Sum
under 18 years old	0.2	0.2	0.2	0.2	0.2	0	1.000
18 ～ 22	0.262	0.302	0.273	0.076	0.047	0.041	1.000
23 ～ 27	0.267	0.293	0.24	0.12	0.053	0.027	1.000
28 ～ 32	0.211	0.263	0.386	0.035	0.053	0.053	1.000
33 ～ 37	0.300	0.371	0.200	0.057	0.029	0.043	1.000
38 ～ 42	0.489	0.191	0.191	0.021	0.043	0.064	1.000
42～ 47	0.636	0.227	0.000	0.000	0.045	0.091	1.000
More	0.410	0.179	0.077	0.026	0.077	0.231	1.000
Sum	0.312	0.281	0.234	0.064	0.049	0.060	1.000

Real number	Less than once	More than twice	Sum
Under 32 years old	168	141	309
More than 32 years old	121	57	178
Sum	289	198	487

Expectation	Less than once	More than twice	Sum

Under 32 years old	183.3696	125.6304	309
More than 32 years old	105.6304	72.36961	178
Sum	289	198	487

Statistic	8.669041
Rejection region	6.634897

The hypothesis is rejected with 1% significance level.
It can generally be said that fewer becomes the presenting frequency, as age grows up.

When young (student or 20th), they have a chance to make present on Xmas or birthday. After married and having children, they make present to lover as well as children. When their children grow up, they often lose such a chance.

Theme13. Anxiety about net shopping grows larger as ages become young.
Null hypothesis: There is not so much difference whether they hold anxiety or not for making net shopping, as ages become young.

Table 14. Cross Tabulation result 13

Q45	Q40-2		
Q46	Not anxious	Anxious	Sum
under 18 years old	0.6	0.4	1.0
18 ～ 22	0.697	0.303	1.0
23 ～ 27	0.849	0.303	1.0
28 ～ 32	0.914	0.086	1.0
33 ～ 37	0.901	0.099	1.0
38 ～ 42	0.957	0.043	1.0
42～ 47	0.864	0.136	1.0
More	0.95	0.05	1.0
Sum	0.832	0.168	1.0

Real number	Not anxious	Anxious	Sum
Under 32 years old	226	65	291
More than 32 years old	166	14	180
Sum	392	79	471

Expectation	Not anxious	Anxious	Sum
Under 32 years old	242.1911	48.80892	291
More than 32 years old	149.8089	30.19108	180
Sum	392	79	471

Statistic	16.88635
Rejection region	6.634897

The hypothesis is rejected with 1% significance level.

It can generally be said that anxiety about net shopping grows larger as ages become young. Meanwhile, some of the senior found to have less anxiety about net shopping. If they have experience of net shopping, they would feel less anxiety about it. 30th through 40th are under the ages that internet shopping has grown big. Once they have experience of purchasing via Internet and also feel that it is convenient and safe, then the market will grow larger.

Theme14. Frequent utilization of Internet does not have direct correlation with the usage of Internet shopping.

Null hypothesis: Frequent utilization of Internet has correlation with the usage of Internet shopping.

Table 15. Cross Tabulation result 14

Q45	Q38(Net shopping)				
Q37(Internet)	Very often	Sometimes	Rarely	Never	Sum
Very often	0.192	0.433	0.163	0.212	1.000
Sometimes	0.027	0.536	0.173	0.264	1.000
Rarely	0.000	0.075	0.300	0.625	1.000

Never	0.000	0.000	0.000	1.000	1.000
Sum	0.129	0.404	0.168	0.299	1.000

Real number	Use	Not use	Sum
Use	257	165	422
Not use	3	63	66
Sum	260	228	488

Expectation	Use	Not use	Sum
Use	224.8361	197.1639	422
Not use	35.16393	30.83607	66
Sum	260	228	488

Statistic	72.81707
Rejection region	6.634897

The hypothesis is rejected with 1% significance level.

It can generally be said that frequent utilization of Internet does not have direct correlation with the usage of Internet shopping. The big difference between them is whether it makes payment or not. Usually, Internet is frequently used for inquiry. But it cannot be said that they often make net shopping.

Theme15. Average purchasing amount of money for Internet shopping by mobile is gradually increasing.

Null hypothesis: There is not so much difference whether purchasing amount of net shopping by cellular phone is gradually increasing or not.

Table 16. Cross Tabulation result 15

Q5	Q12 (%)							
	～5000	～10000	～15000	～20000	～25000	～30000	more	Total
PC	0.126	0.234	0.178	0.217	0.017	0.147	0.080	1.000
Mobile	0.059	0.176	0.235	0.294	0.000	0.176	0.059	1.000
other	0.000	0.250	0.000	0.750	0.000	0.000	0.000	1.000
Sum	0.121	0.231	0.179	0.228	0.016	0.137	0.078	1.000

Real number	Less than 20000	More than 20000	Sum
PC	216	70	286
Mobile	13	4	17
Sum	229	74	303

Expectation	Less than 20000	More than 20000	Sum
PC	216.152	69.8482	286
Mobile	12.8482	4.15182	17
Sum	229	74	303

Statistic	0.00778
Rejection region	3.84146

The hypothesis not rejected.

When the early stage for purchasing goods via cellular phone, customers generally bought rather cheap products than the case via PC. But nowadays, they became similar in purchasing amount. From now on, purchasing via smart phone would prevail.

4.3 Remarks

Internet shopping users are increasing recently as Internet prevails. Who are Internet shopping users? Shop owners/Sales clerks have difficulty in identifying Internet shopping users because they cannot make face to face interconnection. If they do not know users, they cannot make suitable sales promotion. They have to grasp the users' characteristics and their needs, which leads to the expansion of their sales.

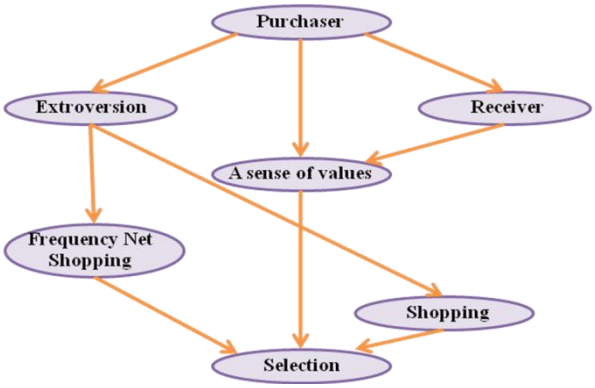
In this paper, various hypotheses were built based upon the past experiences, and executed hypothesis testing. Many of them were the same results as we have assumed, but some of them were not.

These trials let us know the importance of the objective management based upon the facts and their analysis. Further investigation should be executed consecutively hereafter.

5. Bayesian Network Analysis

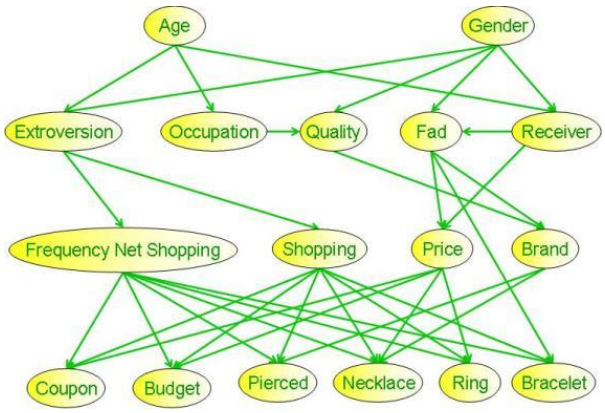
In constructing Bayesian Network, it is required to set an outline of the model reflecting the causal relationship among groups of items. Concept chart in this case is exhibited in Figure 1.

Figure 1. Node and Parameter



Based on this, model is built as is shown in Figure 2.

Figure 2. Built Model



We used BAYONET software (http://www.msi.co.jp/BAYONET/). When plural nodes exist in the same group, it occurs that causal relationship is hard to set a priori. In that case, BAYONET system set the sequence automatically utilizing AIC standard. Node and parameter of Figure 2 are exhibited in Table 12.

Table 17. Node and Parameter

Group Name	Node in group	Parameter				
		1	2	3	4	5
Purchaser	Age	Under22	23～32	33～42	Over43	
	Gender	Male	Female			
	Occupation	Students	Emplyee	Independent	Others	
Receiver	Receiver	Lover	Parents	Sweet Heart	Myself	Others
Extroversion	Extroversion	Outdoor	Indoor	Not Either		
A sense of values	Fad, Brand, Price, Quality	Important	Ordinary	Not Either		
Internet Shopping	Frequency Net Shopping	Often	Sometimes	Rarely	Never	
Shopping	Shopping	Important	Ordinary	Not Either		
Selection	Budget	～10000	～20000	～30000	Over 30000	
	Ring, Necklace, Pierced, Bracelet	Buy	Not			
	Coupon	Important	Ordinary	Not		

"Very important" and "Slightly important" are condensed into one as "Important" in order to decrease node number.

6. Sensitivity Analysis

Now, let's confirm whether the results of Cross Tabulation and the results of probabilistic inference by Bayesian Network coincide or not. We take up Hypothesis 1 as a case. Posterior probability is calculated by setting evidence as, for example, 1.0. Comparing Prior probability and Posterior probability, we can seek the change and confirm whether the Hypothesis is appropriate or not. In Hypotheses 1, set evidence as 1.0 for the "Male" in the group of "Gender", and also set evidence as 1.0 for the "Important" in the group of "Coupon". Generally, we can obtain more clear result when we set evidence to the contraposition item. We assume that "Female would esteem coupon much better than male does", therefore setting evidence 1.0 to "Male" would be suitable in this case. Table 13, 14 show the results of this attempt.

Table 18. Sensitivity Analysis and Odds Ratio for "Male"

Node	Parameter	Prior Probability	Posterior Probability

			Common logarithm	Male	Male Common logarithm	ODDS	ODDS Common logarithm
Gender	Male	0.681	0.833	1.0	-	-	-
	Female	0.319	0.503	0	-	-	-
Receiver	Lover	0.547	0.738	0.624	0.795	1.3744	1.3768
	Myself	0.076	0.088	0.038	0.057	0.4802	0.6264
Extroversion	Outdoor	0.34	0.531	0.371	0.569	1.1450	1.1660
	Indoor	0.325	0.511	0.284	0.453	0.8238	0.7925
Frequency Net shopping	Sometimes	0.284	0.453	0.284	0.453	1.0000	1.0000
	Never	0.257	0.409	0.257	0.409	1.0000	1.0000
Shopping	Important	0.395	0.596	0.395	0.596	1.0000	1.0000
Fad	Important	0.756	0.878	0.745	0.872	0.9429	0.9466
	Not	0.098	0.099	0.099	0.099	1.0113	1.0000
Price	Important	0.377	0.576	0.377	0.576	1.0000	1.0000
	Not	0.28	0.447	0.287	0.457	1.0351	1.0412
Quality	Important	0.683	0.834	0.662	0.82	0.9090	0.9067
Budget	～20000	0.319	0.503	0.319	0.503	1.0000	1.0000
	Over 30000	0.149	0.173	0.15	0.176	1.0079	1.0210
Ring	Buy	0.507	0.705	0.508	0.705	1.0040	1.0000
Necklace	Buy	0.553	0.742	0.553	0.742	1.0000	1.0000
Pierced	Buy	0.323	0.509	0.323	0.509	1.0000	1.0000
Bracelet	Buy	0.228	0.357	0.229	0.359	1.0057	1.0087
Coupon	Important	0.526	0.721	0.525	0.72	0.9960	0.9950
	Not	0.215	0.332	0.215	0.332	1.0000	1.0000

Table19. Sensitivity Analysis and Odds Ratio for "Important"

Node	Parameter	Prior Probability		Posterior Probability			
			Common logarithm	Important	Important Common logarithm	ODDS	ODDS Common logarithm
Gender	Male	0.681	0.833	0.68	0.832	0.9954	0.9929
	Female	0.319	0.503	0.32	0.505	1.0046	1.0080
Receiver	Lover	0.547	0.738	0.542	0.734	0.9800	0.9796
	Myself	0.076	0.088	0.06	0.077	0.7760	0.8646

Extroversion	Outdoor	0.34	0.531	0.342	0.534	1.0089	1.0121
	Indoor	0.325	0.511	0.324	0.51	0.9954	0.9960
Frequency Net shopping	Sometimes	0.284	0.453	0.335	0.525	1.2700	1.3346
	Never	0.257	0.409	0.245	0.389	0.9382	0.9200
Shopping	Important	0.395	0.596	0.446	0.649	1.2331	1.2534
Fad	Important	0.756	0.878	0.758	0.879	1.0109	1.0094
	Not	0.098	0.099	0.094	0.097	0.9549	0.9776
Price	Important	0.377	0.576	0.418	0.621	1.1869	1.2061
	Not	0.28	0.447	0.224	0.35	0.7423	0.6662
Quality	Important	0.683	0.834	0.683	0.834	1.0000	1.0000
Budget	～20000	0.319	0.503	0.33	0.518	1.0515	1.0619
	Over 30000	0.149	0.173	0.134	0.127	0.8838	0.6954
Ring	Buy	0.507	0.705	0.501	0.699	0.9763	0.9717
Necklace	Buy	0.553	0.742	0.555	0.744	1.0081	1.0105
Pierced	Buy	0.323	0.509	0.314	0.496	0.9594	0.9493
Bracelet	Buy	0.228	0.357	0.225	0.352	0.9830	0.9784
Coupon	Important	0.526	0.721	1.0	-	-	-
	Not	0.215	0.332	0	-	-	-

We examined two cases as stated above. One is setting evidence 1.0 to “Male” and another one is to “Important” for coupon. Odds ratio is also calculated. If the Posterior Probability exceeds Prior Probability, its value exceeds 1.0 and if they are equal, the value becomes 1.0. Therefore odds ratio value makes a kind of a normalized index.

It is clear that female esteems coupon better than male by the result of Hypothesis testing (Hypothesis 1). We can see that female esteems coupon on the change of the probability, though the change is little.

It is often seen that the change of the probability becomes small when the hierarchical data cluster is distant. To this point, reinforcement learning, for example, may be one of an improving method to cope with this. For another improving method is to make shallow the depth of the hierarchy of the model. For another attempt of setting evidence 1.0 to “Male”, we can observe that male does not esteem coupon. The value of Posterior Probability slightly decreased. This can also be made much clearer by introducing such as reinforcement learning method. Looking over other parameters, we can find that those who esteem coupon think it important about “Price “ and we can also find that those who like shopping, and/or Internet shopping esteem coupon. We can derive the findings from these results that we would be better to focus upon “Female with small budget” while

issuing coupon. In this way, we can utilize sensitivity analysis to focus target consumers in marketing.

7. Conclusion

Jewelry/accessory buying via the Internet is increasing, especially for young people. They often had difficulty deciding what kind of jewelry/accessory, because there were many kinds of jewelry/accessories to choose from. Consulting service to support decision was required for these matters. In this paper, a questionnaire investigation was executed for on-line network jewelry/accessory purchasing in order to get instruction for an on-line network consulting service. These were analyzed by using Bayesian network. One of the TRIZ methods was extended and applied. Some interesting and instructive results were obtained. These would be utilized for constructing a much more effective and useful on-line network consulting service. Examining such trials should be traced hereafter.

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APPENDIX: Questionnaire Concerning the Purchasing of Jewelry/ Accessories for Gifts Please answer the following questions. Please write down ○ to the answering items. Plural selection is allowed for Question 1, 13, 14, 17, 20, 39, 40, 43, 44. Select ①～⑤ of the right column for the Question 2～11, 21～29, 32～36.

1. When you make a gift of jewelry/ accessory to someone, what point do you stress? (Plural Answers Allowed)

Q1 ①Price ②Brand ③Trend/Design ④Raw Materials/Quality ⑤Kind/Items ⑥Response of the shop members ⑦Existence of Certification ⑧Relatively Cheap ⑨Desire of the receiver of the gift ⑩Miscellaneous (　)

2. When you choose, how is the importance of each item?

Importance	Very important	Slightly important	Ordinary level	Not so important	Not important
Q2 Price	①	②	③	④	⑤
Q3 Brand	①	②	③	④	⑤
Q4 Trend/Design	①	②	③	④	⑤
Q5 Raw Materials/Quality	①	②	③	④	⑤
Q6 Kind/Items	①	②	③	④	⑤
Q7 Response of the shop members	①	②	③	④	⑤
Q8 Existence of Certification	①	②	③	④	⑤
Q9 Relatively Cheap	①	②	③	④	⑤
Q10 Desire of the receiver of gift	①	②	③	④	⑤
Q11 Miscellaneous (　)	①	②	③	④	⑤

3. How much do you spend for one gift? [Unit: yen]

Q12 ①～5,000 ②～10,000 ③～15,000 ④～20,000 ⑤～25,000 ⑥～30,000 ⑦more than that

4. What kind of jewelry/accessory have you given? (Plural Answers Allowed)

Q13 ①Ring ②Necklace/ Pendant ③Pierced earrings ④Bracelet/Bungle ⑤Brooch ⑥Necktie Pin ⑦Miscellaneous (　)

5. Why did you select them? (Plural Answers Allowed)

Q14 ①Desire of the receiver ②Trend ③Because it was popular ④Famous entertainers have them ⑤Recommendation of the sales person in the shop ⑥Budget ⑦Special Sales ⑧Miscellaneous ( )

6. Who do you consult with when you choose?

Q15 ①Lover ②Friend ③Sales person of the shop ④Do not consult with anybody ⑤Miscellaneous ( )

7. Where do you buy gifts?

Q16 ①Department Store ②Jewelry/Accessory Shop ③Remote Sales by Catalogue ④Internet Shop ⑤Miscellaneous ( )

8. Why is it? (Plural Answers Allowed)

Q17 ①Desire of the receiver ②Reliability of the shop ③Plenty of items ④There are favorite brands ⑤Specified shop to buy(Always buy from the shop) ⑥Friends often shop there ⑦Rather cheap compared with quality ⑧Able to get additional points when using a credit card ⑨There is DM(Direct Mail) guidance when gift seasons come ⑩Miscellaneous ( )

9. Whom do you make a gift to?

Q18 ①Lover ②Father/Mother ③Children ④Sweet heart ⑤Myself ⑥Miscellaneous ( )

10. How many times do you make gifts in a year?

Q19 ①Once ②Twice ③Three times ④Four times ⑤More than that ⑥None (Reason:)

11. On what occasions do you give presents? (Plural Answers Allowed)

Q20 ①Birthday ②Xmas ③Valentine day ④White day ⑤Grown up anniversary ⑥Wedding Anniversary ⑦Congratulate for birth ⑧Congratulate for getting job ⑨Congratulate for commencement of studying at school ⑩Miscellaneous ( )

12What is your hobby?

Importance	Very important	Slightly important	Ordinary level	Not so important	Not important
Q21 12-1 Sports: ①Baseball ②Football ③Tennis ④Miscellaneous ( )	①	②	③	④	⑤
Q22 12-2 Reading Books: ①Novel ②Business Affair ③Weekly Magazine ④Comic ⑤Miscellaneous ( )	①	②	③	④	⑤

Q23 12-3 Shopping	①	②	③	④	⑤
Q24 12-4 Traveling: ①Sightseeing ②Hot Springs ③Gourmet ④ Miscellaneous ( )	①	②	③	④	⑤
Q25 12-5 Music: ①Classic ②Western POPS ③Japanese POP ④ Miscellaneous ( )	①	②	③	④	⑤
Q26 12-6 Movie: ①Love ②Action ③Comedy ④Miscellaneous ( )	①	②	③	④	⑤
Q27 12-7 Theater: ①Song ②Dance/Ballet ③Drama ④ Miscellaneous ( )	①	②	③	④	⑤
Q28 12-8 Drinking: ① Beer ② Wine ③ Japanese wine-sake ④ Japanese liquor-shochu ⑤Miscellaneous ( )	①	②	③	④	⑤
Q29 12-9 Miscellaneous: ( )	①	②	③	④	⑤

13. What kind of lifestyle do you like?

Q30 13-1 Pleasure: ①Outdoor ②Indoor ③Not either
Q31 13-2 Work: ①Desk Work ②Outdoor activity such as visiting sales ③Not either

14. Which method of payment do you want to choose?

Importanc	Very important	Slightly important	Ordinary level	Not so important	Not important
Q32 14-1 ①Cash/Cash on Delivery	①	②	③	④	⑤
Q33 14-2 Credit Card	①	②	③	④	⑤
Q34 14-3 Discount	①	②	③	④	⑤
Q35 14-4 Point Card/Coupon	①	②	③	④	⑤
Q36 14-5 Miscellaneous ( )	①	②	③	④	⑤

15.How often do you use the Internet?

Q37①Very often ②Sometimes ③Rarely ④Never

16. How do you use Internet?

Q38 16-1 How often do you use Internet Shopping?: ①Very often ②Sometimes ③Rarely ④Never
Q39 16-2 If you have answered "Yes"(16-1①②), tell us the reason why. (Plural Answers Allowed)
①Convenient ②Able to compare goods easily ③Cheap ④Plenty of goods ⑤Able to consult with other people ⑥Miscellaneous ( )
Q40 16-3 If you have answered "No"(16-1③④), tell us the reason why. (Plural Answers Allowed)

①Difficult to buy ②anxious ③Can not observe actual goods ④Can not identify which shop is good ⑤Can not get goods immediately ⑥Miscellaneous ( )

Q41 16-4 If you have answered "Yes", which method do you use? ①PC ②Mobile Phone ③ Miscellaneous ( )

Q42 16-5 Do you want to buy jewelry/Accessory via the Internet? ①Yes ②Perhaps ③No ④I do not know

Q43 16-6 If you have answered "Yes"(16-5①②), tell us the reason why. (Plural Answers Allowed)

①Convenient ②Able to compare goods easily ③Cheap ④Plenty of goods ⑤Able to consult with other people ⑥Miscellaneous ( )

Q44 16-7 If you have answered "No"(16-5③④), tell us the reason why. (Plural Answers Allowed)

①Difficult to buy ②anxious ③Can not observe actual goods ④Can not identify which shop is good ⑤Can not get goods immediately ⑥Miscellaneous ( )

17. Ask about yourself?

Q45 17-1 Sex: ①Male ②Female

Q46 17-2 Age: ①Under 18 ②18～22③23～27④28～32 ⑤33～37⑥38～42⑦43～47⑧More than 48

Q47 17-3 Occupation: ①Student ②Officer ③Company Employee ④Clerk of Organization ⑤ Independents ⑥Miscellaneous

Q48 17-4 Address: ①Prefecture( ) ②City( )

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BRAND SELECTION AND ITS MATRIX STRUCTURE IN A BRAND BAG PURCHASING CASE

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Abstract

It is often observed that consumers select the upper class brand when they buy the next time. Suppose that the former buying data and the current buying data are gathered. Also suppose that the upper brand is located upper in the variable array. Then the transition matrix becomes an upper triangle matrix under the supposition that the former buying variables are set input and the current buying variables are set output. If the top brand were selected from the lower brand in jumping way, corresponding part in the upper triangle matrix would be 0. A questionnaire investigation for automobile purchasing case is executed and the above structure is confirmed. If the transition matrix is identified, a S-step forecasting can be executed. Generalized forecasting matrix components' equations are introduced. In this paper, brand bag purchasing case is considered and a method of building the ranking table by utilizing correspondence analysis is newly proposed. One of the TRIZ methods is extended and applied. Unless planner for products does not notice its brand position whether it is upper or lower than another products, matrix structure make it possible to identify those by calculating consumers' activities for brand selection. Thus, this proposed approach enables to make effective marketing plan and/or establishing new brand.

Keywords: brand selection, matrix structure, brand position, brand bag, correspondence analysis

1. Introduction

It is often observed that consumers select the upper class brand when they buy the next time. Focusing the transition matrix structure of brand selection, their activities may be analyzed. In the past, there are many researches about brand selection [1-5]. But there are few papers concerning the analysis of the transition matrix structure of brand selection. In this paper, we make analysis of the preference shift of customer brand selection and confirm them by the questionnaire investigation for automobile purchasing case. If we can identify the feature of the matrix structure of brand selection, it can be utilized for the marketing strategy.

Suppose that the former buying data and the current buying data are gathered. Also suppose that the upper brand is located upper in the variable array. Then the transition matrix becomes an upper

triangular matrix under the supposition that the former buying variables are set input and the current buying variables are set output. If the top brand were selected from the lower brand in jumping way, corresponding part in the upper triangular matrix would be 0. These are verified by the numerical examples with simple models.

If the transition matrix is identified, a S-step forecasting can be executed. Generalized forecasting matrix components' equations are introduced. Unless planner for products does not notice its brand position whether it is upper or lower than another products, matrix structure make it possible to identify those by calculating consumers' activities for brand selection. Thus, this proposed approach enables to make effective marketing plan and/or establishing new brand.

A quantitative analysis concerning brand selection has been executed by [4, 5]. [5] examined purchasing process by Markov Transition Probability with the input of advertising expense. [4] made analysis by the Brand Selection Probability model using logistics distribution.

Formerly we have presented the paper and matrix structure was clarified when brand selection was executed toward higher grade brand. In Takeyasu et al. (2007) [6], matrix structure was analyzed for the case brand selection was executed for upper class in an automobile purchasing case. Ranking Table is required before making ranking of the brand. Furthermore, it was hard to make ranking table because there were plural standards to assort. In this paper, a new method to arrange ranking table of brand is proposed, which utilizes correspondence analysis. Brand selection process is calculated by using above table and the effectiveness of this method is clarified through the total calculation process. One of the TRIZ methods is extended and applied. Such research cannot be found as long as searched.

Hereinafter, extended analysis method is stated in section 2. Matrix structure is clarified for the selection of brand in section 3. A block matrix structure is analyzed when brands are handled in a group and a s-step forecasting is formulated in section 4. The method of building the brand ranking table by utilizing correspondence analysis is introduced in section 5. Numerical calculation is executed in section 6. Application of this method is extended in section 7. Section 8 is a summary.

2. Extended Analysis Method

In making brand transition analysis, ranking table of brands is required. But it is sometimes hard to build the ranking table. In this paper, correspondence analysis is utilized to build ranking table which is a new device and it is put as a preliminary process. The function "Extend" is a fundamental function of TRIZ [7],[8]. We can further develop this concept as shown in Figure 1. Based on the TRIZ method, extended analysis is developed. Applying Principle "Preliminary action"[9], the Goods classification by correspondence analysis is set. After evaluating the score of the Goods, the Goods class is evaluated. This is the preliminary action and it is sent to the following process that we have already developed.

These are the process of "Extended Analysis" based upon TRIZ "Extend" and/or Principle "Preliminary action" method. Detailed inspection is executed in section 5.

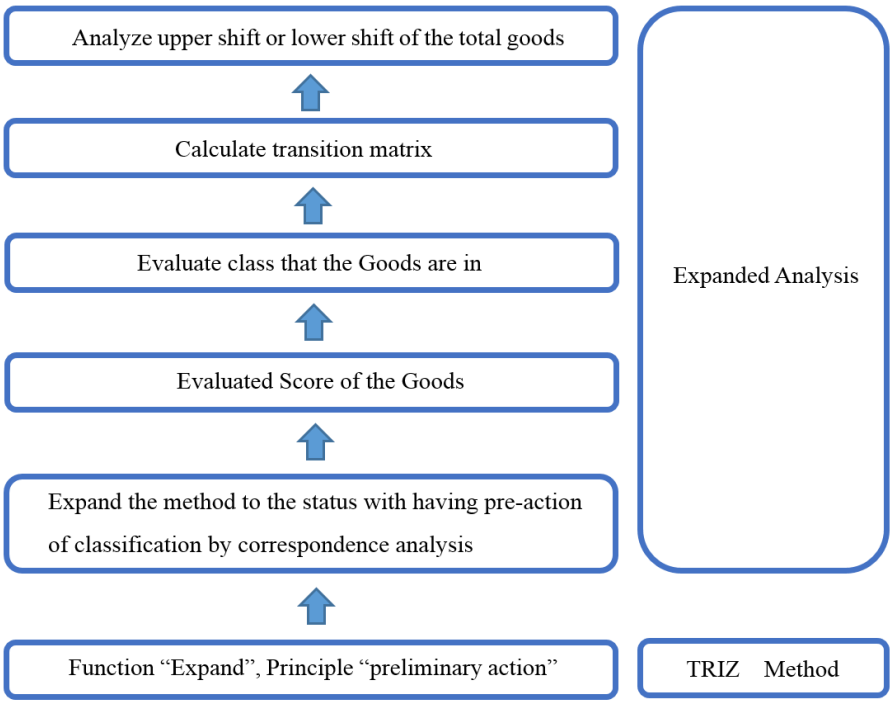

Figure 1. Extended Analysis Method.

3. Brand Selection and Its Matrix Structure

▪3.1 Upper shift of Brand selection

It is often observed that consumers select the upper class brand when they buy the next time. Now, suppose that x is the most upper class brand, y is the second upper brand, and z is the lowest brand. Consumer's behavior of selecting brand would be $z \to y, y \to x, z \to x$ etc. $x \to z$ might be few. Suppose that x is the current buying variable, and x_b is the previous buying variable. Shift to x is executed from x_b, y_b or z_b.

Therefore, x is stated in the following equation.

$$x = a_{11}x_b + a_{12}y_b + a_{13}z_b$$

Similarly,

$$y = a_{22}y_b + a_{23}z_b$$

And

$$z = a_{33} z_b$$

These are re-written as follows.

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ 0 & a_{22} & a_{23} \\ 0 & 0 & a_{33} \end{pmatrix} \begin{pmatrix} x_b \\ y_b \\ z_b \end{pmatrix} \tag{1}$$

Set

$$\mathbf{X} = \begin{pmatrix} x \\ y \\ z \end{pmatrix}, \quad \mathbf{A} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ 0 & a_{22} & a_{23} \\ 0 & 0 & a_{33} \end{pmatrix}, \quad \mathbf{X_b} = \begin{pmatrix} x_b \\ y_b \\ z_b \end{pmatrix}$$

Then, $\mathbf{X}$ is represented as follows.

$$\mathbf{X} = \mathbf{A}\mathbf{X_b} \tag{2}$$

Here,

$$\mathbf{X} \in \mathbf{R}^3, \mathbf{A} \in \mathbf{R}^{3\times 3}, \mathbf{X_b} \in \mathbf{R}^3$$

A is an upper triangular matrix. To examine this, generating the following data, which are all consisted by the upper brand shift data,

$$\mathbf{X^i} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \quad \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \quad \cdots \quad \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \tag{3}$$

$$\mathbf{X_b^i} = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \quad \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \quad \cdots \quad \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \tag{4}$$

$$i = 1, \quad 2 \quad \cdots \quad N$$

Parameter can be estimated using least square method. Suppose

$$\mathbf{X}^i = \mathbf{A}\mathbf{X_b^i} + \boldsymbol{\varepsilon}^i \tag{5}$$

Where

$$\varepsilon^i = \begin{pmatrix} \varepsilon_1^i \\ \varepsilon_2^i \\ \varepsilon_3^i \end{pmatrix} \qquad i = 1, 2, \cdots, N$$

and minimize following J

$$J = \sum_{i=1}^{N} \boldsymbol{\varepsilon}^{iT} \boldsymbol{\varepsilon}^i \rightarrow Min \tag{6}$$

$\widehat{\mathbf{A}}$ which is an estimated value of $\mathbf{A}$ is obtained as follows.

$$\hat{\mathbf{A}} = \left(\sum_{i=1}^{N} \mathbf{X}^i \mathbf{X}_{\mathbf{b}}^{iT} \right) \left(\sum_{i=1}^{N} \mathbf{X}_{\mathbf{b}}^i \mathbf{X}_{\mathbf{b}}^{iT} \right)^{-1} \tag{7}$$

In the data group of the upper shift brand, estimated value $\widehat{\mathbf{A}}$ should be an upper triangular matrix. If the following data, that have the lower shift brand, are added only a few in equation (3) and (4),

$$\mathbf{X}^i = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}, \qquad \mathbf{X}_{\mathbf{b}}^i = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$$

$\widehat{\mathbf{A}}$ would contain minute items in the lower part triangle.

▪3.2 Sorting Brand Ranking by Re-arranging Row

In a general data, variables may not be in order as x, y, z. In that case, large and small value lie scattered in $\widehat{\mathbf{A}}$. But re-arranging this, we can set in order by shifting row. The large value parts are gathered in an upper triangular matrix, and the small value parts are gathered in a lower triangular matrix.

$$\begin{array}{cc} & \hat{\mathbf{A}} \\ \begin{pmatrix} x \\ y \\ z \end{pmatrix} & \begin{pmatrix} \bigcirc & \bigcirc & \bigcirc \\ \varepsilon & \bigcirc & \bigcirc \\ \varepsilon & \varepsilon & \bigcirc \end{pmatrix} \end{array} \qquad \begin{array}{cc} & \hat{\mathbf{A}} \\ \begin{pmatrix} z \\ x \\ y \end{pmatrix} & \begin{pmatrix} \varepsilon & \varepsilon & \bigcirc \\ \bigcirc & \bigcirc & \bigcirc \\ \varepsilon & \bigcirc & \bigcirc \end{pmatrix} \end{array} \tag{8}$$

▪3.3 In the Case that Brand Selection Shifts in Jump

It is often observed that some consumers select the most upper class brand from the most lower class brand and skip selecting the intermediate class brand. We suppose v, w, x, y, z brands (suppose they are laid from the upper position to the lower position as $v > w > x > y > z$). In the above case, the selection shifts would be

$v \leftarrow z$

$v \leftarrow y$

Suppose there is no shift from z to y, corresponding part of the transition matrix is 0 (i.e. $a_{45} = 0$). Similarly, if there is no shift from z to y, from z to w, from y to x, form y to w, from x to w, then the matrix structure would be as follows.

$$\begin{pmatrix} v \\ w \\ x \\ y \\ z \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ 0 & a_{22} & 0 & 0 & 0 \\ 0 & 0 & a_{33} & 0 & 0 \\ 0 & 0 & 0 & a_{44} & 0 \\ 0 & 0 & 0 & 0 & a_{55} \end{pmatrix} \begin{pmatrix} v_b \\ w_b \\ x_b \\ y_b \\ z_b \end{pmatrix} \tag{9}$$

4. Block Matrix Structure in Brand Group and *S*-Step Forecasting

Next, we examine the case in brand groups. Matrices are composed by the Block Matrix

▪4.1 In the Case that Brand Selection Shifts in Jump

Suppose the brand selection shifts from Corolla class to MarkⅡ class in a car. In this case, it does not matter which company's car they choose. Thus, selection of cars is executed in a group and the brand shift is considered to be done from group to group. Suppose brand groups at time n are as follows. $\mathbf{X}$ consists of p varieties of goods, and $\mathbf{Y}$ consists of q varieties of goods.

$$\mathbf{X_n} = \begin{pmatrix} x_1^n \\ x_2^n \\ \vdots \\ x_p^n \end{pmatrix}, \quad \mathbf{Y_n} = \begin{pmatrix} y_1^n \\ y_2^n \\ \vdots \\ y_q^n \end{pmatrix}$$

$$\begin{pmatrix} \mathbf{X_n} \\ \mathbf{Y_n} \end{pmatrix} = \begin{pmatrix} \mathbf{A_{11}}, & \mathbf{A_{12}} \\ \mathbf{0}, & \mathbf{A_{22}} \end{pmatrix} \begin{pmatrix} \mathbf{X_{n-1}} \\ \mathbf{Y_{n-1}} \end{pmatrix} \tag{10}$$

Here,

$\mathbf{X_n} \in \mathbf{R}^p \ (n=1,2,\cdots)$, $\mathbf{Y_n} \in \mathbf{R}^q \ (n=1,2,\cdots)$, $\mathbf{A_{11}} \in \mathbf{R}^{p\times p}$, $\mathbf{A_{12}} \in \mathbf{R}^{p\times q}$, $\mathbf{A_{22}} \in \mathbf{R}^{q\times q}$

Make one more step of shift, then we obtain the following equation.

$$\begin{pmatrix} \mathbf{X_n} \\ \mathbf{Y_n} \end{pmatrix} = \begin{pmatrix} \mathbf{A_{11}}^2, & \mathbf{A_{11}A_{12}} + \mathbf{A_{12}A_{22}} \\ \mathbf{0}, & \mathbf{A_{22}}^2 \end{pmatrix} \begin{pmatrix} \mathbf{X_{n-2}} \\ \mathbf{Y_{n-2}} \end{pmatrix} \tag{11}$$

Make one more step of shift again, then we obtain the following equation.

$$\begin{pmatrix} \mathbf{X_n} \\ \mathbf{Y_n} \end{pmatrix} = \begin{pmatrix} \mathbf{A_{11}}^3, & \mathbf{A_{11}}^2\mathbf{A_{12}} + \mathbf{A_{11}A_{12}A_{22}} + \mathbf{A_{12}A_{22}}^2 \\ \mathbf{0}, & \mathbf{A_{22}}^3 \end{pmatrix} \begin{pmatrix} \mathbf{X_{n-3}} \\ \mathbf{Y_{n-3}} \end{pmatrix} \tag{12}$$

Similarly,

$$\begin{pmatrix} \mathbf{X_n} \\ \mathbf{Y_n} \end{pmatrix} = \begin{pmatrix} \mathbf{A_{11}}^4, & \mathbf{A_{11}}^3\mathbf{A_{12}} + \mathbf{A_{11}}^2\mathbf{A_{12}A_{22}} + \mathbf{A_{11}A_{12}A_{22}}^2 + \mathbf{A_{12}A_{22}}^3 \\ \mathbf{0}, & \mathbf{A_{22}}^4 \end{pmatrix} \begin{pmatrix} \mathbf{X_{n-4}} \\ \mathbf{Y_{n-4}} \end{pmatrix} \tag{13}$$

$$\begin{pmatrix} \mathbf{X_n} \\ \mathbf{Y_n} \end{pmatrix} = \begin{pmatrix} \mathbf{A_{11}}^5, & \mathbf{A_{11}}^4\mathbf{A_{12}} + \mathbf{A_{11}}^3\mathbf{A_{12}A_{22}} + \mathbf{A_{11}}^2\mathbf{A_{12}A_{22}}^2 + \mathbf{A_{11}A_{12}A_{22}}^3 + \mathbf{A_{12}A_{22}}^4 \\ \mathbf{0}, & \mathbf{A_{22}}^5 \end{pmatrix} \begin{pmatrix} \mathbf{X_{n-5}} \\ \mathbf{Y_{n-5}} \end{pmatrix} \tag{14}$$

Finally, we get the generalized equation for a *s*-step shift as follows.

$$\begin{pmatrix} \mathbf{X_n} \\ \mathbf{Y_n} \end{pmatrix} = \begin{pmatrix} \mathbf{A_{11}}^s, & \mathbf{A_{11}}^{s-1}\mathbf{A_{12}} + \sum_{k=2}^{s-1} \mathbf{A_{11}}^{s-k}\mathbf{A_{12}A_{22}}^{k-1} + \mathbf{A_{12}A_{22}}^{s-1} \\ \mathbf{0}, & \mathbf{A_{22}}^s \end{pmatrix} \begin{pmatrix} \mathbf{X_{n-s}} \\ \mathbf{Y_{n-s}} \end{pmatrix} \tag{15}$$

If we replace $n-s \to n, n \to n+s$ in equation (15), we can make a s-step forecast.

▪4.2 Brand Shift Group for the Case of Three Groups

Suppose the brand selection is executed in the same group or to the upper group, and also suppose that the brand position is $x > y > z$ (x is upper position). Then the brand selection transition matrix would be expressed as

$$\begin{pmatrix} \mathbf{X_n} \\ \mathbf{Y_n} \\ \mathbf{Z_n} \end{pmatrix} = \begin{pmatrix} \mathbf{A_{11}}, & \mathbf{A_{12}}, & \mathbf{A_{13}} \\ \mathbf{0}, & \mathbf{A_{22}}, & \mathbf{A_{23}} \\ \mathbf{0}, & \mathbf{0}, & \mathbf{A_{33}} \end{pmatrix} \begin{pmatrix} \mathbf{X_{n-1}} \\ \mathbf{Y_{n-1}} \\ \mathbf{Z_{n-1}} \end{pmatrix} \tag{16}$$

Where,

$$\mathbf{X_n} = \begin{pmatrix} x_1^n \\ x_2^n \\ \vdots \\ x_p^n \end{pmatrix}, \quad \mathbf{Y_n} = \begin{pmatrix} y_1^n \\ y_2^n \\ \vdots \\ y_q^n \end{pmatrix}, \quad \mathbf{Z_n} = \begin{pmatrix} z_1^n \\ z_2^n \\ \vdots \\ z_r^n \end{pmatrix}$$

Here,

$$\mathbf{X_n} \in \mathbf{R}^p \ (n = 1,2,\cdots), \ \mathbf{Y_n} \in \mathbf{R}^q \ (n = 1,2,\cdots), \ \mathbf{Z_n} \in \mathbf{R}^r \ (n = 1,2,\cdots), \ \mathbf{A_{11}} \in \mathbf{R}^{p\times p},$$
$$\mathbf{A_{12}} \in \mathbf{R}^{p\times q}, \ \mathbf{A_{13}} \in \mathbf{R}^{p\times r}, \ \mathbf{A_{22}} \in \mathbf{R}^{q\times q}, \ \mathbf{A_{23}} \in \mathbf{R}^{q\times r}, \ \mathbf{A_{33}} \in \mathbf{R}^{r\times r}$$

These are re-stated as :

$$\mathbf{W_n} = \mathbf{A}\mathbf{W_{n-1}} \tag{17}$$

Where,

$$\mathbf{W_n} = \begin{pmatrix} \mathbf{X_n} \\ \mathbf{Y_n} \\ \mathbf{Z_n} \end{pmatrix}, \quad \mathbf{A} = \begin{pmatrix} \mathbf{A_{11}}, & \mathbf{A_{12}}, & \mathbf{A_{13}} \\ \mathbf{0}, & \mathbf{A_{22}}, & \mathbf{A_{23}} \\ \mathbf{0}, & \mathbf{0}, & \mathbf{A_{33}} \end{pmatrix}, \quad \mathbf{W_{n-1}} = \begin{pmatrix} \mathbf{X_{n-1}} \\ \mathbf{Y_{n-1}} \\ \mathbf{Z_{n-1}} \end{pmatrix}$$

Hereinafter, we shift steps as is done in previous section. In the general description, we state as :

$$\mathbf{W_n} = \mathbf{A^{(s)}}\mathbf{W_{n-s}} \tag{18}$$

Here,

$$\mathbf{A^{(s)}} = \begin{pmatrix} \mathbf{A_{11}}^{(s)}, & \mathbf{A_{12}}^{(s)}, & \mathbf{A_{13}}^{(s)} \\ \mathbf{0}, & \mathbf{A_{22}}^{(s)}, & \mathbf{A_{23}}^{(s)} \\ \mathbf{0}, & \mathbf{0}, & \mathbf{A_{33}}^{(s)} \end{pmatrix}, \quad \mathbf{W_{n-s}} = \begin{pmatrix} \mathbf{X_{n-s}} \\ \mathbf{Y_{n-s}} \\ \mathbf{Z_{n-s}} \end{pmatrix}$$

From definition,

$$\mathbf{A}^{(1)} = \mathbf{A} \tag{19}$$

In the case s=2, we obtain :

$$\begin{aligned}\mathbf{A}^{(2)} &= \begin{pmatrix} \mathbf{A}_{11}, & \mathbf{A}_{12}, & \mathbf{A}_{13} \\ \mathbf{0}, & \mathbf{A}_{22}, & \mathbf{A}_{23} \\ \mathbf{0}, & \mathbf{0}, & \mathbf{A}_{33} \end{pmatrix}\begin{pmatrix} \mathbf{A}_{11}, & \mathbf{A}_{12}, & \mathbf{A}_{13} \\ \mathbf{0}, & \mathbf{A}_{22}, & \mathbf{A}_{23} \\ \mathbf{0}, & \mathbf{0}, & \mathbf{A}_{33} \end{pmatrix} \\ &= \begin{pmatrix} \mathbf{A}_{11}^2, & \mathbf{A}_{11}\mathbf{A}_{12} + \mathbf{A}_{12}\mathbf{A}_{22}, & \mathbf{A}_{11}\mathbf{A}_{13} + \mathbf{A}_{12}\mathbf{A}_{23} + \mathbf{A}_{13}\mathbf{A}_{33} \\ \mathbf{0}, & \mathbf{A}_{22}^2, & \mathbf{A}_{22}\mathbf{A}_{23} + \mathbf{A}_{23}\mathbf{A}_{33} \\ \mathbf{0}, & \mathbf{0}, & \mathbf{A}_{33}^2 \end{pmatrix}\end{aligned} \tag{20}$$

Next, in the case s=3, we obtain :

$$\mathbf{A}^{(3)} = \begin{pmatrix} \mathbf{A}_{11}^3, & \mathbf{A}_{11}^2\mathbf{A}_{12} + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{22} + \mathbf{A}_{12}\mathbf{A}_{22}^2, & P \\ \mathbf{0}, & \mathbf{A}_{22}^3, & \mathbf{A}_{22}^2\mathbf{A}_{23} + \mathbf{A}_{22}\mathbf{A}_{23}\mathbf{A}_{33} + \mathbf{A}_{23}\mathbf{A}_{33}^2 \\ \mathbf{0}, & \mathbf{0}, & \mathbf{A}_{33}^3 \end{pmatrix} \tag{21}$$

Here,

$$P = \mathbf{A}_{11}^2\mathbf{A}_{13} + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{23} + \mathbf{A}_{11}\mathbf{A}_{13}\mathbf{A}_{33} + \mathbf{A}_{12}\mathbf{A}_{22}\mathbf{A}_{23} + \mathbf{A}_{12}\mathbf{A}_{23}\mathbf{A}_{33} + \mathbf{A}_{13}\mathbf{A}_{33}^2$$

In the case s=4, equations become wide-spread, so we express each Block Matrix as follows.

$$\mathbf{A}_{11}^{(4)} = \mathbf{A}_{11}^4$$

$$\mathbf{A}_{12}^{(4)} = \mathbf{A}_{11}^3\mathbf{A}_{12} + \mathbf{A}_{11}^2\mathbf{A}_{12}\mathbf{A}_{22} + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{22}^2 + \mathbf{A}_{12}\mathbf{A}_{22}^3$$

$$\begin{aligned}\mathbf{A}_{13}^{(4)} &= \mathbf{A}_{11}^3\mathbf{A}_{13} + \mathbf{A}_{11}^2\mathbf{A}_{12}\mathbf{A}_{23} + \mathbf{A}_{11}^2\mathbf{A}_{13}\mathbf{A}_{33} + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{22}\mathbf{A}_{23} \\ &\quad + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{23}\mathbf{A}_{33} + \mathbf{A}_{11}\mathbf{A}_{13}\mathbf{A}_{33}^2 + \mathbf{A}_{12}\mathbf{A}_{22}^2\mathbf{A}_{23} \\ &\quad + \mathbf{A}_{12}\mathbf{A}_{22}\mathbf{A}_{23}\mathbf{A}_{33} + \mathbf{A}_{12}\mathbf{A}_{23}\mathbf{A}_{33}^2 + \mathbf{A}_{13}\mathbf{A}_{33}^3\end{aligned} \tag{22}$$

$$\mathbf{A}_{22}^{(4)} = \mathbf{A}_{22}^4$$

$$\mathbf{A}_{23}^{(4)} = \mathbf{A}_{22}^3\mathbf{A}_{23} + \mathbf{A}_{22}^2\mathbf{A}_{23}\mathbf{A}_{33} + \mathbf{A}_{22}\mathbf{A}_{23}\mathbf{A}_{33}^2 + \mathbf{A}_{23}\mathbf{A}_{33}^3$$

$$\mathbf{A}_{33}^{(4)} = \mathbf{A}_{33}^4$$

In the case s=5, we obtain the following equations similarly.

$$\mathbf{A}_{11}^{(5)} = \mathbf{A}_{11}^{5}$$

$$\mathbf{A}_{12}^{(5)} = \mathbf{A}_{11}^{4}\mathbf{A}_{12} + \mathbf{A}_{11}^{3}\mathbf{A}_{12}\mathbf{A}_{22} + \mathbf{A}_{11}^{2}\mathbf{A}_{12}\mathbf{A}_{22}^{2} + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{22}^{3} + \mathbf{A}_{12}\mathbf{A}_{22}^{4}$$

$$\begin{aligned}\mathbf{A}_{13}^{(5)} = {} & \mathbf{A}_{11}^{4}\mathbf{A}_{13} + \mathbf{A}_{11}^{3}\mathbf{A}_{12}\mathbf{A}_{23} + \mathbf{A}_{11}^{3}\mathbf{A}_{13}\mathbf{A}_{33} + \mathbf{A}_{11}^{2}\mathbf{A}_{12}\mathbf{A}_{22}\mathbf{A}_{23} \\ & + \mathbf{A}_{11}^{2}\mathbf{A}_{12}\mathbf{A}_{23}\mathbf{A}_{33} + \mathbf{A}_{11}^{2}\mathbf{A}_{13}\mathbf{A}_{33}^{2} + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{22}^{2}\mathbf{A}_{23} \\ & + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{22}\mathbf{A}_{23}\mathbf{A}_{33} + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{23}\mathbf{A}_{33}^{2} + \mathbf{A}_{11}\mathbf{A}_{13}\mathbf{A}_{33}^{3} \\ & + \mathbf{A}_{12}\mathbf{A}_{22}^{3}\mathbf{A}_{23} + \mathbf{A}_{12}\mathbf{A}_{22}^{2}\mathbf{A}_{23}\mathbf{A}_{33} + \mathbf{A}_{12}\mathbf{A}_{22}\mathbf{A}_{23}\mathbf{A}_{33}^{2} \\ & + \mathbf{A}_{12}\mathbf{A}_{23}\mathbf{A}_{33}^{3} + \mathbf{A}_{13}\mathbf{A}_{33}^{4}\end{aligned} \tag{23}$$

$$\mathbf{A}_{22}^{(5)} = \mathbf{A}_{22}^{5}$$

$$\mathbf{A}_{23}^{(5)} = \mathbf{A}_{22}^{4}\mathbf{A}_{23} + \mathbf{A}_{22}^{3}\mathbf{A}_{23}\mathbf{A}_{33} + \mathbf{A}_{22}^{2}\mathbf{A}_{23}\mathbf{A}_{33}^{2} + \mathbf{A}_{22}\mathbf{A}_{23}\mathbf{A}_{33}^{3} + \mathbf{A}_{23}\mathbf{A}_{33}^{4}$$

$$\mathbf{A}_{33}^{(5)} = \mathbf{A}_{33}^{5}$$

In the case s=6, we obtain :

$$\mathbf{A}_{11}^{(6)} = \mathbf{A}_{11}^{6}$$

$$\begin{aligned}\mathbf{A}_{12}^{(6)} = {} & \mathbf{A}_{11}^{5}\mathbf{A}_{12} + \mathbf{A}_{11}^{4}\mathbf{A}_{12}\mathbf{A}_{22} + \mathbf{A}_{11}^{3}\mathbf{A}_{12}\mathbf{A}_{22}^{2} \\ & + \mathbf{A}_{11}^{2}\mathbf{A}_{12}\mathbf{A}_{22}^{3} + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{22}^{4} + \mathbf{A}_{12}\mathbf{A}_{22}^{5}\end{aligned}$$

$$\begin{aligned}\mathbf{A}_{13}^{(6)} = {} & \mathbf{A}_{11}^{5}\mathbf{A}_{13} + \mathbf{A}_{11}^{4}\mathbf{A}_{12}\mathbf{A}_{23} + \mathbf{A}_{11}^{4}\mathbf{A}_{13}\mathbf{A}_{33} + \mathbf{A}_{11}^{3}\mathbf{A}_{12}\mathbf{A}_{22}\mathbf{A}_{23} \\ & + \mathbf{A}_{11}^{3}\mathbf{A}_{12}\mathbf{A}_{23}\mathbf{A}_{33} + \mathbf{A}_{11}^{3}\mathbf{A}_{13}\mathbf{A}_{33}^{2} + \mathbf{A}_{11}^{2}\mathbf{A}_{12}\mathbf{A}_{22}^{2}\mathbf{A}_{23} \\ & + \mathbf{A}_{11}^{2}\mathbf{A}_{12}\mathbf{A}_{22}\mathbf{A}_{23}\mathbf{A}_{33} + \mathbf{A}_{11}^{2}\mathbf{A}_{12}\mathbf{A}_{23}\mathbf{A}_{33}^{2} + \mathbf{A}_{11}^{2}\mathbf{A}_{13}\mathbf{A}_{33}^{3} \\ & + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{22}^{3}\mathbf{A}_{23} + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{22}^{2}\mathbf{A}_{23}\mathbf{A}_{33} \\ & + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{22}\mathbf{A}_{23}\mathbf{A}_{33}^{2} + \mathbf{A}_{11}\mathbf{A}_{12}\mathbf{A}_{23}\mathbf{A}_{33}^{3} + \mathbf{A}_{11}\mathbf{A}_{13}\mathbf{A}_{33}^{4} \\ & + \mathbf{A}_{12}\mathbf{A}_{22}^{4}\mathbf{A}_{23} + \mathbf{A}_{12}\mathbf{A}_{22}^{3}\mathbf{A}_{23}\mathbf{A}_{33} + \mathbf{A}_{12}\mathbf{A}_{22}^{2}\mathbf{A}_{23}\mathbf{A}_{33}^{2} \\ & + \mathbf{A}_{12}\mathbf{A}_{22}\mathbf{A}_{23}\mathbf{A}_{33}^{3} + \mathbf{A}_{12}\mathbf{A}_{23}\mathbf{A}_{33}^{4} + \mathbf{A}_{13}\mathbf{A}_{33}^{5}\end{aligned} \tag{24}$$

We get the generalized equations for a s-step shift as follows.

$$\mathbf{A}_{11}^{(s)} = \mathbf{A}_{11}^{s}$$

$$\mathbf{A}_{12}^{(s)} = \mathbf{A}_{11}^{s-1}\mathbf{A}_{12} + \sum_{k=2}^{s-1}\mathbf{A}_{11}^{s-k}\mathbf{A}_{12}\mathbf{A}_{22}^{k-1} + \mathbf{A}_{12}\mathbf{A}_{22}^{s-1}$$

$$\begin{aligned}\mathbf{A}_{13}^{(s)} &= \mathbf{A}_{11}^{s-1}\mathbf{A}_{13} + \mathbf{A}_{11}^{s-2}\left(\sum_{k=1}^{2}\mathbf{A}_{1(k+1)}\mathbf{A}_{(k+1)3}\right) \\ &+ \sum_{j=1}^{s-3}\left[\mathbf{A}_{11}^{S-2-j}\left\{\mathbf{A}_{12}\left(\sum_{k=1}^{j+1}\mathbf{A}_{22}^{j+1-k}\mathbf{A}_{23}\mathbf{A}_{33}^{k-1}\right) + \mathbf{A}_{13}\mathbf{A}_{33}^{j+1}\right\}\right]\end{aligned} \tag{25}$$

$$\mathbf{A}_{22}^{(s)} = \mathbf{A}_{22}^{s}$$

$$\mathbf{A}_{23}^{(s)} = \sum_{K-1}^{s}\mathbf{A}_{22}^{s-k}\mathbf{A}_{23}\mathbf{A}_{33}^{k-1}$$

$$\mathbf{A}_{33}^{(s)} = \mathbf{A}_{33}^{s}$$

Expressing them in matrix, it follows :

$$\mathbf{A}^{(S)} = \begin{pmatrix} \mathbf{A}_{11}^{s}, & \mathbf{A}_{11}^{s-1}\mathbf{A}_{12} + \sum_{k=2}^{s-1}\mathbf{A}_{11}^{s-k}\mathbf{A}_{12}\mathbf{A}_{22}^{k-1} + \mathbf{A}_{12}\mathbf{A}_{22}^{s-1}, & Q \\ \mathbf{0}, & \mathbf{A}_{22}^{s}, & \sum_{k=1}^{s}\mathbf{A}_{22}^{s-k}\mathbf{A}_{23}\mathbf{A}_{33}^{k-1} \\ \mathbf{0}, & \mathbf{0}, & \mathbf{A}_{33}^{s} \end{pmatrix} \tag{26}$$

$$\begin{aligned}Q &= \mathbf{A}_{11}^{s-1}\mathbf{A}_{13} + \mathbf{A}_{11}^{s-2}\left(\sum_{k=1}^{2}\mathbf{A}_{1(k+1)}\mathbf{A}_{(K+1)3}\right) \\ &+ \sum_{j=1}^{s-3}\left[\mathbf{A}_{11}^{s-2-j}\left\{\mathbf{A}_{12}\left(\sum_{k=1}^{j+1}\mathbf{A}_{22}^{j+1-k}\mathbf{A}_{23}\mathbf{A}_{33}^{k-1}\right) + \mathbf{A}_{13}\mathbf{A}_{33}^{j+1}\right\}\right]\end{aligned}$$

Generalized them to *m* groups, they are expressed as :

$$\begin{pmatrix} \mathbf{X}_{\mathbf{n}}^{(1)} \\ \mathbf{X}_{\mathbf{n}}^{(2)} \\ \vdots \\ \mathbf{X}_{\mathbf{n}}^{(m)} \end{pmatrix} = \begin{pmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} & \cdots & \mathbf{A}_{1\mathbf{m}} \\ \mathbf{A}_{21} & \mathbf{A}_{22} & \cdots & \mathbf{A}_{2\mathbf{m}} \\ \vdots & \vdots & & \vdots \\ \mathbf{A}_{\mathbf{m}1} & \mathbf{A}_{\mathbf{m}2} & \cdots & \mathbf{A}_{\mathbf{mm}} \end{pmatrix} \begin{pmatrix} \mathbf{X}_{\mathbf{n-1}}^{(1)} \\ \mathbf{X}_{\mathbf{n-1}}^{(2)} \\ \vdots \\ \mathbf{X}_{\mathbf{n-1}}^{(m)} \end{pmatrix} \tag{27}$$

$$\mathbf{X}_{\mathbf{n}}^{(1)} \in R^{k_1},\ \mathbf{X}_{\mathbf{n}}^{(2)} \in R^{k_2},\ \mathbf{X}_{\mathbf{n}}^{(m)} \in R^{k_m},\ \mathbf{A}_{\mathbf{ij}} \in R^{k_i \times k_j}\ (i = 1, \cdots, m)(j = 1, \cdots, m)$$

5. Building the Ranking Table by Utilizing Correspondence Analysis

In this section, the method to build the ranking table by utilizing correspondence analysis is described. Formerly, we have presented the paper, where the matrix structure was clarified when brand selection was executed toward higher grade brand in an automobile purchasing case[6]. The ranking table for automobile was arranged from the interview result to the car dealers and it was rectified by the target zone etc. We cannot deny the possibility that the gap may arise between dealer's ranking table and consumer's ranking table.

In this paper, the ranking table is established by accepting the consumer's thought for the brand ranking. In particular, we collect the data of consumer's perceived quality by executing questionnaire investigation. Next, by utilizing correspondence analysis, we classify some categories depending on these results. It becomes possible to rank brands depending on suitable factors except for price factor by this method.

Suppose take following 4 brands for example. Table 1 shows customers' evaluation to each brand by 5-point scale (highest grade: 5 to lowest grade: 1) from the view point of high grade or not. These are the assumed data.

Table 1. Evaluated Score of the Brand Bags (Ex.).

		Brand Name			
		Gucci	Vuitton	HELMES	COACH
Evaluated Class	5	22	40	48	14
	4	16	25	37	13
	3	33	23	18	28
	2	18	15	6	35
	1	12	1	2	15
Total		101	104	111	105

Based on these data, the brands are ranked by utilizing correspondence analysis. Correspondence analysis is calculated by using SPSS software. Based on the result of analysis, we obtained the following figure.

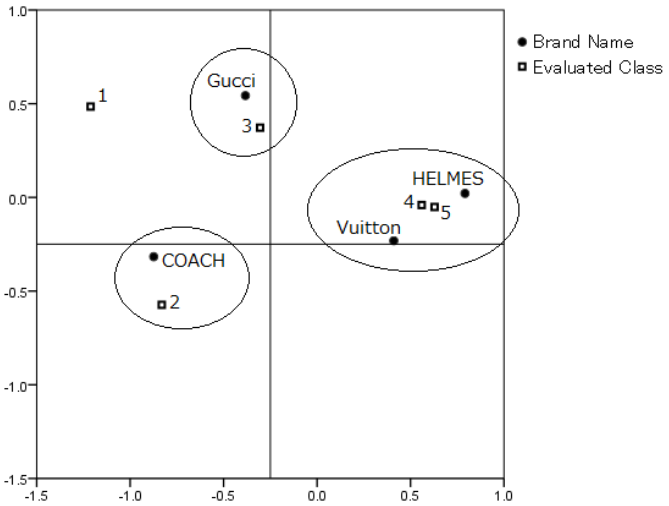

Figure 2. Principal Components' Score Map of the Brand Bags (Ex.).

From this result, HELMES and Vuitton are ranked as the most upper class. Gucci is ranked in the middle class, and COACH is ranked at the lowest class. Based on this ranking table, matrix structure is analyzed hereafter.

6. Numerical Calculation

▪6.1 Numerical Example

Now, the proposed method is examined under the supposition that the data sets (Evaluated class, Purchase history) are obtained. We have 5 brands (A-E), and they are evaluated by 5-point scale (highest grade: 5 to lowest grade: 1) individually from the viewpoint of high grade or not. In this paper, these scores are generated in a random manner. According to this, purchasing data $(\mathbf{X_b}, \mathbf{X})$ is generated by the probability rate shown in Table 2.

Table 2. Brand Shift Probability Rate.

%	5 point Brand	4 point Brand	3 point Brand	2 point Brand	1 point Brand	Total
$\mathbf{X_b}$	15%	15%	20%	25%	25%	100%
$\mathbf{X}$	25%	25%	20%	15%	15%	100%

Following 100 cases are generated.

Table 3. Evaluation Score and Data Shift.

	Evaluation Score					Data Shift		
	A	B	C	D	E	$\mathbf{X_b}$		$\mathbf{X}$
1.	3	4	5	2	1	B	→	C

	Evaluation Score					Data Shift		
	A	B	C	D	E	$\mathbf{X_b}$		$\mathbf{X}$
51.	4	2	1	5	3	E	→	A

2.	5	3	4	1	2	D	→	E
3.	5	2	3	4	1	B	→	C
4.	2	5	4	3	1	E	→	A
5.	5	1	3	2	4	D	→	C
6.	2	1	3	4	5	B	→	B
7.	2	1	3	4	5	A	→	A
8.	4	1	5	3	2	D	→	A
9.	3	2	5	4	1	D	→	C
10.	3	5	1	4	2	C	→	C
11.	4	1	5	2	3	B	→	D
12.	2	4	5	3	1	A	→	D
13.	5	1	3	4	2	B	→	E
14.	3	2	5	1	4	E	→	C
15.	4	1	5	3	2	D	→	A
16.	1	3	2	4	5	B	→	D
17.	5	3	4	2	1	D	→	B
18.	3	4	5	2	1	E	→	E
19.	3	1	4	5	2	E	→	A
20.	1	4	2	3	5	A	→	A
21.	4	3	1	5	2	A	→	D
22.	4	3	2	1	5	A	→	E
23.	1	4	3	2	5	B	→	E
24.	4	1	2	5	3	B	→	B
25.	3	1	5	2	4	D	→	A
26.	4	1	3	5	2	B	→	E
27.	3	5	1	2	4	B	→	B
28.	4	2	1	5	3	C	→	C
29.	2	3	4	5	1	E	→	E
30.	3	5	1	2	4	E	→	E
31.	4	5	2	3	1	D	→	A
32.	5	3	2	4	1	C	→	B
33.	3	2	4	1	5	B	→	A
34.	2	3	5	1	4	A	→	B
35.	1	5	4	3	2	A	→	E
36.	4	1	3	2	5	E	→	E
37.	5	3	2	4	1	B	→	D
38.	1	4	2	3	5	E	→	E
39.	3	1	5	2	4	D	→	A
40.	4	5	3	1	2	E	→	C

52.	2	1	4	3	5	B	→	B
53.	5	1	3	4	2	E	→	C
54.	5	4	1	2	3	E	→	B
55.	5	2	3	4	1	C	→	D
56.	3	2	4	5	1	C	→	C
57.	5	1	4	3	2	E	→	D
58.	1	5	2	3	4	C	→	D
59.	4	1	3	2	5	C	→	A
60.	4	3	1	5	2	E	→	B
61.	5	2	3	1	4	B	→	C
62.	4	3	2	5	1	D	→	D
63.	1	5	3	2	4	A	→	A
64.	4	1	2	5	3	A	→	A
65.	3	4	5	1	2	B	→	C
66.	3	5	2	4	1	A	→	D
67.	5	3	2	4	1	B	→	D
68.	3	2	4	5	1	B	→	A
69.	2	4	5	1	3	B	→	C
70.	3	1	5	2	4	A	→	E
71.	2	4	3	1	5	A	→	C
72.	1	5	4	2	3	E	→	C
73.	5	4	1	2	3	C	→	D
74.	1	3	2	4	5	E	→	E
75.	2	1	5	4	3	D	→	C
76.	5	1	3	2	4	A	→	A
77.	2	4	5	3	1	C	→	C
78.	4	5	2	1	3	D	→	C
79.	4	1	5	3	2	D	→	A
80.	1	5	2	4	3	B	→	B
81.	4	2	3	1	5	D	→	B
82.	4	2	5	1	3	B	→	E
83.	1	3	4	2	5	A	→	D
84.	3	2	5	1	4	C	→	C
85.	2	1	3	5	4	D	→	D
86.	1	4	5	2	3	A	→	A
87.	4	2	1	5	3	A	→	D
88.	5	3	4	2	1	D	→	D
89.	3	4	2	5	1	A	→	B
90.	5	1	4	3	2	B	→	B

41.	2	1	3	4	5	D	→	E	91.	3	4	5	2	1	D	→	A
42.	1	4	5	2	3	E	→	B	92.	1	3	2	5	4	E	→	E
43.	5	3	4	2	1	D	→	B	93.	1	4	2	3	5	C	→	D
44.	1	5	2	4	3	B	→	B	94.	3	4	1	5	2	C	→	C
45.	4	3	5	2	1	B	→	A	95.	2	5	1	4	3	E	→	D
46.	5	4	2	1	3	D	→	C	96.	5	1	2	4	3	E	→	D
47.	2	1	3	4	5	B	→	B	97.	1	3	4	2	5	E	→	E
48.	2	3	5	1	4	D	→	A	98.	4	5	1	2	3	D	→	E
49.	5	1	4	3	2	B	→	B	99.	4	2	1	5	3	D	→	D
50.	4	5	1	3	2	E	→	D	100.	1	2	5	3	4	C	→	C

▪6.2 Correspondence Analysis

Now, the proposed method is examined to the data sets shown in Table 3. We obtained table 4.

Table 4. Summary for Evaluated Score.

		Brand name				
		A	B	C	D	E
Evaluated Score	5	21	17	25	18	19
	4	25	19	18	21	17
	3	20	20	20	18	22
	2	16	16	22	27	19
	1	18	28	15	16	23
Total		100	100	100	100	100

We obtained Figure 3.

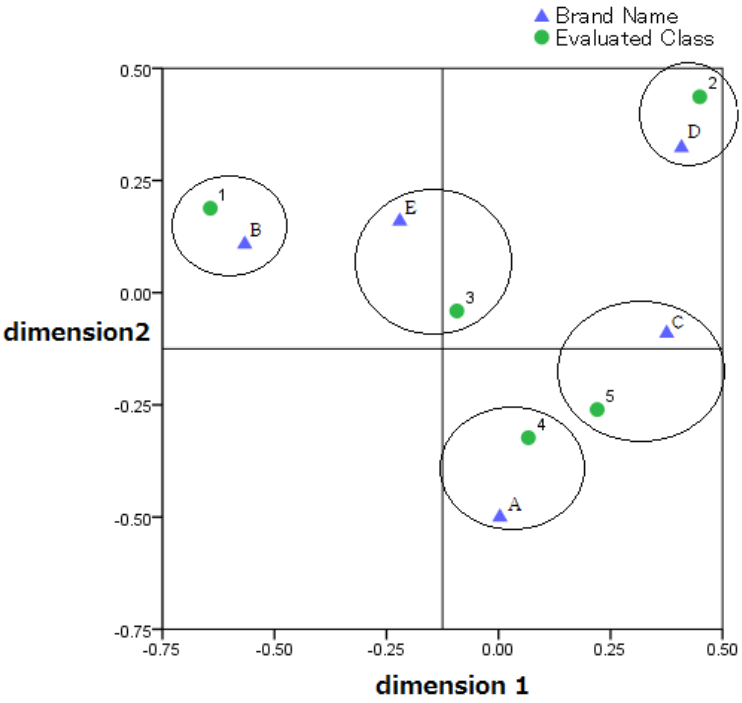

Figure 3. Principal Components' Score Map of the Brand Bags.

From these results, the brands are ranked as follows (Table 5).

Table 5. Evaluation of the Brand Rank.

Brand Name	Evaluated Score	Evaluated Class
A	4	2
B	1	5
C	5	1
D	2	4
E	3	3

▪6.3 Matrix Calculation

In this section, the shift data is transformed into vectors based on Table 5. Vector sets $\mathbf{X}, \mathbf{X_b}$ in the cases for 1 through 10 in Table 3 are expressed as follows.

$$1.\quad \mathbf{X} = \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \quad \mathbf{X_b} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{pmatrix} \quad 2.\quad \mathbf{X} = \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{pmatrix} \quad \mathbf{X_b} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{pmatrix} \quad 3.\quad \mathbf{X} = \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \quad \mathbf{X_b} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{pmatrix}$$

4. $\mathbf{X}=\begin{pmatrix}0\\1\\0\\0\\0\end{pmatrix}$ $\mathbf{X_b}=\begin{pmatrix}0\\0\\1\\0\\0\end{pmatrix}$ 5. $\mathbf{X}=\begin{pmatrix}1\\0\\0\\0\\0\end{pmatrix}$ $\mathbf{X_b}=\begin{pmatrix}0\\0\\0\\1\\0\end{pmatrix}$ 6. $\mathbf{X}=\begin{pmatrix}0\\0\\0\\0\\1\end{pmatrix}$ $\mathbf{X_b}=\begin{pmatrix}0\\0\\0\\0\\1\end{pmatrix}$

7. $\mathbf{X}=\begin{pmatrix}0\\1\\0\\0\\0\end{pmatrix}$ $\mathbf{X_b}=\begin{pmatrix}0\\1\\0\\0\\0\end{pmatrix}$ 8. $\mathbf{X}=\begin{pmatrix}0\\1\\0\\0\\0\end{pmatrix}$ $\mathbf{X_b}=\begin{pmatrix}0\\0\\0\\1\\0\end{pmatrix}$ 9. $\mathbf{X}=\begin{pmatrix}1\\0\\0\\0\\0\end{pmatrix}$ $\mathbf{X_b}=\begin{pmatrix}1\\0\\0\\0\\0\end{pmatrix}$

10. $\mathbf{X}=\begin{pmatrix}0\\0\\0\\1\\0\end{pmatrix}$ $\mathbf{X_b}=\begin{pmatrix}0\\0\\0\\0\\1\end{pmatrix}$

Shift data in the cases for 11 through 100 are omitted. Substituting these to Eq.(7), we obtain the following equation.

$$\hat{\mathbf{A}}=\begin{pmatrix}7&1&4&5&5\\1&6&3&8&3\\0&3&8&3&4\\4&5&4&4&4\\1&2&3&3&9\end{pmatrix}\begin{pmatrix}13&0&0&0&0\\0&17&0&0&0\\0&0&22&0&0\\0&0&0&23&0\\0&0&0&0&25\end{pmatrix}^{-1}=\begin{pmatrix}\frac{2}{5}&\frac{17}{126}&\frac{12}{91}&\frac{4}{97}&\frac{10}{167}\\\frac{1}{7}&\frac{55}{126}&\frac{4}{13}&\frac{20}{97}&\frac{29}{167}\\\frac{1}{7}&\frac{5}{21}&\frac{22}{91}&\frac{24}{97}&\frac{26}{167}\\\frac{1}{7}&\frac{1}{14}&\frac{2}{13}&\frac{30}{97}&\frac{31}{167}\\\frac{6}{35}&\frac{5}{42}&\frac{15}{91}&\frac{19}{97}&\frac{71}{167}\end{pmatrix} \tag{28}$$

Eq.(32) becomes to be an upper triangular matrix on the whole. From this result, it becomes clear that the ranking table utilizing correspondence analysis is effective. 40 cases are the upper shifts, 34 cases are the same rank movement, and 26 cases are the lower shifts.

7. Remarks

Applications of this method are considered to be as follows. Consumers' behavior may converges by repeating forecast under the above method and the total volume of sales of all brands may be reduced. Therefore, the analysis results suggest when and what to put the new brand into the market which contribute to the expansion of the market. There may arise following cases.

Consumers and producers do not recognize the brand position clearly. But the analysis of consumers' behavior let them know their brand position in the market. In such a case, strategic marketing guidance to select the brand would be introduced. Setting in order the brand position of various goods and taking suitable marketing policy, enhancement of sales would be enabled. Setting the higher ranked brand, consumption would be promoted.

8. Conclusion

It is often observed that consumers select the upper class brand when they buy the next time. Suppose that the former buying data and the current buying data are gathered. Also suppose that the upper brand is located upper in the variable array. Then the transition matrix become an upper triangle matrix under the supposition that former buying variables are set input and current buying variables are set output. If the top brand is selected from the lower brand in jumping way, corresponding part in an upper triangle matrix would be 0. A questionnaire investigation for automobile purchasing case was executed and the above structure was confirmed.

Formerly we have presented the paper and matrix structure was clarified when brand selection was executed toward higher grade brand. In Takeyasu et al. (2007) [6], matrix structure was analyzed for the case brand selection was executed for upper class. In this paper, the method of building the ranking table utilizing correspondence analysis was newly proposed. It becomes clear that the ranking table utilizing correspondence analysis is effective with the demonstration of numerical example.

If the transition matrix is identified, a *s*-step forecasting can be executed. Generalized forecasting matrix components' equations were introduced. One of the TRIZ methods was extended and applied. Unless planner for products does not notice its brand position whether it is upper or lower than other products, matrix structure makes it possible to identify those by calculating consumers' activities for brand selection. Thus, this proposed approach enables to make effective marketing plan and/or establishing new brand.

Such research as questionnaire investigation of consumers' activities in brand wine / whisky purchasing cases should be executed in the near future to verify obtained results.

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Optimization in Allocating Goods to Shop Shelves Utilizing Genetic Algorithm Under the Introduction of Sales Probabilities

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Abstract. How to allocate goods in shop shelves makes great influence to sales amount. Searching best fit allocation of goods to shelves is a kind of combinatorial problem. This becomes a problem of integer programming and utilizing genetic algorithm may be an effective method. Reviewing past researches, there are few researches made on this. Formerly, we have presented a papers concerning optimization in allocating goods to shop shelves utilizing genetic algorithm. In those papers, the problem that goods were not allowed to allocate in multiple shelves and the problem that goods were allowed to allocate in multiple shelves were pursued. In this paper, we examine the problem that allows goods to be allocated in multiple shelves and introduce the concept of sales profits and sales probabilities. Optimization in allocating goods to shop shelves is investigated. Expansion of shelf is executed. One of the TRIZ methods is extended and applied. Utilizing genetic algorithm, optimum solution is pursued and verified by a numerical example. Various patterns of problems must be examined hereafter.

Keywords: display, genetic algorithm, optimization, shelf

1. INTRODUCTION

Displaying method in the shop makes influence to sales amount, therefore various ideas are devised. What kind of items should be placed where in the shop, how to guide customers to what aisle in the shop are the big issues to be discussed. Searching best fit allocation of goods to shelves is also an important issue to be solved. In this paper, we seek how to optimize in allocating goods to shop shelves.

As for allocating good to shop shelves, following items are well known (Nagashima, 2005).

Shelf height is classified as follows.

・Shelf of 135cm height: Customers can see the whole space of the shop. Specialty stores often use this type.

・Shelf of 150cm height: Female customers may feel pressure to the shelf height. This height may be the upper limit to look over the shop.

・Shelf of 180cm height: It becomes hard to look over the shop. Therefore it should not be used for island display (display at the center or inside the shop).

Next, we show the following three functions of shelf for display.

1. Exhibition of goods function
2. Stock function
3. Display function

Effective range for exhibition is generally said to be 45cm-150cm. The range of 75cm-135cm is called golden zone especially. For the lower part under 45cm, goods are stocked as well as displaying.

Reviewing past papers, there are many papers concerning lay out problem. As for the problem of the distribution of equipment, we can see B. Korte *et al*. (2005), M. Gen *et al*. (1997) for the general research book. There are many researches made on this. Yamada *et al*. (2004) handles the lay out problem considering the aisle structure and intra-department material flow. Y. Wu *et al.* (2002) and Yamada *et al.* (2004) handle this problem considering aisle structure. Ito *et al.* (2006) considers multi-floor facility problem.

Although there are many researches on corresponding theme as stated above, we can hardly find researches on the problem of optimization in allocating goods to shop shelves.

Formerly, we have presented a paper concerning optimization in allocating goods to shop shelves utilizing genetic algorithm (Takeyasu *et al.*,2008). In those papers, the problem that goods were not allowed to allocate in multiple shelves and the problem that goods were allowed to allocate in multiple shelves were pursued. In this paper, we examine the problem that allows goods to be allocated in multiple shelves and introduce the concept of sales profits and sales probabilities. Expansion of shelf is executed. One of the TRIZ methods is extended and applied. Optimization in allocating goods to shop shelves is investigated. Utilizing genetic algorithm, optimum solution is pursued and verified by a numerical example.

The rest of the paper is organized as follows. Extended Analysis Method is stated in section 2. Problem description is stated in section 3. Genetic Algorithm is developed in section 4. Numerical example is exhibited in section 5 which is followed by the remarks of section 6. Section 7 is a summary.

2. Extended Analysis Method

The function "Moves" is a fundamental function of TRIZ [15],[16]. We can further develop this concept as shown in Figure 1. Based on the TRIZ method, extended analysis is developed. Applying "Extend" function and/or Principle "Parameter changes"[17], the shelf is extended from 2 to 3. These are the process of "Extended Analysis" based upon TRIZ "Extend" method. Detailed inspection is executed in section 4.

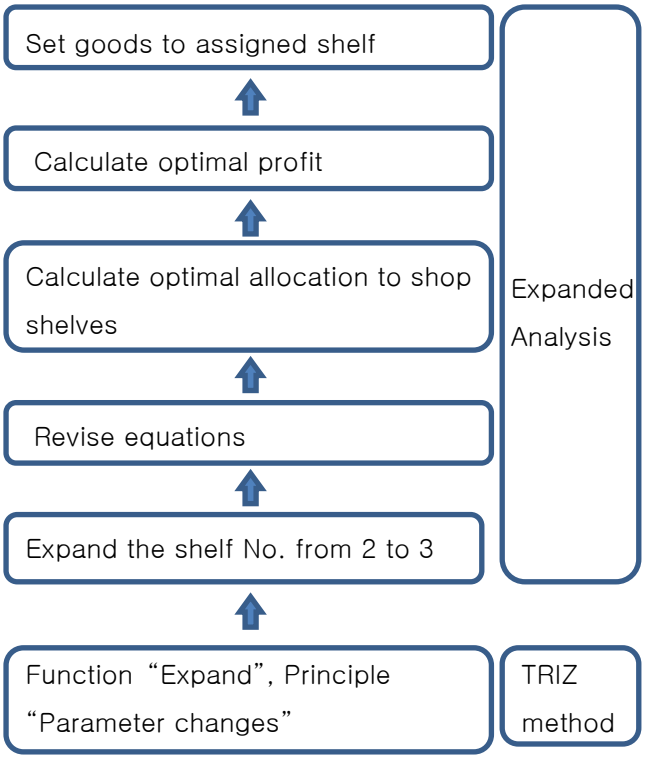

Figure1. Extended Analysis Method

3. PROBLEM DESCRIPTION

Shelf model is constructed as Figure 2. There are five shelf positions. Shelf position 1 is mainly to put big and heavy goods including stock function. Shelf position 3, 4 at the height of the range 75cm to 135cm are the space of golden zone. Thus, we can use shelves properly by assuming these shelves. In numerical example, we examine using these five shelves. First of all, we make problem description in the case there is only one shelf (case 1). Then we expand to the case there are multiple shelves (case 2).

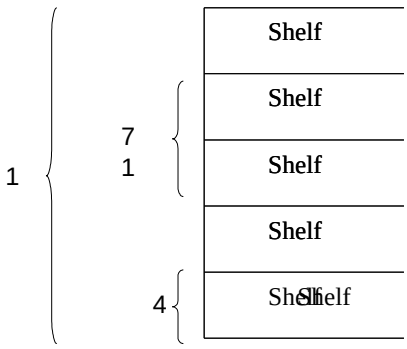

Figure 2: Shelf Model

(1)Case 1: The case that there is only one shelf

Although there are few cases that there is only o ne shelf, it makes the foundation for multiple shelves case. Therefore we pick it up as a fundamental one. S 3uppose shelf position k is from 1 to L (Figure 2).

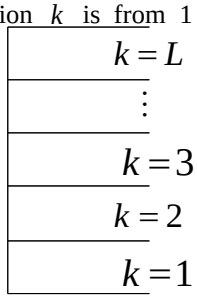

Figure 3: Shelf Position

Suppose there are N amount of goods $(i = 1, \cdots, N)$. Set sales profit of goods i as H^i. Table 1 shows the sales probabilities when each goods is placed at each shelf position. The values in this ta ble are written for example.

Table 1: Sales probability for each goods

Day of the Week	Time Zone(t)	Shelf j=1			Shelf j=2			…	Shelf $j=m$		
		Shelf Position			Shelf Position			…	Shelf Position		
		k=1	…	$k=L_1$	k=1	…	$k=L_2$	…	k=1	…	$k=L_m$
(Mon.)	0-1(t=1)	0.01	…								
	1-2(t=2)	0.02									
	…										
	23-24(t=24)	0.03									
(Tue.)	0-1(t=25)	0.02									
	1-2(t=26)	0.02									
	…										
	23-24(t=48)	0.03									
…	…	…	…	…	…	…	…	…	…	…	…
(Sun.)	0-1(t=145)	0.02									
	1-2(t=146)	0.03									
	…										
	23-24(t=168)	0.04									

Suppose goods are sold in the period from t_1 to t_n. In addition, a new goods i is replenished when goods i is sold out.

Set the accumulated sales probability of goods i in time zone t, shelf j, and shelf position k in the table as $HK^i_{t,j,k}$.

Then, the sales probability $K^{i,j,k}_{t_1/t_n}$ of goods i in the period will be described as follows.

$$K^{i,j,k}_{t_1/t_n} = \sum_{t=1}^{n} HK^i_{t,j,k}$$

This can take the value more than 1. For example, the value 2 means that 2 amount of goods were sold during the period.

Set Benefit in the sales period from t_1 to t_n as $P^{i,j,k}_{t_1/t_n}$ $(i=1,\cdots,N)$ $(j=1,\cdots,m)$ $(k=1,\cdots,L)$ when goods i is placed at shelf j and shelf position k.

Where Benefit means:

$$\text{Benefit} = \text{SalesProbability} \times \text{SalesProfit}$$

Therefore, this equation is represented as follows.

$$P^{i,j,k}_{t_1/t_n} = K^{i,j,k}_{t_1/t_n} \cdot H^i \tag{1}$$

where j=1 because one shelf case is considered here.

Set $x_{i,k}$ as:

$x_{i,k} = 1$: Goods i is placed at shelf position k.

$x_{i,k} = 0$: Else

Suppose only one goods can be placed at one shelf position and also suppose that goods is allowed to allocate in multiple shelf positions. Then constraints are described as follows.

$$x_{i,k} = 1,0 \ (i=1,\cdots,N)\ (k=1,\cdots,L) \tag{2}$$

$$\sum_{i=1}^{N} x_{i,k} = 1 \ (k=1,\cdots,L) \tag{3}$$

Under these constraints,

$$Maximize\ J = \sum_{k=1}^{L}\sum_{i=1}^{N} P_{t_1/t_n}^{i,j,k} x_{i,k} \tag{4}$$

(2) Case 2: The case that there are m shelves

Suppose there are m shelves (Figure 4). Set Benefit as $P_{t_1/t_n}^{i,j,k}$ $(i=1,\cdots,N)$, $(j=1,\cdots,m)$, $(k=1,\cdots,L_j)$ where goods i is placed at shelf position k of shelf j. The sales period is the same with above stated (1).

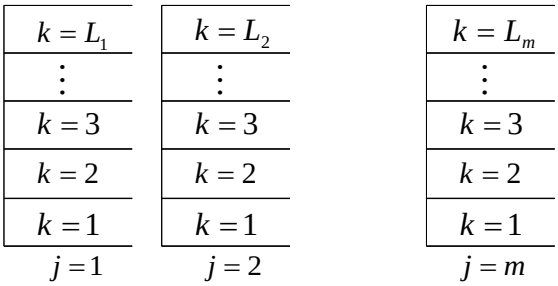

Figure 4: Shelf Position under multiple shelves

Set $x_{i,j,k}$ as:

$x_{i,j,k}=1$: Goods is placed at shelf position k of shelf j

$x_{i,j,k}=0$: Else

Suppose only one goods can be placed at one shelf position and also suppose that goods is allowed to allocate in multiple shelf positions. Then constraints are described as follows. The sales period is the same with before.

$$x_{i,j,k}=1,0\ (i=1,\cdots,N)\ (j=1,\cdots,m)\ (k=1,\cdots,L_j) \tag{5}$$

$$\sum_{i=1}^{N} x_{i,j,k}=1\ (j=1,\cdots,m)\ (k=1,\cdots,L_j) \tag{6}$$

Under these constraints,

$$Maximize\ J = \sum_{i=1}^{N}\sum_{j=1}^{m}\sum_{k=1}^{L_j} P_{t_1/t_n}^{i,j,k} x_{i,j,k} \tag{7}$$

4. ALGORITHM

We can make problem description as stated above, although these are somewhat under restricted cases. As far as only these are considered as they are, there is little difference between these and the conventional optimization problems. However, as soon as the number of involved shelves becomes larger, the number of variables dramatically grows greater, to which the application of Genetic Algorithm solution and Neural Network solutions may be appropriate. There are various means to solve this problem. When that variable takes the value of 0 or 1, the application of genetic algorithm would be a good method. As is well known, the calculation volume reaches numerous or even infinite amounts in these problems when the number of variables increases. It is reported that GA is effective for these problems (Gen et al. (1995), Lin et al. (2005), Zhang et al. (2005)).

A. The Variables

Suppose the number of goods, shelf position, and shelf are 20, 5, 3 respectively. In this paper, shelf position is expanded from 2 to 3. Then the number of variables becomes three hundred.

$$x_{i,j,k}=1,0\ (i=1,\cdots,20)\ (j=1,2,3)\ (k=1,\cdots,5)$$

Therefore, set chromosome as follows.

$$\begin{aligned} X = (&x_{1,1,1}, x_{2,1,1}, x_{3,1,1}, \cdots, x_{20,1,1},\\ &x_{1,1,2}, x_{2,1,2}, x_{3,1,2}, \cdots, x_{20,1,2},\\ &\vdots\\ &x_{1,1,5}, x_{2,1,5}, x_{3,1,5}, \cdots, x_{20,1,5},\\ &x_{1,2,1}, x_{2,2,1}, x_{3,2,1}, \cdots x_{20,2,1},\\ &x_{1,2,2}, x_{2,2,2}, x_{3,2,2}, \cdots, x_{20,2,2}\\ &\vdots\\ &x_{1,2,5}, x_{2,2,5}, x_{3,2,5}, \cdots, x_{20,2,5},\\ &x_{1,3,1}, x_{2,3,1}, x_{3,3,1}, \cdots, x_{20,3,1},\\ &x_{1,3,2}, x_{2,3,2}, x_{3,3,2}, \cdots, x_{20,3,2},\\ &\vdots\\ &x_{1,3,5}, x_{2,3,5}, x_{3,3,5}, \cdots, x_{20,3,5}) \end{aligned} \tag{8}$$

B. Initialize population

Initialization of population is executed. The number of initial population is M. Here set $M=100$. Set gene at random and choose individual which satisfies constraints.

C. Selection

In this paper, we take elitism while selecting. Choose P individuals in the order which take maximum score of objective function.

Here, set $P=20$

D. Crossover

Here, we take uniform crossover.

Set crossover rate as:

$$P_c = 0.7 \tag{9}$$

E. Mutation

Set mutation rate as:

$$P_m = 0.01 \tag{10}$$

Algorithm of GA is exhibited at Table 2.

Table 2: Algorithm of multi-step tournament selection method

Step 1：	Set maximum No. as $g_{\max}$, population size as P, crossover rate as p_c, mutation rate as p_m.
Step 2：	Set $t=1$ for generation No. and generate initial solution matrix $x_p(t)=\left(x_{i,j,k}^{p}\right)$ $(p=1,\cdots,M)$.
Step 3：	Calculate Objective function $J\left(x_p(t)\right)$ for all solution matrix $x_p(t)$ $(p=1,\cdots,P)$ in generation t.
Step 4：	Set $t=t+1$ until $t>g_{\max}$.
Step 5：	Crossover Generate new individual by crossover utilizing the method of above stated *D*.
Step 6：	Mutation Reproduce by mutation utilizing the method of above stated *E*.
Step 7：	Calculate objective function for reproduction of generation t.
Step 8：	Selection Next generation is selected by elitism. Go to Step 4.

Introducing the variable y_s such that:

$$y_s = i \tag{11}$$

where

$$s = k + (j-1)\cdot 5 \tag{12}$$

when

$$x_{i,j,k} = 1$$

then (8) is expressed as:

$$Y = \left(y_1, y_2, \cdots, y_{15}\right) \tag{13}$$

5. NUMERICAL EXAMPLE

Now, we execute numerical example using POS sales data. Numerical example is executed in “Case 2” of 2 (2). Suppose the sales period is 5 days for Monday through Friday. Table 3 shows the unit sales profit H^i of each goods.

Table 3: Unit Sales Price and Sales Profit of each goods

Lot i	Sales Price	H^i	
1		6000	
2		5500	
3		5500	
4		5000	
5		4500	For Women
6		4500	
7		4000	
8		3500	
9		3000	
10		3000	
11		6000	
12		5500	
13		5000	For Men
14		4500	
15		4000	
16		3500	
17		3000	
18		4000	For Kids
19		3000	
20		2000	

Supposing a general daytime retail store, we set opening time to be 9 through 18 o’clock. Table 4 shows the sales probabilities of lot i as an example.

Table 5 shows the sales probability by shelf for each shelf position. Table 6 shows the value in which Table 4 and Table 5 are multiplied. Table 7 shows the benefit Table in which accumulated probability of Table 6 and Sales Profit of Table 3 are multiplied.

Table 4: Sales Probability of Lot i (Time Zone)

Day of the Week	Time Zone(t)	Sales Probability	Day of the Week	Time Zone(t)	Sales Probability
(Mon.)	9-10		(Thu.)	9-10	
	10-11			10-11	
	11-12			11-12	
	12-13			12-13	
	13-14			13-14	
	14-15			14-15	
	15-16			15-16	
	16-17			16-17	
	17-18			17-18	
(Tue.)	9-10		(Fri.)	9-10	
	10-11			10-11	
	11-12			11-12	
	12-13			12-13	
	13-14			13-14	
	14-15			14-15	
	15-16			15-16	
	16-17			16-17	
	17-18			17-18	
(Wed.)	9-10		(Sat.)	9-10	
	10-11			10-11	
	11-12			11-12	
	12-13			12-13	
	13-14			13-14	
	14-15			14-15	
	15-16			15-16	
	16-17			16-17	
	17-18			17-18	

Table 5: Sales Probability of Lot i (Shelf Position)

Shelf j =1					Shelf j =2					Shelf j =3				
Shelf Position					Shelf Position					Shelf Position				
k =1	k =2	k =3	k =4	k =5	k =1	k =2	k =3	k =4	k =5	k =1	k =2	k =3	k =4	k =5
0.7	0.9	1.2	1.2	0.9	0.8	1.0	1.3	1.3	1.0	0.8	0.9	1.2	1.3	1.1

In Table 5, shelf j =2 is located near the entrance therefore the table value reflects this condition.

Table 6: Sales Probability of Lot i

Day Of The Week	Time Zone(t)	Shelf j=1					Shelf j=2					Shelf j=3				
		Shelf Position					Shelf Position					Shelf Position				
		k =1	k =2	k =3	k =4	k =5	k =4	k =5	k =3	k =4	k =5	k =1	k =2	k =3	k =4	k =5
(Mon.)	9-10															
	10-11															
	11-12															
	12-13															
	13-14															
	14-15															
	15-16															
	16-17															
	17-18															
(Tue.)	9-10															
	10-11															
	11-12															
	12-13															
	13-14															
	14-15															
	15-16															
	16-17															
	17-18															
(Sat.)	9-10															
	10-11															
	11-12															
	12-13															

	13-14															
	14-15															
	15-16															
	16-17															
	17-18															

Table 7 shows the benefit when each goods is placed at each shelf position of each shelf.

Table 7: Benefit Table

	Shelf 1					Shelf 2					Shelf 3				
	Shelf Position					Shelf Position					Shelf Position				
Lot i	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	2580	4380	5400	5220	4380	5220	7020	7980	7800	7020	2780	4880	5650	5800	5180
2	2750	4620	5610	5390	4620	5005	6820	7810	7590	6820	2950	5120	5860	6000	5420
3	3025	4840	5830	5610	4840	4840	6600	7590	7425	6600	3225	5340	6100	6200	5640
4	3200	5000	6000	5800	5000	4600	6400	7400	7200	6400	3400	5500	6250	6400	5800
5	3420	5130	6750	6345	5130	4230	6750	7830	7560	6660	3645	5670	7110	6975	5985
6	3600	5400	6390	6210	5400	4185	5985	7020	6795	5985	3800	5900	7150	6800	6200
7	3800	5600	6600	6400	5600	4000	5800	6800	6600	5800	4000	6100	6650	7000	6400
8	3990	5810	6790	6615	5810	3815	5600	6615	6405	5600	4200	6310	6850	7200	6600
9	4200	6000	6900	6810	6000	3600	5400	6300	6210	5400	4400	6500	7050	7400	6800
10	4410	6210	7200	6990	6210	3390	5190	6210	6000	5190	4610	6710	7150	7600	7000
11	2220	4980	5820	6000	5580	4200	7020	7800	7980	7620	2420	5500	7450	6600	6400
12	2420	5225	5995	6215	5830	4015	6820	7590	7810	7425	2620	5720	6070	6820	6600
13	2600	5400	6200	6400	6000	3800	6600	7400	7600	7200	2800	5900	6250	7000	6800
14	2790	5580	6390	6615	6210	3600	6390	7200	7380	7020	3000	6100	6450	7210	7000
15	3000	5800	6600	6800	6400	3400	6200	7000	7200	6800	3200	6300	6650	7400	7200
16	3185	5985	6790	7000	6615	3185	5985	6790	7000	6615	3400	6500	6850	7600	7400
17	3390	6240	6990	7200	6810	3000	5790	6600	6810	6390	3600	6700	7050	7800	7600
18	6800	6800	3200	2400	200	8000	8000	4400	3400	1400	7000	7300	6450	3000	1000
19	6990	6990	3390	2610	390	7800	7800	4200	3210	1200	7200	7500	6650	3200	1200
20	7200	7200	3600	2800	600	7600	7600	4000	3000	1000	7400	7700	6850	3400	1400

Experimental results are as follows. The expression Eq. (8) is complicated. Therefore we use expression by Eq. (13). A sample set of initial population is exhibited in Table 6.

Table 6: A Sample Set of Initial Population

$Y_1 =$	(	7	20	2	9	9	5	19	5	17	14	19	4	9	12	20	)
$Y_2 =$	(	11	14	4	13	11	16	11	3	5	18	10	8	5	9	12	)
$Y_3 =$	(	12	18	10	15	2	20	4	12	19	15	3	7	1	18	13	)
						⋮											
$Y_{98} =$	(	11	2	6	12	20	12	18	16	9	9	9	15	20	14	5	)
$Y_{99} =$	(	9	16	6	11	3	18	6	3	10	6	12	9	3	3	16	)
$Y_{100} =$	(	8	12	4	17	15	12	13	7	14	2	11	8	6	12	5	)

Convergence process is exhibited in Figure 5.

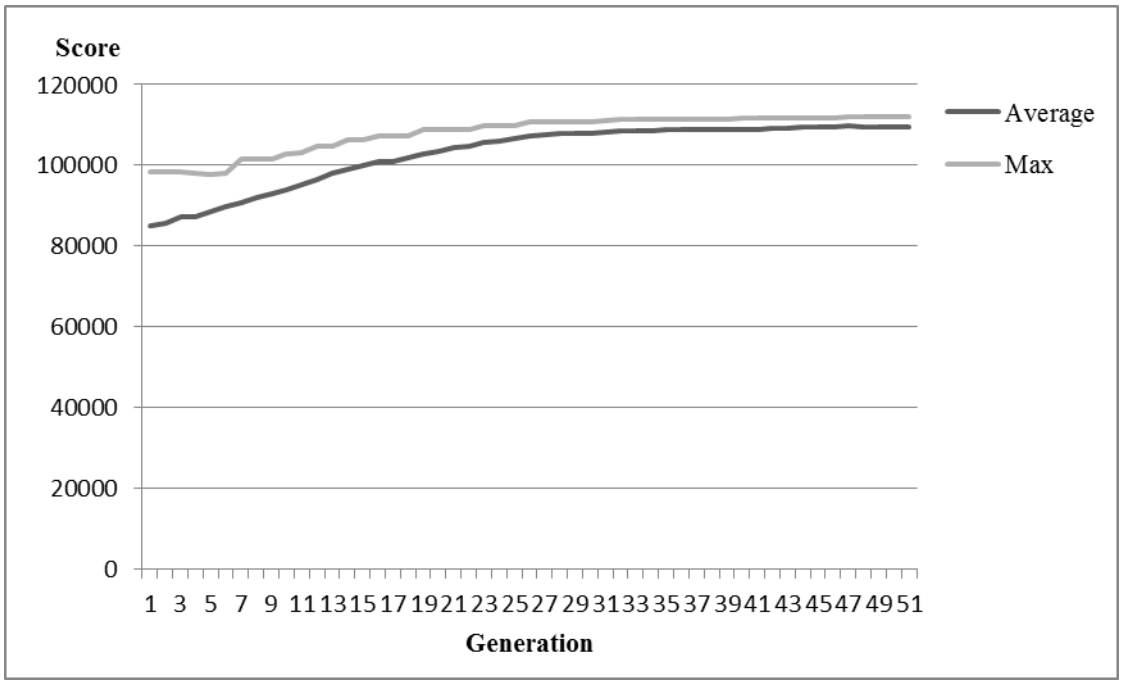

Figure 5: Convergence Process of Case 2

The problem is simple, so combination of genotype for crossover saturates in the 170thgeneration. Genotype in which objective function becomes maximum is as follows.

$$Y = (20,\ 20,\ 10,\ 17,\ 17,\ 18,\ 18,\ 1,\ 11,\ 11,\ 20,\ 20,\ 11,\ 17,\ 17)$$

This coincides with the result of optimal solution by the calculation of all considerable cases, therefore it coincides with a theoretical optimal solution. We take up simple problem and we can confirm the effectiveness of GA approach. Further study for complex problems should be examined hereafter.

6. REMARKS

As there are few papers made on this theme, we constructed prototype version before (Takeyasu et al.,2008). In this paper, we examined the problem that allowed goods to be allocated in multiple shelves and introduced the concept of sales profits and sales probabilities. An application to the shop with POS sales data was executed. We can see that genetic algorithm is effective for this problem.

In practice, following themes occur.

1. Sales probabilities should be arranged correctly.
2. There are various types of shelves corresponding to goods characteristics (For example, cold storage good s).
3. Furthermore, genotype must be devised in construction when there are huge number of goods and sh elves.

For these issues, expanded version of the paper will be built hereafter consecutively. As for 1, constraints are relaxed than those of this paper. As for 2, expansion is easy to make. As for 3, constructing genotype from the shelf side would bear much more simple expression.

7. CONCLUSION

How to allocate goods in shop shelves makes great influence to sales amount. Searching best fit allocation of goods to shelves is a kind of combinatorial problem. This becomes a problem of integer programming and utilizing genetic algorithm may be an effective method. Reviewing past researches, there were few researches made on this. Formerly, we had presented papers concerning optimization in allocating goods to shop shelves utilizing genetic algorithm. In those papers, the problem that goods were not allowed to allocate in multiple shelves and the problem that goods were allowed to allocate in multiple shelves were pursued. In this paper, we examined the problem that allowed goods to be allocated in multiple shelves and introduced the concept of sales profits and sales probabilities. Expansion of shelf was executed. One of the TRIZ methods was extended and applied. Optimization in allocating goods to shop shelves was investigated. Utilizing genetic algorithm, optimum solution was pursued and verified by a numerical example. Various patterns of problems should be examined hereafter.

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Multivariate Analysis for the Questionnaire Investigation in the Support of High School Teachers by the School Social Worker

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Abstract

High School teachers in Japan are sending very busy days on their daily works including teaching, support for the club activities and deskwork. Among them, they share a lot of time for managing the club actives of students compared with other countries. In that area, professionals can make instruction much better than teachers for the special sports like Judo and Kendo (Japanese fencing) etc. School Social Worker can coordinate the professionals out of school and can help teachers by decreasing their burden on that area. There are few related papers concerning the support of club activities by utilizing the professionals outside. In this paper, questionnaire investigation is executed in order to clarify their current condition and their consciousness, and to seek the possibility of utilizing school social worker for their support. Fundamental statistical analysis, Hypothesis Testing, Factor Analysis and Multi Corresponding Analysis are performed. One of the TRIZ methods is extended and applied. Some interesting and instructive results were obtained.

Keywords: School Social Worker, High school teacher, Multi Corresponding Analysis, Factor Analysis

1. Introduction

Teacher at High school / Junior High School in Japan are sending very busy days in general on their daily works including teaching, support for the club activities and deskwork. Among them, they share a lot of time for managing the club actives of students compared with other countries. In particular, it takes time to manage the club activities for sports. In that area, professionals can make instruction much better than teachers for the special sports like Judo and Kendo (Japanese fencing) etc. School Social Worker can coordinate the professionals out of school and can help teachers by decreasing their burden on that area.

There are many researches made on School Social Workers' function. For example, H. Konyuba (2011) analyzed the teacher's sparing time for club activities and pointed out that there is a difference between the

sports club and the culture club. K.Yonekawa (2011) discussed the mental health support by school social worker. M.S.Kelly et al. (2010) made School Social work survey and derived instructive insight.
OECD (Organisation for Economic Co-operation and Development) has released the investigation report of "Teaching And Learning International Survey (TALIS)" on June 25/2014. It is reported that the teacher's total working hours for a week in Japan were the most among 33 countries. Main data are as follows.
/Teacher's total working hours for a week in Japan: 53.9 (Average: 38.3)
/ Teacher's working hours of support for the club activities for a week in Japan: 7.7(Average: 2.1)
/Teacher's working hours of deskwork for a week in Japan: 5.5 (Average: 2.9)
/Teacher's teaching hours for a week in Japan: 17.7 (Average: 19.3)
Teacher's working hours of support for the club activities were nearly triple, and those of deskwork double compared with the average, while the teaching hours were less than those of the average. They are too busy for the support of the club activities and deskwork, which causes bad influence on their teaching activities.
Although there are some related papers as these, but there are few related papers concerning the support of club activities by utilizing the professionals outside especially in the Japanese case.
In this paper, questionnaire investigation is executed in order to clarify their current condition and their consciousness, and to seek the possibility of utilizing school social worker for their support. Fundamental statistical analysis, Hypothesis Testing, Factor Analysis and Multi Corresponding Analysis are performed. One of the TRIZ methods is extended and applied. Some interesting results were obtained.
The rest of the paper is organized as follows. Extended analysis method is stated in section 2. Outline of questionnaire investigation is stated in section 3. Hypothesis Testing is carried out in section 4, Factor Analysis is conducted in section 5 and Multi Corresponding Analysis is executed in section 6 which is followed by the Remarks of section 7.

2. Extended Analysis Method

We made a questionnaire investigation and analyzed them by the Hypothesis Testing. In order to confirm these results by another viewpoint, we made Factor Analysis and Multi Corresponding Analysis. This may be the "Another Dimension" viewpoint.
The function "Extend" is a fundamental function of TRIZ [6],[7]. We can further develop this concept as shown in Figure 1.1. Based on the TRIZ method, extended analysis is developed. Applying Principle "Another Dimension"[8], Factor Analysis and Multi Corresponding Analysis were executed.
These are the process of "Extended Analysis" based upon TRIZ "Extend" and/or Principle "A nother Dimension" method. Detailed inspection is executed in section 5 and 6.

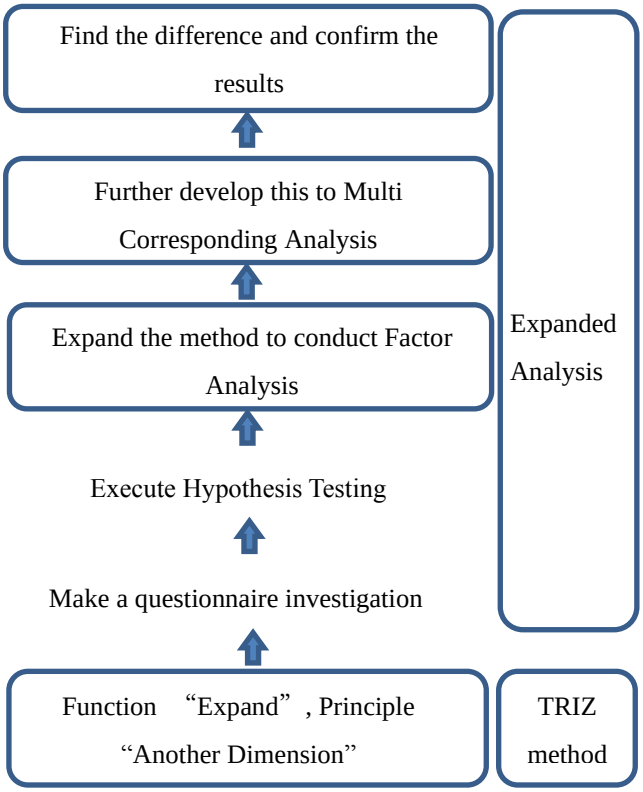

Figure1.1 Extended Analysis Method

3. Outline and the Basic Statistical Results of the Questionnaire Research

3.1 Outline of the Questionnaire Research

We make a questionnaire investigation for the Support of High School Teachers by the School Social Worker. The outline of questionnaire research is as follows. Questionnaire sheet is attached in Appendix.

(1)	Scope of investigation	:	High School Teacher, 7 High Schools in Aomori Prefecture, Japan
(2)	Period	:	January ～March 2014
(3)	Method	:	Leave until called for
(4)	Collection	:	Number of distribution 231 Number of collection 170(collection rate 73.6%) Valid answer 170

3.2 Basic Statistical Results

Now, we show the main summary results by single variable.

3.2.1 Characteristics of answers (Q4)

(1) Sex (Q4-1)
Male: 64.12%
Female: 31.76%
(Not filled in: 4.12%)

(2) Age (Q4-2)
20～29: 16.47%
30~39: 28.82%
40~49: 22.35%
50~59: 29.41%
More than 60: 1.76%
(Not filled in: 1.19%)

(3) Position (Q4-3)
Deputy Principal: 3.53%
A person in charge of educational affairs: 8.24%
Teacher: 74.71%
Lecturer: 9.41%
Assistant: 1.18%
Miscellaneous: 2.93%

(4) Experience as a teacher (Q4-4)
More than 10 years consists 2/3.

(5) How many years are you working for the present school?
5~9 years and more than 10 years consist nearly 3/4.

3.2.2 Faculty Course (Q1-2)

Ordinary Course and Technical Course consist of nearly 2/3 in the total.

3.2.3 Club Activities

(1) Sports Club (Q 1-2-1)
Large part one is Basketball (7.06%), Baseball (5.88%), Soccer (5.29%) and Badminton (5.29%). Miscellaneous (14.12%) includes Ice hockey, Softball, Bowling, Boxing, Karate etc. “99” means “Else”.

(2) Culture Club (Q1－2－2)
Main items are as follows.
/ART: 2.35%, /Broadcast Department: 2.94%, /Theater Photo Department: 1.76%,
23(25.29%) consists by the following clubs with small number % ratio.
/Housing Research, /PC, /Manufacturing, /Baton etc.
On the whole, sports clubs consist nearly 60% and culture clubs 40%.

（3） How about the sort of job? (Q1－2－2－3)
/Adviser: 86.47%, /Deputy Adviser: 11.18%, Miscellaneous: 2.35%
Adviser takes the majority.

(4) Is the club strong enough to participate in the national sports match? (Q1－2－2－4)
Nearly 1/5 of them are the strong teams to participate in the national sports match.

(5) Is the club activity active? (Q1－2－2－5)
More than half of them have selected “Yes”.

(6) How long a time do you spare for the club activity (Include moving time) (Q1－2－2－6)
60 hours in month exceeds half and 90 hours reaches 3/4 in the total.

3.2.4 Consciousness for the daily works (Q2)

(1) Feel it burden to teach (Q2-1)
Nearly 15% of the teachers feel it burden to teach. This is rather a small value.

(2) Feel it burden to prepare for teaching (Q2-2)
Nearly 21% of the teachers feel it burden to prepare for teaching. This is rather a small value.

(3) Feel it burden to instruct for learning(Q2-3)
Nearly 22% of the teachers feel it burden to instruct for learning.

(4) Feel it burden to handle the students’ performance(Q2-4)
Nearly 24% of the teachers feel it burden to handle the students’ performance.
The value is slightly increasing compared with above.

(5) Feel it burden to guide students (Q2-5)

Nearly 31% of the teachers feel it burden to guide students.
This value is rather big compared with before.

(6) Feel it burden to guide club activities(Q2-6)
Nearly 17% of the teachers feel it burden to guide club activities.

(7) Feel it burden to manage the class(Q2-8)
Nearly 19% of the teachers feel it burden to manage the class.

(8) Feel it burden to deal with meeting, advance arrangement(Q2-9)
Nearly 28% of the teachers feel it burden to deal with meeting, advance arrangement.
This value is rather big compared with before.

(9) Feel it burden to deal with parents(Q2-10)
Nearly 17% of the teachers feel it burden to deal with parents.

3.2.5 Consciousness for guiding the club activities (Q3)

(1) Worthwhile to guide club activities (Q3-1)
Positive attitude to this theme can be seen.

(2) It is better for the professionals to guide club activities (Q3-2)
Strong positive attitude to this theme can be confirmed.

(3) I do not know the club field precisely that I take charge of (Q3-3)
Rather many teachers (33.5%) feel anxiety for their expertise in their club field.

(4) Quite tired because of the activity on holiday (Q3-5)
Nearly 1/3 of them feel tired because of the club activity on holiday.

(5) Have a hard time for the technical guidance (Q3-6)
40% of them have a hard time for the technical guidance.

(6) Have a hard time for the mental guidance (Q3-7)
Nearly 45% of them have a hard time for the mental guidance.

(7) Want to have a person to consult with in guiding club activities (Q3-8)

Nearly 38% of them want to have a person to consult with in guiding club activities.

4. Hypothesis Testing

Hereinafter we make hypothesis testing based upon the questionnaire investigation data.

4.1 Setting Hypothesis

First of all, we start from the hypothesis testing.

Two main issues are set as follows.

A When they have a hard time in guiding club activities, they think that they want to have a person to consult with or it is better for the professionals to guide club activities.

B When they feel worthwhile to guide club activities, they feel less burden for it.

Next, we set the following 13 themes (sub issues) before setting Null hypothesis.

A-1 If they feel it burden to teach, they think that it is better for the professionals to guide club activities.

A-2 If they feel it burden to teach, they think that they cannot share enough time to prepare for teaching because of the workload for the guidance of club activities.

A-3 When they have a hard time for the technical guidance, they think that they want to have a person to consult with in guiding club activities.

A-4 When they have a hard time for the mental guidance, they think that they want to have a person to consult with in guiding club activities.

A-5 When they do not know the club field precisely, they think that they want to have a person to consult with in guiding club activities.

A-6 If they feel that they cannot share enough time to prepare for teaching because of the workload for the guidance of club activities, they think that they want to have a person to consult with in guiding club activities.

A-7 If they feel quite tired because of the activity on holiday, they think that they want to have a person to consult with in guiding club activities.

B-1In the technical course, teachers in charge of club activities spare a lot of time.

B-2 Where the club activities are active, teachers in charge of club activities spare a lot of time.

B-3 Where the club is strong enough to participate in the national sports match, they feel worthwhile to guide club activities.

B-4 Even when they feel worthwhile to guide club activities, they feel it burden to guide club activities

B-5 Even when they feel worthwhile to guide club activities, they think that it is better for the professionals to guide club activities.

B-6 If the club activity is active, they feel worthwhile to guide club activities.

Now, we set the following 13 Null hypothesis.

Null Hypothesis

A-1 Even if they feel it burden to teach, they do not think that it is better for the professionals to guide club activities.
A-2 Even if they feel it burden to teach, they do not think that they cannot share enough time to prepare for teaching because of the workload for the guidance of club activities.
A-3 Even when they have a hard time for the technical guidance, they do not think that they want to have a person to consult with in guiding club activities.
A-4 Even when they have a hard time for the mental guidance, they do not think that they want to have a person to consult with in guiding club activities.
A-5 Even when they do not know the club field precisely, they do not think that they want to have a person to consult with in guiding club activities.
A-6 Even if they feel that they cannot share enough time to prepare for teaching because of the workload for the guidance of club activities, they do not think that they want to have a person to consult with in guiding club activities.
A-7 Even if they feel quite tired because of the activity on holiday, they do not think that they want to have a person to consult with in guiding club activities.

B-1In the technical course, teachers in charge of club activities do not spare a lot of time.
B-2 Even if where the club activities are active, teachers in charge of club activities do not spare a lot of time.
B-3 Even if where the club is strong enough to participate in the national sports match, they do not feel worthwhile to guide club activities.
B-4 When they feel worthwhile to guide club activities, they do not feel it burden to guide club activities
B-5 When they feel worthwhile to guide club activities, they do not think that it is better for the professionals to guide club activities.
B-6 Even if the club activity is active, they do not feel worthwhile to guide club activities.

4.2 Hypothesis Testing

The results of statistical hypothesis testing are as follows.

The null hypothesis A-1 is rejected with 6% significance level. It can be said that if they feel it burden to teach, they think that it is better for the professionals to guide club activities.
The null hypothesis A-2 is rejected with 1% significance level. It can be said that if they feel it burden to teach, they think that they cannot share enough time to prepare for teaching because of the workload for the guidance of club activities.
The null hypothesis A-3 is rejected with 1% significance level. It can be said that when they have a hard time for the technical guidance, they think that they want to have a person to consult with in guiding club activities.
The null hypothesis A-4 is rejected with 1% significance level. It can be said that when they have a hard time

for the mental guidance, they think that they want to have a person to consult with in guiding club activities.
The null hypothesis A-5 is rejected with 1% significance level. It can be said that when they do not know the club field precisely, they think that they want to have a person to consult with in guiding club activities.
The null hypothesis A-6 is rejected with 1% significance level. It can be said that if they feel that they cannot share enough time to prepare for teaching because of the workload for the guidance of club activities, they think that they want to have a person to consult with in guiding club activities.
The null hypothesis A-7 is rejected with 1% significance level. It can be said that if they feel quite tired because of the activity on holiday, they think that they want to have a person to consult with in guiding club activities.
The null hypothesis B-1 is rejected with 1% significance level. It can be said that in the technical course, teachers in charge of club activities spare a lot of time.
The null hypothesis B-2 is rejected with 1% significance level. It can be said that where the club activities are active, teachers in charge of club activities spare a lot of time.
The null hypothesis B-3 is not rejected with 9% significance level. It cannot be said that even if where the club is strong enough to participate in the national sports match, they feel worthwhile to guide club activities.
The null hypothesis B-4 is not rejected with 9% significance level. It cannot be said that even when they feel worthwhile to guide club activities, they feel it burden to guide club activities
The null hypothesis B-5 is not rejected with 9% significance level. It cannot be said that even when they feel worthwhile to guide club activities, they think that it is better for the professionals to guide club activities.
The null hypothesis B-6 is rejected with 1% significance level. It can be said that if the club activity is active, they feel worthwhile to guide club activities.

4.3 Remarks

The Results for Hypothesis Testing are as follows.
Main issue A consists of 7 sub issues (A-1~A-7). All of their Null Hypotheses were rejected and the main issue A was insisted clearly. 6 sub issues were set for the main issue B. Three of their Null Hypotheses were rejected (B-1,B-2,B-6). Three of them were not rejected. But the statement of B-4 and B-5 are inversely expressed. Therefore, that it is not rejected means the consistency to the main issue B. Thus, it means that 5 out of 6 coincide with the main issue B substantially.

5.Factor Analysis

Factor Analysis is executed. As for the extraction method of the factor, “the principal axis factoring” is adopted, and as for the rolling-method, “the varimax rotation which is accompanied by the normalization of kaiser as orthogonal rotation” is adopted. Also, we confirmed the validity of the model in the KMO (Kaisel-Meyer-Olkin) specimen validity measure. When the value is more than 0.8, it is said meritorious, more than 0.7 middling, more than 0.6, mediocre. Bartlett sphericity test is executed as well. If the score is less than

0.05, then it is said that there is a correlation among observation variables.

(1) Q2 "We ask you a consciousness for the daily works"

KMO measure is 0.852 and Bartlett Score is 0.000. We can confirm a rather appropriate common factor. From the Factor Matrix after rotation (Table 5.1), we can extract 3 meaningful axes. Summary of factor loading value is 52.700% therefore extracted 3 factors can explain 52.700% of the data. We can see that the first axis is the factor about "Teaching and learning for student" as the score for "1.Teaching","2. Preparing Teaching","3. Instructing Learning","4. Handling Students Performance" and "5. Student Guidance" are high (Exhibition of characters in the Figure is limited therefore abbreviated expression is used.). Second axis is the factor about "Miscellaneous jobs without Teaching, Learning and Management" as the score for "7. Committee Guidance", "9. Meeting" and "10. PTA meeting" are high. Third axis is the factor about "Management" as the score for "6. Club Activities" and "8. Class Management" are high.

Table 5.1 Factor Matrix after rotation

	Factor		
	1	2	3
1.Teaching	.748	.050	.255
2.Preparing Teaching	.796	.149	.246
3.Instructing Learning	.623	.218	.060
4.Handling Students Performance	.684	.399	.009
5.Student Guidance	.618	.312	.400
6.Club Activities	.096	.092	.559
7.Committee Guidance	.163	.417	.176
8.Class Management	.361	.448	.558
9.Meeting	.370	.522	.131
10.PTA meeting	.068	.760	.087

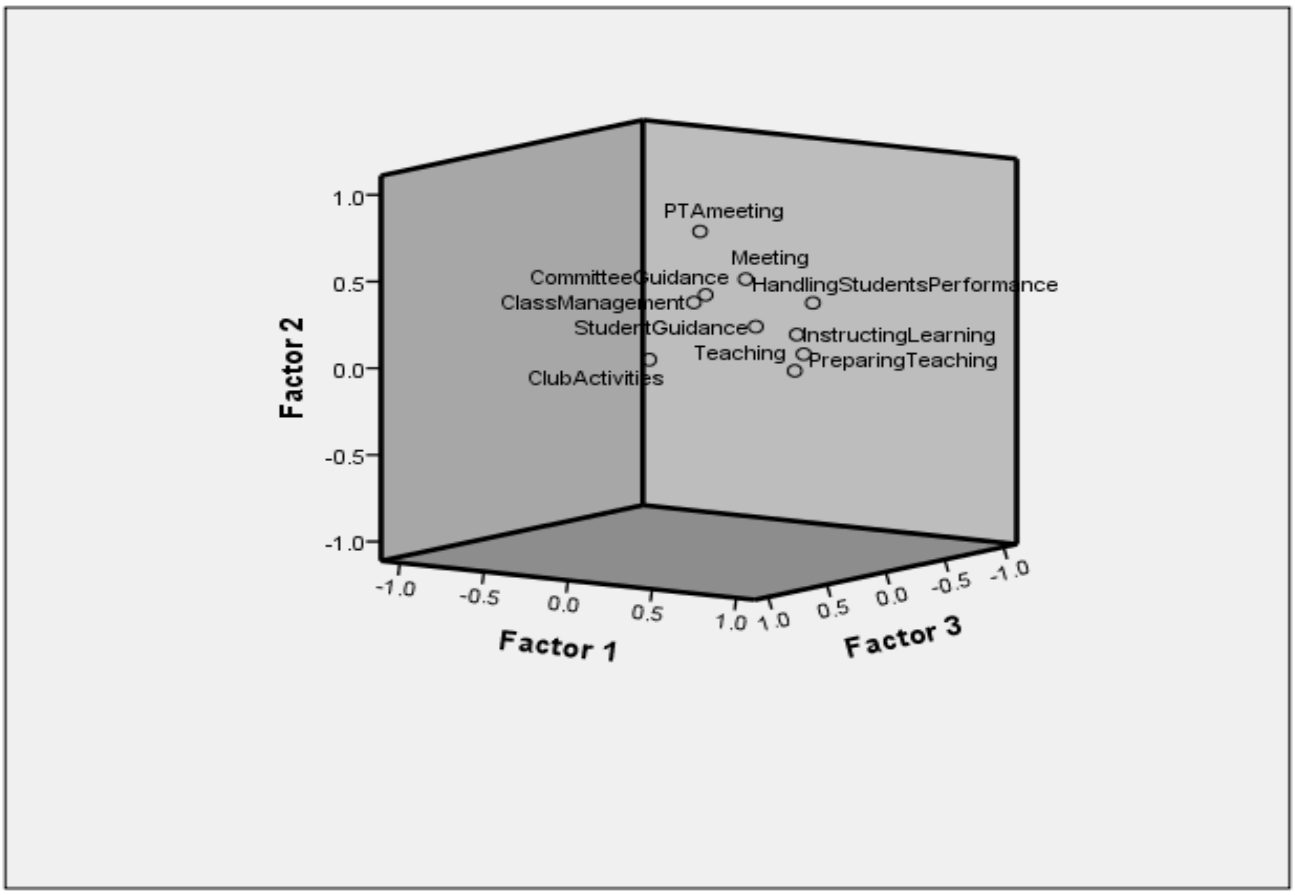

Figure 5.1 Factor Plotting in Factor Space

⑵ Q3 “We ask you a consciousness for guiding the club activities”

KMO measure is 0.741 and Bartlett Score is 0.000. We can confirm a rather appropriate common factor. From the Factor Matrix after rotation, we can extract 2 meaningful axes. Summary of factor loading value is 37.855% therefore extracted 2 factors can explain 37.855% of the data. We can see that the first axis is the factor about “Feel it burden for the club activities” as the score for “5.Burden for Holiday Activities”,” 6.Struggling in Technical Guidance”,” 4.Cutting Subject Preparation Time”,” 8.Want the person to consult with”, and ” 7.Struggling in Mental Guidance” are high. Second axis is the factor about “Career” as the score for “1.Feel Worthwhile” and ” 3.Inexperience” are high.

Table 5.2 Factor Matrix after rotation

	Factor	
	1	2
1.Feel Worthwhile	.044	.405
2.Better for the professionals to Guide	.073	.171
3.Inexperience	.456	-.572
4.Cutting Subject Preparation Time	.613	.058
5.Burden for Holiday Activities	.700	.205
6.Struggling in Technical Guidance	.677	.102
7.Struggling in Mental Guidance	.605	.388
8.Want the person to consult with	.610	-.154

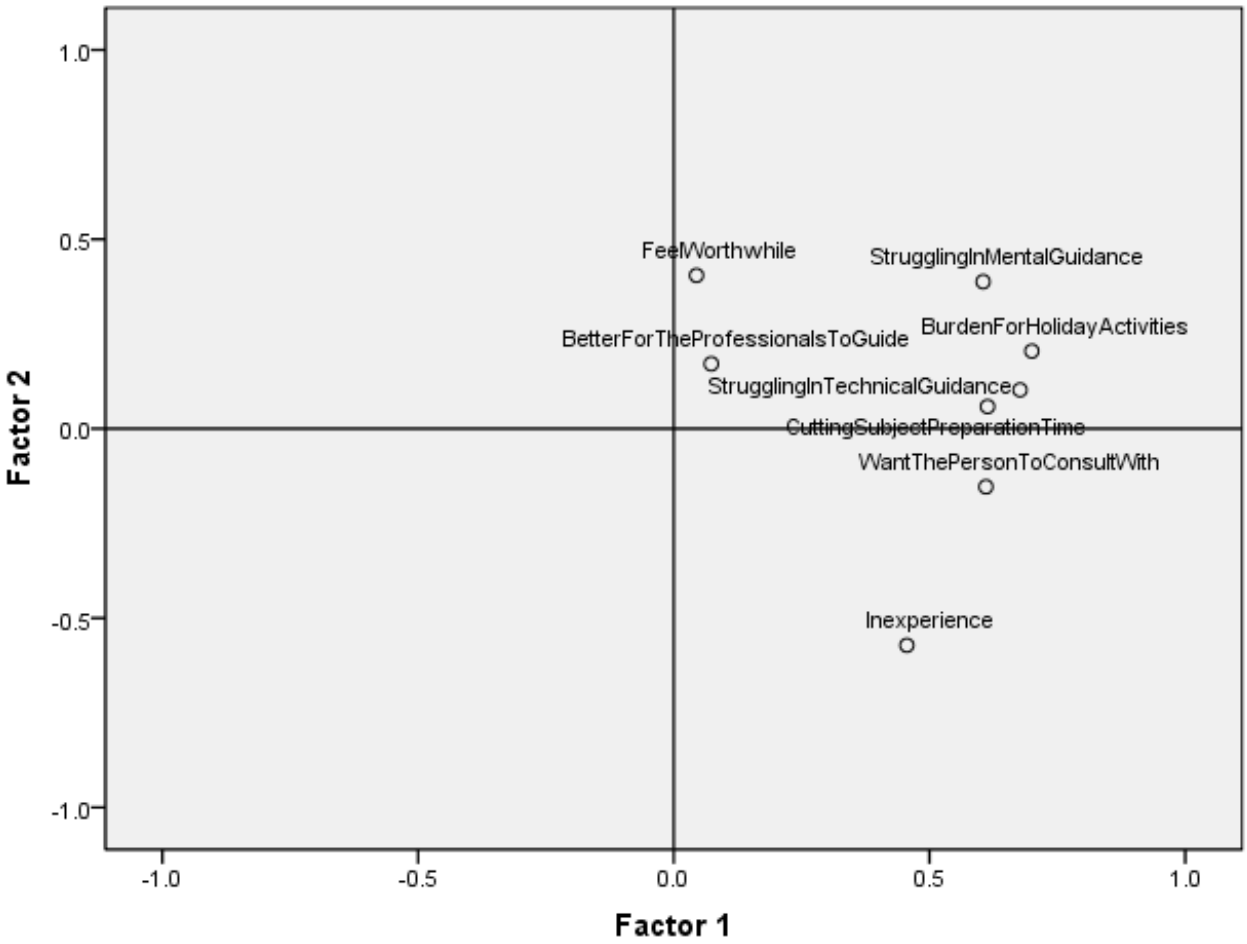

Figure 5.2 Factor Plotting in Factor Space

In the above Table, there was no hatched part in “2.Better for the professionals to Guide” therefore we skip this part and check it again without this.

KMO measure is 0.743 (nearly the same with before) and Bartlett Score is 0.000. We can confirm a rather appropriate common factor. From the Factor Matrix after rotation, we can extract 2 meaningful axes. Summary of factor loading value is 43.039% therefore extracted and it can be said that the relation among items became much clearer. The meaning of the first axis is basically the same with before. While the second axis is the factor about “Negative Career” as the score for ” 3.Inexperience” is high.

Table 5.3 Factor Matrix after rotation

	Factor	
	1	2
1.Feel Worthwhile	.123	-.351
3.Inexperience	.322	.676
4.Cutting Subject Preparation Time	.608	.081
5.Burden for Holiday Activities	.730	-.055
6.Struggling in Technical Guidance	.680	.049
7.Struggling in Mental Guidance	.685	-.266
8.Want the person to consult with	.560	.287

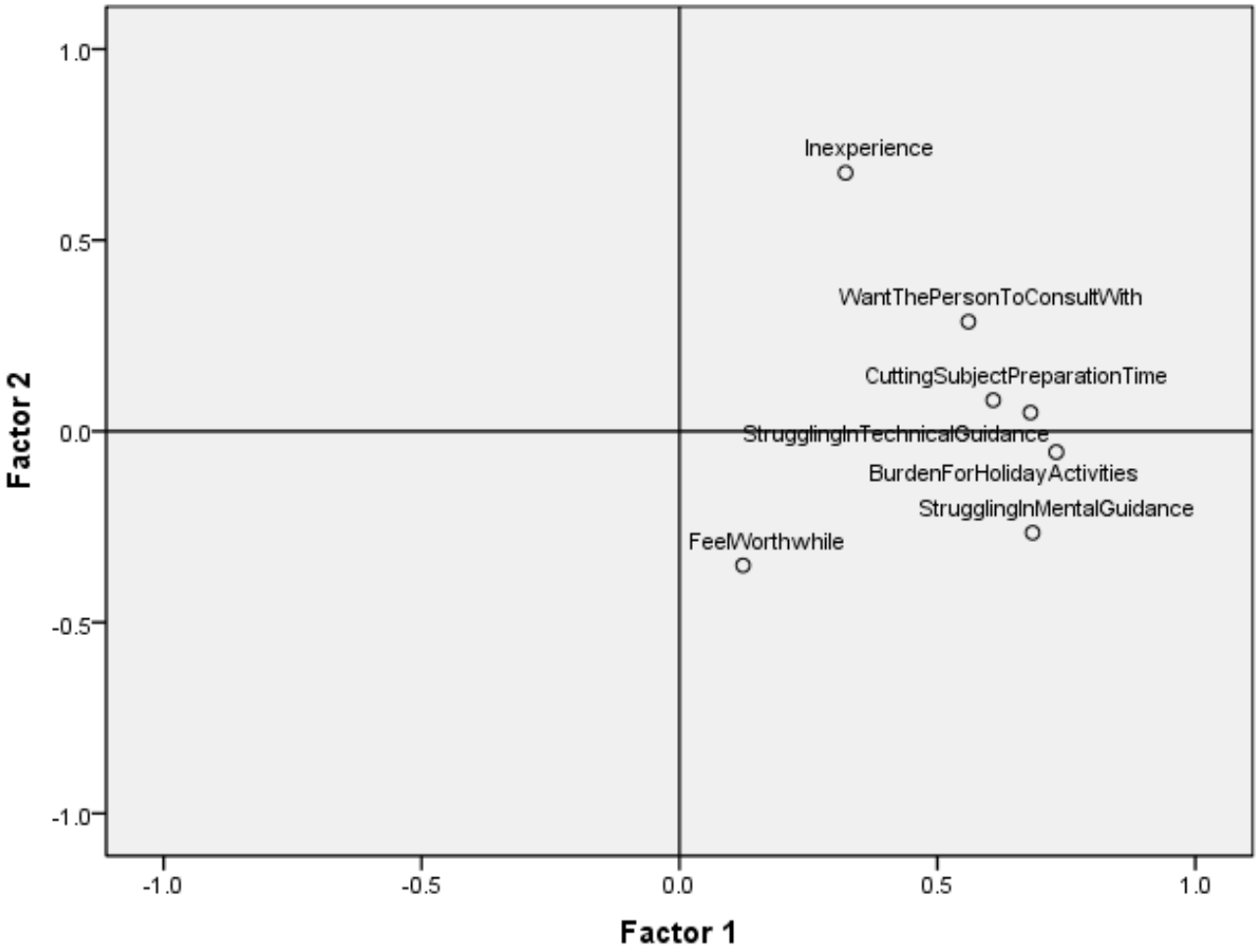

Figure 5.3 Factor Plotting in Factor Space

In the above Table, there was no hatched part in “1.Feel Worthwhile” therefore we skip this part and check it again without this.

KMO measure is 0.748(nearly the same with before) and Bartlett Score is 0.000. We can confirm a rather appropriate common factor. From the Factor Matrix after rotation, we can extract 2 meaningful axes. Summary of factor loading value is 47.102% therefore extracted and it can be said that the relation among items became much clearer. We can see that the first axis is the factor about “Feel it burden for the club activities” as the score for “7.Struggling in Mental Guidance” ,“5.Burden for Holiday Activities”,” 6.Struggling in Technical Guidance” and ” 4.Cutting Subject Preparation Time” are high. Second axis is the factor about “Lack of Experience” as the score for ” 3.Inexperience”, ” 8.Want the person to consult with” are high and this meaning of axis became much clearer.

Table 5.4 Factor Matrix after rotation

	Factor	
	1	2
3.Inexperience	.066	.688
4.Cutting Subject Preparation Time	.524	.318
5.Burden for Holiday Activities	.695	.225
6.Struggling in Technical Guidance	.627	.281
7.Struggling in Mental Guidance	.738	.003
8.Want the person to consult with	.399	.513

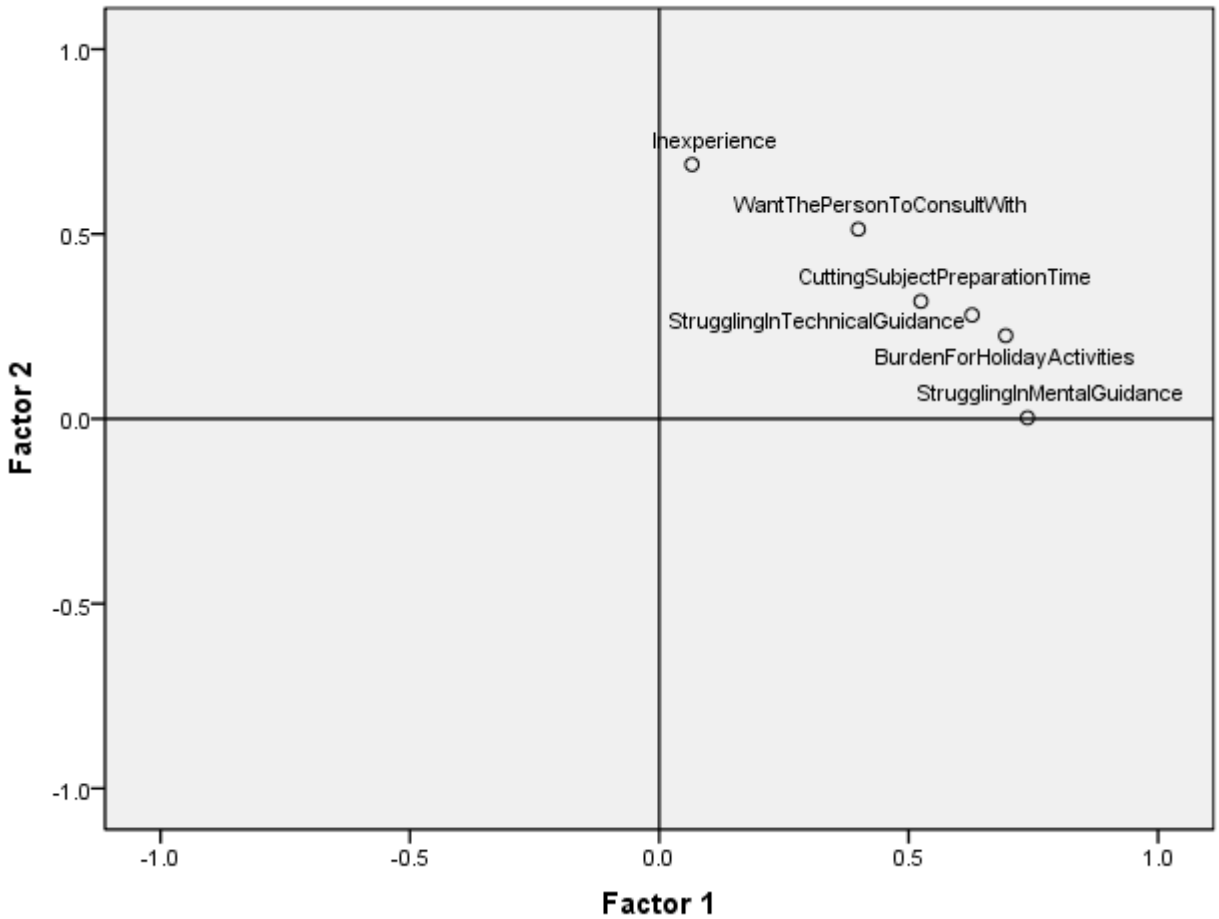

Figure 5.4 Factor Plotting in Factor Space

6. Multi Corresponding Analysis

We execute the multi correspondence analysis in Q2 “We ask you a consciousness for the daily works” and Q3 “We ask you a consciousness for guiding the club activities” in order to find the correlation of each items.

(1) Q2 “We ask you a consciousness for the daily works”

We can observe the following result from Figure 6.1. From the data, an eigenvalue of Dimension 1 axis is 0.527 and those of Dimension 2 is 0.428. 95.4% can be explained by these two major axes. We can extract 6 clusters. We can assume that the first cluster (Right Upper) shows “Jobs concerning teaching” (2.Preparing Teaching, 4.Handling Students Performance, 3.Instructing Learning). The second one(Right Middle) would mean “Jobs about Teaching” (1.Teaching, 5.Student Guidance, 8.Class Management). Other 4 clusters are the independent item clusters. Among them, the cluster “6.Club Activities” is far from other clusters and it shows the uniqueness of its characteristics.

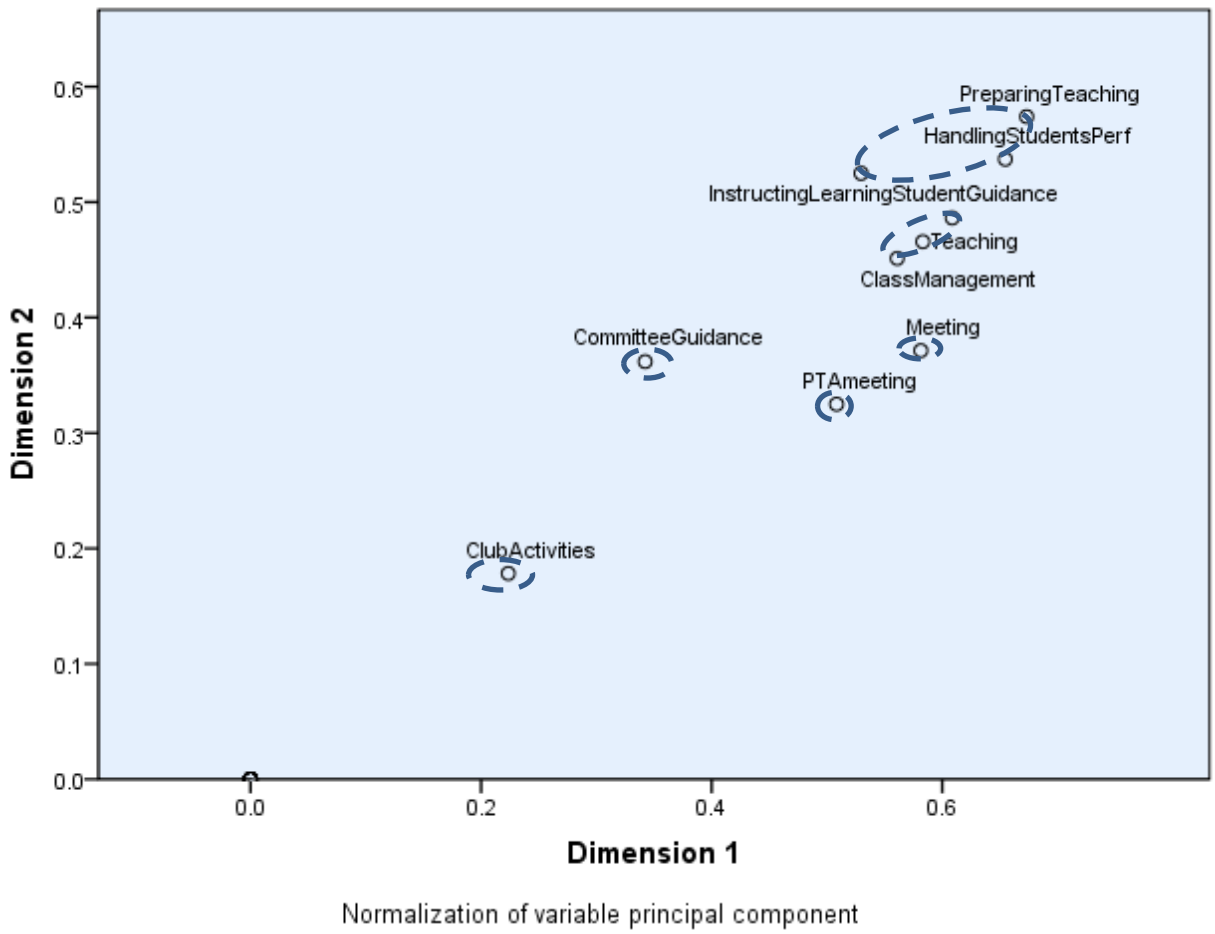

Figure 6.1 Q2 Consciousness for the daily works

(2) Q3 “We ask you a consciousness for guiding the club activities”

We can observe the following result from Figure 6.2. From the data, an eigenvalue of Dimension 1 axis is 0.430 and those of Dimension 2 is 0.324. We can extract 5 clusters. We can assume that the first cluster (Right Upper) shows “Hardness in guiding” (6.Struggling in Technical Guidance, 7.Struggling in Mental Guidance). The second one(Right Middle) would mean “Mental burden” (5.Burden for Holiday Activities, 8.Want the person to consult with). The third cluster (Left Upper) would mean “Lack of Specialization” (3.Inexperience, 2.Better for the professionals to Guide). Other 2 clusters are the independent item clusters.

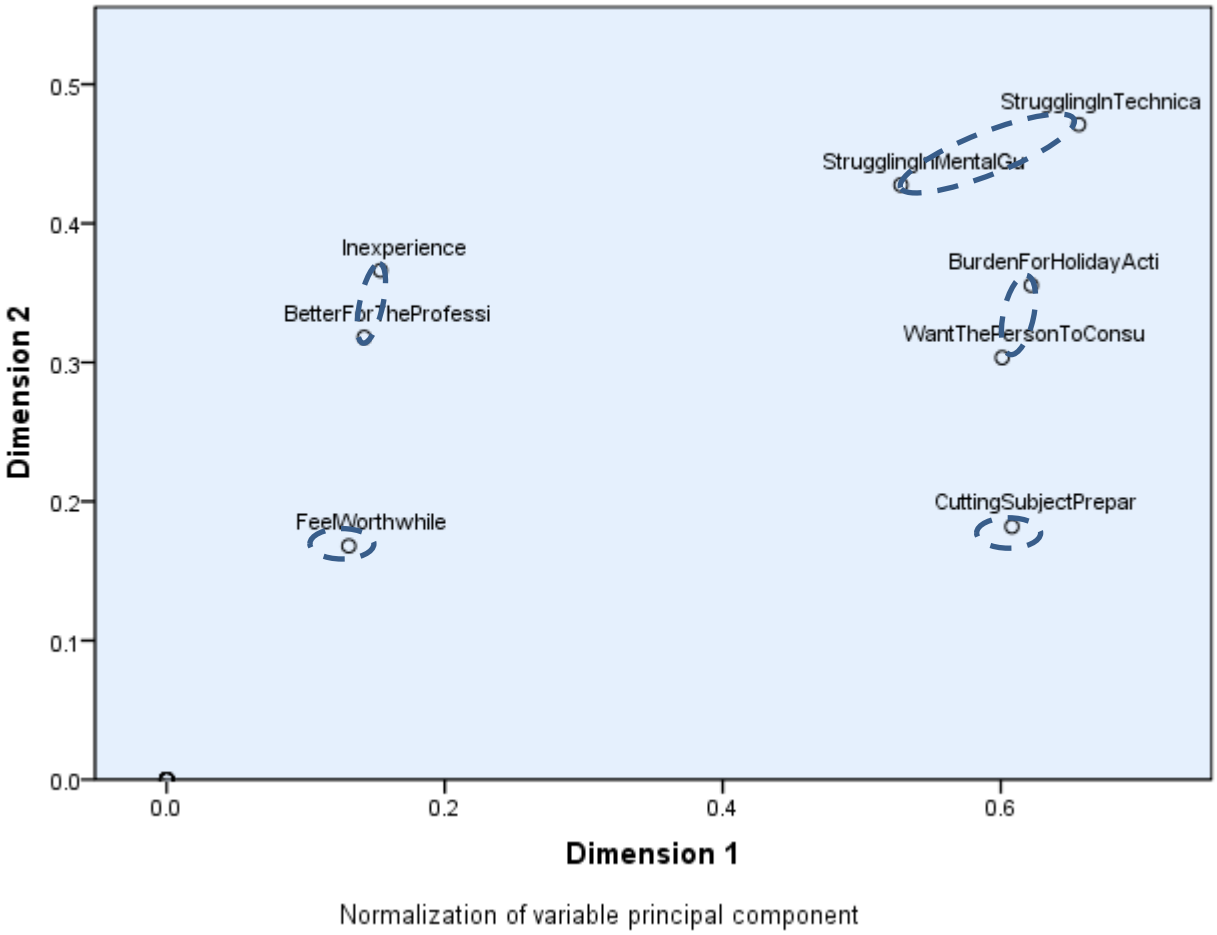

Figure 6.2 Q3 Consciousness for guiding the club activities

7. Remarks

In this paper, questionnaire investigation is executed in order to clarify their current condition and their consciousness, and to seek the possibility of utilizing school social worker for their support. Hypothesis testing was executed based on that. We have set two such main issues as:

A When they have a hard time in guiding club activities, they think that they want to have a person to consult with or it is better for the professionals to guide club activities.

B When they feel worthwhile to guide club activities, they feel less burden for it.

For the A part, it consists of 7 sub issues and all of their Null Hypotheses were rejected and the main issue A was insisted clearly. For the B part, 6 sub issues were set and three of their Null Hypotheses were rejected. Three of them were not rejected. But the statement of B-4 and B-5 are inversely expressed. Therefore, that it is not rejected means the consistency to the main issue B. Thus, it means that 5 out of 6 coincide with the main issue B substantially.

In the Factor Analysis, 3 meaningful axes could be extracted in the consciousness for the daily works. “Club Activities” and “Class Management” consisted the third factor. In the Multi Corresponding Analysis, 6 clusters could be confirmed. Among them, the cluster “6.Club Activities” consisted as an independent item and was located far from other clusters and it shows the uniqueness of its characteristics.

Considering these facts, these suggest that unique/original approach should be executed to the “Club Activities”. Based upon the results of hypothesis testing, teachers’ burden may be decreased by utilizing outer specialist in guiding club activities. School Social Worker can coordinate the professionals out of school and can help teachers by decreasing their burden on that area. This suggests the possibility of developing the new activity field for the School Social Worker.

8. Conclusion

High School teachers in Japan are sending very busy days on their daily works including teaching, support for the club activities and deskwork. Among them, they share a lot of time for managing the club actives of students compared with other countries. In that area, professionals can make instruction much better than teachers for the special sports like Judo and Kendo (Japanese fencing) etc. School Social Worker can coordinate the professionals out of school and can help teachers by decreasing their burden on that area. There are few related papers concerning the support of club activities by utilizing the professionals outside. In this paper, questionnaire investigation is executed in order to clarify their current condition and their consciousness, and to seek the possibility of utilizing school social worker for their support. Fundamental statistical analysis, Hypothesis Testing, Factor Analysis and Multi Corresponding Analysis were performed. One of the TRIZ methods was extended and applied. Based upon the results, these suggest that unique/original approach should be executed to the “Club Activities”. Based upon the results of hypothesis testing, teachers’ burden may be decreased by utilizing outer specialist in guiding club activities. School Social Worker can coordinate the professionals out of school and can help teachers by decreasing their burden on that area. This suggests the possibility of developing the new activity field for the School Social Worker. Further study on this should be executed such as text mining analysis. Various cases should be investigated here after.

ACKNOWLEDGEMENTS

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Appendix: Questionnaire about the Club Activities at High School

1． **Please select the appropriate item in each column.**

1	① Private	②Public		
2	① Ordinary course	② Technical course	③ Commercial course	④ Miscellaneous （ ）
	（1） **Select the club you are in charge of.**			
Sports club	① Baseball ②Tennis ③Rugby ④Soccer ⑤Track-and-field ⑥Hockey ⑦Archery ⑧Golf ⑨Kyudo (Japanese Archery) ⑩ Horsemanship ⑪ Basketball ⑫ Badminton ⑬Heavy gymnastics ⑭Volleyball ⑮Table tennis ⑯Judo ⑰Kendo ⑱Alpine ⑲Skiing ⑳Swimming ㉑ Miscellaneous ( )			
Culture club	①Human sciences ②Research section ③Living thing research section ④Chemistry research section ⑤ Physics research ⑥ Mathematics research ⑦ Brass ensemble ⑧ Instrumental music ⑨ Literature ⑩Shogi (Japanese Chess) ⑪Art ⑫Calligraphy ⑬Railroad research ⑭ESS ⑮Newspaper ⑯Broadcast Department ⑰Classic ⑱Theater ⑲Debating ⑳Photo department ㉑Radio ㉒ Movie research ㉓Miscellaneous（ ）			
	（2） **How about the she sort of job?**			
3	① Adviser	② Deputy Adviser	② Miscellaneous（ ）	
	Is the club strong enough to participate in the national sport meet?			
4	①Yes	②Cannot say either	③No	
	It the club activity active?			
5	①Yes	②Cannot say either	③No	
	How long a time do you spare for the club activity (Include moving time)			
6	（ ） hours / month			

2. We ask you a consciousness for the daily works.

1	2	3	4	5
Think it very much	Slightly think so	Cannot say either	Slightly do not think so	Do not think so

1.	Feel it burden to teach	1 2 3 4 5
2.	Feel it burden to prepare for teaching	1 2 3 4 5
3.	Feel it burden to instruct for learning	1 2 3 4 5
4.	Feel it burden to handle the students' performance	1 2 3 4 5
5.	Feel it burden to guide students	1 2 3 4 5
6.	Feel it burden to guide club activities	1 2 3 4 5
7.	Feel it burden to attend conference	1 2 3 4 5
8.	Feel it burden to manage the class	1 2 3 4 5
9.	Feel it burden to deal with meeting, advance arrangement	1 2 3 4 5
10.	Feel it burden to deal with parents	1 2 3 4 5

3. We ask you a consciousness for guiding the club activities.

1.	Feel worthwhile to guide club activities.	1 2 3 4 5
2.	It is better for the professionals to guide club activities.	1 2 3 4 5
3.	I do not know the club field precisely that I take charge of.	1 2 3 4 5
4.	I cannot share enough time to prepare for teaching because of the workload for the guidance of club activities.	1 2 3 4 5
5.	Quite tired because of the activity on holiday.	1 2 3 4 5
6.	Have a hard time for the technical guidance.	1 2 3 4 5
7.	Have a hard time for the mental guidance.	1 2 3 4 5

8.	Want to have a person to consult with in guiding club activities.	1 2 3 4 5

4. We ask questions about yourself.

1	Sex	① Male	② Female					
2	Age	②20～29	③30～39	④40～49	⑤50～59	⑥More than 60		
3	Position.	① Principal	② Deputy Principal	③a person in charge of educational affairs	④Teacher	⑤ Lecture	⑥ Assistant	⑦ Miscellaneous ( )
4	Experience as a teacher.	① Within 1 year	② 1 ～ 2 years	③ 3 ～ 4 years	④5～9 years	⑤ 1 0 years or more		
5	How many years are you working for the present school?	① Within 1 year	② 1 ～ 2 years	③ 3 ～ 4 years	④5～9 years	⑤ 1 0 years or more		
6	Blood Type.	① A Type	② B Type	③ O Type	④ A B Type	⑤ Unknown		
7	Are you married ?	① Single	② Married					
8	How many children do you have?	① Member-of-society (daughter who got married) ( ) people	② College student ( ) people	③High school student ( ) people	④Junior high school student ( ) people	⑤ Schoolchild ( ) people	⑥Less than kindergarten ( ) people	⑦Nothing
9	Are you positive to do anything ?	③ Positive	② Cannot choose either	①Not positive				
10	Do you like to be alone?	⑤ Think it so much	④ Slightly think it so	③ Cannot choose either	②Slightly do not think it so	①Not think it so		

11	How do you spend holidays？	① Outdoor	② Indoor	③ Cannot choose either				
12	What is most important to you? Choose only one.	① Affection	② Money	③ Honor	④ Clothes/Eating/ House	⑤Self-realization	⑥ Miscellaneous ( )	
13	Do you have a brother?	①Yes	②No					
14	In what situation among brothers?	①The eldest son or the eldest daughter	② Between ① and ③	③ Youngest child				
	（1） We ask questions about your current condition.							
		⑤ Very good	④ Rather good	③ Ordinary level	②Not so good	①Bad		
15	How about your physical condition?	⑤	④	③	②	①		
16	Is your work progressing smoothly?	⑤	④	③	②	①		
17	Do you living a full life?	⑤	④	③	②	①		

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Optimization in Allocating Goods to Shop Shelves for Cup Noodles

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Abstract

How to allocate goods in shop shelves makes great influence to sales amount. Searching best fit allocation of goods to shelves is a kind of combinatorial problem. This becomes a problem of integer programming and utilizing genetic algorithm may be an effective method. Reviewing past researches, there are few researches made on this. Formerly, we have presented a papers concerning optimization in allocating goods to shop shelves utilizing genetic algorithm. In those papers, the problem that goods were not allowed to allocate in multiple shelves and the problem that goods were allowed to allocate in multiple shelves were pursued. In this paper, we examine the problem that allows goods to be allocated in multiple shelves and introduce the concept of sales profits and sales probabilities. Expansion of shelf is executed. One of the TRIZ methods is extended and applied. Optimization in allocating goods to shop shelves is investigated. An application to the convenience store with POS sales data of cup noodles is executed. Utilizing genetic algorithm, optimum solution is pursued and verified by a numerical example. Various patterns of problems must be examined hereafter.

Keywords: display, genetic algorithm, optimization, shelf

1. Introduction

Displaying method in the shop makes influence to sales amount, therefore various ideas are devised. What kind of items should be placed where in the shop, how to guide customers to what

aisle in the shop are the big issues to be discussed. Searching best fit allocation of goods to shelves is also an important issue to be solved. In this paper, we seek how to optimize in allocating goods to shop shelves.

As for allocating good to shop shelves, following items are well known (Nagashima, 2005).

Shelf height is classified as follows.

・Shelf of 135cm height: Customers can see the whole space of the shop. Specialty stores often use this type.

・Shelf of 150cm height: Female customers may feel pressure to the shelf height. This height may be the upper limit to look over the shop.

・Shelf of 180cm height: It becomes hard to look over the shop. Therefore it should not be used for island display (display at the center or inside the shop).

Next, we show the following three functions of shelf for display.

1. Exhibition of goods function
2. Stock function
3. Display function

Effective range for exhibition is generally said to be 45cm-150cm. The range of 75cm-135cm is called golden zone especially. For the lower part under 45cm, goods are stocked as well as displaying.

Reviewing past papers, there are many papers concerning lay out problem. As for the problem of the distribution of equipment, we can see B. Korte et al. (2005), M. Gen et al. (1997) for the general research book. There are many researches made on this. Yamada et al. (2004) handles the lay out problem considering the aisle structure and intra-department material flow. Y. Wu et al. (2002) and Yamada et al. (2004) handle this problem considering aisle structure. Ito et al. (2006) considers multi-floor facility problem.

Although there are many researches on corresponding theme as stated above, we can hardly find researches on the problem of optimization in allocating goods to shop shelves.

Formerly, we have presented a paper concerning optimization in allocating goods to shop shelves utilizing genetic algorithm (Takeyasu et al.,2008). In those papers, the problem that goods were not allowed to allocate in multiple shelves and the problem that goods were allowed to allocate in multiple shelves were pursued. In this paper, we examine the problem that allows goods to be allocated in multiple shelves and introduce the concept of sales profits and sales probabilities. Expansion of shelf is executed. One of the TRIZ methods is extended and applied. Optimization in allocating goods to shop shelves is investigated. An application to the convenience store with POS sales data of cup noodles is executed. Utilizing genetic algorithm, optimum solution is pursued and verified by a numerical example.

The rest of the paper is organized as follows. Extended Analysis Method is stated in section 2. Problem description is stated in section 3. Genetic Algorithm is developed in section 4. Numerical example is exhibited in section 5 which is followed by the remarks of section 6. Section 7 is a summary.

2. Extended Analysis Method

The function "Moves" is a fundamental function of TRIZ [15],[16]. We can further develop this concept as shown in Figure 1. Based on the TRIZ method, extended analysis is developed. Applying "Extend" function and/or Principle "Parameter changes" [17], the shelf is extended from 2 to 3. These are the process of "Extended Analysis" based upon TRIZ "Extend" method. Detailed inspection is executed in section 4.

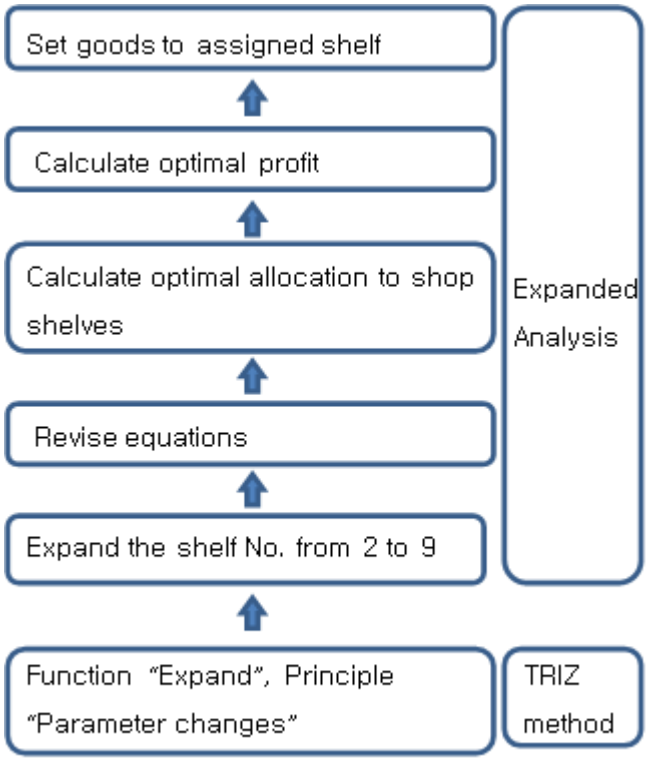

Figure1. Extended Analysis Method

3. PROMLEM DESCRIPTION

Shelf model is constructed as Figure 2. There are five shelf positions. Shelf position 1 is mainly to put big and heavy goods including stock function. Shelf position 3, 4 at the height of the range 75cm to 135cm are the space of golden zone. Thus, we can use shelves properly by assuming these shelves. In numerical example, we examine using these five shelves. First of all, we make problem description in the case there is only one shelf (case 1). Then we expand to the case there are multiple shelves (case 2).

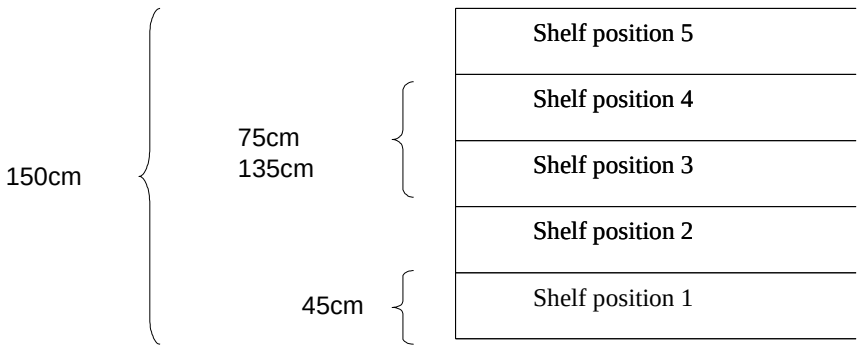

Figure2. Shelf Model

1)Case 1: The case that there is only one shelf

Although there are few cases that there is only one shelf, it makes the foundation for multiple shelves case. Therefore we pick it up as a fundamental one. Suppose shelf position k is from 1 to L (Figure 3).

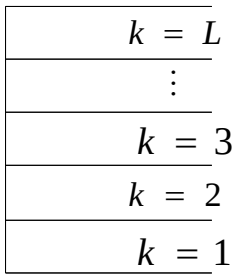

Figure 3: Shelf Position

Suppose there are N amount of goods $(i = 1, \cdots, N)$. Set sales profit of goods i as H^i.

Table 1 shows the sales probabilities when each goods is placed at each shelf position. The values in this table are written for example.

Table 1: Sales probability for each goods

Day of the Week	Time Zone(t)	Shelf j=1			Shelf j=2			…	Shelf $j=m$		
		Shelf Position			Shelf Position			…	Shelf Position		
		k=1	…	$k=L_1$	k=1	…	$k=L_2$	…	k=1	…	$k=L_m$
(Mon.)	0-1(t=1)	0.01	…								
	1-2(t=2)	0.02									
	…										
	23-24(t=24)	0.03									
(Tue.)	0-1(t=25)	0.02									
	1-2(t=26)	0.02									
	…										
	23-24(t=48)	0.03									
…	…	…	…	…	…	…	…	…	…	…	…
(Sun.)	0-1(t=145)	0.02									
	1-2(t=146)	0.03									
	…										
	23-24(t=168)	0.04									

Suppose goods are sold in the period from t_1 to t_n. In addition, a new goods i is replenished when goods i is sold out.

Set the accumulated sales probability of goods i in time zone t, shelf j, and shelf position k

in the table as $HK^{i}_{t,j,k}$.

Then, the sales probability $K^{i,j,k}_{t_1/t_n}$ of goods i in the period $t_1 \sim t_n$ will be described as follows.

$$K^{i,j,k}_{t_1/t_n} = \sum_{t=1}^{n} HK^{i}_{t,j,k}$$

This can take the value more than 1. For example, the value 2 means that 2 amount of goods were sold during the period.

Set Benefit in the sales period from t_1 to t_n as $P^{i,j,k}_{t_1/t_n}\ (i=1,\cdots,N)\ (j=1,\cdots,m)\ (k=1,\cdots,L)$ when goods i is placed at shelf j and shelf position k.

Where Benefit means:

$$\text{Benefit} = \text{SalesProbability} \times \text{SalesProfit}$$

Therefore, this equation is represented as follows.

$$P^{i,j,k}_{t_1/t_n} = K^{i,j,k}_{t_1/t_n} \cdot H^{i} \qquad (1)$$

where j =1 because one shelf case is considered here.

Set $x_{i,k}$ as:

$x_{i,k} = 1$: Goods i is placed at shelf position k.

$x_{i,k} = 0$: Else

Suppose only one goods can be placed at one shelf position and also suppose that goods is allowed to allocate in multiple shelf positions. Then constraints are described as follows.

$$x_{i,k} = 1,0\ (i=1,\cdots,N)\ (k=1,\cdots,L) \qquad (2)$$

$$\sum_{i=1}^{N} x_{i,k} = 1\ (k=1,\cdots,L) \qquad (3)$$

Under these constraints,

$$Maximize\ J = \sum_{k=1}^{L}\sum_{i=1}^{N} P^{i,j,k}_{t_1/t_n} x_{i,k} \qquad (4)$$

(2) Case 2: The case that there are m shelves

Suppose there are m shelves (Figure 4). Set Benefit as $P^{i,j,k}_{t_1/t_n}\ (i=1,\cdots,N),(j=1,\cdots,m)$, $(k=1,\cdots,L_j)$ where goods i is placed at shelf position k of shelf j. The sales period is the same with above stated (1).

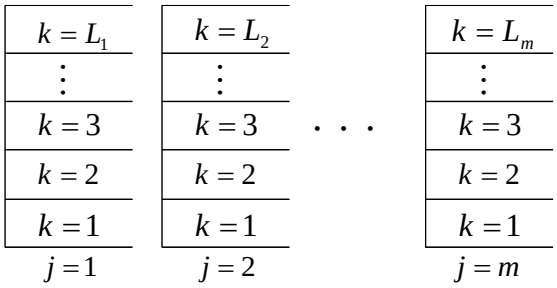

Figure 4: Shelf Position under multiple shelves

Set $x_{i,j,k}$ as:

$x_{i,j,k} = 1$: Goods is placed at shelf position of shelf

$x_{i,j,k} = 0$: Else

Suppose only one goods can be placed at one shelf position and also suppose that goods is allowed to allocate in multiple shelf positions. Then constraints are described as follows. The sales period is the same with before.

$$x_{i,j,k} = 1,0 \ (i = 1, \cdots, N) \ (j = 1, \cdots, m) \ (k = 1, \cdots, L_j) \tag{5}$$

$$\sum_{i=1}^{N} x_{i,j,k} = 1 \ (j = 1, \cdots, m) \ (k = 1, \cdots, L_j) \tag{6}$$

Under these constraints,

$$Maximize \ J = \sum_{i=1}^{N} \sum_{j=1}^{m} \sum_{k=1}^{L_j} P_{t_1/t_n}^{i,j,k} x_{i,j,k} \tag{7}$$

4. ALGORITHM

We can make problem description as stated above, although these are somewhat under restricted cases. As far as only these are considered as they are, there is little difference between these and the conventional optimization problems. However, as soon as the number of involved shelves becomes larger, the number of variables dramatically grows greater, to which the application of Genetic Algorithm solution and Neural Network solutions may be appropriate. There are various means to solve this problem. When that variable takes the value of 0 or 1, the application of genetic algorithm would be a good method. As is well known, the calculation volume reaches numerous or even infinite amounts in these problems when the number of variables increases. It is reported that GA is effective for these problems (Gen et al. (1995), Lin et al. (2005), Zhang et al. (2005)).

A. The Variables

Suppose the number of goods, shelf position, and shelf are 20, 2, 9 respectively. In this pap er, shelf is expanded from 2 to 9. Then the number of variables becomes 360.

$$x_{i,j,k} = 1,0 \ (i = 1, \cdots, 20) \ (j = 1, \cdots, 9) \ (k = 1, 2)$$

Therefore, set chromosome as follows.

$$
\begin{aligned}
X = (&x_{1,1,1}, x_{2,1,1}, x_{3,1,1}, \cdots, x_{20,1,1}, \\
&x_{1,1,2}, x_{2,1,2}, x_{3,1,2}, \cdots, x_{20,1,2}, \\
&\vdots \\
&x_{1,2,1}, x_{2,2,1}, x_{3,2,1}, \cdots x_{20,2,1}, \\
&x_{1,2,2}, x_{2,2,2}, x_{3,2,2}, \cdots, x_{20,2,2} \\
&\vdots \\
&x_{1,9,1}, x_{2,9,1}, x_{3,9,1}, \cdots, x_{20,9,1}, \\
&x_{1,9,2}, x_{2,9,2}, x_{3,9,2}, \cdots, x_{20,9,2},)
\end{aligned}
\tag{8}
\tag{8}
$$

B. Initialize population

Initialization of population is executed. The number of initial population is M. Here set $M = 100$. Set gene at random and choose individual which satisfies constraints.

C. Selection

In this paper, we take elitism while selecting. Choose P individuals in the order which take maximum score of objective function.

Here, set $P = 20$

D. Crossover

Here, we take uniform crossover.

Set crossover rate as:

$$P_c = 0.7 \tag{9}$$

E. Mutation

Set mutation rate as:

$$P_m = 0.01 \tag{10}$$

Algorithm of GA is exhibited at Table 2.

Table 2: Algorithm of multi-step tournament selection method

Step 1：Set maximum No. as $g_{\max}$, population size as P, crossover rate as p_c, mutation rate as p_m.
Step 2：Set $t = 1$ for generation No. and generate initial solution matrix $x_p(t) = \left(x_{i,j,k}^p\right)$ $(p = 1, \cdots, M)$.
Step 3：Calculate Objective function $J\left(x_p(t)\right)$ for all solution matrix $x_p(t)$ $(p = 1, \cdots, P)$ in generation t.
Step 4：Set $t = t + 1$ until $t > g_{\max}$.
Step 5：Crossover Generate new individual by crossover utilizing the method of above stated *D*.
Step 6：Mutation Reproduce by mutation utilizing the method of above stated *E*.
Step 7：Calculate objective function for reproduction of generation t.
Step 8：Selection Next generation is selected by elitism.

Go to Step 4.

Introducing the variable y_s such that:

$$y_s = i \tag{11}$$

where

$$s = k + (j-1) \cdot 2 \tag{12}$$

when

$$x_{i,j,k} = 1$$

then (8) is expressed as:

$$Y = (y_1, y_2, \cdots, y_{18}) \tag{13}$$

5. NUMERICAL EXAMPLE

Now, we execute numerical example using POS sales data. Numerical example is executed in "Case 2" of 2 (2). Suppose the sales period is 7 days for Monday through Sunday. Table 3 shows the unit sales profit H^i of each goods.

Table 3: Unit Sales Price and Sales Profit of each goods

Lot i	Sales Price	H^i
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Supposing a general daytime retail store, we set opening time to be 9 through 18 o'clock. Table 4 shows the sales probabilities of lot i as an example.

Table 5 shows the sales probability by shelf for each shelf position. Table 6 shows the value in which Table 4 and Table 5 are multiplied. Table 7 shows the benefit Table in which accumulated probability of Table 6 and Sales Profit of Table 3 are multiplied.

Table 4: Sales Probability of Lot i (Time Zone)

Day of the Week	Time Zone(t)	Sales Probability	Day of the Week	Time Zone(t)	Sales Probability
(Mon.)	9-10		(Thu.)	9-10	
	10-11			10-11	
	11-12			11-12	
	12-13			12-13	
	13-14			13-14	
	14-15			14-15	
	15-16			15-16	
	16-17			16-17	
	17-18			17-18	
(Tue.)	9-10		(Fri.)	9-10	
	10-11			10-11	
	11-12			11-12	
	12-13			12-13	
	13-14			13-14	
	14-15			14-15	
	15-16			15-16	
	16-17			16-17	
	17-18			17-18	
(Wed.)	9-10		(Sat.)	9-10	
	10-11			10-11	
	11-12			11-12	
	12-13			12-13	
	13-14			13-14	
	14-15			14-15	
	15-16			15-16	
	16-17			16-17	
	17-18			17-18	

Table 5: Sales Probability of Lot i (Shelf Position)

Shelf j =1		Shelf j =2		Shelf j =3		Shelf j =4		Shelf j =5		Shelf j =6		Shelf j =7		Shelf j =8		Shelf j =9	
Shelf Position		Shelf Position		Shelf Position		Shelf Position		Shelf Position		Shelf Position		Shelf Position		Shelf Position		Shelf Position	
k =1	k =2	k =1	k =2	k =1	k =2	k =1	k =2	k =1	k =2	k =1	k =2	k =1	k =2	k =1	k =2	k =1	k =2
1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.1	1.0	1.0	0.9	0.9

In Table 5, shelf j =2 is located near the entrance therefore the table value reflects this condition.

Table 6: Sales Probability of Lot i

Day of the Week	Time Zone(t)	Sales Probability										
		Shelf j =1		Shelf j =2		Shelf j =3		…	Shelf j =8		Shelf j =9	
		k =1	k =2	k = 1	k = 2	k =1	k =2	….	k =1	k =2	k = 1	k =2
(M o n.)	9-10							....				
	10-11							….				
	11-12							…				
	12-13							....				
	13-14							….				
	14-15							….				
	15-16							….				
	16-17							….				
	17-18							….				
(Tue.)	9-10							….				
	10-11							….				
	11-12							….				
	12-13							….				
	13-14							….				
	14-15							….				
	15-16							….				
	16-17							….				
	17-18							….				
(Sat.)	9-10							….				
	10-11							….				
	11-12							….				
	12-13							….				
	13-14							….				
	14-15							….				

	15-16							….				
	16-17							….				
	17-18							….				

Table 7 shows the benefit when each goods is placed at each shelf position of each shelf.

Table 7: Benefit Table

Lot i	Shelf 1		Shelf 2		Shelf 3		Shelf 4	
	k = 1	k = 2	k = 1	k = 2	k = 1	k = 2	k = 1	k = 2
1	500	800	510	810	510	810	630	1270
2	540	924	520	900	450	850	450	850
3	820	390	820	390	820	390	912	500
4	400	841	400	841	400	841	419	859
5	836	401	820	390	820	390	820	390
6	410	840	410	840	420	860	410	840
7	820	390	835	400	820	390	820	390
8	670	290	670	290	670	290	670	290
9	820	390	820	390	913	501	820	390
10	500	900	500	900	400	800	400	800
11	500	900	539	923	450	850	450	850
12	560	900	560	900	400	850	400	850
13	670	290	670	290	670	290	670	290
14	800	380	800	380	800	380	800	380
15	821	395	821	395	822	396	822	396
16	370	840	370	840	370	840	400	900
17	500	800	520	800	520	800	520	800
18	680	295	680	295	680	295	680	295
19	790	310	790	310	790	310	790	310
20	390	900	390	900	380	830	460	990

Shelf 5		Shelf 6		Shelf 7		Shelf 8		Shelf 9	
k = 1	k = 2	k = 1	k = 2	k = 1	k = 2	k = 1	k = 2	k = 1	k = 2
550	1010	540	1010	550	1100	560	1100	560	1010
450	850	450	850	450	850	450	850	450	850
800	360	800	360	670	300	670	300	670	300
400	841	400	841	400	841	400	841	400	841
800	360	800	360	670	300	670	300	670	300
410	840	410	840	410	840	410	840	410	840
800	380	800	380	670	310	670	310	670	310
670	290	670	290	680	300	680	300	689	301
790	350	790	350	660	280	660	280	660	280
500	1000	500	1000	500	1000	614	1272	500	1000
450	850	450	850	450	850	450	850	450	850
630	1140	550	1000	550	1000	550	1000	550	1000

670	290	670	290	688	300	690	302	688	300
815	403	800	380	680	300	680	300	680	300
801	401	801	400	681	295	681	296	911	500
400	900	629	1139	460	990	460	990	460	990
610	1100	615	1100	615	1273	600	1200	600	1100
680	295	680	295	691	303	685	300	685	300
790	310	814	402	680	290	680	290	680	290
460	990	460	990	460	990	460	990	605	1191

Experimental results are as follows. The expression Eq. (8) is complicated. Therefore we use expression by Eq. (13). A sample set of initial population is exhibited in Table 6.

Table 6: A Sample Set of Initial Population

$$Y_1 = (15\ 8\ 10\ 16\ 4\ 16\ 17\ 1\ 6\ 7\ 18\ 2\ 17\ 18\ 14\ 18\ 18\ 11)$$

$$Y_2 = (11\ 10\ 9\ 2\ 7\ 18\ 15\ 10\ 8\ 20\ 18\ 13\ 4\ 4\ 20\ 10\ 9\ 1)$$

$$Y_3 = (12\ 4\ 14\ 11\ 9\ 2\ 18\ 15\ 7\ 12\ 8\ 11\ 16\ 14\ 16\ 20\ 12\ 13)$$

$$\vdots$$

$$Y_{98} = (20\ 15\ 4\ 16\ 13\ 16\ 5\ 15\ 4\ 4\ 12\ 16\ 15\ 15\ 18\ 7\ 10\ 10)$$

$$Y_{99} = (2\ 20\ 5\ 17\ 6\ 16\ 1\ 7\ 9\ 7\ 16\ 7\ 10\ 5\ 11\ 12\ 15\ 5)$$

$$Y_{100} = (8\ 7\ 7\ 8\ 11\ 7\ 18\ 20\ 8\ 10\ 6\ 11\ 20\ 4\ 5\ 1\ 14\ 20)$$

Convergence process is exhibited in Figure 5.

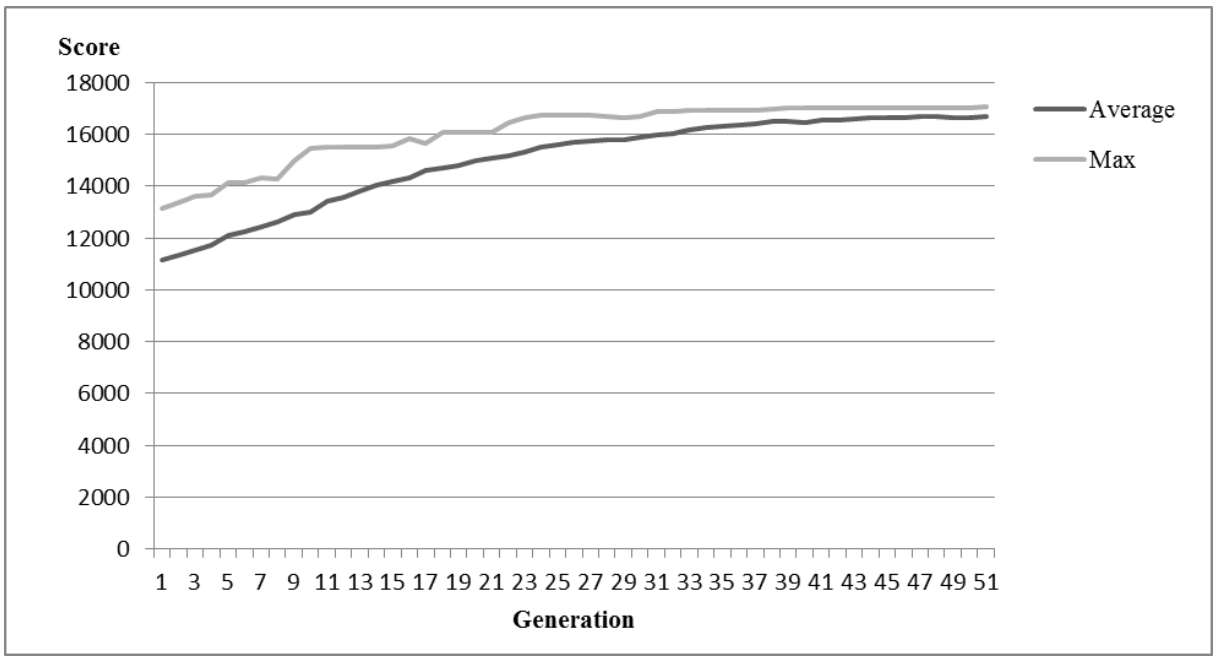

Figure 5: Convergence Process of Case 2

The problem is simple, so combination of genotype for crossover saturates in the 125th generation. Genotype in which objective function becomes maximum is as follows.

Y = (5, 2, 7, 11, 9, 6, 3, 1, 14, 12, 19, 16, 18,17, 13, 10, 15, 20)

This coincides with the result of optimal solution by the calculation of all considerable cases, therefore it coincides with a theoretical optimal solution. We take up simple problem and we can confirm the effectiveness of GA approach. Further study for complex problems should be examined hereafter.

6. REMARKS

As there are few papers made on this theme, we constructed prototype version before (Takeyasu et al.,2008). In this paper, we examined the problem that allowed goods to be allocated in multiple shelves and introduced the concept of sales profits and sales probabilities. An application to the shop with POS sales data was executed. We can see that genetic algorithm is effective for this problem.

In practice, following themes occur.

1. Sales probabilities should be arranged correctly.
2. There are various types of shelves corresponding to goods characteristics (For example, cold storage goods).
3. Furthermore, genotype must be devised in construction when there are huge number of goods and shelves.

For these issues, expanded version of the paper will be built hereafter consecutively. As for 1, constraints are relaxed than those of this paper. As for 2, expansion is easy to make. As for 3, constructing genotype from the shelf side would bear much more simple expression.

7. CONCLUSION

How to allocate goods in shop shelves makes great influence to sales amount. Searching best fit allocation of goods to shelves is a kind of combinatorial problem. This becomes a problem of integer programming and utilizing genetic algorithm may be an effective method. Reviewing past researches, there were few researches made on this. Formerly, we had presented papers concerning optimization in allocating goods to shop shelves utilizing genetic algorithm. In those papers, the problem that goods were not allowed to allocate in multiple shelves and the problem that goods were allowed to

allocate in multiple shelves were pursued. In this paper, we examined the problem that allowed goods to be allocated in multiple shelves and introduced the concept of sales profits and sales probabilities. Expansion of shelf was executed. One of the TRIZ methods was extended and applied. Optimization in allocating goods to shop shelves was investigated. An application to the convenience store with POS sales data of cup noodles was executed. Utilizing genetic algorithm, optimum solution was pursued and verified by a numerical example. Various patterns of problems should be examined hereafter.

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Riding the Wave of Big Data: Towards a Rapid Systematic Innovation Framework

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Abstract

Big data is now woven into the fabric of the global economy, the effective use of big data has the potential to transform economies and deliver a new wave of growth and innovation. Moreover, the use of big data is becoming a crucial way for leading companies to outperform their peers. Therefore, companies are increasingly looking at harvesting big data: a) to better understand their customers; b) to design better products; and c) to provide clients with more customised services. However, very few studies have investigated how firms can harvest big data to facilitate product innovation. To sustain growth and build competitive advantage, how can firms use big data to shorten product development times and costs? The purpose of this research is to propose and test an accelerated innovation framework to assist firms in product innovation by shortening the time to market, improving customers' product adoption and reducing costs. It is termed the ACE framework because it is based on the principles of accelerated process (A), connection (C) and ecosystem (E). The ACE framework was shown to be a new way to help firms unlock the power of big data which we believe represents a paradigm shift, can provide deeper insights into successful product innovation through the use of big data. It can help firms to make product development dramatically faster, less costly, and in a systematic manner.

Keywords: Big Data, Systematic Innovation, Product Development, Accelerated Innovation, Rapid Innovation

1. Introduction

How can big data are used to support innovation? And how can innovation be accelerated using big data?

Big data can enhance firms' innovation capabilities in many respects (Manyika et al., 2011; Gobble, 2013; Tan et al., 2015). Manyika et al., (2011) reports that predictive modelling using big data can cut three to five years off the approximately 13 years healthcare companies generally need to bring a new drug to market. Capgemini (2012) estimates that the process improvements enabled by big data may lead to an average 26% performance improvement over a three-year period. Moreover, the analysis of big data may have huge operational and strategic impacts on business process innovation

at the firm and supply-chain levels (Trkman et al., 2012), and may therefore allow adopting firms to achieve competitive advantage.

Chiesa and Frattini (2011) point out new products have a remarkably high failure rate, at around 40-50%, and this performance has not changed much over the past 20 years. Therefore, effective product innovation demands urgent attention. Although there are various systematic approaches to product innovation, Storbacka and Nenonen (2015) point out that systematic innovation approaches require more market focus and need to avoid becoming too complex to manage efficiently and effectively. Some researchers also argue that current approaches are too time-consuming; too many are either simply a waste of time or are cost ineffective; others are too bureaucratic and provide no focus (Ortt and Duin, 2008; Sheu and Lee, 2011; Cooper, 2014). They believe that a good product innovation process should be adaptable, provide companies with a much more efficient roadmap, bring products to market faster and improve the use of scarce resources (Cooper 1994; Vrande et al., 2009; Sheu and Lee, 2011; Bucherer et al., 2012; Wooder and Baker, 2012; Christofi et al., 2014). With big data, firms can gain a better understanding of their products, customers and markets, and this is crucial to innovation (Manyika et al., 2011; 2013; Wong, 2012). However, the main challenge to firms is how to use big data to make the development of new products faster and less costly.

This paper seeks to propose and test a big data induced innovation framework, that is, a systematic approach based on ACE principles that is able to help firms accelerate their product innovation. To assist our understanding of utilising big data to facilitate product innovation, this paper next reviews how big data is transforming traditional product innovation and the evolution of innovation approaches. It then proposed a systematic ACE innovation framework based on three principles. This proposed ACE framework is then tested in three successful company case studies. The implications for practitioners and academia are discussed and, finally, conclusions drawn.

2. Big Data Transforming Product Innovation

Taking advantage of the valuable knowledge that can be extracted from big data is essential if today's enterprises are to be competitive (Barton and Court, 2012; Ross, 2013; Wamba et al., 2015; Tan et al., 2015). According to Davenport (2013), the use of big data offers several key benefits: dramatic cost reductions, substantial improvements in the time required to perform a computing task, or new production innovation and service offerings. Laney (2012) highlights the 3 Vs in interpreting big data – that is volume, velocity and variety.

The explosion in the volume of data is a natural consequence of the fact that, if harvested properly, it can provide companies with better product innovation (Wong, 2012). According to Dutta and Bose (2015), big data provides organisations with big ideas, which can lead to big concepts and big solutions – the growth engines of the future. The acquisition of large amounts of information from different sources facilitates product innovation (Li et al., 2014). An example of such data acquisition would be an enterprise quickly ascertaining market acceptance of its new products, customers' needs or even competitors' market movements (Gobble, 2013; Opresnik and Taisch, 2015). In terms of the variety, a firm's success will rely on its ability to draw insights from the various kinds of data available to it, which includes both traditional and non-traditional data (Wong, 2012). The ability to analyse all types

of data will create more opportunity and more value for an enterprise (Dijcks, 2013; IBM, 2013). A company that can integrate heterogeneous resources and tools from different disciplines to generate big data will be able to gain great advantage, by developing better customer services, identifying potential new customers, identifying and developing new products and services, increasing its operational efficiency, and having a better-informed strategic direction, and so on (Zhang et al., 2011; Chen et al., 2012; Lohr, 2012; Demirkan and Delen, 2013; Fulgoni, 2013; Wamba et al., 2015). On top of the velocity, for instance, firms can easily track online customers' clickstream data from the Web and use that to leverage a behavioural analysis, which in turn can be used to support product innovation (Procter et al., 2014). Such rapid market feedback can make new product development dramatically faster and less costly (Cooper, 2011; Chuang et al., 2015). Firms are now capable of gathering users' feedback in near real time to track changes in customer behaviour. Such data need to be communicated to the R&D team, who can then ensure that product development is sufficiently flexible to incorporate new functionality quickly (Lavalle et al., 2011; Mayer-Schönberger and Cukier, 2013; Kitchin, 2014).

Although many studies have shown that the use of big data can offer great competitive advantage, there is no systematic framework available to guide managers on the value captured from big data for product innovation, from idea through to launch (Wong, 2012; Manyika et al., 2011; 2013; Gobble, 2013; Mayer- Schönberger and Cukier, 2013). According to Cooper (2014), the new generation of product innovation should be leaner, faster, adaptive and flexible. Therefore, this research summarises the progress made to date in product innovation (as Table 1 shows), it can be historically categorised into four generations (Rothwell, 1994; Niosi, 1999; Liyanage et al., 1999; Miller, 2001; Ortt and Duin, 2008).

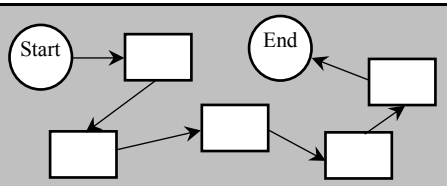
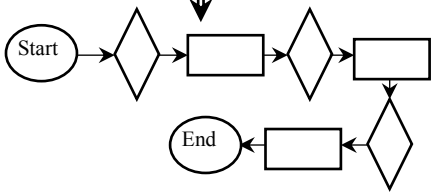
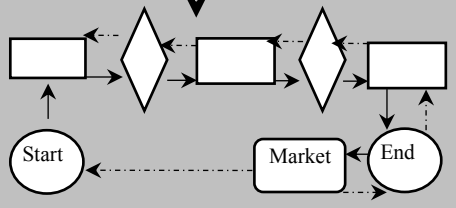
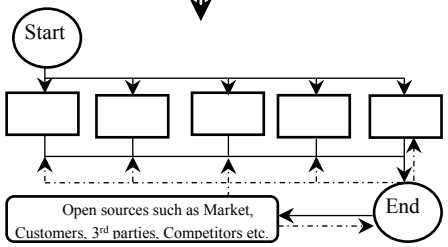
Period	Approach to innovation	Characteristics	Features	Examples
First Generation: the post-war period to the mid-1960s		The innovation process is perceived as a linear progression from scientific discovery to marketplace	• High degree of uncertainty and serendipity • Focus on R&D • Linear progression	• Flash of genius or Brainstorming (Knight, 1967)
Second Generation: the mid-1960s to the late 1970s		The innovation process is generally organised in multi-disciplinary projects. Linear sequential process in a project, starting with market needs	• Linear progression • Starts with market needs • Well organised to reduce uncertainty	• Multi-divisional and sequential process (Utterback and Abernathy, 1975)
Third Generation: the late 1970s to the early 1990s		Models are essentially linear, with sequential progress; innovation is driven by market feedback and requirements	• Logically sequential but not necessarily a continuous process • Function departments work interactively • Gathers feedback from each department to improve	• Stage-Gate innovation process (Cooper, 1990; 1994)
Fourth Generation: the early 1990s to present		Models are simultaneously processing through a wide range of networks and partners in order to facilitate innovation and increase speed	• Simultaneous processing • Cross-function departments work independently • Fast development • Gathers feedback from customers and market quickly	• Open innovation (Chesbrough, 2003, 2006)

Table 1: Evolution of product innovation approaches

In short, the table indicates that the evolution in innovation approaches has been characterised by a shortening of product lifecycles, simultaneous working process, increased understanding of customers, and a higher degree of collaboration with partners. Many sophisticated innovation approaches have been described, and indeed successfully applied, all over the world (Cooper, 1994; 2008; 2012; Christensen and Overdorf, 2000; Mann, 2002; 2007; Brandenburg, 2002; Chesbrough, 2003; Hansen and Birkinshaw, 2007; Sheu and Lee, 2009; Casadesus-Masanell and Zhu, 2011; Williamson and Yin, 2014). Nonetheless, what is required today is a new framework to guide the product innovation process, one which can utilise big data to accelerate the problem-solving element, and shorten the overall process, in part through effective connection to customers, as well as ensuring low cost (especially when limited resources are available).

3. ACE Framework Development

Therefore, a much better framework is needed to assist manager to better make use of the available big data to facilitate product innovation. In this part, a framework was developed to assist firms in product innovation through harvesting big data to shorten the time lead to market, improve customers' product adoption and reduce costs. It is termed the ACE framework because it is based on the principles of Accelerated process (A); Customer connection (C); and Ecosystem of innovation (E) (see Figure 1).

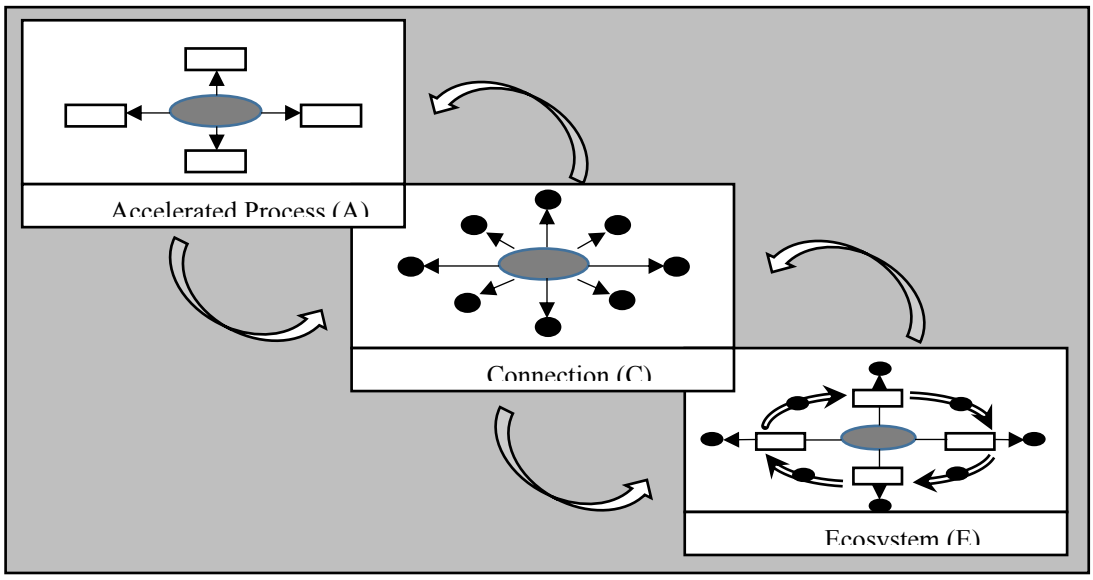


Figure 1: The Approaches of accelerated innovation

3.1 Accelerated Process

Speed yields competitive advantages: being the first on the market can result in a quicker realisation of profit, and there will be a lower risk that the competitive situation or market has changed before the new product can be launched (Cooper and Kleinschmidt, 2002; Steinfeld

and Beltoft, 2014). One of the principles of ACE framework is accelerated process, figure 2 shows the most important elements on achieving the accelerated process principle.

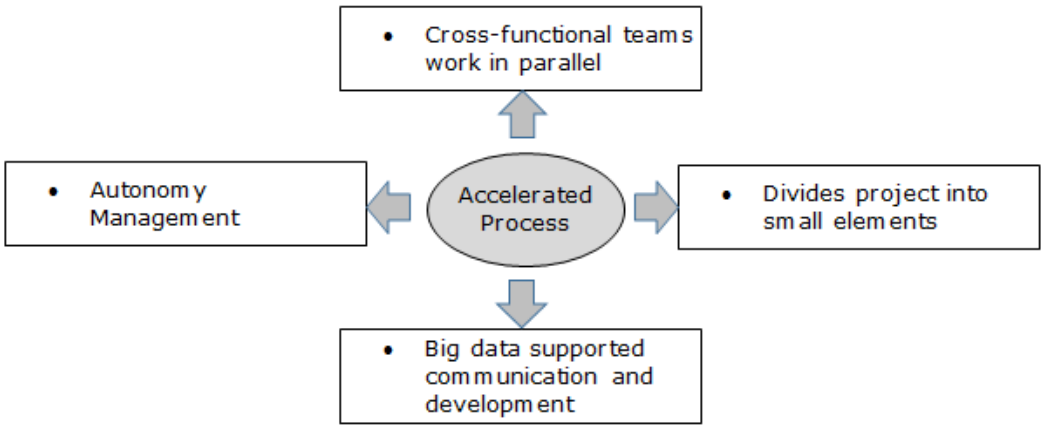


Figure 2: Accelerated Innovation Process

Autonomy is the mother of motivation and creativity (Wynen et al., 2014; Chen et al., 2015). The most important thing in the principle of accelerated process is to give autonomy to the innovation teams. This means allowing R&D team members a high level of freedom to make decisions by themselves in their workplace. Autonomy here also implies that project teams work in parallel, rather than sequentially. Under autonomy management, a group leader is allocated to supervise the output of the project. The project approach begins with dividing the innovation process into many small elements. After that, the divided project activities are undertaken by cross-function teams (which mean a team of people from different functional areas) and work on different elements in parallel. By doing this, the so-called innovation "assembly line" can be accelerated and results can be delivered quickly (Davenport, 2013; Nordigården et al., 2014). Autonomy does not mean being separate: project teams need alignment with the core, using big data to share innovation portfolios as well as to cultivate a network of peers and relationships, to facilitate innovation (Yalabik et al., 2012; Chen et al., 2015).

Big data plays a significant role. In terms of traditional innovation approaches, many companies have found it hard to implement the autonomy principle, because of barriers such as unwillingness by engineers to release information early and difficulties in coordinating multidisciplinary teams (Berglund and Sandström 2013; Li et al., 2014). Companies now can rely directly on big data to gather the latest information; team members are now working and living in a big data environment which ensures their communication and knowledge sharing are both effective and efficient.

3.2 Customer Connection

In addition to being able to develop new products rapidly, product innovation has to be close to the market to stay abreast of the evolving needs for functionality, which in turn are

driven by quickly evolving customers' taste (Prahalad and Ramaswamy, 2013; Steinfeld and Beltoft, 2014). The second principle of the ACE framework is customer connection, i.e. a focus on building a close relationship with customers via big data (see Figure 3).

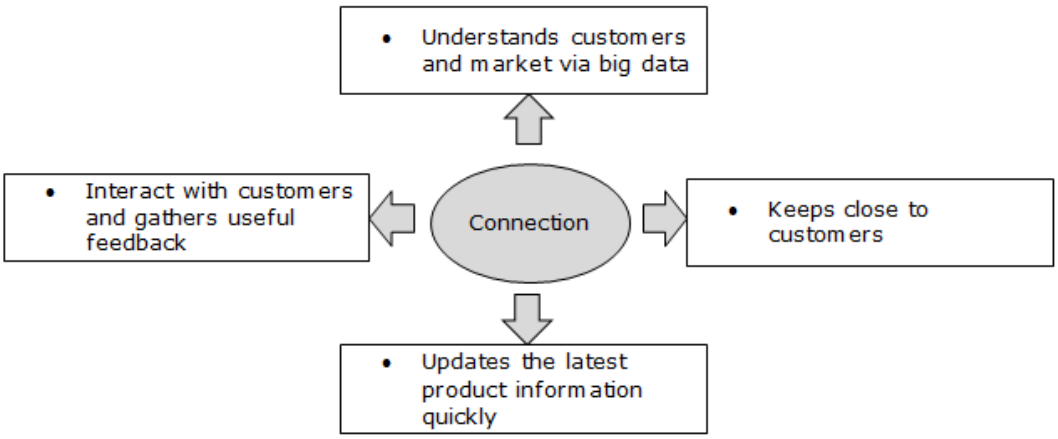


Figure 3: Customer Connection

On the one hand, innovation can be facilitated by evolving ideas while listening to the voice of customers. The product is better when potential customers can be identified and their needs satisfied (Prahalad and Ramaswamy, 2013; Steinfeld and Beltoft, 2014; Cooper, 2014). Engineers and R&D teams are not mind readers. With poor customer connections, they often have to back-track to make the product right. Thus, they waste considerable time in defining projects appropriately. This development process can be speeded up by building better customer connections. What is more, instead of making changes late in the project, customer connection encourages changes to occur earlier, when they are less expensive (Williamson and Yin, 2014).

On the other hand, the involvement of customers is an emerging trend (Cooper, 2011; 2014; Dunn and Dahl, 2012; Williamson and Yin, 2014). The innovation process can be dramatically accelerated by using big data in the form of, for example, usage information, which is much more rapidly available than, say, the results of market surveys (Li et al., 2014). Big data in the form of feedback can be an important source of useful information and new ideas. Key questions need to be focused at this stage, such as: Who exactly is the target customer? What functionalities and features should be developed to give the product a differential advantage? What exactly should the product be to make it a winner? By answering such questions, companies can gain a better understanding of their customers, markets and products.

3.3 Fast Launch-and-Improve Ecosystem

The third principle of the ACE framework is this ecosystem, i.e. an innovation and market testing environment to develop new products at dramatically fast speeds and lower costs. It bridges the gap between the need for the new product definitions and the changeable market

conditions as development proceeds (Gupta, 2013). Figure 4 demonstrates the most important elements how to achieve the Ecosystem principle.

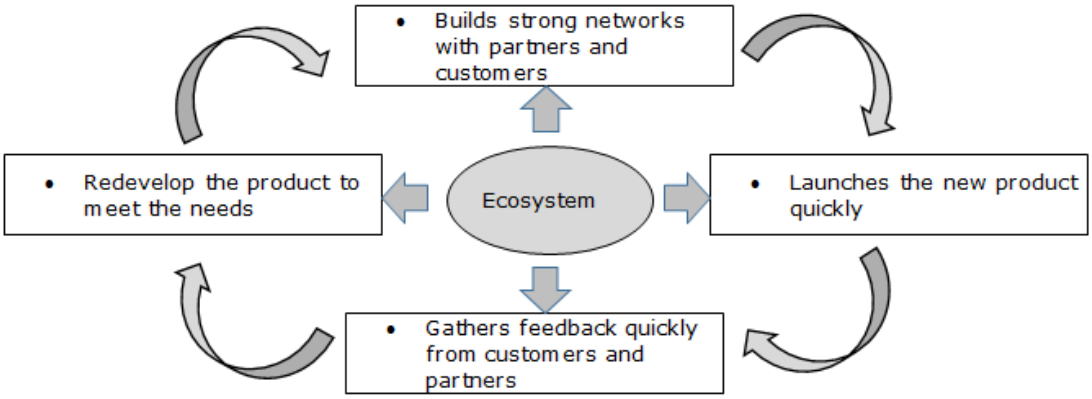


Figure 4: Fast Launch-and-Improve Ecosystem

Adner (2006) points out that innovation ecosystem have become a core element in the growth strategies of organisations in a wide range of industries. The ecosystem principle of the ACE framework indicates that the company network is used to acquire new requirements and the components of product development process externally or from intermediates, in order to create a fast launch-and-improve environment that is able to launch a product quickly and less costly. A fast launch-and-improve ecosystem involves the concept of autonomy and customer connection. It helps the product team to move quickly to a market-winning product through a series of iterations: new product ideas; fast launch; gather feedback; fast improvement; re-launch.

The core competitive advantage of this ecosystem arises from the use of big data to attract and connect to a wide range of networks in each step of product development (McAfee and Brynjolfsson, 2012). This might be through the presentation of mock-ups, images or videos of the new product to customers and thus the gathering of feedback early in the process of product development (Tuulenmäki and Välikangas, 2011). In the ecosystem, innovations are made from interrelated networks (Ogle, 2007; Wang 2009) and these empower organisations to rapidly integrate useful feedback from customers and partners. Through repeated accelerated innovation cycles, project teams can iterate the product in sync with evolving market requirements and stay ahead of the competition. With the innovation ecosystems, firms are better able to respond to today's fluid, changeable information and evolving market conditions.

4. Methodology and Case Studies

Much of the existing literature is based around concepts of the characteristics and well-established theories of big data, its uncovered value and traditional innovation approaches (Wong, 2012; Manyika et al., 2011; 2013; Wamba, 2015). While stochastic theories and industrial economics shed light on some phenomena of interest, they are far from full

explanations of the use of big data to facilitate innovation. To study how the proposed framework can support firms to facilitate product innovation, this part adopted an inductive approach. Three cases of emergent leading companies in China were selected: (1) Xiaomi, a manufacturer of smartphones; (2) Lenovo, a computer hardware and electronics company; and (3) Didi Dache, a taxi service company. Brief outlines of the three firms are provided in Tables 2.

Company	Industry	Position of Interviewees	Revenue (£)	Position of Participants
Xiaomi	Consumer Electronics and Computer Hardware	Smartphones, Tablet Computers and Home Devices	8b	Project Manager; Accessories Program Manager
Lenovo	Computer Hardware and Electronics	Smartphones, Computers, Peripherals and Storage Devices	27b	Marketing Manager; Product Manager
Didi Dache	Software Company	Smartphone Applications	2b	Executive Assistant; Technicians

Table 2: Summary of company background and interviewed industrialists

These cases were selected for a number of reasons. First, all have used big data to speed up their product innovation. Williamson and Yin (2014) argue that the ability of Chinese firms to launch new products in rapid succession over short periods of time is worth worldwide attention, as this could inform the next generation of innovation. Second, the three cases reflect certain aspects of the dynamism and rapid growth of Chinese companies in recent years. Third, they collectively provide coverage of different industries. Fourth, these cases show diverse innovation paths can be achieved through big data analytics.

In reviewing the product innovation approaches of these three leading Chinese companies, each of the cases can be seen as an independent part. The objective is to try to understand their main innovation approaches and big data activities, that is, how they integrate big data to increase efficiency and reduce the cost and cycle time in product innovation. In this study, the data collection resorted to multiple sources of evidence, which allowed us to increase the validity of our constructs (Yin, 1994). They involved: on-site observations, semi-structured interviews with key respondents, industrial reports, strategic planning reports, annual reports, newsletters, technical or non-technical documents and project reports. Each company case took approximately one week and was recorded. According to Yin (1994) argues that a richer portrait of any particular case can be acquired by using multiple sources information and by mitigating bias in historical data interpretation. The next main section of the paper then draws together some of the common findings from these three cases and suggests lessons for accelerated innovation.

Case 1: Xiaomi Inc.: Xiaomi Inc., a five year old young Chinese mobile phone company, is now the world's third largest manufacturer of smartphones and is worth more than $46 billion (BloombergNews, 2014). Like any other producer, it has a chain of design, R&D and selling

functions. The first of Xiaomi's smartphones was released in August 2011, and since then it has been trying to expand to a wider range of consumer electronic markets; it now has its own mobile apps and related electronic products. The company has gained an important status. Some 60 million Xiaomi smartphones were sold in 2014 and $1.1 billion of new funding from investors was received towards the end of December 2014 (BBC News, 2014), which made the company the world's most valuable technology start-up; at that time, its valuation exceeded $46 billion (Linshi, 2014) (see Table 3).

Case 2: Lenovo Group Ltd: Lenovo Group Ltd was founded as a Chinese computer technology company in 1984. It is currently valued at some $38.7 billion and has expanded its operations across more than 160 countries (Annual Report, 2014). There is deep integration across its 'Idea'-branded consumer PCs, 'Think'-branded commercial PCs, workstations, servers and mobile Internet devices, including tablets and smartphones. It is the largest personal computer vendor in China and the second largest in the world (Annual Report, 2014) (see Table 4).

Case 3: Didi Dache Inc.: DiDi Dache, which means 'hire a taxi quickly', is a Chinese taxi services company founded in September 2012. It is among China's 13 most valuable start-ups and was valued at over $3 billion in April 2014 (Dididache, 2015). Currently, it has over 60 percent of the Chinese market, with over 154 million users, one million registered licensed taxi drivers, 5.2 million peak daily orders, and it covers over 300 cities (Clover, 2014) (see Table 5).

Xiaomi Inc.

Innovation approach	Big Data Activities	Benefits
Teams work independently with Xiaomi customers	Cross-function teams are working independently as well as simultaneously with Xiaomi customers. Under this approach, Xiaomi develops new smartphones in 3 months on average. The collection and use of big data not only helps teams to communicate with each other (through Chinese communication services such as Wechat, Weibo and Renren), but also turns every customer into Xiaomi's friend. Customers' suggestions and feedback are quickly rendered as inputs to Xiaomi's product improvement ideas.	• Fast product development • Lower development costs • Flexibility to incorporate new functionality quickly
The company connects and communicates with its customers	Xiaomi has forums across all the key social media platforms in China and leverages big data as its primary channel to interact with customers. For example, the main forum is called 'Xiaomi forum' on its official website. It posts (in different formats) more than 500,000 topics per day, including new product information, announcements, feedback and discussions. The core operating system of Xiaomi, MIUI, is highly customisable, allowing more than 85 million keen users upload their ideas and suggestions to facilitate the company's product innovation and invention of new features.	• Low research costs • Signals a firm commitment to improvement through co-creation • Gets feedback and ideas extremely quickly and effectively
Fast launch-and-improve ecosystem	Xiaomi collects feedback from customers and partners on a daily basis and updates its operating system on a weekly basis. The new features and functionalities are co-developed with various business partners. The ecosystem of Xiaomi involves app stores, games centre cloud storage services, theme stores, browsers, suppliers and intermediates. For example, one of the partners of Xiaomi is Tudou Youku, which has more than 500 million monthly users and its daily video views have passed 800 million. Xiaomi gathers feedback and transfers the latest information on the most promising features quickly via its supportive ecosystem.	• Fast development and release • Turns feedback to advantage quickly • Increases brand and customer loyalty • Lower development and research costs

Table 3: Innovation approaches of Xiaomi Inc.

Lenovo Group Ltd.

Innovation approach	Big Data Activities	Benefits
Different cross-function teams work in parallel	Team members are from different departments and work together on different product development elements in parallel, but under one project leader's supervision. Research teams are encouraged to engage users independently, and as early as possible. Product concepts tend to go through dozens of labs/tests at the same time before being put on the market. The new product innovation cycle of Lenovo is about 6 months for a personal computer and 3 months for a smartphone, which is at least three times quicker than for comparable Chinese companies using other innovation approaches to their product development	• Low research and development costs • Fast new product development • Autonomy improves creativity as well as efficiency • Makes a large portion of the wide range of products the company produces compatible with each other
Connects customers promptly	The company connects with its customers through its own Talend big data platform. It understands customers' behaviours and needs better by acquiring datasets from about 300 processes that run simultaneously and come from sources including third parties, social networking feeds and Application Programming Interfaces (APIs).	• Faster and smarter decision making in product development • Cost saving • More flexible in making decisions/strategies toward the changing market
Customer feedback and improve network	Lenovo Group Ltd builds complex but powerful networks with thousands of partners in 44 different countries. It has launched a customer feedback programme to collect billions of pieces of information from its users and partners on a daily basis. For example, a thriving 'voice of the customer' programme gathers feedback from more than 30 million customers online per day to improve customers' experience and to facilitate product innovation.	• Low research costs • Understands customers better • Interprets data and reacts quickly to develop new products • Validates impact and monitors results over time

Table 4: Innovation approaches of Lenovo Group Ltd.

Didi Dache Inc.

Innovation approach	Big Data Activities	Benefits
Divides a project into small elements and groups work separately	Groups are drawn from different functions and work separately in parallel to accelerate the innovation process. For example, it took only 1 month to develop the first version of Didi Dache App (excluding the time spent on market research). Big data is used to maintain connections and communication, such as idea exchanges between groups, market investigation of problems identified, as well as to characterise market size, competitors, etc.	• Low research and development costs • Fast new product development • Flexible and fast incorporation of new functionality
Build a terminal system that connects drivers and travellers	The Didi Dache app is a platform that connects to 100 million users, sending an average of 5 million customer orders a day. It uses real-time mobile internet data (text message, locations, voice message, images, etc.) to determine traffic conditions, connect to customers, redistribute taxi resources and gather feedback at the same time.	• Time saving for both taxi drivers and travellers • Improves traffic conditions • Cost saving
Fast launch-and-improve ecosystem	Didi Dache has a strong partnership with Tencent which is the largest and most used Chinese internet service company. After integrating with Tencent's Wechat service platform in Jan 2014, its registered users doubled from 20 million to 40 million within 3 weeks. Didi Dache creates a variety of channels to encourage feedback and rapidly communicate this to the R&D team. This informs the development of new versions, with better features and functionalities. For example, after the first release of the app, Didi Dache gathered feedback quickly and launched 3 new versions with new functions and capabilities over two months. More recently, the app has been updated approximately once per month.	• Low research and development costs • Interprets and reacts quickly to develop new products • Gains more market opportunities

Table 5: Innovation approaches of Didi Dache Inc.

In summary, all three companies focus on establishing teams that can work both autonomously and simultaneously in order to speed up product development. They also connect with their wide range of customers at the earliest stage possible of product development. They launch their new products as quickly as possible to gain market recognition as well as further feedback from customers to trigger further continuous innovation. In order for them to harvest big data to inform product innovation, they identify and remove time and cost wasting processes during the innovation as much as possible, and they are adaptable enough to provide organisations to explore different possibilities in different situations. In short, all three companies are able to use the ACE principles to facilitate a more agile, lean, dynamic product innovation process that is faster and adaptive. They also ensure that the innovation is consistent with their company's' core goals, and make necessary adjustments along the way.

5. Discussion

In the proposed ACE framework, big data can offer companies not just opportunities for innovation, but also a network for learning knowledge in different ways that can support their problem solving. From the case studies, we have evidence to indicate that the proposed ACE framework appropriately reflects the smooth integration of big data and accelerated innovation. In general, most managers agreed with the principles of the ACE framework and endorsed many of the suggested guidelines in the framework.

Traditionally, the new product development process has involved inefficient sequential processing of information between functional specialties. The ACE framework allows firms to adapt and respond rapidly to changing market needs and to develop innovative products in such an environment. Rather than spending years to exploit in-house capabilities, the ACE framework can be used to build a network to piece together production on capabilities. Hence, it ensures the company remains on the cutting edge of product innovation. Proactive assessment of customer needs and behaviours is vital in today's competitive environment (Brown and Bessant, 2003; Narasimhan et al., 2006; Mahr and Lievens, 2012; Stanko and Bonner, 2013). The demand for intelligence on product defects, improvements and usage has never been greater, especially in high-technology firms in the healthcare and telecommunications industries (Oke, 2007; Lee et al., 2011; Salge et al., 2013). The accelerated approach is meaningful for products and services with short product life cycles, notably the consumer electronics industry and social media applications, where demand is driven mainly by lifestyle trends. Moreover, the case also highlighted that achieving innovation and flexibility requires considerable planning and coordination through the various phases of development. Thus, top-level management support through a product champion and tight interfacing with social media and the target market are essential components of accelerated innovation.

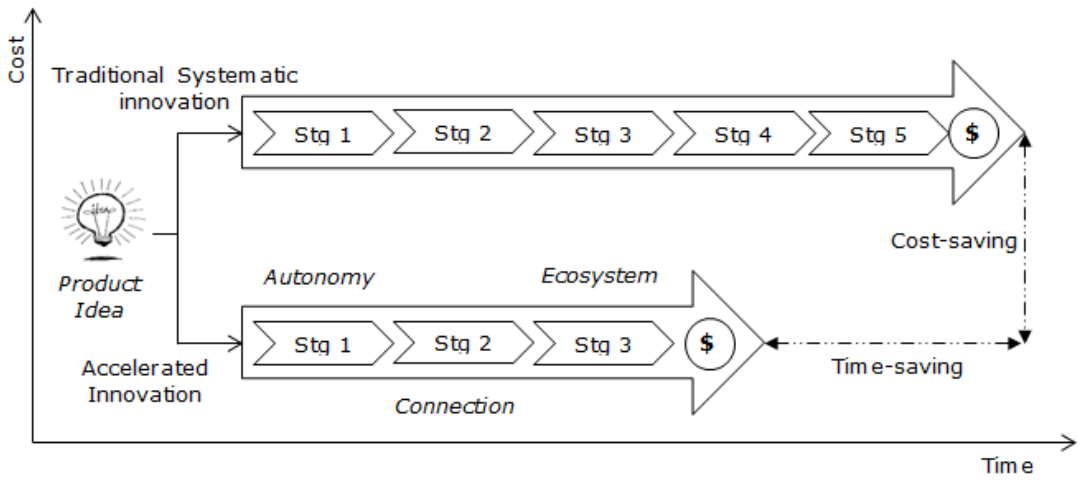


Figure 5: Comparison between traditional innovation approaches and ACE framework

As Figure 5 shows above, compared with traditional innovation approaches, the ACE framework gives particular emphasis to efficiency and cost saving. There is no magic formula for innovation. However, firms could expand their existing innovation competence in many ways by tapping into the knowledge afforded by big data. The ACE framework provides a blueprint for using big data to make product innovation dramatically faster and less costly. By using the ACE framework, firms are leveraging big data analytics to embed customer sentiment in product development. This enables firms to move away from product-focused innovation and to turn their attention to innovation around the customer experience. The proposed paradigm-shifting innovation approach enables firms to find ways to innovate – to make new product development dramatically faster and less costly.

6. Conclusion

The ACE framework proposed in this research is based on information elicited from the literature, and was validated in three successful Chinese firms. The framework presented in this paper can facilitate better planning and organisation of parallel work teams and groups that may be involved in rapid new product development. This paper extends the accelerated innovation boundaries pointed out by Williamson and Yin (2014), and provides further evidence to ascertain the vital role of the innovation ecosystem in new product development.

This paper points to the vital role of big data in helping firms to accelerate innovation. The incorporation of big data into the fast launch-and-improve ecosystem can be significant (Hamm, 2014). First of all, it allows organisations to launch new products to market as quickly as possible. Secondly, it helps organisations to determine the weaknesses of the product earlier in the development cycle. Thirdly, it allows functionalities to be added to a product that customers are willing to pay a premium for, while eliminating features they don't want. Last but not least, it identifies and then prioritises customer needs for specific markets.

However, this study has its limitations. First, since using big data to support accelerated innovation is new, there is little literature to build on, and we have had to rely on investigation of some trends of increasing importance in product innovation evolution to develop the ACE framework, and

use three successful firms' case study to verify the framework. Second, the case studies were conducted on Chinese firms; it is not known to what extent the approach can be generalised beyond the Chinese context. Third, developing a high-level framework for such a complicated phenomenon as accelerated innovation may highlight some obvious connections while failing to capture others.

Future empirical studies might test the ACE framework across different industries. An interesting question is whether this type of innovation approach extends to other countries or industries where product life cycles are comparatively long. Second, this research could take a longitudinal approach to analysing ACE implementation in a firm over time. Learning and innovation processes can be properly studied only over a period of time. The findings would have useful implications for future research and policy design and implementation.

Post Script

The proposed ACE framework was subsequently tested in two different firms. The authors are happy to share the case study results if requested.

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Patent Circumvention of Tea Bag Filter

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Abstract

This paper discusses the patent circumvention of Japanese patent JP5152779, a bag for extracting luxury drink. The patent is to solve a stability problem of the filter for luxury drink. Since instability of holding the tea bag filter can cause the hot drink spilled out off the tea/coffee cup, thus burning the user. It also causes a safety problem. By providing a double V-shaped structure between the extraction bag and cup holding parts, it provides the middle portion of the structure with great stretch capability. In this way the holding, safety, and extraction properties of the extraction bag are elevated. To circumvent this patent structure, a functional analysis is performed on the components of the patent product to give us a bird-eye view of the components and their functions. By using the TRIZ inventive principle 13 inverse, the inverted T plate which is originally attached to the filter, is separate from the filter and attached to the cup holding part. This forces the middle portion of the structure to be adhered to the filter and the cup holding part modified as a two-tooth handle. This handle is put at the top of the paper cup to secure the bag. Thereby a new design is created with a totally new structure different from the original bag structure, thus circumvents the Japanese patent JP5152779.

Keywords: Tea bag filter, stability, functional analysis, stretch, two-tooth handle

1. Introduction

Tea drinking has been a custom for both Eastern and Western world. There has been a long history in Chinese culture for drinking tea which can be dated back to Tang Dynasty (760 CE) (History of tea, 2015). Tea and China are twins. Not only China is the motherland of tea but tea growers in China today still produce tremendous amount of tea with traditional methods. Tea seems to be as an un-American produce. However, it is popular around the United States. When families get together, tea is

often served. Japanese people has been trying to enhance the preparation of tea drinking, the way of tea, to a mystic experience of Zen in the famous tea ceremony (Bussey, 2001). Traditionally, people prepare their tea by brewing loose-leaf tea in boiled water. However, a more popular and convenient way of preparing green tea now is simply brewing a teabag in boiled water for three minutes suggested by the teabag manufacturers.

The development of tea bag filter has gone through a long way to the modern tea bag filter. In this paper, we present a patented tea bag filter in Japanese patent JP5152779 (Tadashi and Kazunori, 2013) with a patent circumvention procedure. This is used as a teaching drill in the first author's class. Introduction to patent is for the sophomore class. There are two reasons for choosing it as a curriculum. First, there is the patent for the patent product which is available in Taiwan as the students can see the actual product when they go through the patent document. Second, the patent product of Japanese patent JP5152779, owned by Yamanaka, used to be accused of patent infringement by another Japanese company, OHKI, who owns a Japanese patent JP3166151 (Mitsunori, Toyoko and Fumio, 2001). The appealing of OHKI goes from an Osaka District Court all the way to Intellectual Property High Court. However, On January 25, 2010, the Japanese Intellectual Property High Court affirmed the Osaka District Court's non-infringement sentence (IP High Court Affirmation, 2015). This means that the tea bag sold by Yamanaka does not infringe the patent JP3166151. This legal case provides a very good example on the patent infringement, especially in the doctrine of equivalents, which is out of the scope of this paper. Our paper focuses on the method of patent circumvention particularly in the functional analysis and problem solving with TRIZ inventive principle 13, inverse (Mann, 2002).

The rest of the paper is organized as follows. Section 2 provides literature review on patent circumvention and functional analysis. Section 3 describes the research methodology used to design around patent. Section 4 describes our case study which presents the results of our analysis. Section 5 concludes the paper.

2. Literature Review

Patents contain useful insight for engineering design (Mueller, 2012). They contain technical drawings and procedures to solve industry problems. In the claim section of a patent document, the first claim is an independent claim which describes a system with several technical features to enable the system to work to solve the problem described in the problem statement. This problem statement is usually described in the background section of the patent document. According to Genrich Altshuller, the inventive levels of some patents are so high that they contain contradiction, which Altshuller coined as the inventive problems (Altschuller, 1984). Not all the patents solve inventive problems. Some patent problems can be solved by basic engineering knowledge, brain storming and rudimentary creative thinking as proposed by Edward de Bono (De Bono, 1990; De Bono, 1999; De Bono, 2007). However, those methods lack of systematic approaches, they focus on the components of the object which is under investigation, not the functions they provide. It usually leads to the improvement of physical structure, seldom render drastic change of the original design. With the help of functional

analysis, people can focus on function the components render. It not only gives us a perspective view of the problem, but also empowers us to think out of the box. As function release us from the constraints of physical components. In the functional analysis, each component of the system is related to other components by a function statement. If we take the system in the first independent claim and apply the functional analysis to it, it is clear that technical features become the components and the interaction of the technical features can be described as the functions offered by the components in the system.

To infringe a patent claim means to copy the whole technical features of the first independent claim either in a literal meaning or in an equivalent. In other words, not to infringe (circumvent/design around) a patent claim means avoid using some technical features in the first independent claim or significantly change the function, way and result of some technical features. Trimming is a good tool to achieve the omission of certain technical features; whereas different tools in TRIZ such as Su-field model with 76 standard solution and contradiction matrix with 40 inventive principles (Mann, 2002; Altschuller, 2001) can be also used to significantly change the technical features in terms of its function, way and result.

3. Research Methodology

There are many different flowcharts describing the implementation of functional analysis and patent circumvention (Li et al. 2015; Sheu et al. 2013). Li et al. (2015) illustrates a general process of Patent design around consists 4 stages (Figure 1), which are design around target definition, design around problem identification, problem solving and solution evaluation. This process, though is complete, is not easy to implement for the inexperienced users of TRIZ. Therefore, here we propose a simple and easy to understand process to implement functional analysis and patent circumvention as shown in Figure 2. The steps in Figure 2 are explained as followed. The first step, patent problem analysis, includes read on the claim, especially the first independent claim and to understand the scope of its patent right. Figures and detailed description in the patent document should be referred. Next, key technical features identification, includes listing all the technical features in the first independent claim. To scale down the analysis, only key technical features should be put in the functional analysis as described in the third step. In our study, only TRIZ 40 inventive principles will be used to tackle the modification of the component structure in the fourth step. Of course, 76 standard solution for the Su-Field model can be implemented in this section along with other TRIZ tools. Lastly, new design solution is generated.

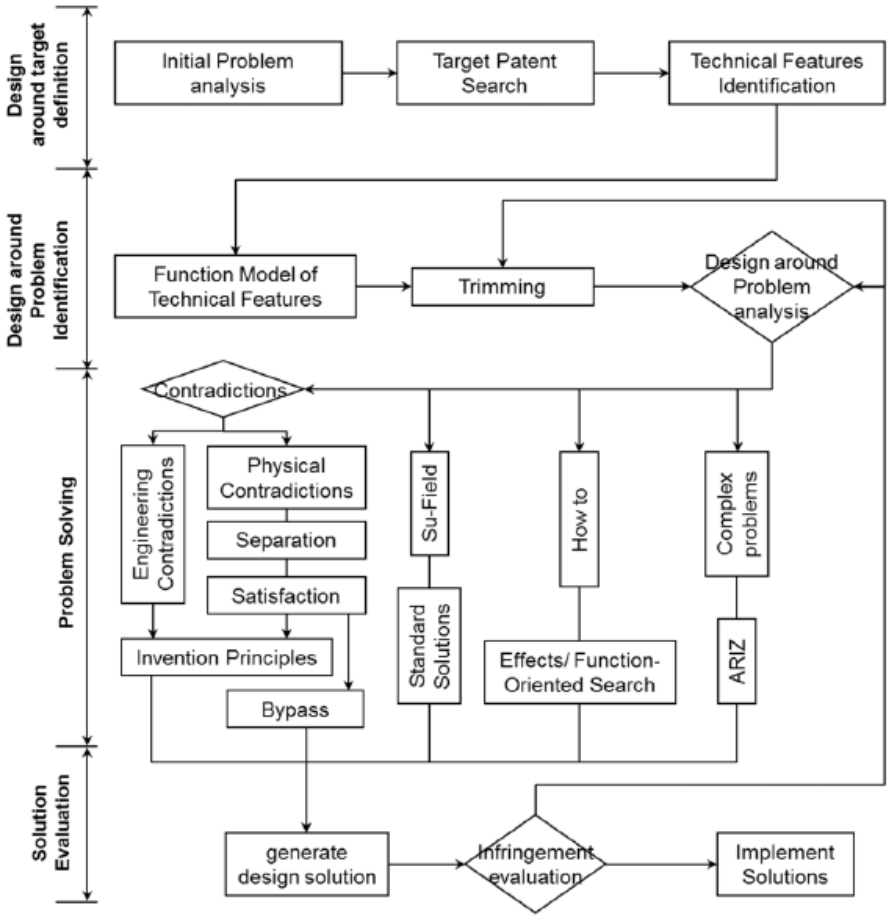

Figure 1. General process of patent design around (reproduced from Li et al., 2015).

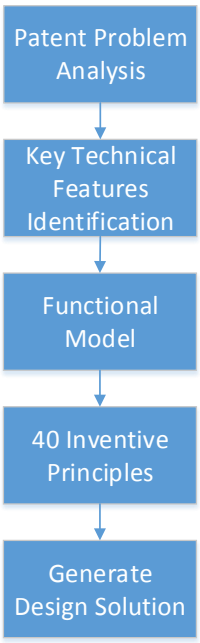

Figure 2. Simplified process of patent design around.

4. Case Study

The original bag design of JP5152779 is drawn with Rhino and shown in Figure 3. The cup holding parts is depicted as the two edges shown in the bottom-right in Figure 3 as a right view. Thereby an inverted V shape is formed between cup holding part and middle portion of the structure. The inverted V shape pivoted at the boundary line on the top of the cup holding part. Meanwhile, a V shape is formed between middle portion of the structure and inverted T portion of the support sheet which is adhered to the filter. The V shape pivoted at another boundary line on the bottom of the inverted T portion of the support sheet. This double V shape structure is clearly seen from the right view in Figure 3. With this double V shape structure filter is securely held on the cup rim and thereby hold the drink in stability. Figure 4 shows the operation of the filter on the paper cup. Thereby cup holding part is put at the top of the cup. Between the cup holding part and the filter, the double V shape structure serves as the bridge to hold and secure the filter in the open position ready to take in the hot water to extract the flavor of the tea/coffee deposited in the filter.

The functional analysis is depicted in Figure 5. The numerals in Figure 5 depicts the parts in Figure 6 which is a close-up shot of Figure 3. In Figure 5 the cut holding part is abbreviated as handle 12 which is hung over the rim of the cup. With the handle 12 and middle portion 8 of the structure, it forms an inverted V shape. In Figure 6 a bent boundary line is clearly seen and it serves as a pivot to allow the handle 12 to be pulled in the outward direction. While it is pulled, an inverted V shape is formed between the handle 12 and middle portion 8 of the structure. Furthermore, the inverted T plate 7 and middle portion 8 of the structure form a V shape. This V shape structure pivots at a boundary line located at the bottom of the inverted T plate. It serves as a holding mechanism to hold fast the middle portion 8 of the structure so that the middle portion 8 of the structure can be stretched between the inverted T plate 7 and handle 12. Because of the stretching ability of the middle portion 8 of the structure, the bag can fit into a cup with almost any shape and size.

The original first independent claim of JP5152779 is very lengthy, which implies the scope of patent right is very small. It contains the tedious description of the two boundary lines for pivoting the inverted V shape and V shape structures among inverted T plate 7, middle portion 8 of the structure and handle 12. In additions, fin structure is also incorporated into the claim. These tedious technical features are eliminated in the functional analysis to scale down the size of analysis. Only key technical features are put in the functional analysis.

As mentioned before, a TRIZ inventive principle 13 inverse, is applied to the middle portion 8 of the structure. The movable property of middle portion of the structure is inverted to be fixed property. The middle portion of the structure is adhered to the support plate 4. Consequently, the stretch property of the middle portion of the structure is eliminated. This stretch function is transferred to the inverted T portion 7. Here its shape is inverted to T shape portion. Thus in the original bag design, the middle portion of the strucure has two parts, each of them is located on the left and right side of the inverted T portion 7. Now the new design has only one middle portion which has a T shape. In order to hold

the middle portion with a T shape tightly, the support plate 4 is changed from the inverted U shape to the square shape. This further changes the handle 12 from a U shape to the two-tooth shape.

Figure 7 shows the modified functional analysis of the new design after applying the TRIZ inventive principle. Comparing Figures 5 and 7, it is clear that the two components in Figure 5, inverted T plate 7 and handle 12 are changed to two forks 7' and teeth 12'. Note that two forks 7' are combined into the support plate 4'. The new design is demonstrated in Figure 8, whereas a close-up of Figure 8 with numerals is shown in Figure 9.

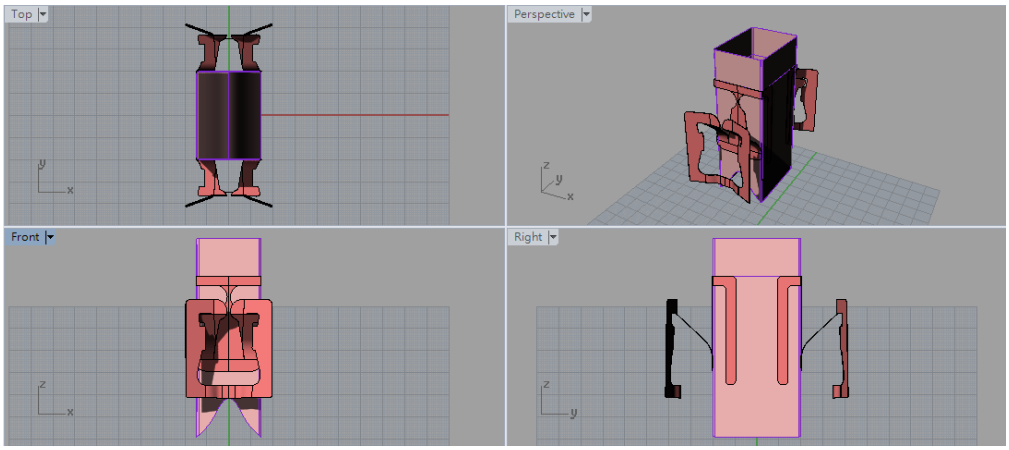

Figure 3. The original design in JP5152779.

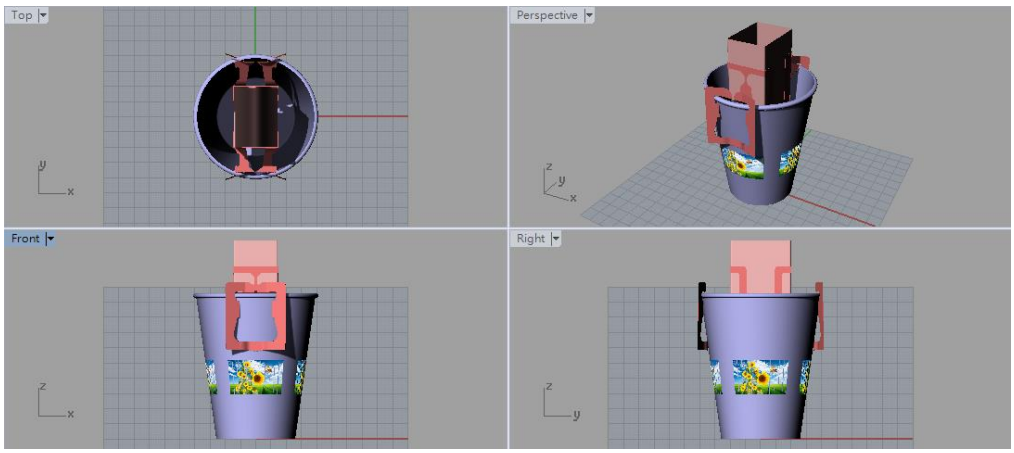

Figure 4. Filter with cup.

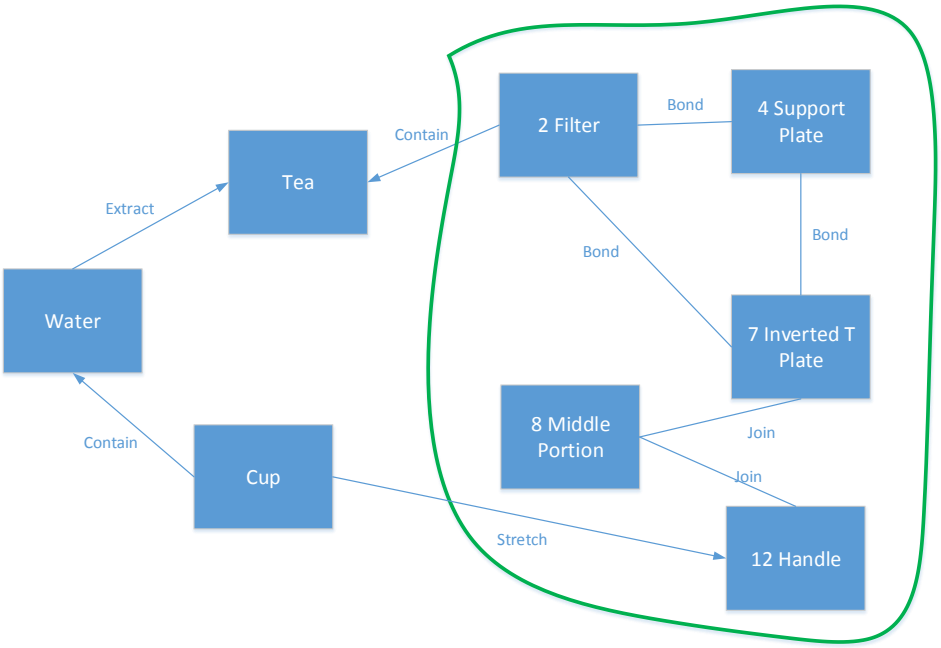

Figure 5. Functional analysis of components in JP5152779.

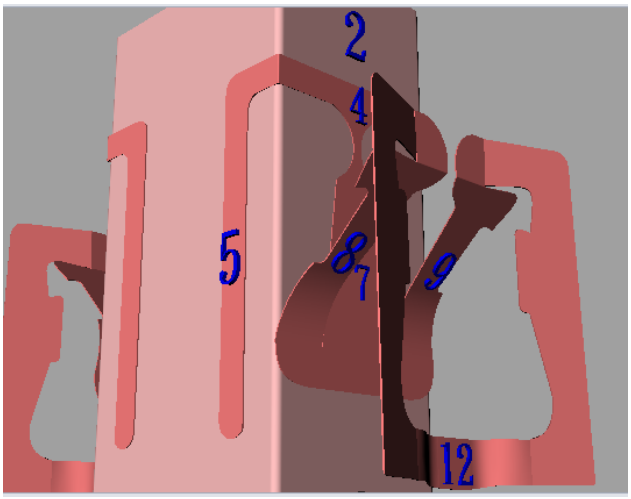

Figure 6. Numerals of components in JP5152779.

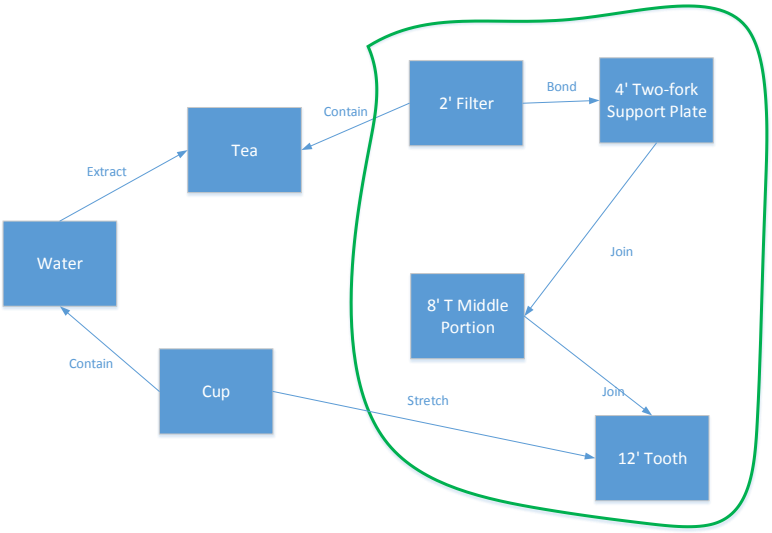

Figure 7. After-trim functional analysis of components in JP5152779.

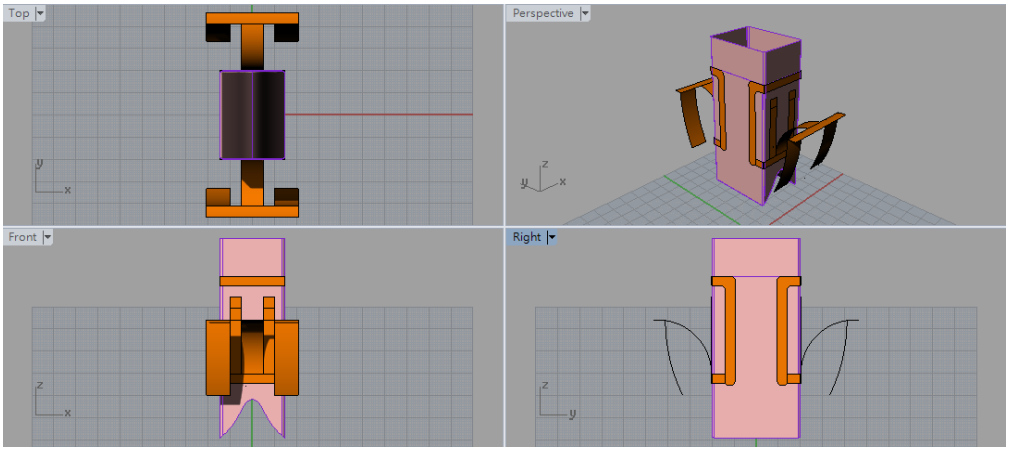

Figure 8. Circumvention of JP5152779.

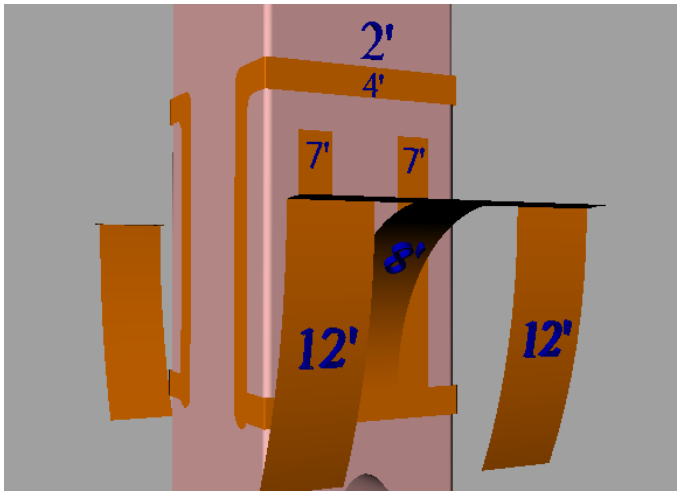

Figure 9. Numerals of components in circumvented design.

5. Conclusion

A bag for extracting luxury drink, with patent JP5152779, is used as an example to illustrate the patent circumvention and functional analysis. The original bag design includes: a double V shape structure among inverted T plate and handle. The handle and middle portion of the structure form an inverted V shape; whereas the inverted T plate and middle portion of the structure form a V shape. In this way, the middle portion of the structure can be stretched between the inverted T plate and handle. Because of the stretching ability of the middle portion of the structure, the bag can fit into a cup with almost any shape and size.

A simplified process of patent design around is proposed to enhance the usability of patent circumvention. After read on the first independent claim of the patent, some key technical features are used as the components of the functional analysis. In this way, the complexity of the analysis is greatly reduced. A TRIZ inventive principle 13 inverse, is used to modify the structures of the components. This results in a new design with the movable property of middle portion of the structure is inverted to be fixed property. The middle portion of the structure is adhered to the support plate. Consequently, the stretch property of the middle portion of the structure is eliminated. This stretch function is transferred to the inverted T portion. Here its shape is inverted to T shape portion. In the original bag design, the middle portion of the structure has two parts, each of them is located on the left and right side of the inverted T portion 7. Now the new design has only one middle portion which has a T shape. In order to hold the middle portion with a T shape tightly, the support plate is changed from the inverted U shape to the square shape. This further changes the handle from a U shape to the two-tooth shape.

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A Method for Identifying Patents' Target Products

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Abstract

Each patent has its intended products, and thus the method for identifying target products of patents has much potential as the basis for various patent intelligence systems which in particular deal with large-scale patents. In this paper, we propose a novel approach for determining patent-product connections. The approach is composed of 1) identifying product name occurrences from patents (1,110,582 patents granted between 2009 and 2013) using our product database (186,805 products), 2) structuring each product (or patent) into a main group-level IPC distribution vectors using product occurrences in patent text, and 3) determining each patent's target products by calculating similarity measures among product- and patent-IPC distribution vectors. This method will become the cornerstone for other later patent intelligence studies at the product level. In this paper, we describe the proposed method's details and performance test results.

Keywords: Patent and target product; Patent analysis; Systematic method

1. Introduction

As an area of the systematic innovation, patent intelligence has been actively researched over the last decade. Patent intelligence-the transformation of content found in multiple patents into technical, business and legal insight-is considered to be a key in gaining competitive advantages in technologically competitive environments [1]. Researchers engaged in this field have proposed the large-scale patent based approaches for technology trends analysis [2], technology forecasting [3] and technology opportunity identification [4]. The typical process of these approaches collects patents related to a specific technology or industry, and then applies statistical methods, information mapping techniques, analytical measures and data mining techniques to achieve their own purposes [5].

Most of the prior studies use patent sets as a technology or technologies, and thereby their methods are executed at the technology level. However, each patent in general has its intended products, so the ability to identify target products of patents has much potential as the basis for various patent intelligence systems which in particular deal with large-scale patents. Such ability can

allow product-level patent intelligence, including product development trends, product competition among firms and product opportunity identification.

A recent task of TOD project is to determine the target products on which each patent intends. A simple method for patent-product connections is to identify the occurrence of product names in patents. However, the occurrence of a product name in a patent does not always indicate that the patent intends the product as its target product, because the patent's textual sections, such as title, abstract, claims, may include the patent's target products as well as irrelevant sub-components that constitute the patent.

Therefore, this study proposes an approach to determine patents' target products by measuring the potential relation between patents and their intended products. This approach consists of 1) identifying product name occurrences from large-scale patents using our TOD product DB, 2) structuring each product and patent into International Patent Classification (IPC) distribution vectors using the product occurrences in patent text, and 3) determining each patent's target products by calculating similarity measures, such as Hellinger distance and Cosine similarity, among the structured IPC distribution vectors of products and patents.

The contributions of this study are twofold. First, this study is the initial study to computationally identify patents' intended products. Second, related to the first contribution, this study will be the basis to build various product-level technology intelligence systems

2. Patent and product databases

The method proposed in this paper is based on the analysis of large-scale patents and product occurrences in the patents' textual sections. Therefore, this section describes the fundamental materials for our method: patent database and product database.

First, to design and analyze the proposed method, we constructed a patent database that includes all of the patents granted in the USPTO patent database between 2009 and 2013 [6]; the total number of patents is 1,110,582. To construct this database, we exploited the Google patents. Google have provided the online service for USPTO patent bulk download (https://www.google.com/googlebooks/uspto-patents.html). Bulk patents are all represented into an XML format, so we could obtain the whole information of patents, including bibliographic information, detailed descriptions, and claims.

Second, why studies for product-level patent intelligence could not be conducted is that it was a very difficult task to obtain feasible product names from massive patents. Recently, Korea Institute of Science and Technology Information (KISTI) started a research project "Establishment of Information Analysis Intelligence Systems" to develop an information system for technology opportunity discovery (TOD) . The main objective of this project is to provide the product-level technology intelligence service. As a part of the project, KISTI constructed a database that contains

feasible product names in patents, called "TOD product DB". This TOD product DB was first developed through natural language processing of United States Patent and Trademark Office (USPTO) product dictionary and patents' textual information. Then, irrelevant product names were removed by human inspection. TOD product DB has evolved and it now covers 186,805 representative product names; a total of 234,121 product names including variations. For example, product names "abnormality detection device", "abnormality detection system" and "abnormality detector" are grouped into the representative product name "abnormality detector".

3. Proposed method for patent-product connection determination

This paper proposes a novel method to determine target products for which patents intend. The method is composed of 4 steps (Figure 1): 1) extracting product occurrences from patents, 2) identifying product-IPC distribution vectors for products, 3) identifying patent-IPC distribution vectors for patents, and 4) determining patent-product connections by measuring IPC distribution similarities between patents and products. The following subsections describe each step in more detail.

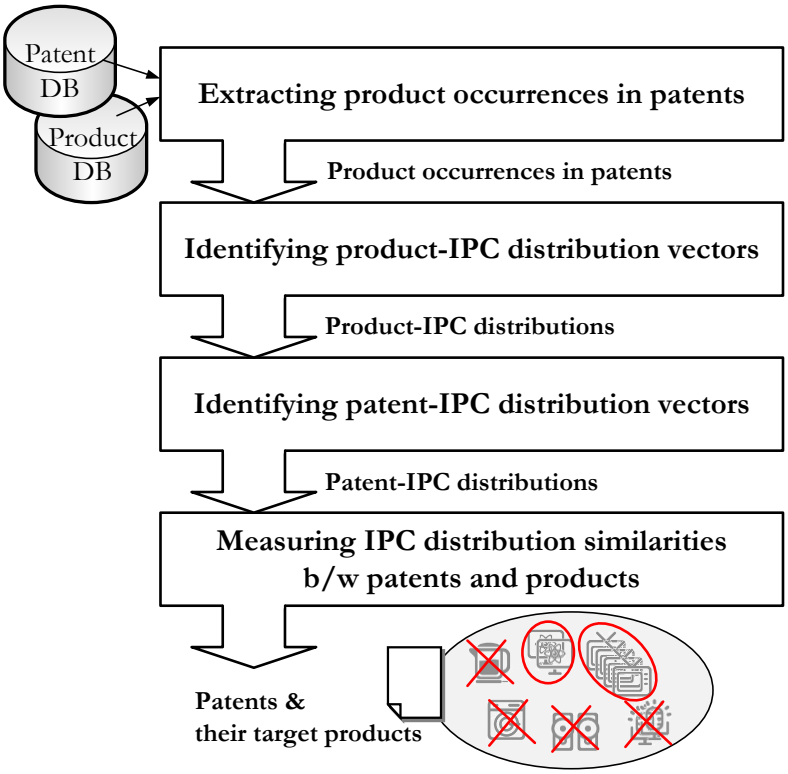

Figure 1. Overall procedure of the proposed approach

3.1. Extracting product occurrences in patents

To produce the basic materials for our method, this step extracts the occurrence information of representative product names in patents, by taking into consideration representative product names'

variations. This step exploits text parsing to store occurrences of products for each of the title, abstract and representative claim of each patent.

3.2. Identifying product-IPC distribution vectors

This step identifies product-IPC distribution vectors using product occurrence information of patents. To this end, first, this step represents a product as a vector with IPC frequencies. A product name can appear in different patents, which have their own IPCs.

The IPC system, as an international standard to represent technological areas of patents, has a hierarchical classification structure that is composed of section, class, subclass, main group and sub-group. For example, patent A with two IPC codes "H(section)01(class)L(subclass) 21(main group)/02(sub-group)" and "H01V 3/02" means that it is classified into the two technological classifications. Prior studies have used class-level IPCs, which are composed of section, class and subclass, to analyze technology trends at an overall technology area level; "H01L" indicates a technology class "semiconductor devices and electric solid state devices", and "H01V" indicates "electric devices exhibiting specific physical effects". However, this study uses main group-level IPC codes, which are composed of section, class, subclass and main group; for example, "H01L 21" and "H01V 3". These main group-level IPC codes can describe specific products or mechanisms related to inventive knowledge. IPC code "H01L 21" indicates "processes or apparatus adapted for the manufacture or treatment of semiconductor or solid state devices" and "H01V 3" indicates "thermos-electric devices without junction of dissimilar materials, thermo-magnetic devices and selection of materials therefor".

Each product can appear in patents and each patent has their classification codes, so this step represents the product into an array of IPC frequencies of the patents in which the product is included, and subsequently, this array can be converted to a product-IPC distribution vector (Figure 2). The product-IPC distribution vectors have the ability to describe what main group-level IPCs each product is most likely related to.

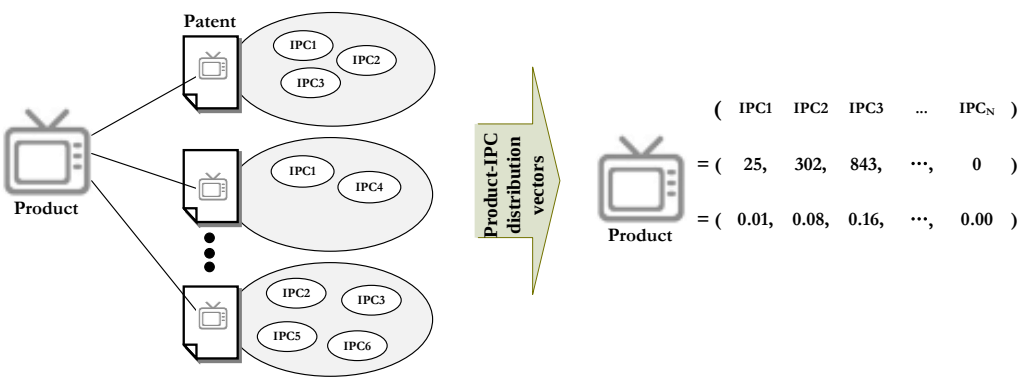

Figure 2. The concept of generating product-IPC distribution vectors

3.3. Identifying patent-IPC distribution vectors

This step generates patent-IPC distribution vectors so that the proposed method measures the IPC distribution similarities between product-IPC distribution vectors and patent-IPC distribution vectors. To this end, this step constructs patent-IPC distribution vectors by exploiting product-IPC frequency vectors. Although each patent contain a list of IPC codes in its bibliographic section, this study estimates the patent's IPC distribution by using product names appearing in the patent, instead of directly using the patent's IPC codes.

A patent may include product names in its textual sections, so a patent-IPC frequency vector can be represented by integrating product-IPC frequency vectors of the patents appearing in the patent. Taking into consideration weighting factors based on the occurrence frequencies of product names in the patent, this step structures a patent into a set of IPC frequencies, thereby generating a patent-IPC distribution vector (Figure 3).

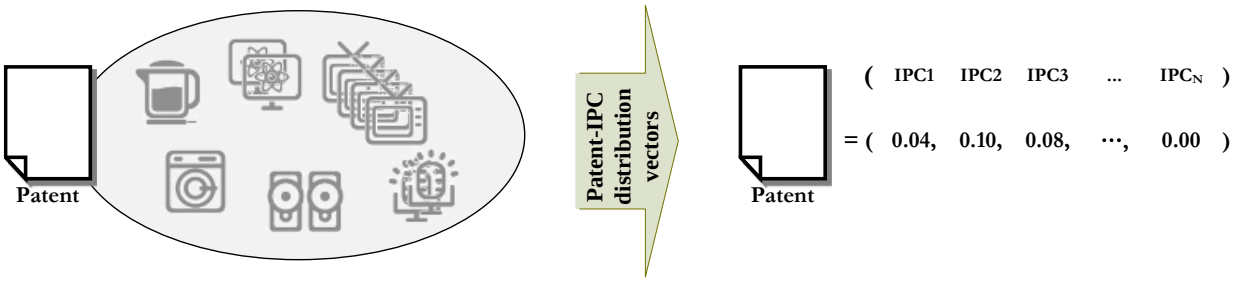

Figure 3. The concept of generating patent-IPC distribution vectors

3.4. Measuring IPC distribution similarities between patents and products

Using the distribution vectors of the previous steps, this step calculates the IPC distribution similarities among products and patents. Each of product-IPC distributions and patent-IPC distributions is a discrete probability distribution for the same IPCs, so determining patent-product connections can be converted into the problem of measuring the similarities between patent-IPC distributions and product-IPC distributions. Given a product-IPC distribution $\mathrm{P} = (\mathrm{p}_1, \dots, \mathrm{p}_n)$ and a patent-IPC distribution $\mathrm{Q} = (q_1, \dots, q_n)$, the similarity between pairs of distributions can be defined using Hellinger distance [7] or Cosine similarity as Equations (1) and (2).

$$\mathrm{SIM}_{Hellinger}(\mathrm{P}, \mathrm{Q}) = \frac{1}{\sqrt{2}} \sqrt{\sum_{i=1}^{n} (\sqrt{\mathrm{p}_i} - \sqrt{\mathrm{q}_i})^2} \qquad \text{Equation (1)}$$

$$\mathrm{SIM}_{Cosine}(\mathrm{P},\mathrm{Q}) = \frac{P \cdot Q}{|P| \times |Q|} = \frac{\sum_{i=1}^{n}(\mathrm{p}_i \times \mathrm{q}_i)}{\sqrt{\sum_{i=1}^{n}(\mathrm{p}_i)^2} \times \sqrt{\sum_{i=1}^{n}(\mathrm{q}_i)^2}} \qquad \text{Equation (2)}$$

$\mathrm{SIM}_{Hellinger}$ has the value between 0 and 1, and $\mathrm{SIM}_{Hellinger} = 0$ means the two distributions are identical. $\mathrm{SIM}_{Cosine}(\mathrm{P},\mathrm{Q})$ has the value between 0 and 1, and $\mathrm{SIM}_{Cosine}(\mathrm{P},\mathrm{Q}) = 1$ means the two distribution are identical. Finally, the connection between a patent and a product can be determined by choosing a proper threshold ρ.

4. Results

According to the proposed method, we first extracted occurrences of product (186,805 representative product names) in all of the USPTO patents (1,110,582 patents granted between 2009 and 2013). Then, we structured IPC distributions of products and patents, and subsequently determined patent-product connections by measuring IPC distribution similarities among pairs of patents and products and setting various threshold values to exclude patent-product connections with low similarities.

We extracted the occurrences of product names in patents' textual sections, such as titles, abstracts and representative claims. The total occurrence frequencies of products were 661,658 in patent titles, 1,874,910 in abstracts and 2,125,252 in representative claims.

Table 1. Statistical results of product name occurrences in patents

Titles	Abstracts	Representative claims
661,658	1,874,910	2,125,252

To test the performance of the proposed method, we randomly selected a set of 150 sample patents. Then, we identified the real target products of each sample patent by manual task of patent experts (Table 2); irrelevant products were excluded by this task although they appeared within the sample patents, and target products with lower case are the product names that are not included in the TOD product DB. According to the analysis of the sample patents, patents were found to have 2 or 3 target products on average.

Table 2. Part of the real target products of sample patents by manual task

Patent application number	Target product1	Target product1	Target product1	Target product1

2000-203639	AMINO ACID	ISOLATED NUCLEIC ACID	amino acid sequence	
2002-057206	NOBLE METAL	noble metal substrate		
2002-497301	fragment separator	MAGNETIC SEPARATOR	food processor	
2003-516342	KINASE SUPPRESSOR	ANTI-SENSE OLIGO-NUCLEOTIDE		
2003-737841	REDUCING AGENT			
2004-522372	AMPHIBIOUS VEHICLE	VEHICLE CONTROLLER	TRIM TAB	
2004-577648	display	PLASTIC SUBSTRATE		
2004-792074	aerosol actuator	AEROSOL CONTAINER	AEROSOL VALVE	
2004-861823	UV-radiation absorbing glass	BORO-SILICATE GLASS		
2004-890301	,COMMUNICATION NETWORK SYSTEM	security controller		
2005-163953	WATER PURIFICATION DEVICE	RESILIENT MAT		
2005-238473	WIND TURBINE	ASYNCHRONOUS GENERATOR		
2005-320861	PRINTED CIRCUIT BOARD	semi-conductor		
2005-323990	REDUCED SIZE VEHICLE			
2005-568575	LUBE BASE OIL	LUBRICATING OIL		
2005-575355	BRUSHLESS DC MOTOR	CONTROL CIRCUIT	DC POWER SUPPLY	
2005-631127	solid urea ammonium sulphate fertilizer	SOLID UREA	SULFURIC ACID	AMMONIUM SULFATE
2007-520038	rotary charging device	charging device	SHAFT FURNACE	
2007-624064	FATTY ACID	UN-SATURATED FATTY ACID	saturated fatty acid	
2007-678847	RF POWER AMPLIFIER	POWER AMPLIFIER		

Next, we used Hellinger distance as a similarity measure between the IPC distributions of patents and products. In addition, we applied various threshold values, ranging from 0 to 0.7. We compared the results between our method and the simple occurrence-based method; the simple occurrence-based method considers all product names appearing in a patent as the patent' target products. The simple occurrence-based method considers all of the product names appearing in patent text as target products, so its recall was relatively high, while its precision was very low. Recall of our method (0.7732 to 0.7786) was found to be a bit lower than one of the simple occurrence-based method (0.8024), but precision of our method (0.5370 to 0.5732) was much better than one of the simple occurrence-based method (0.3391). The best threshold value to make our approach's performance best was found

Table 3. Part of performance test results

Threshold values	Proposed method			Simple occurrence-based method		
	Recall	Precision	F-measure	Recall	Precision	F-measure
0.01	0.7742	0.5690	0.6559	0.8024	0.3391	0.4767
0.02	0.7764	0.5732	0.6595			
0.03	0.7764	0.5716	0.6584			
0.04	0.7814	0.5732	0.6613			
0.05	0.7814	0.5620	0.6537			
0.06	0.7814	0.5620	0.6537			
0.07	0.7814	0.5620	0.6537			
0.08	0.7814	0.5618	0.6537			
0.09	0.7814	0.5602	0.6525			
0.1	0.7814	0.5602	0.6525			
0.11	0.7786	0.5580	0.6501			
0.12	0.7786	0.5526	0.6464			
0.13	0.7786	0.5513	0.6455			
0.14	0.7786	0.5420	0.6391			
0.15	0.7786	0.5420	0.6391			
0.16	0.7786	0.5403	0.6379			
0.17	0.7743	0.5447	0.6395			
0.18	0.7743	0.5447	0.6395			
0.19	0.7759	0.5414	0.6378			
0.2	0.7732	0.5370	0.6338			

5. Discussions and concluding remarks

Although a patent has occurrences of product names in its text, all of the products do not always become the target products of the patent. Therefore, this paper proposed a method to determine patent-product connections. The method structures each of products and patents into a main group-level IPC distribution vectors, and then measures how closely connected a patent and the product names appearing within the patent text are by using similarity measures. Finally, weak connections between patents and their products were able to be excluded. The proposed method was found better than the simple occurrence-based method.

The contributions of this study are twofold. First, this study is the initial study to computationally identify patents' intended products. Second, related to the first contribution, this study will be the basis to build various product-level technology intelligence systems

Despite the contributions, challenges still remain for further studies. First, this study used only 1,110,582 patents, all USPTO patents granted during 2009 and 2013, to structure product- and patent-IPC distributions. However, using much more patent information could lead to better patent-product connection determination, so a future topic will extend the patent set to structure product- and patent-IPC distributions. Second, although the TOD product DB includes 186,805 representative product names, its coverage for product names is not exhaustive. Further study should be conducted to gather more product names. Third, this study proved our method to be much better than the simple occurrence-based method, but there is some room for further improvement. For example, the proposed method could include some rules to determine patent-product connections. According to our analysis, if a patent has product names appearing in its title or the first sentence of its abstract, then these product names were mostly considered the patent's target products. Therefore, a further research topic should aims at improving the performance of detecting patent-product connections.

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Research on decoupling method of axiomatic design based on Standard Solution

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Abstract

Independent axiom is the first important one in Axiomatic Design which emphaise the independence between the functional requirements in target design problem. AD`s main purpose is to avoid the possible coupled design problem in design. However the AD had not mention ed the decoupling method. A effective decoupling method is needed to solve such problem. All the known decoupling methods are belongs to the category of parameter adjustment and the seeking of alternative technologies. These methods are often ignored part of the coupling which low and then seek the best iteration order, so it is hard to get a satisfactory solution .Combined the similarity between the conflicts in TRIZ and the coupling in AD, we can propose a decoupling method which is apply the theory of standard. Then use the standard solution processes and methods to solve problems. Establish S-F analysis model for the research questions, and select the corresponding standard solution to decouple. Using a engineering example to explain it.

Keywords: Independent axiom decouple standard solution

1. Introduction

The design and development of new product is the key to the competition in today's world of intense competition. Design belongs to a kind of creative activity, and its essence is creativity and innovation. After years of research, the professor of the Massachusetts institute Nam P.Suh with his research team put forward the axiomatic design based on years of research results[1]. Independence axiom and information axiom of the axiomatic design provide designers with a design framework and the design criteria to judge the optimal design. Many of the existing design theory only stay at the physical level and technical level, however, the axiomatic design involves many principles of a deeper level, such as function domain and information content of the design. Therefore the axiomatic design can direct the designers to make the right decisions in the design process. Axiomatic design provides that a qualified design should satisfy the independence axiom, but did not put forward ways and means of solving the coupling of the design, so there are many difficulties in solving practical engineering design which is belong to the coupling, thus this theory exists many disadvantages in the coupling.

Decoupling is the weakness of axiomatic design theory, it has a great deal of research space. Thus decoupling research is one of the main research content in today's theory expand. There are a great many expert and scholar which are doing the study of the decoupling in home and abroad at present. SU ect. use two ways that analytic hierarchy process and Two-way comparison strategy to measure functional coupling degree, and then converted to the traveling salesman problem with directions and full path to consider[2]. in order to find optimal iterative sequence; JOHANNESSON and others attempts to solve the functional coupling problem of the structural design, they define the functional coupling and did the classification and quantitative assessment for the coupling[3]. In other words, by decoupling and separating operational planning function. These methods belong to the range of adjusting the coupling parameters or seek alternative technologies. This usually requires that we should ignore the coupling which is the part of low degree, then seek the best iteration order. However, this does not get a satisfactory solution, and therefore we need to find ways, more creative and more instructive. In this paper, we use the TRIZ and AD to decouple, as both of them are committed to establishing a scientific basis for the field of design. TRIZ gives the analysis of the problem and some of the solutions to the problem, As shown in FIG is the tools to analyze and solve problems of architecture of classical TRIZ.

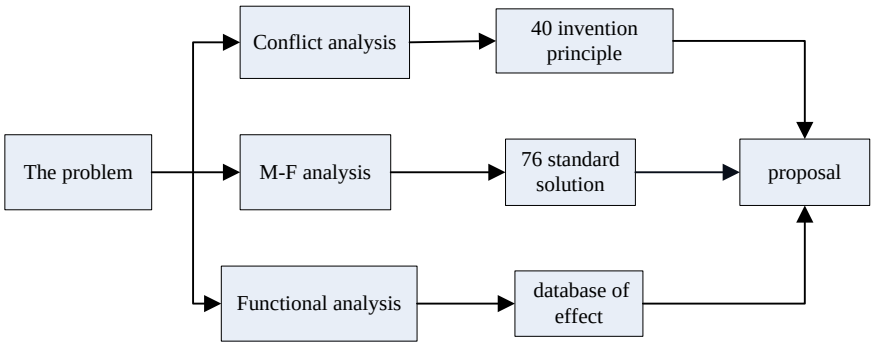

Fig.1 The tool to analyze and to solve the problem of TRIZ

Axiom Design Inference 1: If the function of the proposed design is coupled or interdependent[4], then we need to decouple or separate some part of solution. In this paper, we use the substance-field and the standard solutions in TRIZ to analysis the functions which is coupling or interdependent, and decouple them. And we can result in a satisfactory solution.

2. Substance - field analysis and standard solutions

(1) Altshuller identify and summarize the following three laws through the study of the function, 1.All functions can be decompose into three basic elements.2. An existing function must consists of three elements.3.the function is formed by three elements, which are interacted and composed organically. That is, the interact relation between the two substances and a field is used to describe the function, and it is called substance - field model. Material - field model is an important frequently-used tool for structuring, describing and analyzing problems in triz theory. It can decompose a complex system into a simple system. A minimum system which is able to work can be shown with material -

field model[5]. Material - field model and its analysis method provide a way to determine the core issues in a system. Material - field model analysis divides any system which has a function into three parts, as shown in the chart:

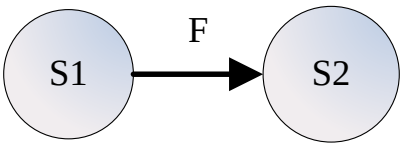

Figure 2: the simplest model o.f
a.functioning system

a material will come to exist from another material under the action of a given field F . The material represents some object or process, or the whole system and environment, depending on the user and the actual situation when analyzing. It depends on the field to connect substances. The field can be understood as a certain or a series of operations. including simple gravity, electricity, heat and man-made complex system operation. When analyzing problems with Material-field model, you need to set up the model of every function at first. The functions of TRIZ are divided into four categories: (1) Effective complete function: the three components of this kind of function are all exist and effective, which is the effect pursuing by designer. (2) Incomplete function: some of the three components are not exist, so that adding components to realize full function or replacing it with a new function is needed. (3)Non- effective complete function: the three components of the function are all exist, but the effect that the designer wants to realize is not fully realized. For example, the force is not big enough or the temperature is not high enough .etc. (4) Harmful Function: the three components of the function are all exist, but there is a conflict between the effect and that the design wants to realize. We need to eliminate the harmful function in the process of innovation. The procedure of setting up the Material-field model: Step1: make it clear what is the components of the problem happening (Identify component field F and two substances). Step2: Describe the material - field model under this circumstance. Confirm the interaction between material and express suggestions on the interaction whether it is successful (Namely, Evaluating the

integrity and effectiveness of the system). Step3: To deal with the material - field model identified in second step. As for every material-field model, you must transfer the general solution of the mole recommended by the material-field five rules into particular solution of the model. Step4: Use the field to translate the specific solution of the model into an idea of the solution.Step5: Determine the most appropriate solution. Material – field analysis is the tool of analyzing problems and corresponding to it, the tool of solving problems is Standard Solution. Standard Solution is a tool of solving technology problems based on knowledge. Only by using Material - field model and the standard solutions together do them work better.

(2) Standard solutions are divided into five categories, 76 in total[6]. Class 1 standard solution contains the solution of an incomplete system or the non-effective complete system. In the Material - field model, incomplete system refers to a system not containing the field F or one of materials S1 or

S2, and the non-effective complete function can refer to the field F not big enough. Class 2 standard solution is to improve the system by describing the system's bigger change of the Material - field model. Class 3 standard solution is to transmit the system to the dual-system, multi-system, or micro level. Class 4 standard solution is detecting and measuring. Detecting and measuring is typical control loop. Detecting refers to check some states happen or not happen. Measuring has the characteristics of quantization and a certain accuracy. Some innovative solution is to use physical, chemical, geometric effect to complete automatic control rather than detecting and measuring. Class 5 standard solution is to simplify or improve the standard solution above in order to get a simplified solution.

3. Axiomatic design

Axiomatic design's goal is to establish a scientific basis for the design, and to improve the design activities providing a theoretical basis based on logic and rational thought process and tools for designers. Axiomatic design makes four fields namely user domain, functional domain, domain(DP), and process domain correspond to each other primarily through mapping. Make the adjacent two design domain mapping and transforming from top to down, fully considering the relationship between the two domain can make the process of description and design more fully and more accurately. In the mapping process, the use of independent axiom and information axiom to ensure the design matrix is uncoupled and the design parameters is not interacted each other. Only in this way, we can get a designing scheme, unique and accurate. Relations between functional domains and domains can be obtained by {FR} = [A]. {DP} expressed, [A] is the design matrix. Independent axiom refers to the functional requirements to maintain the independence of each other[7]. When A is a diagonal matrix, the design is uncoupled; when A is a triangular matrix, the design is an acceptable coupling design. When A is any other form of matrix, the design is coupling. In the design, A is a diagonal matrix is the result what we want, we need to decouple if it is not. The independent axiom of AD shows that the smaller of the interaction between the functional requirements of the product design process, the better of the property of the product, and the cost of production can reduce and the productivity can improve. The AD also noted that the information content of the non-coupled design is smaller than the coupling. So when a design is coupled, we need to decouple it.

4.Using the standard solution to decouple

To use the standard solution to decouple, at first, we need to analyze and study the existed couple problem. We need to decompose the functions of a design, the procedure of which is that determine the total function of the system through the black box model and then decompose the total function into sub-function and sub-function into function unit. The function in the independent axiom just refers to this function unit. After decomposing the function, we determine the corresponding design parameters of the functions at different levels and then through "zigzag" shape transformation, list the design matrix of each level, respectively. Through adjusting the corresponding design parameters of the design matrix, transform the design matrix. If the design matrix is a diagonal matrix, it represents an uncoupled design. If the design matrix is a triangle matrix, it represents quasi coupling

design. And if the design matrix is neither a diagonal matrix nor a triangle matrix, it represents a coupling design. A coupling design can also be understood as that the function requirements in the design overlap in some degree and that is because the components in the design may have two or more attributes. For example, the filter of a vacuum cleaner not only has the function of filtering dust and junk, but also the function of ventilation, providing the vacuum power. This multiple attribute causes the possibility of functions overlapping in a design. Using the standard solution to decouple is to set up a relevant material-field of the substance involved in the design parameters which has an impact on the functions out of the corresponding functions and select the standard solution corresponding to it and then use the procedure of standard solution solving problems to solve the problems existed in the system.

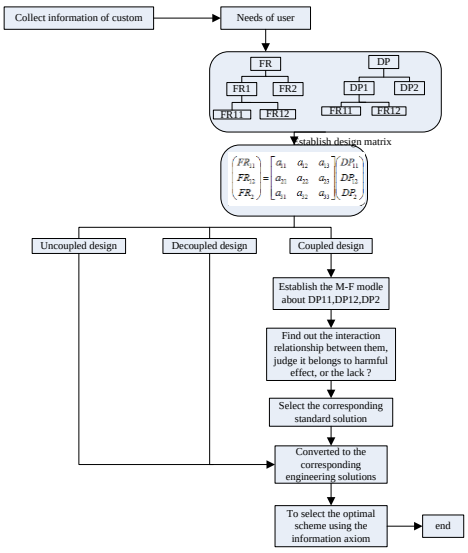

Fig.3.The decoupling process based on TRIZ

5. An engineering example

(1)Problem description: In the bridge erecting machine, because of the oil cylinder aimed to upper or lower leg at the middle position, Left and right sides of the leg tilting are not synchronized when it rises. It is caused friction between the upper and the lower sleeve, even result the sleeves frozen. Then it is difficult to make the hole in the right place. Each pin has to bear a lot of bending moments and pressure, so there is great friction when it pull in and pull out, and it result in the pin can ‘t remove.

(2) Analyze the functional needs

FR_1: Offer the power FR_2: Perform movements FR_3:maintaining support FR_4:achieving lock

Corresponding to the design parameters DP_1: Hydraulic system DP_2: a sleeve structure movable portion DP_3: a sleeve structure immobile part DP_4: pin

(3)Design matrix

$$\begin{Bmatrix} FR_1 \\ FR_2 \\ FR_3 \\ FR_4 \end{Bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 \end{bmatrix} \begin{Bmatrix} DP_1 \\ DP_2 \\ DP_3 \\ DP_4 \end{Bmatrix}$$

(4)select the corresponding standard solution

By design matrix can be seen, this design is coupled design, we need to decouple. We know that the coupling between FR_2 and FR_3 made the hole alignment difficult. We need to decouple the coupling of them. Establish the M-F for DP_2 and DP_3.

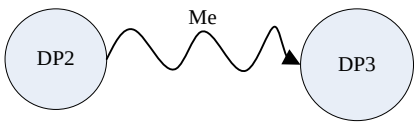

Fig.4 the Su-Field in the leg design

From the fig.5, we know it belongs to harmful effect, so we choose the standard solution:” To eliminate or offset the harmful effects”. It is said that if there exist useful and harmful effects at the same time in a system, and the related parts don’t have to contact directly, to introduce something to eliminate the harmful effect. so as to realize and separation, eliminate the harmful effect.

(5) The scheme materialized

The mainly problem is the friction between the upper and the lower legs, so we need to introduce something to solve the problem.

Specific programs: set up many of the ball projection of the same shape on the contact surface structure of the bridge machine leg sleeve. They separates the upper and lower portion of the sleeve structure, the raised ball greatly reduce the friction. Thus when the oil cylinder jacks the legs of the machine, the friction reduces a lot, then the difficult problems of the hole is solved. The specific structure is shown in Figure 6.

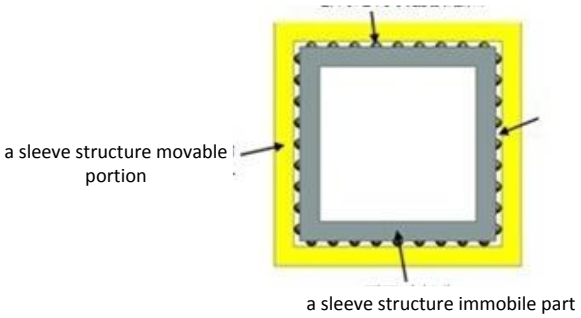

Fig.5 The new sleeve structure

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Using an Autonomous sinking lure to enhance the fish catch rate

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Abstract

As incomes rise in Taiwan, leisure activities are receiving greater emphasis from Taiwanese. Fishing, long a traditional sport, has become more popular in recent years. To attract fish, fishermen frequently use lures, which offer both high catch rates and environmental friendliness. Fishermen who use lures must constantly reel the fishing line in and out to make the lure move back and forth, stimulate fish attacks on the lure, and increase catch rates. This study uses the Theory of Inventive Problem Solving (TRIZ) to constructs a technical contradiction matrix and performs a function and attributes analysis. Based on the depth at which the targeted fish swims, it produces a sinking/autonomous sinking design. Since the lure can move by itself, fishermen do not need to constantly move the line, improving fishing performance.

Keywords: TRIZ, active lure, sinking/autonomous sinking lure

1. Introduction

Most fisherman use lures, popular because of their high catch rates and environmental friendliness. However, because the lure is dead, the fisherman must manipulate the line in and out to make the lure move back and force, since the lure is most effective when it imitates the movements of living bait. This research addresses the problem of creating an active lure that moves in a lifelike way. Using construction of a technical contradiction matrix and implementation of a function and attribute analysis, the dead lure is improved. A types of lure is designed in this study, a sinking/autonomous lure that functions autonomously. This design enable the lure to move by itself in the water, enhancing their attractiveness to game fish and increasing the catch rate.

2. Literature Review

Fishing poles are important tools of fishermen. There are two types, hand poles and fly rods. Hand poles are used for shallow fresh water fishing. Their length is restricted, and they do not have

equipment for paying out the fishing line. Fly rods can be used for shallow water using floating/suspended lure or for deeper water using sinking/autonomous sinking lures for catching swimming fish and bottom fish in fresh water or in the ocean. Since a longer line is required, such rods use reels for reeling the line in and out.

Traditionally many things are used as bait, from rice and leaves to worms and insects. Bait is not convenient, however. Hence, fishermen use lures, a form of artificial bait. Lures are moved by the fisherman, making it look like live bait to game fish. When the fish strikes, it is captured by the hook attached to the lure.

In 1936 Rapala became the first to use thin pine boards to carve artificial minnow bodies, which he then wrapped in tin foil to give them a fishlike look, thus making the world's first lure[1]. Using lures, he then found that if the lure resembled live bait, game fish would strike. Because the lure had the function of live bait but was far more convenient and lures are more environmentally friendly than live bait, they have steadily grown in popularity.

Since that time, lures in an endless variety of materials, shapes, sizes, and colors have been manufactured, with lures specialized for ocean, lake, and river fishing. These include poppers, which can lure fish from the depths, pencils, which are shaped like pencils and wiggle back and forth in the water, cranks, which give a swimming motion at any water depth, spoons, which reflect like metal or spray, along with spinners, jigs, and many others[1]. Taiwan's largest lure maker, Strikepro, produces 400,000 lures annually, helping to make Taiwan an advanced maker of lures.

Different water depths and water layers call for different types of lures. Steven Jenkins (2009) divided the water depth into the water surface, the surface layer, and the bottom layer, identifying three types of lures specifically for each of these layers as well as a fourth type suitable for all layers [2]. Wassenberg and Hill (1990) divided minnow-shaped lures into floating, suspending, and sinking lures [3]. Based on water depth and lure behavior, lures may be divided into four types: floating, sinking, suspended, and autonomous sinking lures.

A sinking lure is operated via a fly rod and is used to lure fish in deeper water. After it sinks, the fisherman plays out the line, then stops for 1 or 2 seconds, then reels the line in and out in steps, letting the lure sink, performing this action continuously. The lure then resembles a swimming fish. Autonomous sinking lures that can be used at any depth sink after being cast using a fly rod. When reeled in, the lure will imitate the movements of a fish swimming upwards. Generally, when fishermen use fly rods, they use the four kinds of lures based on the type of fish sought, the water depth, and preferences. However, the different types of lures for different depths are all lifeless and must be continuously moved by the user's operation of fly rod reel in order to make the lifeless lure simulate the movements of a real fish.

The Theory of Inventive Problem Solving (TRIZ, from the Russian Teoriya Resheniya Izobreatatelskikh Zadatch) is a systematic approach to technology innovation. It was developed by the Russian inventor Genrich Altshuller and his colleagues beginning in 1946. They analyzed 200,000 patented inventions for pens and classified the innovations into different levels and types to create a systematic approach to innovation [9]. TRIZ offers an innovation system for inventors to help them resolve technology innovation problems. First, the type of potential specific problems associated with the invention must be clarified. Based on the thinking of previous inventors in solving problems, through researching and thinking of improvements that are beneficial to the product, then classify problem solving approaches. When faced with a specific problem, TRIZ can standardize them, enabling them to be treated as standard problems. Key tools of TRIZ include: 40 inventing principles, 39 engineering elements, a contradiction matrix, and substance field analysis. TRIZ permits standardized problem approaches to converge on a particular solution. This enables to problem solving to break through the problems of individual experience, talent, and psychology that, when using traditional methods, may cause solutions to diverge. Mann (2006) proposed a TRIZ convergence process, shown in Figure 1 [4].

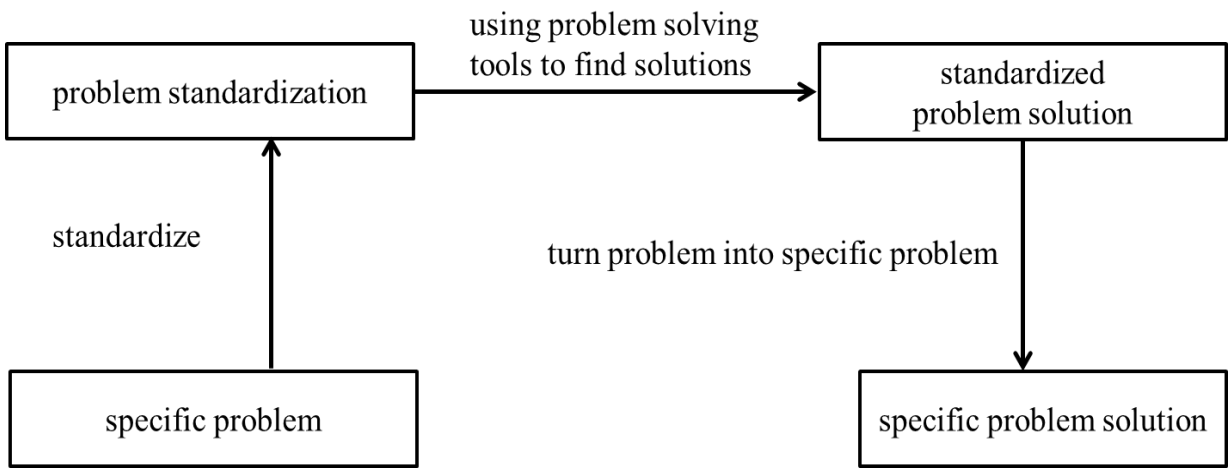

Figure 1. Common TRIZ problem solving process (Mann, 2006)

This research uses the TRIZ convergence process structure of Mann(2006). It uses the convergence of evolutionary trends to view the current status of fishing lures. The trend predicts the future evolution of lures. This is paired with a function attribute analysis that performs similarity matchning of the functions and attributes of lures, as well as improvement of lifeless lures or equipping them with the ability to move on their own. This process is shown in Figure 2 [5].

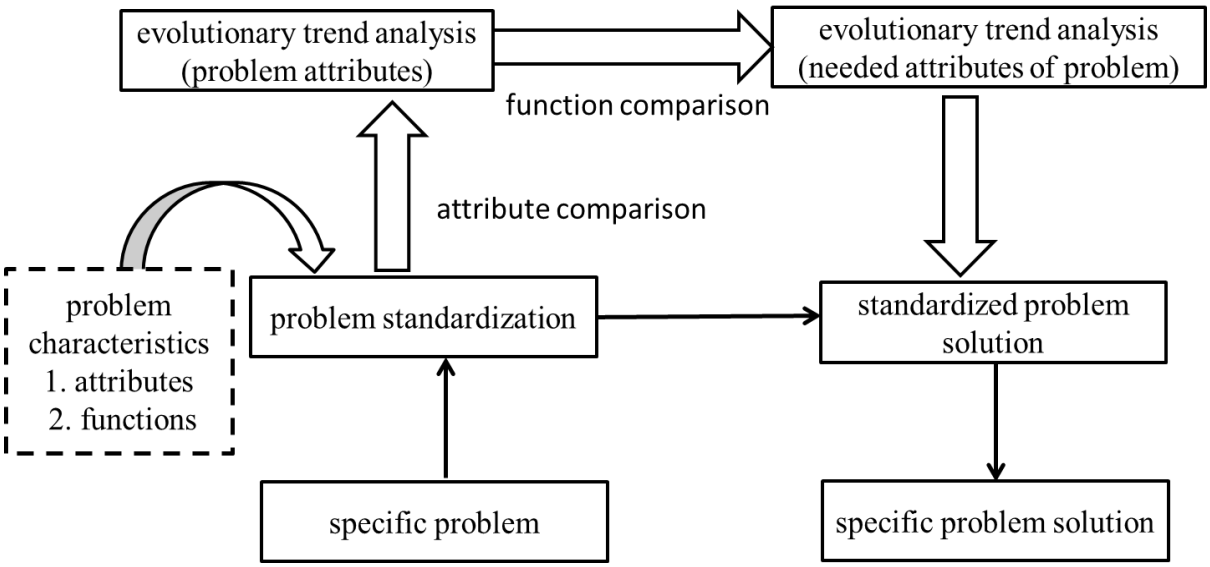

Figure 2. The TRIZ process of evolutionary trend and function attribute analysis used in this research.

3. Considerations in Enhancing Lure Effectiveness

In order to enhance the lure's ability to move and attract game fish, this research considers two technology levels. First, it uses the technical contradiction innovation principles to identify the elements needed to enable a lure to move on its own. Second, it uses the elements identified in the previous step to perform a function attribute analysis and create the optimum design for an active lure.

3.1 Technical Contradiction

Contradictions occur when two or more statements, ideas, or actions are inconsistent. In formal logic, a contradiction is defined as the simultaneous assertion of a proposition and its negation. Contradictions are the core of solving systematic technology innovation issues. Contradictions that are produced during systematic technology innovation may be divided into two types: technical contradictions, and physical contradictions. Technical contradictions occur when improvement in one parameter leads to worsening of another, for example, when greater brightness reduces energy saving, or when reducing costs leads to reduced quality. When technical contradictions occur, they can be resolved via the technical contradiction matrix. Physical contradictions occur when two parameters are in opposition, such as cold and hot or long and short. When a physical contradiction occurs, they can be resolved via the separation principle of the physical contradiction matrix. Both the physical and technical contradiction matrixes use the 40 inventive principles as the method for solving problems [6].

This research explores the lifeless lures currently used by fisherman, that require the fisherman to continuously move them. For a lure, swimming like a real fish represents a dynamic function. Thus, the parameters that must be improved in this system should not reduce the lure's ability to function at different depths and in different water layers without outside assistance, force, and control. This

represents the technical contradiction problem. The 39 engineering parameters are used to solve technical contradictions. When the features of the system's contradictions are known, the items that should be improved include item 10, Force, and Item 37, Complexity of Control. Parameters that should not be worsened include Item 13, Stability of object, because the lure needs to be stable in the water, and Item 14, Strength, because the lure must be strong in order to move in the water like a lure on a fishing line. These problems are used to construct the technical contradiction matrix, as shown in Table 1. Based on the technical contradiction matrix shown in Table 1, 12 inventive principles can be used: 35, 10, 21, 11, 22, 39, 30, 14, 27, 3, 15, and 28.

Parameters that should not be worsened		Stability of Object	Strength
		Item 13	Item 14
Force	Item 10	35 10 21	35 10 14 27 15
Complexity of Control	Item 37	11 22 39 30	27 3 15 28

Table 1. Technical Contradiction Matrix

Among the 12 inventive principles, to enable the lure to swim like a fish without outside assistance, the necessary elements were found to include the six inventive principles: 15, 22, 10, 11, 30, and 3. The remaining six did not appear to have any clear effect on improvement of the lure and were not used.

Inventive principle 15, Dynamics, states that in order to adjust object or environmental performance and enable all stages of work to achieve optimal performance, the object should be divided into parts capable of movement relative to each other. If an object (or process) is rigid or inflexible, it should be made movable or adaptive. To use these principles to resolve the problems found, the lure must be equipped either internally or externally with a propulsion system to enable it to move without outside assistance.

Inventive principle 22, Blessing in disguise, states that harmful factors (especially harmful environmental effects) can lead to beneficial consequences. For example, one harmful factor may be combined with another to eliminate the negative effects of either or both, or a harmful factor may be increased to such a degree that it is no longer harmful. Using this principle to find solutions for problems indicates that a water battery should be used to provide propulsion. This is more economical and does not cause water pollution like an ordinary battery since it uses contact with water to generate electricity.

Inventive principle 10, Preliminary action, states that required changes to the object (whole or in part) must be implemented before they are needed. Objects should be pre-positioned in the most

convenient location, enabling them to be used without loss of time. Using this principle to find solutions for the problem shows that control board must be built into the lure in order to enable to simulate the swimming motion of a fish.

Inventive Principle 11, Beforehand cushioning, states that emergency measures must be prepared in advance to compensate for the relatively low reliability of an object. For the propulsion unit to be used, water must enter it. Using this principle to solve the problem, a pipe for the water must be installed. The control board must control the speed of the propulsion system operations in order to simulate the movements of a fish. To increase the stability of the lure when moving, fins or an inflatable bag should be installed to enhance its balance and flotation ability.

Inventive principle 30, Flexible shells and thin films, states us flexible shells and thin films instead of three dimensional structures. Isolate the object from the external environment using flexible shells and thin films. Using this principle to solve the problem, a flexible shell should be designed to increase its ability to float.

Inventive principle 3, Local quality, states that an object's structure can be changed from uniform to non-uniform, or an external environment or influence may be changed from uniform to non-uniform. Each of the object's parts should be made to function in the conditions most suitable for its operation, and each part should fulfill a different and useful function. Gunzo K. and Toshihisa (2002) found that the catch rate was highest when the lure was red, or black, followed by yellow, green, orange, pink, and while [7]. Using this principle to solve the problem, the exterior of the lure should be a color that is attractive to game fish, and the lure should resemble a fish in appearance to the extent possible.

The technical contradiction matrix shows that to make a lifeless lure into a lure that simulates the movements of a fish, at least 5 components should be added to the lure, and its color should be changed. These five items include: (1) a water battery; (2) control board; (3) propulsion unit; (4) stabilizer fins and an inflatable bag; and (5) a pipe for water. We next perform a function attribute analysis of the five components. Through examining of their cause and effect relationships, we can find the optimal design for the new lure.

3.2 Function attribute analysis

Function attribute analysis (FAA) examines system and subsystem components to identify relationships between components and assemblies, as well as the components of main and subsidiary functions. The purpose of this analysis is to determine which functions and relationships exceed, are insufficient, or harm system functioning. Such functions are termed negative functions. Using the relationships between negative functions and each component, points of contradiction of problems may be identified and used to resolve the problems[8].

This study investigated the lure's components using function attribute analysis. It draws a border around the causal chain of the function attributes. The causal chain shows the cause and effect relationships between the 5 components. Function attribute analysis is then performed. As shown in

Figure 3, the water battery adds weight, which must be prevented from affecting the swimming motion of the lure. Consequently, stabilizer fins or an inflatable bag must be added to enhance its ability to float and move in the water. As a result, the water battery, stabilizer fins, and inflatable bag are excessive functions. The water battery merely drives the propulsion unit, and both are insufficient functions. A control board is necessary to control the operation of the two propulsion units in order to enable the propulsion unit to operate when water is flowing through the lure, intake and release differing amounts of water, and simulate the movements of a fish. Because of this, the propulsion unit and the water pipe are useful functions. To maintain the lure's ability to swim, all components must balance each other. Because the water battery is heavy, it is necessary to place it at a location where it balances the water pipe. Consequently, their relationship is harmful. Since water goes in and out of the pipe, it will make the lure unstable. Further, the battery, water pipe, and propulsion unit must be balanced. Thus, using stabilizer fins and an inflatable bag to enable the lure to stably produce the swimming motion of a fish, requires overcoming the harmful function of the water pipe and water battery and water pipe and stabilizer fins /inflatable bag.

Additionally, the lure's color must be one that is attractive to fish such as an underlying color of red or black, mimicking a real fish, to give it a higher catch rate.

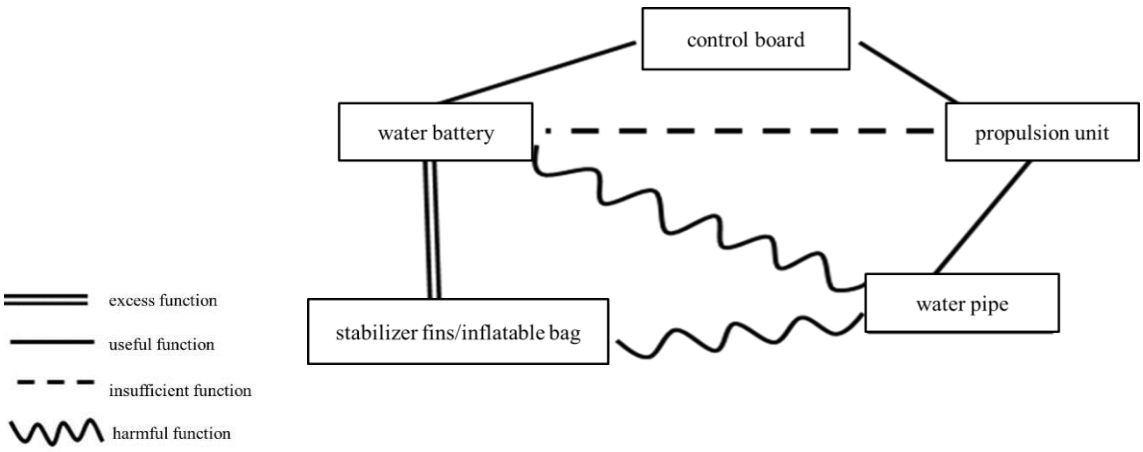

Figure 3. Lure Component Function Attribute analysis

4. Design of the active lure

The sinking/autonomous sinking lure is designed to give the lure the behavior of a lure operated by a fisherman. After the lure is set in the water by a fly rod, the control board initiates control, and the lure will sink repeatedly, stop, sink again, and then rise. At lower depths, this will attract game fish. After being set in the water, the control board will initiate and the lure will rise and sink on its own, swimming and floating at depth. Based on the aforementioned description, the heaviest of the needed components for the proposed lure is the water battery, followed by the propulsion unit. To balance these devices, a design that balances them by separating them was adopted. The water battery was placed at the front of the lure, while the two propulsion units and the water pipe were located at the

rear. In the center were placed the active stabilizer fins to maintain its balance as it moves. The spinning of the propulsion units and the angle of the moving fins are controlled by the control board. In this way the lure can simulate the movements of a floating or sinking lure operated by a fisherman and replicate the movements of a fish, as show in Figure 4.

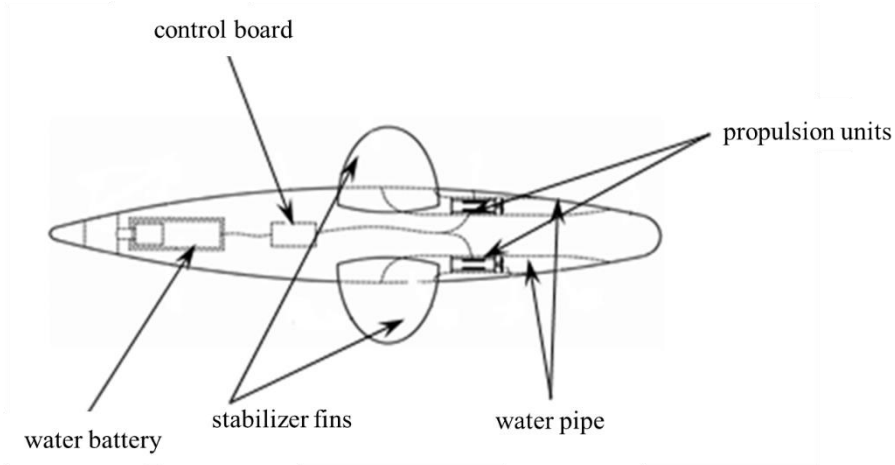

Figure 4.

Sinking/autonomous sinking lure

5. Conclusion and Recommendations

Using the TRIZ approach, this study enhanced a lure to enable it to actively swim like a fish. We first performed an evolutionary trends analysis in order to determine the future path of lure development. This found that lures are moving toward active lures that embody reduced user operation, increased ability to move, and increased ability to move like a fish. Materials are moving toward becoming as soft and colorful as an actual fish. The technical contradiction matrix was used to identify functions to enable the active to simulate a fish. Five components were identified: (1) water battery; (2) control board; (3) propulsion unit; (4) stabilizer fins or inflatable bag; and (5) water pipe. The final step of this study was the function attribute analysis. The lure design is created a sinking/autonomous sinking lure. The sinking/autonomous sinking lure can sink and operate at all depths. This design enable the lure to simulate the movements of a fish. Using the proposed lures, fisherman will no longer need to work the rod and reel to move the lure, and will experience higher catch rates.

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An Inventive Standards-Based Approach in the field of Inventive Problem Solving with CAI Tools

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Abstract

An Inventive Standards-based approach to solve inventive problems with CAI tools was proposed in order to gradually guide designers to analyze problem and effectively expand their thinking during the inventive problem solving process, and to build more than one Specific Solution Concept with multi-level angel. Su-Field Analysis changes the specific problem into a generic one and corresponding standards are obtained after System Functional Analysis. Taking advantage of the knowledge relevance of Inventive Standards, evolution rule, inventive principle and separation method, available resource and physical effects are recommended to extend the solution concept space based on the constraints of Inventive Standards. Resource Analysis is applied to figure out internal and external available resources of the system. The search range of available sources could be narrowed down by its properties or functions. Meanwhile, association effects and instances are recommended under the interaction of input flow, output flow and the functional effect reasoning. Finally, the relevant knowledge resource demonstrates the correlation between problems and knowledge in the way of knowledge map based on ontology which abstracts resource, physical effects and instances as nodes. It can help designers rapid get access to the relevant knowledge and inspire them to produce creative design scheme. Our project team has completed the software system based on this model. The proposed software system although is still at a prototype. At last the operation process of the system was demonstrated by an example to verify its integrity and feasibility.

Keywords: Inventive Standards, Knowledge Map, TRIZ, CAI.

1. Introduction

TRIZ, the theory of inventive problem solving, was one of the important theories of innovation design. The typical process of using TRIZ to solve a specific inventive problem includes: standardizing a specific problem, mapping it to a General Problem, finding a General Solution and finally creating

new ideas for the specific problem (Altshuller, 1999). Inventive Standards is a tool to solve the inventive problem by applying Su-Field Analysis as well as provide concrete and effective methods for the concrete practice of technology innovation (Savransky, 2000). Su-field Analysis is much easier for beginners to tackle a specific problem and widely used in the training and teaching of TRIZ theory by Chinese enterprises.

Many experts have studied the inventive problem solving process：Classic TRIZ ARIZ algorithm (Altshuller,1984) is one of the earliest inventive problem solving process which puts many tools in a sequence to explore a solution such as Inventive Principle, Inventive Standards, Effects etc. Becattin (Becattini et al., 2013) proposed a dialogue-based model for Inventive Problem Solving, integrating Ariz algorithm and OSTM-TRIZ model. This model directed the designers to get a comprehensive analysis of system problems and parameterize problem related elements through question answering, and problem solution's formation relied on information retrieval in Interdisciplinary knowledge database. REN et al. (REN et al.,2014) constructed an innovative conceptual design model to overcome the inertia of thinking through obtain the depth knowledge from patents and the analysis and research of TRIZ, brainstorming and methods. Mann (2001) investigated the relationship between the generic Inventive Principle and specific problem solution in order to establish a more automated systematic innovation process with the help of nine window methods and combining with brainstorming from two dimensions of time and space. In addition, the models above are the whole analysis process, and some scholars have concentrated on the stage of conceptual solutions arising. Yang et al. (2013) proposed an innovative solving model based on the multi-level reciprocating mapping under the interaction of design flow and knowledge flow which supported problems being abstracted repeatedly to generate more conceptual solutions. Gao et al. (2006) decomposed a problem in three basic dimensions of Conceptual Solution Space such as Time, Space and Object. The controllable thinking process was established to search conceptual solution based on the constraints of TRIZ generic solution; Yan et al. (2014) proposed a new way of representing physical effects to facilitate the use in Su-Field Analysis. The Concept solution set was explored with the support of the reasoning process of using physical effects. Furthermore, a representative of the computer-aided innovation software integrated innovative approaches and innovative knowledge database to solve inventive problems have been developed, such as Goldfire by Invention Machine, and InventionTool1.0,InventionTool2.0,InventionTool3.0, InventionTool-net1.0, InventionTool-net 2.0,inventionTool-web(Invention Knowledge Cloud (Ma, 2012)) developed by Hebei University of Technology.

Since the designers sometimes fail to use TRIZ to solve the particular problem, The main reasons are as follows: On the one hand, People is in the dominant position during the inventive problem solving process, it is common that they are limited by their own thinking inertia, that means the above methods are too macro. On the other hand, most of the software systems integrate a variety of auxiliary innovative tools in the process of invention problem solving. The presence of such a large variety of tools makes most of the designers, especially beginners, confused in the case of choosing the right tool

and organizing the design process. Simultaneously, the designers sometimes fail to grasp opportunity to expand the concept solution space due to ineffectively utilize design knowledge.

Our project team developed a computer-aided innovative design public service platform--Innovation Knowledge Cloud (IKC), which integrated innovative approaches and innovative knowledge database. This paper introduces the ontologies built by the IKC platform that contains resource ontology and physical effects ontology. According to the above, an Inventive Standard-based approach to solve inventive problems is proposed. This process consists of four phases: problem description, problem analysis, problem solution, and solution formation. Taking advantage of the relevance of Inventive Standards, evolution rule, inventive principle and separation method, available resource and physical effects are recommended to increase the visibility between knowledge and knowledge source and encourage designers to produce creative design scheme based on the constraints of Inventive Standards.

2. Innovation Knowledge Cloud and Inventive Standards

2.1 Innovation Knowledge Cloud(IKC)

Innovation Knowledge Cloud is a cloud services platform of computer-aided innovative design used to solve the inventive problems oriented toward the innovative designers, which can achieve a certain semantic extended query and association. The IKC platform consists of five functional modules: IKC-Creative Thinking, IKC- Design Tool, IKC- System Analysis Tool, IKC- Knowledge Retrieval and IKC- Private Cloud Services.

2.2 Inventive Standards

2.2.1 Inventive Standards

Inventive Standards is a powerful tool for solving Su-Field model, a model that describes the problem model of a system. By changing the substances and the interaction between them to transform the Su-Field model, one can achieve technological innovation and quickly meet market demand as well as provide an effective approach for technological innovation.

2.2.2 The relevance between Inventive Standards and other tools

As a general method, problem solving rules of TRIZ should be generalized as far as possible. But the more generalized the problem solving rules are, the more generalized the solutions we get. In general, the abstract of generic solution is the bottleneck for attaining the specific solution. As an important part of TRIZ, this problem also exists in the inventive standards. The standards provide a general direction of problem solving rather than specific solution. Since the formation of the specific solution need to rely on the designer's own experience and knowledge system, utilizing TRIZ tools and the knowledge database rationally is becoming more important.

After careful evaluation, inventive standards have knowledge correlation with evolution law, inventive principle and separation method (Mao, 2007). Using multiple tools can provide further information of specific solution and reduce the difficulty of forming a specific solution. Figure1 shows the knowledge correlation. In addition, inventive standards focus on the substance and field operations. The search range of available sources could be narrowed down by its properties or functions provided by inventive standards. These resources, as input flow or output flow, expand the scope of physical effects. It can help designers rapid get access to the relevant knowledge and inspire them to produce creative design scheme.

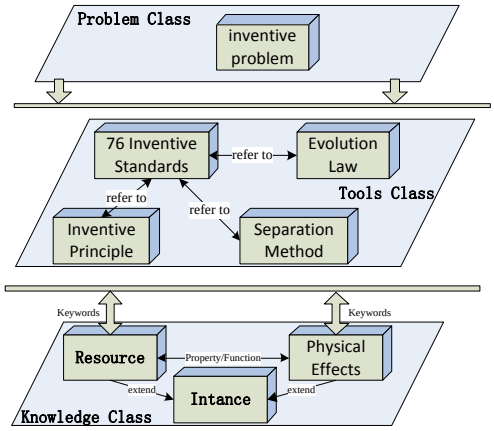

Figure 1.The relevance between Inventive Standards and other tools

3. An Inventive Standards-Based Approach in the field of Inventive Problem Solving with CAI tools

3.1 Innovative tools introduction

(1) Functional analysis

Functional analysis is a process of functional modeling, including the status of execution or completion of its function.The purpose is to optimize the function of technology system and reduce consumption, helping to identify defective system components, and to provide the basis for determining the conflict areas.

(2) Root-cause analysis

When faced with a technical issue that involves many factors, the designers often do not know how to deal with it. Root-cause analysis encourages designers to analyze the root causes in essence rather than on the surface.The key of the analysis is to mine internal and external resources of system and to find the most effective solution to the scheme from various angles.

(3) Ideality analysis

Idealized solution is the one where in the beginning of problem solving, the designer lays down various objective constraints, defines the problem in terms of an ideal solution, and makes clear the direction and position of the ideal solution. This method avoids the disadvantages of lacking goals in the traditional innovative design approach and enhances the efficiency of innovative design.

(4) Nine-windows analysis

Nine-windows analysis tool takes into consideration not only the current scenario and the explored problem, but also their position and roles in the aspect of hierarchy and time. We can view the explored problem as a set of interrelated issues, and can acquire a more comprehensive understanding about it.

3.2 Knowledge Ontologies

The knowledge ontologies built by the IKC platform that contains resource ontology and physical effects ontology, including concepts, parameter and a series of instances of the class.Resource ontology base includes resource ontology, property ontology, function ontology, instance ontology,and physical effect ontology mainly contains effect ontology, function ontology, instance ontology, function ontology. Function ontology is divided into the subclass of verb and noun. The verb class constitutes the operation ontology used to describe the verb of function. Noun class is used to describe the noun of function, parameters, flow and flow property of effects and instances, and is further subdivided into object noun and parameter noun. The object ontology is corresponding to resource ontology, and the parameter ontology is corresponding to property ontology. Figure 2 shows the structure of knowledge ontology.

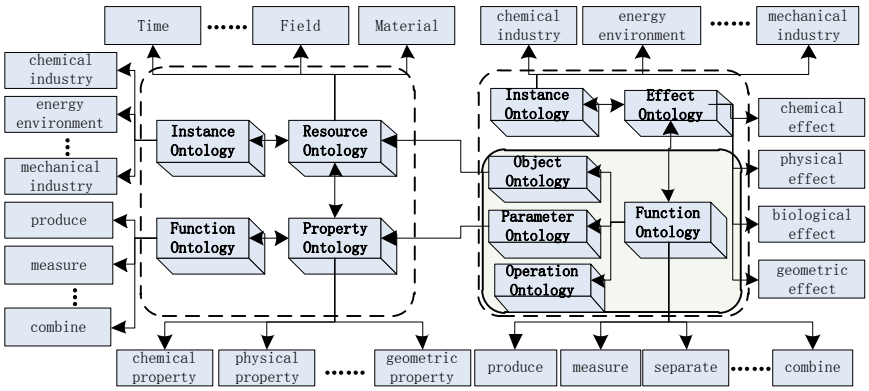

Figure 2.The structure of knowledge Ontologies

3.3 An Inventive Standards-Based Approach in the field of Inventive Problem Solving with CAI tools

A systematic problem solving process based on existing tools in TRIZ transformed the initial state of a fuzzy problem into a clear standard model of the problem step by step. This process consists

of four phases: problem description, problem analysis, problem solution, and solution formation. Figure3 shows the structure of the approach.

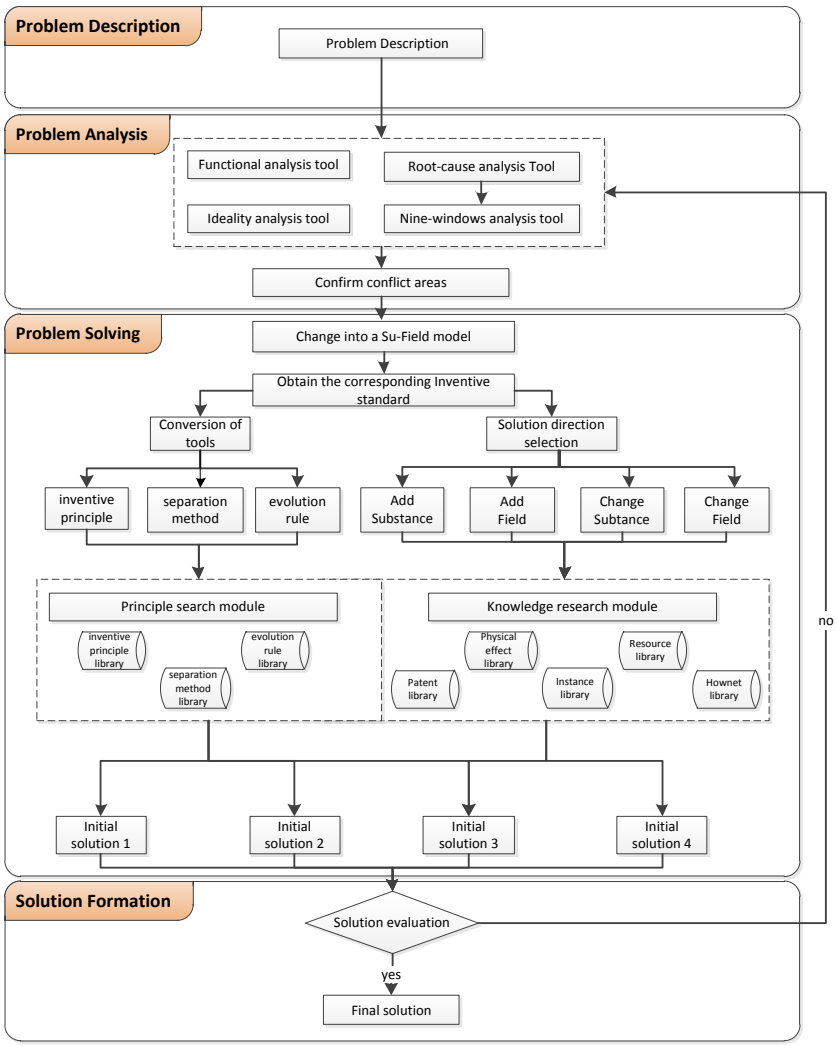

Figure 3.The process of an inventive standards-based approach in the field of inventive problem solving with CAI tools

3.3.1 Problem description

A clear description of the problem plays a decisive role for problem analysis and solving. Inventive problem solving is developing the process toward determining "cause of the problem" and "direction to solve the problem".

a. Defined the target functions of the system.

b. Describe the main problem and the conditions causing the problem.

c. Describe the ideal goal of solving the problem.

3.3.2 Problem analysis

The main goal of problem analysis phase is to convert the initial state of a fuzzy problem into a clear standard model of the problem through the use of problem analysis tools. With the help of problem analysis tools, designers can make clear the conflict areas and lay a foundation for the next phase transformation.

a. With the help of functional analysis tool, designers describe the interaction relationship between system components by the way of functional description. With analysis we can identify undesired interaction, such as harmful, excessive or insufficient interaction, and make clear the conflict areas, thus paving the way for further enhancement and core of further work.

b. Root-cause analysis is applied to take a backward analysis of the problem, clarifying the cause of the problem gradually, and marked the core reason of the cause chain.

c. Ideality analysis helps designers setting the direction of improving technology systems, especially the ideal resources that build a list of available resources.

d. Nine-windows analysis tool sorts out the list of available substance and field in the aspect of hierarchy and time. The list of available resources could narrow down the search range of available sources.

3.3.3 Problem solving

The phase target of solving problems is forming a preliminary concept scheme. Aiming at the former formation model, we should turn it into a Su-Field model. The components of functional analysis model which connect with the harmful, excessive or insufficient impact transform into the "substance" in the Su-Field model, and the undesired impact are expressed as the "field". Moreover, on the basis of semantic structure parsing of the core reason, defective system components and its properties are obtained to build a Su-Field model.

According to the problem described by the model of Su-Field, we can find general and standard solutions corresponding to TRIZ theory, and different Su-Field model corresponding to different standard solution. The standard solution provides a general direction of problem solving rather than specific solution by the way of changing the substances and the interaction between them. We need to focus on the problem existing in the technology system, considering the practical limitations of the system, and apply it flexibly. In many cases, we need to integrate multiple standard solutions. Meanwhile, the relevance between inventive standards and other tools provide further information of specific solution with multi-level angel, and the list of available resources built by Ideality analysis or Nine-windows analysis is regarded as the basis of resource searching and extension in order to urge designers to search available knowledge purposefully.

Existing resources or introducing resources of Su-Field model are taken as the initial node of knowledge map in the process of searching for available knowledge.According to a variety of principles between resource and function, function and physical effect, physical effect and instance, resource and property, association effects and instances are recommended to mine deeper levels of recessive resources and derivative resource under the interaction of input flow, output flow and the functional effect reasoning. Resource, Physical Effects and instances are abstracted as nodes and function and properties as mediation. The knowledge map with multi angle and multi-level increase the visibility between knowledge and knowledge and expand the concept solution space. It can help designers rapidly get access to the relevant knowledge and inspire them to produce creative design scheme.

3.3.4 Problem formation

With the purpose of the former conceptual scheme, designers evaluate the scheme with resource utilization, cost and time, deleting an unreasonable solution, choosing a way of evaluating scheme, and in the end select the most suitable conceptual scheme and final solution. If the end evaluated solutions is feasible, you can select generate text report and fill all documents of the entire solution process and compile detailed content of the solution. At the same time, you can add solution to private or shared knowledge base to improve the mobility and reusability of knowledge. Otherwise, if the plan is not feasible, you can reiterate the whole process or withdraw the process altogether.

4. Engineering Applications

A software prototype was developed to test this approach. The process is presented in detail taking the case of a beam-extraction machine as an example and some running interface is displayed.

The rod pumping system has been occupied large proportion in mechanical recovery. Because of its simple structure, high reliability and strong adaptability, beam-extraction machine is a widely used rod pumping equipment. As the traction system of beam-extraction machine, wire rope is influenced by the large alternating load and natural environment during the work, affect the normal operation of the extraction machine. The traditional maintenance method is smear butter manually, but work high above the ground put workers in danger, and that the wells have been shut off for a long time lead to the deterioration of underground operation conditions. So maintenance method needs to be improved. It is an ideal way that the wire rope completes lubrication by itself during runtime.

4.1 Problem Description

a. Defined the target functions of the system: the rod pumping system has been occupied large proportion in mechanical recovery. Because of its simple structure, high reliability and strong adaptability, beam-extraction machine is a widely used rod pumping equipment.

b. Describe the main problem: as the traction system of beam-extraction machine, wire rope is easy to appear failure behavior, such as rust or fracture.

c. Describe the ideal goal of solving the problem: It is an ideal way if the wire rope completes lubrication by itself during runtime.

4.2 Problem analysis

We choose functional analysis and nine-windows analysis in the problem analysis phase. Functional model is set up to analysis the interaction among system components and super-system components. System components include crank, lubricating grease, motor, speed reducer, connecting rod, belt wheel, beam, wire rope, pedestal, stents, sucker rod. People, sun, rain and wind consist of super-system components. As can be seen, the insufficient effects are between the people and the lubricating grease, and the lubricating grease and the wire rope; the harmful effects are between the wire rope and the external environment (for example sun, rain and wind). Figure 4 is functional analysis in action.

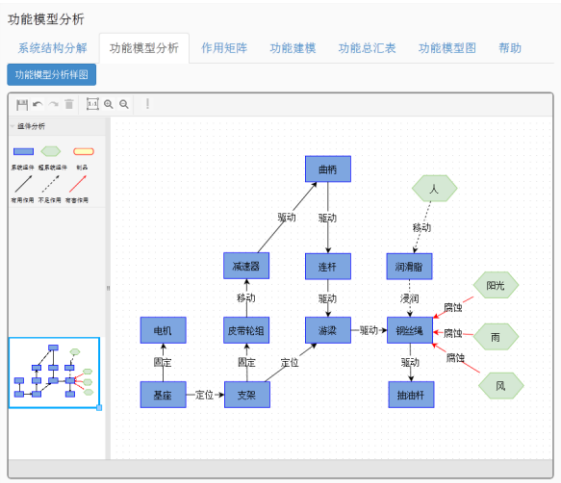

Figure 4. Functional analysis in action

Nine-windows analysis tool is used to sort out the list of available substance and field in the aspect of hierarchy and time. Figure 5 is the list of available resources.

Figure 5.The list of available resources

4.3 Problem solving

The Su- field models are set up respectively to solve the problems. Take the insufficient effects between the people and the lubricating grease as example.

By converting people and the lubricating grease into “substance”, shown in Figure 6, the Su- field model can be established.

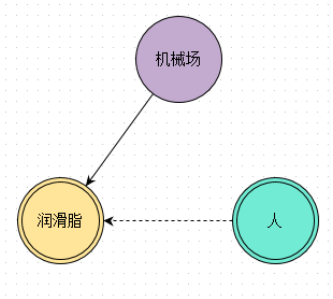

Figure 6.Su-Field model diagram

According to Su-Field model, we can find general and standard solutions corresponding to TRIZ theory. The list of standard solution is shown in figure 7.

Figure 7.The list of standard solution

The problem model can be described as this: insufficient effects are between the people and the lubricating grease. The ideal result is that the wire rope completes lubrication without the participation of people during runtime. The 67th standard solution suggests changing the phase state of existing material. Existing resources are taken as the initial node of knowledge map and association resource, physical effects and instances are recommended.Take the lubricating grease as initial node and lubrication function as mediation build a knowledge map shown in figure 8. Inspired by the 67th standard solution guide, we can use "synthetic lubricants" instead of” lubricating grease ". Furthermore, synthetic lubricant has good oxidation resistance and heat stability, suitable for use under high temperature and harsh conditions, and can further improve lubrication.

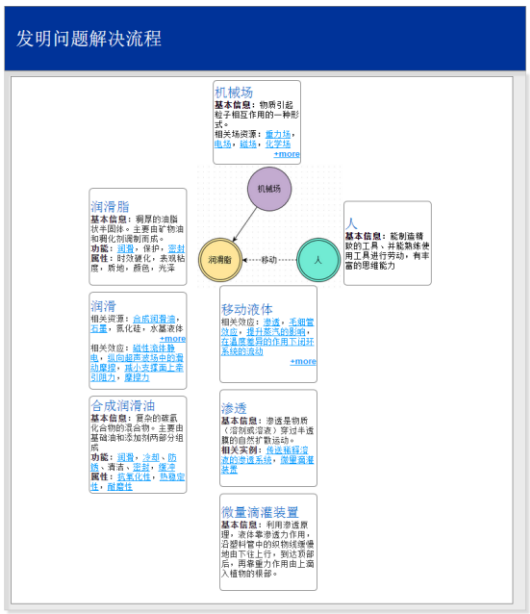

Figure 8.Knowledge map

At this time, the problem model can be described as this：Insufficient effects are between the people and the synthetic lubricants. The interaction can be described as move-> synthetic lubricants. Move liquid can be picked up and taken as initial node of knowledge map. Under the guidance of knowledge map, we can find the Penetration effect and relevant instance "trace drip irrigation device”, and the details shown in figure 9.By utilize penetration effect, the liquid rises slowly from the bottom depending on the penetration force, reaching the top, and then drops from the root of the plant relying on gravity. Inspired by the instance, follow the 1nd concept solution: We can place a container filled with synthetic lubricants on the beam-extraction machine. One end of a sufficiently long thread immerse in synthetic lubricants, and the other end of the contact wire rope. Under the effect of penetration, the synthetic lubricants will continually flow from one end of the thread to the other side, and the speed is slow, suitable for lubrication of wire rope.

Figure 9.Trace drip irrigation device

In addition, the standard solutions can be used again. The corresponding invention principle of the 16th standard solution suggests use dynamic field instead of static field. Time Resources including cyclical movement produce a scheme combining with the 1nd concept solution. Now follow the 2nd concept solution: We can place a container filled with synthetic lubricants on the horsehead. In one movement cycle of beam-extraction machine, the rope is in an upright position when the horse head at its lowest point. Under the action of gravity, the synthetic lubricants pass along to the low end of the rope, lubricating efficiently. The cyclical movement can realize the rhythm control of the lubrication.

We can take the same way to deal with the undesired effect between the lubricating grease and the wire rope, and the wire rope and the external environment. Now follow the 3nd concept solution and 4nd concept solution. The 3nd concept solution is stated as: The lubricating grease is passed into the entire section of wire rope along the gap between thread in a horizontal pressure so that the wire rope is adequately lubricated. The 4nd concept solution is stated as: In order to improve the corrosion resistance of wire rope, the wire rope is vacuum packed, and a protective film is formed, which can improve working condition and prolong the service life.

4.4 Solution formation

Using the analysis of the system, and making a synthesis of the four solutions that were generated, we can find: The improvement in 1nd concept solution and 2nd concept solution is during the runtime of beam-extraction machine, and the improvement in 3nd concept solution and 4nd concept solution occur in production of wire rope. The methods mentioned above could effectively improve the strength and service life of wire rope. In addition, from an economic point of view, we can finally come up with a solution to the problem: Combination of 2nd concept solution and 3nd concept solution can not only use the existing resources reasonably and operate conveniently but also do not need to set up special device, which can be widely used in the lubrication of the wire rope of beam-extraction machine.

5. Conclusion

Based on the analysis of Inventive Standards are applied, this paper proposes an inventive Standards-based approach with CAI tools to help designers to solve inventive problems. Taking advantage of the relevance of Inventive Standards, evolution rule, inventive principle and separation method, available resource and physical effects are recommended to increase the visibility between knowledge and knowledge source in the way of knowledge map with multi-angle and multi-level. It can help designers rapid get access to the relevant knowledge, inspiring them to produce creative design scheme, and improve the design efficiency. For further research, the knowledge acquisition and reuse is also of great significance for the innovation design. How to reasonably recommend and effectively utilize knowledge is still a hot research area in computer aided design. Future work in this direction will be to establish and improve the knowledge base and the reasoning mechanism

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Using Systematic Innovation to Deliver Valuable Customer Service in the Automobile Industry: An Exploratory Study

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Abstract

With the progress of the automobile industry in recent years, automobile manufacturers do not only emphasize product quality, but they also strive to gradually improve service quality in the hope of providing the best service for customers. Similarly, cloud computing technology has also grown with the development of network technology. At present, Taiwan's automotive service industry has yet to engage in the cloud computing environment. It has to find out the shortcomings of the original network service more accurately and make improvements on the cloud computing service amid its rapid development.

This study is based on the TRIZ method. The TRIZ method uses a contradiction matrix and 40 innovation principles so as to make the cloud computing service more applicable to the automobile industry. By doing so, this study aims to solve the problems of the current system through a thinking with systematic innovation. Moreover, it intends to provide a set of innovative and problem-solving methods for the appointment service in the automobile industry, which highly values innovation and changes. Hence, it helps the automobile industry apply the cloud computing technology in a competitive service market earlier than others.

Keywords: Systematic Innovation**,** TRIZ, Customer Service

1. Introduction

With the rapid growth of technology, a lot of enterprises during the past ten years have gradually developed customer services through the internet . But this kind of service model seems to have reached a bottleneck, because most consumers now use more mobile device instead of PCs. Epecially in recent years, both the government and private companies are vigorously promoting cloud services. This caused the trend of using traditional channels to change in the automobile industry. Currentlly the important issue is how to identify the most beneficial service for customers with related technology to increase competitiveness.

Customer service is a very significant factor for success. Most companies provide multiple channels to deliver services. Traditionally, the most popular and common communication channels include telephones and internet. However, in the new era of mobile devices, developing a mobile application such as an APP becomes an urgent task. Identifying the key functions to be included in an APP is a great challenge for delivering customer services in a mobile platform. This work utilizes systematic innovation method to assist in figuring out key functions. A case study is conducted in one well-known automobile dealer,

The best way to identify the most beneficial service for customers with related technology is to use systematic innovation. This work chooses TRIZ as a tool to solve contradicitons of services for the automotive industry.

2. Research Background

Good-quality customer service could bring in a lot of profits for the industry. In recent years the mobile becomes the mainstream communication platform of companies' service. Especially the concept of service innovation is significant in providing high-quality service. The related works are presented in Table 1.

Table 1 Literature Review of Service Innovation

author	year	content
Bongsug (Kevin) Chae	2012	This paper applies two models of complexity theory (Kauffman's NK model in biology and organiza- tional ambidexterity in organization science) for service innovation and proposes a novel perspective on service innovation as an evolutionary process, which is interactive, local, unpredictable, and emergent.
Yuan-Chieh Chang etal.	2012	The concept of service regime is developed to extend and test Miozzo and Soete's service taxonomy. Derived from the synthesis approach of service innovation, the service regime considers sources of innovation, innovation trajectories, and appropriability. Hypotheses on firm patterns of innovation are tested on a dataset of 5711 Taiwanese service firms
Erin M. Ferguson *Gruhl*	2012	This paper and the proposed formulation contribute to an apparent gap in transit research by integrating equity considerations into the transit frequency-setting problem.

3. Methodology

To generate a better solution for customer service, this study proposes TRIZ methodology. The overall process contains five steps shown in figure 1. First, we have to clearly define the problem to be solved. Then this problem is analyzed by Root Conflict Analysis to find critical causes. After several potential important causes are found, the most significant cause is then identified by a binary problem ranking . Finally, Contradiction Matrix and 40 Inventive Principles are used to solve contradictions and generate a better solution.

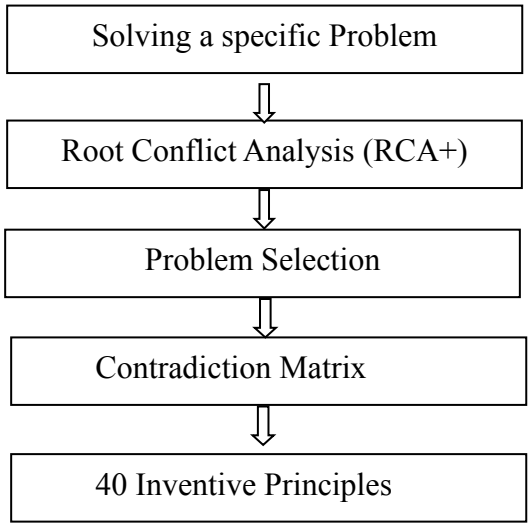

Figure 1 TRIZ Roadmap for Problem Solving (Valeri Souchkov 2015)

4. Case Study

The study collected information from one well-known automobile dealer in Taiwan during a two-year period. This research team assisted this dealer in improving their service process to retain customers and increase customer loyalty..

4.1 Problem Description and Definition

Based on the analyis of this study, auto repair processes consist of four major componets: interactive channel, appointment process, repair process and after-sales service. The major problem is that a lot of new customers lose loyalty in about two years. Besides, customers usually like to use phone and internet as the interactive media. They also consider it time consuming to go through the appointment and the repair process.

4.2 Root Conflict Analysis

Root conflict analysis is a method to map of all causal chain of causes and effects for a problem, which is represented as a negative effect (Valeri Souchkov 2015). When you reach a cause that contributes to both positive and negative effects, that is what's called "a root conflict" or "root contradiction".

The major problem we found from the information colleted is that new customers usually lose their loyalty in a few years. Because they felt it too time consuming to either make an appointment and to have their cars repaired (see Figue 2). Two major reasons lead the customers to consider it time-consuming to have their cars repaired:long waiting time and long distance to the repair shop. The reason for a long waiting time is poor scheduling. Because customers come in randomly, it is difficult to arrange schedule. The other reason is that customers did not care about the distance to the repair shop and went to the shop they were familiar with. For time-consuming to make an appointment, using traditional media to make an appointment seems to take too much time.

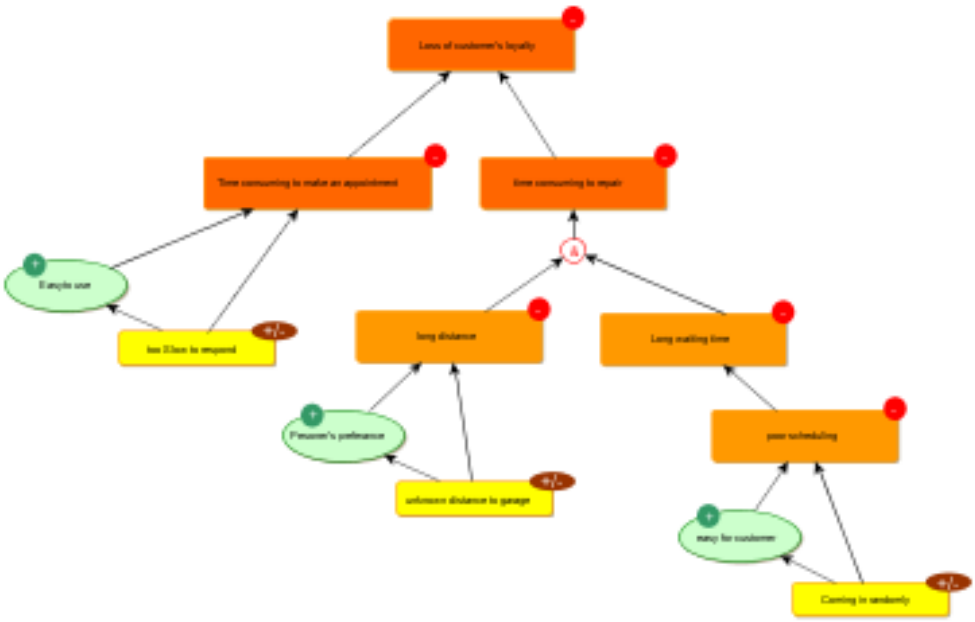

Figure 2 Root conflict analysis for Auto Repair

4.3 Problem Selection

Based on the theory of finding a root contradiction, we found that "too slow to respond" is a root contradiction.

4.4 Contradiction Matrix and 40 Inventive Principles

From the previous analysis, the positive effect is "easy to use" (system convenience) and the negative effect is "too slow to respond" (system time). When we searched the universal matrix for business and management by using the positive effect (system convenience) and the negative

effect (system time), we got principles (34, 28,18, 38) from the universal matrix (Valeri Souchkov 2015). The inventive principles and ideas are shown in table 2.

Table 2 Inventive Principles and Ideas.

Principle No.	Principle Name	Idea
34	Discard and Recover	Flexible, variable-sized project teams
28	Principle Replacement	Using mobile phone
18	Resonance	Approaching a customer with an offer of a value-added product service when selling the product
38	Enriched Environment	Online Shops

To make decisions, we defined the following criteria to evaluate the ideas:

Criteria1: Attractive for customers

Criteria2: Easy to implement

Criteria3: Increase the purchase

Criteria4: Easy to work with

Then, this study decided the score and ranking for each idea from table 2 and present them in table 3.

Table 3 Binary Problem Ranking

Criteria / Idea	1	2	3	4	Final Score	Ranking
1 Flexible project teams	0	-1	0	1	0	3
2 Using mobile phone	1	1	1	1	4	1
3 Using social media as a value-adding product service	1	0	1	0	2	2
4 Developing APP to assist online shops	1	-1	1	1	2	2

4.5 Solution Strategies and Evaluation

To evaluate the solution strategies, the estimated time to market and final score are applied to draw the ideas landscape. The estimated time to market for each idea is shown in table 4.

Table 4 estimated time to market

Idea	Time to market
Flexible project teams	1 month

Using mobile phone	0 month
Social Media for service	0.5 month
APP for service	6 month

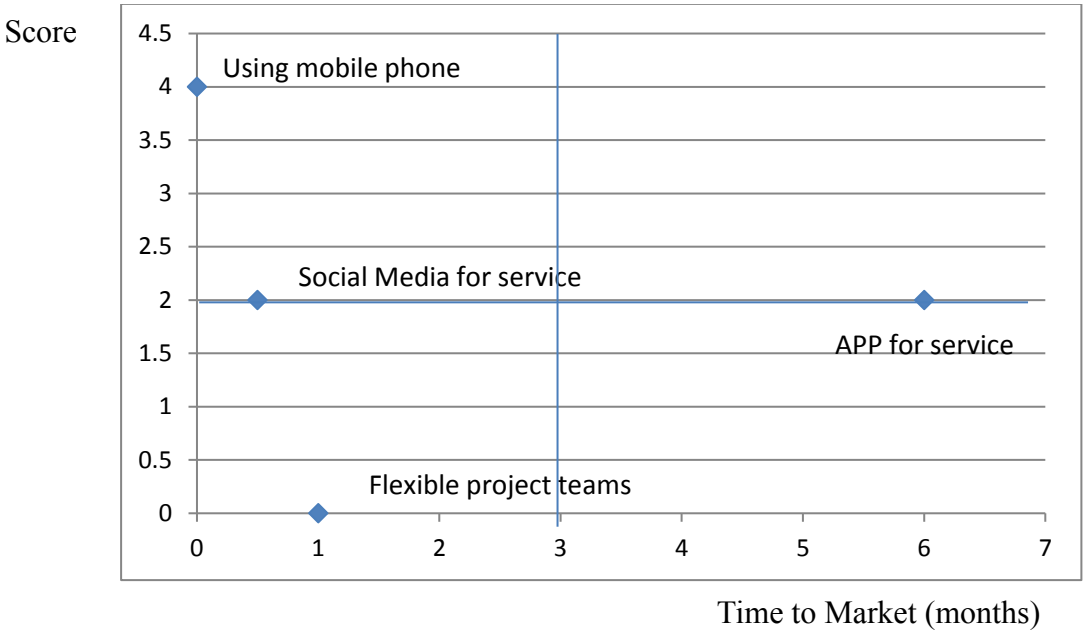

Figure 3 Ideas Landscape

To identify the ideas, the outcome for auto repair is shown in Figure 3. The most feasible idea is "using mobile phone", followed by" using social media ", "Flexible project teams" and " developing an APP".

5. Conclusion

There's an increasing trend to provide customer services through a new media. This study proposes to apply the concept of systematic innovation to solve such difficulties.

Two steps were implemented in this study. First, we collected problems from customer services of an automobile dealer. Second, systematic innovation was applied to find solutions to bridge the gap between customers' problem and the services delivered by companies. The TRIZ method was used to propose the ideas which will be implemented in an auto dealer.

. We got some findings from this study. The most feasible idea is "using mobile phone", followed by" using social media ", "Flexible project teams" and "developing an APP". Based on above ideas, smart phone is a significant tool to serve customers. A smart-phone-based social media application such as Line is a good way to provide services. A smart phones app for providing company specified services is an important tool to interact with customers. In the near future, a specified APP will be developed to solve contradictions of customer's services.

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Identifying technology opportunities based on firms' technology capability using patent classifications and collaborative filtering

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Abstract

Utilizing the current technological capabilities can be a good technology strategy for the firms which lack technology experts, facilities and technology information. Therefore, this paper proposes a method to detect technology opportunities customized to a firm by using patent classifications and collaborative filtering techniques. Using a firm's technological capability defined as the set of the firm's own patents, this method recommends technology items with high potential in heterogeneous fields. The proposed method in this paper is composed of 1) structuring firm-IPC (International Patent Classification, main group-level) distribution vectors using IPCs of each applicant's patents, 2) calculating the recommendation scores of IPCs for a target firm using collaborative filtering, and 3) identifying IPC-based opportunities by using the newly proposed indexes: heterogeneity, growth rate and competition level. This method contributes to systematic identification of technology opportunities. In this paper, we explain the proposed method's details and our future research plan.

Keywords: Technology Opportunities, Patent Analysis, International Patent Classification, Collaborative Filtering, Technology capabilities

1. Introduction

Under the intensified technological competition environment, technology-based firms are endeavoring to create technology opportunities and values to achieve sustained growth. Therefore, research and development (R&D) is necessary to find out new technological opportunities, and also the result of R&D impacts greatly on firms' profit and sustained growth.

However, firms' R&D results are not always successful; despite the low success rate, such R&D requires many resources, including skilled manpower, facilities, time and costs, because most R&D depends on experience, intuition and professionalism of expert (Hall, 2002). Due to the risk of R&D investment, many Small and medium sized enterprises (SMEs) are hesitating about conducting R&D due to the practicality of their R&D (Cho, Yoon, Coh, & Lee, 2015; Kleinknecht & Reijnen, 1992; Savioz & Blum, 2002).

For such SMEs, utilizing the current technological capabilities can be a practical technology strategy. Therefore, this paper proposes a method to identify technology opportunities customized to a firm's current technological capability by using patent classifications and collaborative filtering techniques. Using a firm's technological capability defined as a set of the firm's own patents, this method recommends technology items with high potential in heterogeneous fields. The method proposed in this paper is composed of 1) structuring firm-IPC (International Patent Classification, main group-level) distribution vectors using IPCs of each applicant's patents, 2) calculating the recommendation scores of IPCs for a target firm using collaborative filtering, and 3) identifying IPC-based opportunities by measuring the newly proposed indexes: heterogeneity, growth rate and competition level.

This method contributes to systematic identification of technology opportunities. In this paper, we explain the proposed method's details and our future research plan.

2. Theoretical background

This study suggests a systematic R&D item identification method for SMEs, so this section briefly overviews the literature for technology opportunity discovery and the collaborative filtering.

▪2.1 Technology opportunity discovery

Technology opportunity discovery is generally defined as a process to find out "the potential of technology" or "technologies with high potential", or a process of searching technologies or products that have technological and economical value. (Klevorick, Levin, Nelson, & Winter, 1995) defined technological opportunities as the potential of technology development, and (Olsson, 2005) defined that technology opportunity is the potential of specific technology areas or general science areas for technology progress. Finding out technology opportunities is important for firms' sustained development and survival, considering that technology lifecycles are shortening in today's emulous environment.

The method of technology opportunity discovery is classified into expert-based qualitative approach and data-based quantitative approach. The qualitative approaches, the traditional ways, such as Delphi method, scouting method and morphological method, find out technology opportunities based on expert's intuition and empirical knowledge within a target technology area. However, these approaches have limitations, in that they are time-consuming and costly, and in that they requires frequent interventions by experts' subjectivity (Yoon & Park, 2005; Yoon, Phaal, & Probert, 2008; Yoon & Kim, 2011). For this reason, objective data-based quantitative approaches have been presented by the studies using patents data. The data-based approaches have an advantage of reducing costs, time, expert dependence and finding out unexpected new technology opportunity areas by experts (Yoon & Park, 2005; Yoon & Kim, 2011). The patent data-based approaches typically use the relation of extracted keywords, functions and citations of patents. This study identifies technology

opportunities based on a firms' own technological capability, which is defined as a set of patents, for further R&D of SMEs.

▪2.2 Collaborative filtering

The collaborative filtering is one of the recommendation system that anticipates the preferences of items for a user by using preferences of items from other users (Breese, Heckerman, & Kadie, 1998; Goldberg, Roeder, Gupta, & Perkins, 2001; Groh & Ehmig, 2007; Herlocker, Konstan, & Riedl, 2002). A large number of service firms have provided personalized services which recommend favorite items to users, based on accumulated personal information and purchase patterns on the World Wide Web, and also these services have increased customers' satisfaction and firms' profit (Kautz, Selman, & Shah, 1997; Linden, Smith, & York, 2003).

The method of collaborative filtering calculates the similarities among users using item preferences of each user, and then provides preference scores of certain items to a target user (Breese et al., 1998; Sarwar, Karypis, Konstan, & Riedl, 2001). The advantage is that collaborative filtering can calculate potential user's preferences for each item, although the user's preference information for each item is not presented explicitly (Good et al., 1999; Herlocker, Konstan, Terveen, & Riedl, 2004; Koren, 2008).

Therefore, this study recommends potential technology opportunities using collaborative filtering based on firms' capability. Users and items, the two elements of collaborative filtering, are converted into patent applicants (firms) and IPCs of the applicant's patents. This study collects IPCs of each applicant, and then recommends IPCs which can be technology opportunities to a target firm.

3. Methodology

This study suggests a new systematic supporting system to recommend technology opportunities that have high practicability and potential based on firms' current technological capability. For this purpose, this paper defines firms' capability as a set of their own patents, and then recommends the potential IPC (International Patent Classification, main group level) using collaborative filtering techniques. The reason of using and recommending main group-level IPCs is that main group-level IPCs can be considered specific products, processes and mechanisms. The system suggested in the paper consists of : 1) structuring firm-IPC distribution vectors using IPCs of each applicant's patents, 2) calculating the recommendation scores of IPCs for a target firm using collaborative filtering, and 3) identifying IPC-based opportunities by using the newly proposed indexes: heterogeneity, growth rate and competition level (Figure 1).

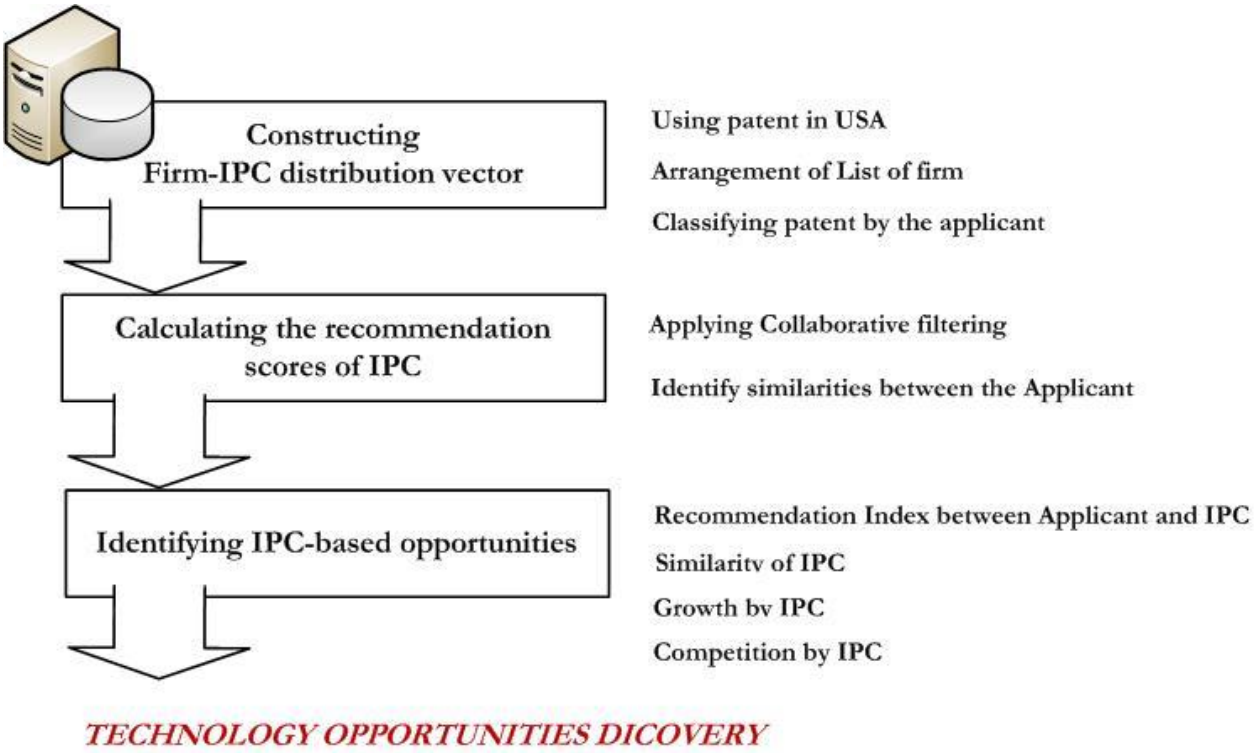

Figure 1. Overview of the proposed method

▪3.1 Constructing firm-IPC distribution vectors

Collaborative filtering works by two elements, that is, customers and their item preferences. To apply the concepts of collaborative filtering, this step considers applicants as users and the IPC codes that the applicants' patents include as items. The IPC code is a complex hierarchical classification system consisting of sections, classes, sub-classes, main groups and sub-groups (Table 1). The IPC code divides all technological area into sections. While early studies use the subclasses level of IPC code for analysis (Dereli & Durmusoglu, 2009; Jun, 2011), this study uses the main group level-IPC codes. By using the main group level-IPC codes, we can more express firms' technological capabilities, such as specific products, processes and mechanisms.

In constructing firm-IPC distribution vectors, data preprocessing is needed. First, applicants are organized because some applicants, such as research institutes of universities and governments have a wide range of IPCs. Therefore, such applicants should be excluded from the list of applicants, because they affect the performance of our collaborative filtering method. Based on the applicant list, each firm's own patents and the IPC codes obtainable from the firm's patents are organized to construct firm-IPC distribution vectors.

Table 1. Hierarchical structure of IPC codes

IPC hierarchy		Description
Section	G	Physics
Classes	G10	Musical instrument : Acoustics
Subclasses	G10D	Stringed musical instrument Wind-actuated musical instrument Percussions musical instrument Musical instruments not otherwise provided for;
Group	G10D 1/02	Of violins, violoncellos, basses

This study utilizes a total of 1,110,582 patents, registered in USPTO (United States Patent and Trademark Office) between 2009 and 2013, to construct firm-IPC distribution vectors. To obtain this big data, this study uses the USPTO patents bulk download service provided by google (https://www.google.com/googlebooks/uspto.html) (Figure 2). These webpage provides the whole information of the USPTO patents such as bibliographic information, text, and image.

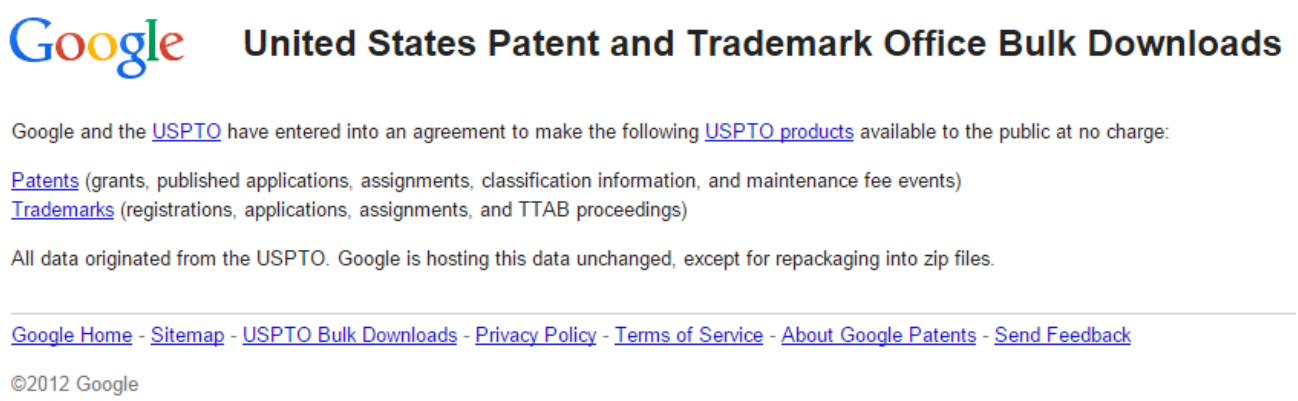

Figure 2. Google' USPTO bulk download web page

▪3.2 Calculating the recommendation scores of IPC

This study identifies technology opportunities using collaborative filtering. Collaborative filtering consist of two steps: 1) calculating similarities between a target applicant and other applicants, and 2) calculating recommendation score of the IPCs untapped by the target applicant.

The main idea of collaborative filtering is to recommend suitable items for a target user by analyzing users who has similar preferences to the target user. Because of this idea concept, this study calculates similarity scores between a target applicant and the other all applicants. Similarity measures for applicant similarity vary, for example, Pearson correlation coefficient, Cosine similarity, Mean-square difference, Jaccard similarity and so on. Given these measures use explicit information only, this study utilizes LDA (Latent Dirichlet allocation) that considers latent factors. LDA, one of the topic

modeling methods, expresses customer's preferences into feature vectors and matches these feature vectors to hidden topics (Bíró, Szabó, & Benczúr, 2008; Blei, Ng, & Jordan, 2003). Applying LDA can consider the latent information due to reflecting hidden topics, so this study calculates similarity scores between applicants using topic distribution of applicants (Krestel, Fankhauser, & Nejdl, 2009).

Recommendation scores are calculated based on firms' technological capability and similarity score between each applicant calculated by LDA. Recommendation scores between target firm and IPCs is calculated to normalize multiplying number of specific IPC in other firms and similarity score between target firm and other firm, as in Equation (1). This recommendation score is quantitative relation between target applicant and IPCs. When recommendation score between target firm and IPC1 is high, we can recognize that probability of inroad IPC area is high because of recommendation score based on firms' technology capability.

$$
\begin{aligned}
&Rs(App_{target}, IPC_1) = \left(\sum_{i=1} Sc(App_{targrt}, App_i) \times R(App_i, IPC_1)\right) / \mu \\
&\mu = \sum_{i=1} Sc(App_{target}, App_i) \\
&Rs = recommendation\ scores \\
&Sc = number\ of\ IPC_i\ in\ APP \\
&App = applicant
\end{aligned}
\tag{1}
$$

▪3.3 Identifying IPC-based opportunities

Although recommended IPCs have high potential to technology opportunity, all of the recommended IPCs cannot be technology opportunities for the target firm. Therefore, this study proposes several indexes to judge whether or not the recommended IPCs has the potential to be technology opportunities. The indexes are heterogeneity, growth rate and competition level.

The index of heterogeneity is used for whether recommended IPCs are suitable for a target firm. In this study, heterogeneity is defined as the difference between firms' IPCs and recommended IPCs. The index of heterogeneity is measured using the hierarchical information of IPC. If the index of heterogeneity between recommended IPC and firm' IPC is low, it is hard to judge that recommended IPC is technology opportunity. Therefore, this study identifies that recommended IPC is technology opportunity, if the heterogeneity index of such IPC is higher than certain level in this study.

The index of growth rate is used to identify whether recommended IPCs are promising within their technology area. For this purpose, this study estimates this index by using the rate of increase of the number of patents in each recommended IPC. If the index of growth rate of recommended IPC is low than specific level, the IPC could not be a technology opportunity because a low growth rate index of IPC means that the IPC is not attractive. Therefore, this study considers the IPCs with higher growth rate as technology opportunity IPCs.

The index of competition level is estimated in two ways: the number of patents and the number of applicants in a recommended IPC. If many patents are applied already in the recommended IPC, we can consider that the IPC belongs to competitive areas. In a similar way, if too many firms belong to the recommended IPC area, then the recommended IPC could be considered as a technology opportunity in a competing area; non-competitive IPCs would be better for SMEs.

4. Conclusion

Despite the importance of developing new technological opportunities, many SMEs hesitate about conducting R&D projects because of the low success rate and high investment of R&D. In response, our method identifies technological opportunities customized to firms' capability so that they increase the R&D practicability with their existing resources.

To this end, this study defined a set of firms' own patents as firms' technological capability, and then recommends IPCs, which is defined technology area and is extracted from patents, using collaborative filtering. In addition, this paper develops several indexes of identifying characteristics of recommended IPCs. In this paper, we explained the proposed method only. Currently, this study is an ongoing work; the procedure of calculating firm-IPC distribution vectors and calculating recommendation score are completed, and the procedure of identifying IPC-based opportunities will be furthered.

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A System for Filtering Noise Patents

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Abstract

Patent-based technology analysis mostly goes through collecting valid patents. To prevent the loss by missing valid patents, most field experts, including patent attorneys, collect an initial patent set using relatively loose patent retrieval statements, and then exclude irrelevant patents, called noise patents, from valid patents. However, this filtering process is known to require a lot of time and effort; according to the experience of patent attorneys, it is assumed that up to 80% of initial patents come under noise patents. To dramatically increase the efficiency of noise patent filtering process, this paper suggests a semi-automated system based on Shannon's entropy theory and latent Dirichlet allocation. The system's process is composed of 1) preprocessing patent data and structuring patent text data, 2) recommending noise seed patents by measuring the information quantity of each patent, 3) determining potential noise patents similar to the noise seed patents by measuring semantic patent similarities based on latent Dirichlet allocation, and 4) recommending and excluding noise patent groups. We believe that this system will considerably reduce the experts' labor costs and time involved in noise patent filtering, as well as will be used for patent-based technology analyses, irrespective of technology domains. In this paper, we explain the current progress and future plan of the proposed system.

Keywords: Noise patent filtering, Expert system, Shannon's entropy theory, Latent dirichlet allocation.

1. Introduction

Patent-based technology analyses mostly go through collecting valid patents. Global patents are being increasingly applied, and these patents are considered as technical index, and patent data are analyzed for measuring the availability of technology (Ko et al, 2014). The importance of patents is also growing as time goes on, especially, by development of information technology; improving accessibility for patent databases contributes to the high practicality of patent analysis (Lee et al, 2009).

For these reasons, patents have been used as the data for technology forecasting, technology monitoring, and R&D planning. However, trade-off between defining a patent retrieval query and obtaining initial patents set always exist in obtaining valid patents; loose patent search queries may return many irrelevant patents, while tight patent search queries may miss some of the valid patents

that should be included for patent analysis. In practice, patent experts, including patent attorneys, adopt the strategy that uses loose patent search queries not to miss valid patents. Naturally, the initial patent set may include irrelevant patents, called noise patents. Accordingly, excluding noise patents form valid patents, called the noise patents filtering process, is necessary.

Until now, this noise patent filtering process has been considered as a simple repetitive work only by high involvement of human experts. Therefore, this process involves a lot of time and effort as well as includes mistakes by simple repetitive tasks. According to our experiences, it was found that the noise patent filtering process comprises a large proportion (approximately 60-80%) of the total patent analyses.

Therefore, to reduce the efforts in obtaining valid patents, this research suggests a semi-automated method for patents noise filtering, based on Shannon's entropy and semantic patent similarities. In this paper, we describe the current progress and future plan of the proposed method. The method will significantly reduce the time and costs required by human experts in noise patent filtering processes. Therefore, it will help experts to more concentrate on their higher valued-added and knowledge intensive tasks, such as core patent identification and patent strategy formulation.

2. Background work

▪2.1 Information Entropy Theory

Information entropy, initially proposed by Shannon in 1948, is called information entropy or Shannon entropy. It can be used as a criterion for measuring the uncertainty in any probability distribution (Li et al, 2015). In addition, it can quantify the amount of the information contained in systems. Actually, in information science studies, Shannon entropy have been used to evaluate the amount of information about one system (Shannon and Claude, 2001).

Information entropy is considered an important conception in information theory, and is a measurement method for inherent uncertain random variables; in other words, measuring the uncertainty under any condition. Information entropy is also considered as the amount of information that a system contains; the information quantify is high under high uncertain conditions, while it is low under low uncertainty condition. For instance, throwing a coin (two cases; head and tail), includes the lower amount of information than throwing a dice (six cases). If all incidents in a system have the same probability, the system has the biggest amount of information, because it is harder to forecast the results. However, the lower amount of information is contained when incidents have different probabilities. The information entropy of a system can be defined as a formula with incident probabilities; in equation (1), h_i is the probability of i incident.

$$H(X) = -E(\ln f) = \sum_{i=0}^{k} h_i \log_2 \frac{1}{h_i} \tag{1}$$

▪2.2 Latent Dirichlet Allocation

Latent dirichlet allocation (LDA) is based on the assumption that authors generally have a writing process about specific topics. Writing about any topic means a probabilistic word selection process from the words which are related to the topic (Krestel et al, 2009). Therefore, a document is composed of the mixtures of different latent topics, and each latent topic has a word distribution of features (Figure 1). This is the fundamental idea of LDA (Blei et al, 2003).

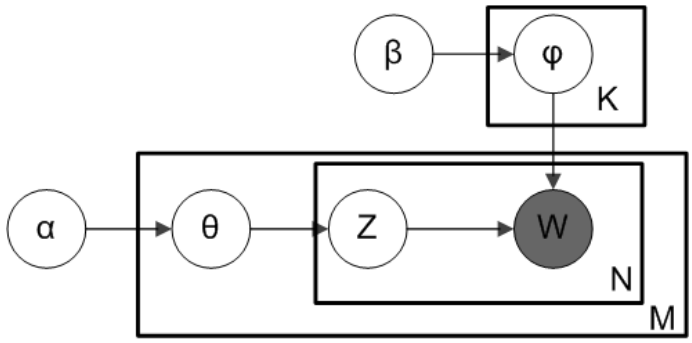

Figure 1. The concept of LDA modeling

LDA assumes the following generative process for a corpus D, consisting of M documents each of length N_i:

1. Choose $\theta_i \sim Dir(\alpha)$, where $i \in \{1,\ldots,M\}$

2. Choose $\varphi_k \sim Dir(\beta)$, where $k \in \{1,\ldots,K\}$

3. For each of the word positions i, j, where $j \in \{1,\ldots,N_i\}$, and $i \in \{1,\ldots,M\}$

   A. Choose a topic $z_{ij} \sim Multinomial(\theta_i)$

   B. Choose a word $w_{ij} \sim Multinomial(\varphi_{zij})$.

, where α is the parameter of the Dirichlet prior on the per-document topic distributions, β is the parameter of the Dirichlet prior on the per-topic word distribution, θ_i is the topic distribution for document i (sum of θ_i is 1.0), φ_k is the word distribution for topic k, z_{ij} is the topic for the jth word in document i, and w_{ij} is the specific word.

3. Methodology

This section describes a systemic and efficient method for the patent noise filtering, an essential step for patent-based studies. The proposed method is a repetitive refining process of obtaining valid patents, by eliminating noise patents from the initial patent set obtained by a patent retrieval query. By

this method, seed patents having the high potential as noise patents are recommended, and patents similar to the seed patents are clustered and excluded (Figure 2). This process is very similar to the crystal growth process, which uses a seed to generate a crystal from solvent.

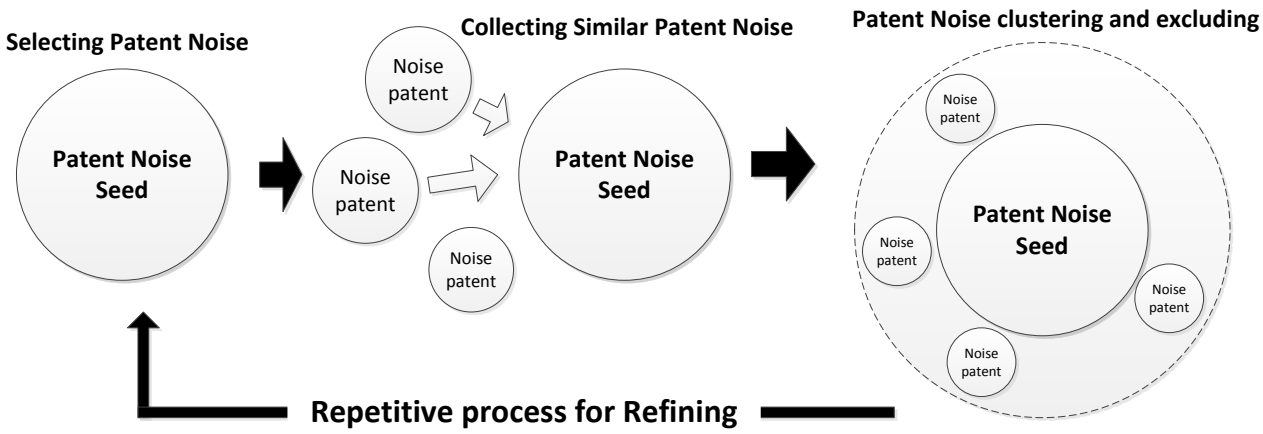

Figure 2. Basic concepts of the proposed patent noise filtering system

The proposed method is composed of a total four steps (Figure 3). This research uses technological keywords of the collected patents to structure them. Each patent is evaluated using the amount of information based on Shannon entropy; information quantity values are the criterion for recommending noise patent seeds, and users can select some of the patent seeds for a given patent set. Latent topics are identified by the LDA process and semantic similarities among patents are computed, thereby generating noise patent clusters that are composed of patents highly similar to noise seeds. Consequentially, noise patent clusters are finally removed from the initial patent set, and users repeat this process to reduce the time and costs required to obtain valid patents.

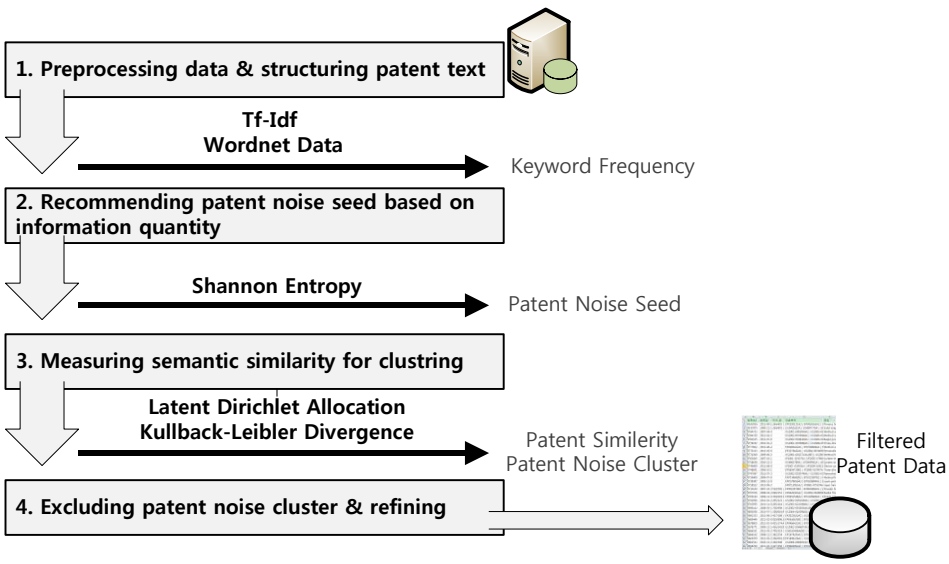

Figure 3. Overview of systematic patent noise filtering process

▪3.1 Preprocessing and structuring patents

The prerequisite for our method is to preprocess patents of the initial patent set and structure them as keyword vectors. This preprocessing task includes extracting text data from patents, splitting the text by words, excluding meaningless words, and counting frequencies of valid words. These frequencies are used to generate a priority matrix that represents word importance for a document. The importance is figured by Term Frequency(TF)-Inverse Document Frequency(IDF). TF is the appearance frequency of a word in a document, and DF is the number of documents that contain a specific word. Equation (2) defines the formula of TF-IDF. The *tf(t,d)* is the frequency of word *t* in document *d*, $|D|$ is the total number of documents, and $|d \in D;\ t \in d|$ is the number of documents which contain word *t*.

$$tfidf(t,d,D) = tf(t,d) \times idf(t,D)$$
$$idf(t,D) = \log \frac{|D|}{|d \in D : t \in d|} \qquad (2)$$

3.2 Recommending noise patent seeds based on information quantity

The material to calculate the amount of information for patents is the keywords which are used in patent retrieval queries. For each document, the information quantity value is measured using Shannon entropy conception. Therefore, noise patent seeds are recommended using the information quantities of documents. Patents that contain the low amount of information have high possibility of being noise patents. In this step, users can select some of the patents that will be used as a seed.

Then, the values computed by information entropy formula contain entropy about unnecessary information. Therefore, the information quantity needs to be calculated by modified information entropy formula which can measure the amount of necessary information to classify valid patents and noise patent seeds. The equation (3) is the proposed modified formula for measuring necessary information quantity. Words of each document are categorized into *k* classes, class 1,…,k-1are the keywords necessary for a patent searching query; however, all of the unnecessary words are assigned to class k. Thus, by using equation (3), the amount of required information can be estimated.

$$H(X) = \sum_{i=1}^{k-1} h_i \log_2 \frac{1}{h_i} \qquad (3)$$

3.3 Measuring semantic similarities for patent clustering

Patents, which are contextually similar to noise patents, need to be clustered. LDA can generate topic distributions with TF-IDF values that were produced using keywords and documents. This step enables to measure semantic similarities among different patent documents, unlike simple keyword matching.

However, the result of LDA modeling produces topic probability distributions only. Therefore, this step performs an additional work where semantic similarities among patents are generated by Hellinger distance or Kullback–Leibler divergence. For instance, the Hellinger distance is used to quantify the similarity between two probability distributions in probability and statistics (Hellinger and Ernst, 1909). Hellinger distance for discrete distance assumes that there are two discrete probability distributions $P = (p_1, \ldots p_k)$ and $Q = (q_1, \ldots q_k)$, their Hellinger distance is defined as equation (4);

$$H(P,Q) = \frac{1}{\sqrt{2}} \sqrt{\sum_{i=1}^{k} (\sqrt{p_i} - \sqrt{q_i})^2} \tag{4}$$

3.4 Excluding patents noise cluster and refining

In this step, patents noise clusters are excluded and thereby the initial patent set is refined. Clustering patents similar to noise patent seeds can be resized by adjusting similarity threshold values. Appropriate similarity values need to be chosen. A high threshold value reduces the size of poise patent clusters, so it may increase the number of repeating the refining process.

4. Conclusion

Patents data are generally used for technology analyzing, technology monitoring, and R&D. Initial patent sets may include irrelevant patents to technology of analysis, so noise patents exclusion process is essential to obtain valid patents. However, patents noise filtering process involves many iterations and frequent human interventions. Thus, there would be some room for improving repetitive and time-consuming tasks by systemizing the patents noise filtering process.

In this paper, we proposed a systemic method for supporting noise patent filtering process, by using Shannon entropy and LDA. First, the method analyzes the amount of information quantity for each patent using the keywords used in patent retrieval queries. Second, the method recommends patent noise seeds by measuring the patents' information quantity. Third, the method measures semantic patent similarities among different patents using topic distributions by LDA. Finally, this method identifies noise patent clusters and refines the initial patent set by excluding these noise patent clusters. Our method contributes to developing a noise filtering system; still, the noise patent filtering process depends heavily on human experts' manual tasks.

Despite the contribution, limitations still remain for future research. First, this paper introduces the basic concept for semi-automated noise patent filtering process. Therefore, a future topic will more elaborate the proposed method. Second, this paper does not currently prove the effect and performance of the proposed method. Therefore, further research will implement the proposed method into an integrated system. By doing so, we will test its practical performance and compare the time and cost by our method with ones by manual task.

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Integration of Manufacturing-based Monozukuri Concept with TRIZ: Case Study on the Thai-Nichi Institute of Technology

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Abstract

Manufacturing industries are facing ever-increasing demand from customers for high quality products and services. Besides, in order to survive in present environment of borderless competition, manufacturing industries are required to be more innovative in new product development for sustainable growth.

This paper aims to solve the above problems by integrating the concept of Monozukuri which is the product creation principles deeply rooted in Japanese manufacturing industries, with TRIZ (Theory of Inventive Problem Solving) originated in Russian Engineering Community for idea generation. Case Study on the Thai-Nichi Institute of Technology's introduction of Monozukuri culture and teaching methods are explained together with examples from the subject on Creativity for Innovative and Technology. Finally, the results of introducing Monozukuri concept and TRIZ into the organization are explored and discussed.

Keywords: Monozukuri, TRIZ, Manufacturing industries, new product development

1. Introduction

The concept of Monozukuri is deeply rooted in the history of Japanese culture and traditional craftsmanship. But it was not until the late 1990s that the concept of Monozukuri captured public attention and mass media in the depths of Japan's despair to reaffirm the core strengths of Japanese manufacturing firm (Robert E. Cole and D. Hugh Whittaker, 2006). Many manufacturing firms have begun to deploy concept of Monozukuri into their company policies and strategies. For example, in 2005 NEC integrated all the Monozukuri-related departments that had been distributed across the corporation into the Monozukuri Innovation Unit. This policy enabled the promotion of the strengthening of Monozukuri at the corporate level (Enomoto, 2008). In 1999, the Basic Act on the Promotion of Core Manufacturing Technology was enacted to promote the position of Monozukuri in the Japanese economy. Three ministries-METI,MEXT and the Ministry of Health, Labor and Welfare-were required to address manufacturing problems and produce the Monozukuri White Paper, published annually since 2000 and 'The Monodzukuri Nippon Grand Award' presented by the prime minister of

Japan to those individuals whose achievements are on the cutting edge of Monodzukuri has originated in 2005. And in May 2008, Keizai Doyukai (Japan Association of Corporate Executives) has suggested three recommendations with six courses of action for enhancing the competitive edge of Japanese 'Monozukuri' industries and user confidence worldwide (Keizai Doyukai, 2008)

Monozukuri is the art and spirit of creating high quality products by utilizing technology and skill to meet the requirement of customers. It is the combination of Japanese words, Mono（物) which means Product and Tsukuri（造り) which means Making or Creation. Thus, Monotsukuri or Monozukuri means Product Creation. The spirit of Monozukuri is made up from Skill, Spirit, Zest, Pride and Determination to deliver best product (Krisada, 2000). Monozukuri concept embraces more than the literal meaning; it offers the idea of possessing the "spirit to produce excellent products and the ability to constantly improve a production system and process". It covers the chain of all production processes from product design to after-sale service (J.P. Malhotra, 2012).

Monozukuri is also viewed as a development of human resources or Hitozukuri where Hito (人) means human. It is sometimes claimed that industry and academia are two very different cultures, with the former concerned with how to deliver reasonably-priced high quality products to customers, while the latter academic institutions, focus on education, research, and service. Yet this difference does not mean there is no common ground. Toyota's Chairman, Fujio Cho stressed the importance of "hitozukuri and monozukuri" in his anniversary lecture at Toyota Motor Vietnam. A common mission does exist between companies that value "hitozukuri and monozukuri" and academic institutions that focus on education and research (Kozo et al., 2011).

There are many researches and implementations on Monozukuri in education to prepare students with skill and knowledge for industries (Masahiro et al., 2008). One of the famous University in Japan with philosophy based on Monozukuri is the Institute of Technologist (or Monotsukuri University). One of the events held at Monotsukuri University is Karakuri Contest. Karakuri is the use of mechanical devices to create movement developed during the 18th and 19th century in Japan. Thai-Nichi Institute of Technology (TNI) has participated in Karakuri Contest at Monotsukuri University and has exchanged knowledge and experiences of Monozukuri culture and teaching methods with her through student and lecturer exchanges and internship programs.

2. Monozukuri and Hitozukuri at Thai-Nichi Institute of Technology (TNI)

TNI is a private university established by Technology Promotion Association (Thailand-Japan) in 2007. It has adopted the concept of Monozukuri and Hitozukuri into its core value from the very beginning and has introduced Monozukuri as one of its strategic goals to be the center of excellence and to produce high quality graduates for the society. Monozukuri Education at TNI aims to teach its students to be determined to produce high quality work, to be skillful with hands-on training and project based learning, to be creative in solving innovative problems and to understand and abide by the rules of 5G. The word 5G comes from Japanese words comprising 1. Genri (原理) : Learning from

theories, 2. Gensoku (原則): Learning from rules and regulations, 3. Genba (現場): Learning from the workplace, 4. Genbutsu (現物): Learning from the work environment and real material and 5. Genjitsu (現実): Learning from practice in real situations (Rungsun, 2014).

Besides Monozukuri with 5G, TNI has also included other management tools into its policy called TNI Way which emphasizes Monozukuri Concept, 5S, Teamwork, Kaizen and Creativity where 5S, Teamwork and Kaizen are Japanese styles of management with the objectives to keep up with the best practices and continuously improve them with participation from all people concerned as in Figure 1.

Figure 1. TNI Way.

In implementing TNI's strategy of Monozukuri and Hitozukuri, apart from educating its students and staffs to understand the philosophy and spirit of Monozukuri, TNI has developed hands-on teaching method into its curriculum and organized various events and activities to transfer knowledge and practical experiences to students such as learning by making product or project based learning, teaching by experts from industry (Masuda, 2012), cooperating and utilizing industries' equipments and machines in student training and internship program, and holding karakuri and monozukuri contests (Awaji, 2013) as in Figure 2.

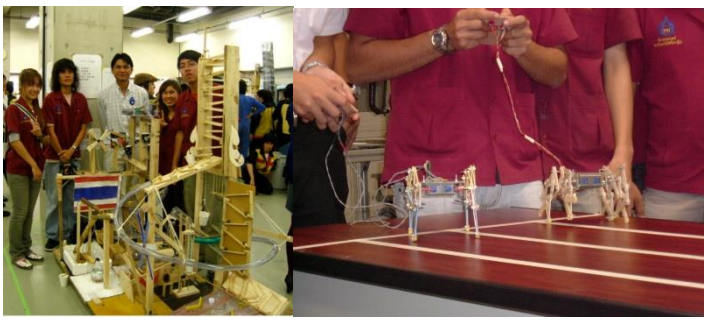

Figure 2. TNI karakuri and monozukuri contests

3. Integration of Monozukuri Concept with TRIZ

As the spirit of Monozukuri concept aims to produce high quality and best product, it is necessary to know how to solve the encountered problems creatively where imagination and knowledge only is not enough. We need an effective tool to connect imagination and knowledge to generate ideas for potential solutions efficiently without resorting to the inefficient trials-and-errors method as in Figure 3.

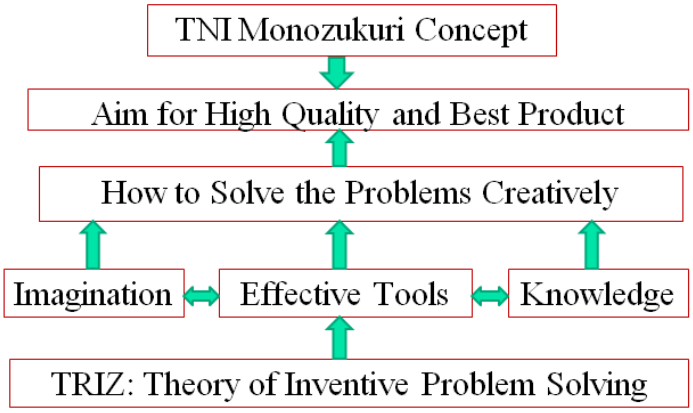

Figure 3. Integration of Monozukuri Concept with TRIZ

One of the most effective tools is known as TRIZ or Theory of Inventive Problem Solving which is developed by Genrikh Altshuller, a Russian scientist who studied thousands of patents to find that evolution of technical system is not random and that creativity is not a gift but can be learned through the successes of inventors in the past who have solved their problems inventively. TRIZ comprises several tools, knowledge base and process called algorithm of inventive problem solving (ARIZ) as shown in Figure 4.

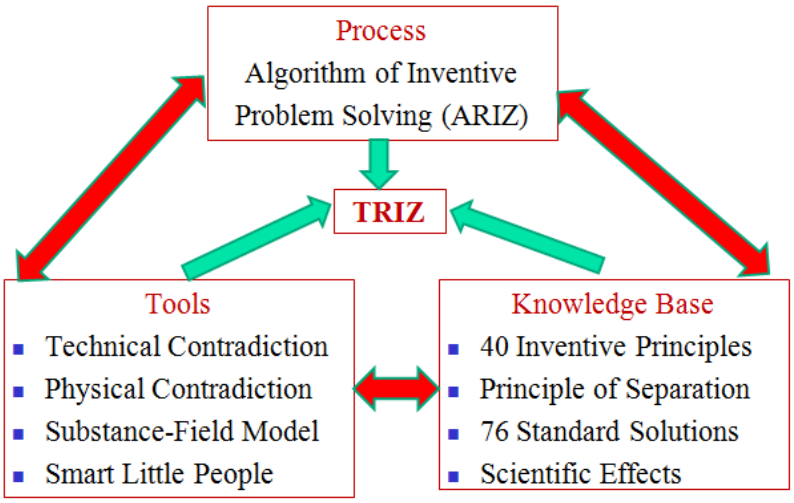

Figure 4. TRIZ's Body of knowledge

In order to prepare students with effective tool to solve the problems inventively, TRIZ is integrated into TNI's Monozukuri education by opening a subject called "Creativity for Innovation and Technology" where TRIZ is taught to help students solve their problems in Monozukuri-related projects with practical examples and real life problems as in Figure 5.

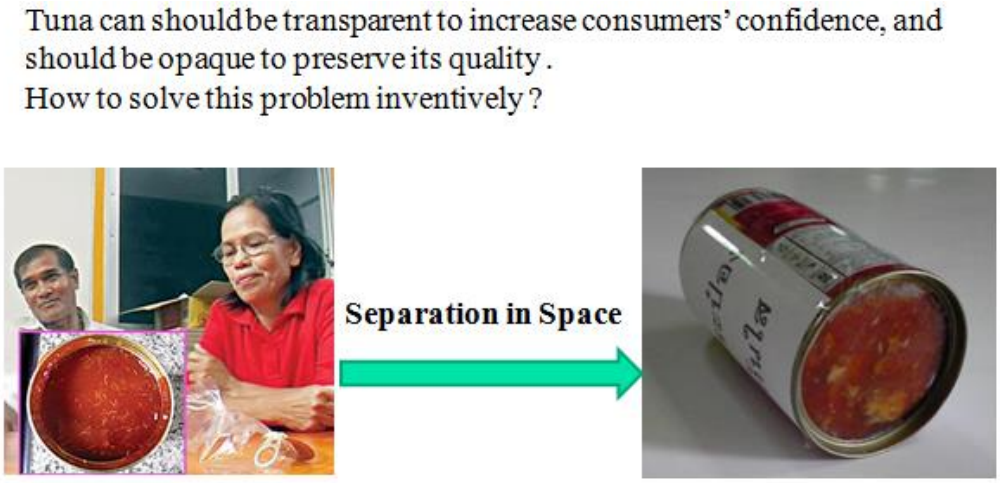

Figure 5. Practical Example for Physical Contradiction

TRIZ is also applied to solve real-life problem in research project as in Figure 6 (Benjaboonyazit, 2014).

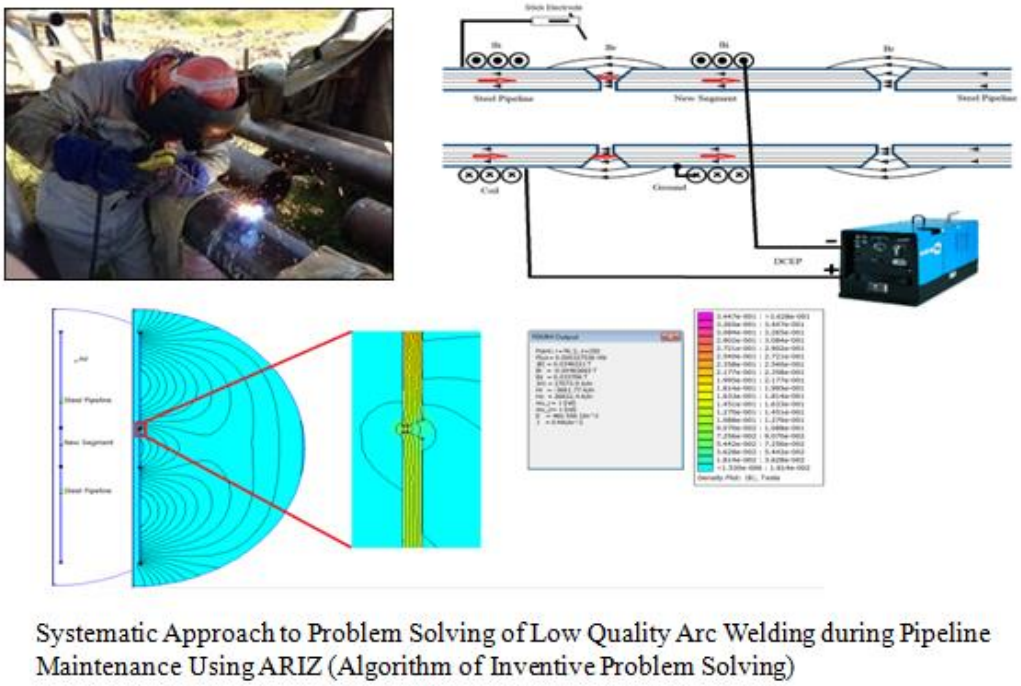

Figure 6. Monozukuri & TRIZ in Research Project

And Creativity Contest where students are divided into groups to find practical problems and solve them with TRIZ is held and exhibited for knowledge sharing as in Figure 7.

Figure 7. Student Creativity Contest

4. Case Study

Case Study of integrating Monozukuri concept with TRIZ in teaching and holding Creativity Contest is demonstrated as below.

▪4.1 Problem Description

The primitive car-wheel-lock with 3 rods welded to the cover plate is effective in illegal car parking enforcement, but is too bulky to carry. To solve this problem, a simple car-wheel-lock has been invented with only 1 rod locked through the frame of the wheel as shown in Figure 8.

Figure 8. Problem of Car-wheel-lock

But the wheel can be easily removed from the car and replaced with the spare wheel after which the illegal car parker runs away with the police's car-wheel-lock.

▪4.2 Problem Analysis

The Engineering System of Car-Wheel-Lock is consisted of components and super-system components as follows,

- Components: Frame, Insert rod, Keyhole, Key, Stop plate
- Super-system component: Police Officer, Car Wheel, Car

The function model of the system can be formulated as in Figure 9.

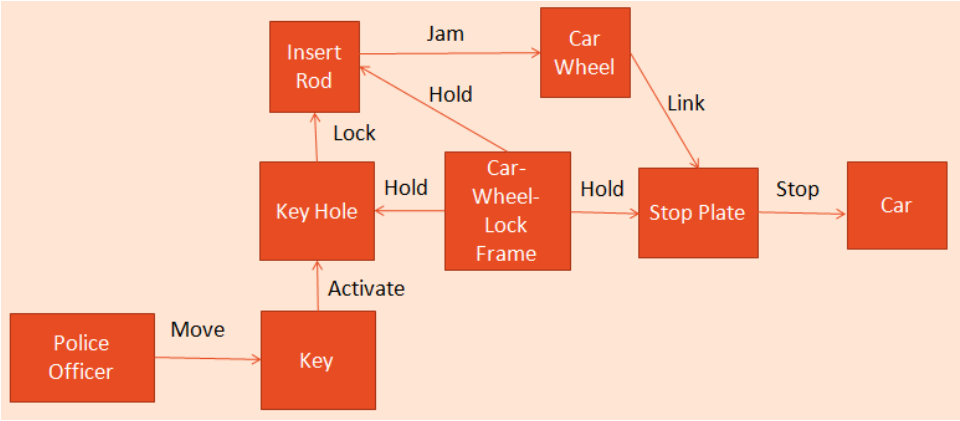

Figure 9. Function model of the Car-Wheel-Lock system

From the Function model in Figure 9, the 1 rod Car-Wheel-Lock looks like functioning perfectly as designed. But the problem occurs when the driver removes the locked wheel and replaces it with spare wheel. It is necessary to find the root cause or key problem. The Cause-Effect Chains Analysis is deployed to find the key disadvantage or key problem as in Figure 10.

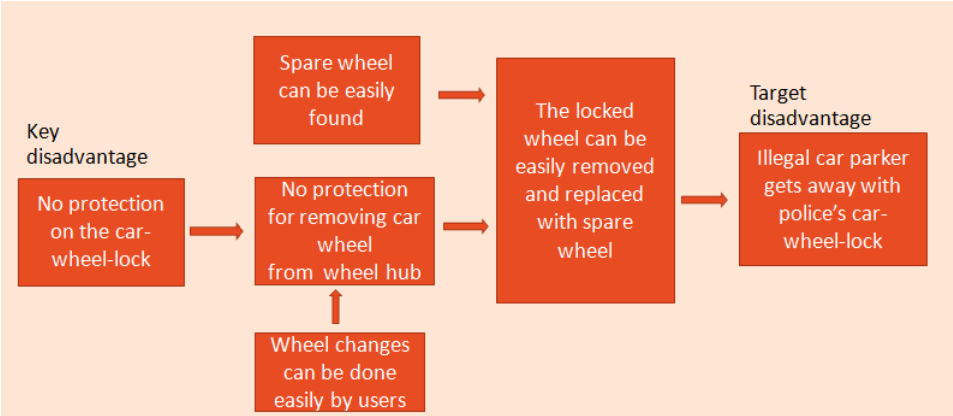

Figure 10. Cause-Effect Chains Analysis

From the Cause-Effect Chains Analysis in Figure 10, the key disadvantage or key problem is identified as no protection on the car-wheel-lock to prevent illegal car parker from removing the locked wheel. The key problem is then analyzed and solved with TRIZ tools as follows,

- Technical Contradiction

The Project team had analyzed the problem and found that there was a technical contradiction between trying to improve the convenience of use and the reliability of the product.

- 40 Inventive Principles

So we tried to solve the problem of technical contradiction by using TRIZ 40 Inventive Principles and had come up with the ideas of using Principles Segmentation, Nesting and Dynamicity to make the car-wheel-lock easier to carry and more effective to enforce the law.

▪4.3 Ideas and Potential Solution

The dynamic car-wheel-lock consists of 3 steel rods with steel plate in the center like that of the primitive car-wheel-lock, but the rods can be nested together to save space and make it easier to carry, and can be expanded to cover the wheel hub which will prevents the locked wheel from being removed as shown in Figure 11 and Figure 12.

Figure 11. Dynamic car-wheel-lock

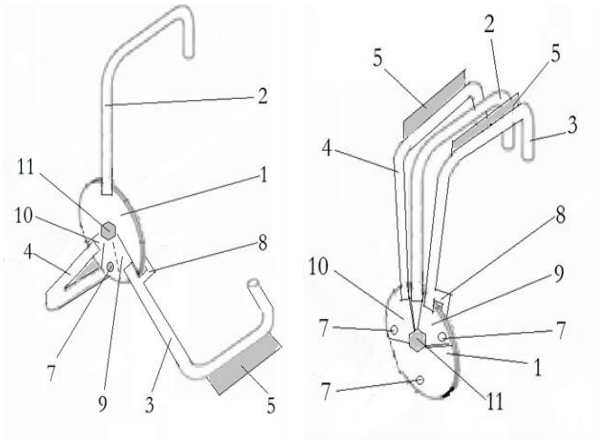

Figure 12. Potential Solution (Patent Pending)

5. Discussion and Conclusions

In this paper, the integration of manufacturing-based Monozukuri concept with TRIZ is explored with the case study on the Thai-Nichi Institute of Technology. By introducing Monozukuri concept into its strategic goals, TNI is on its path to be the center of excellence and to produce high quality graduates with the successful increase of number of graduates from 73 in 2009 to 519 in 2013. Nearly all the graduates are welcomed and employed by the industries (87 %) with other 9 % of continuing study for higher degree and 4 % of self-employed. As the spirit of Monozukuri concept aims to produce high quality and best product, it is necessary to know how to solve the encountered problems creatively.

The integration of TRIZ into the Monozukuri education at TNI has shown satisfactory result with the examples of problem solving using TRIZ in faculty's research projects and in students' project-based learning.

This integration of manufacturing-based Monozukuri concept with TRIZ can be easily extended to manufacturing industries to help them cope with ever-increasing demand from customers for high quality products and services and to be more innovative in new product development for sustainable growth in present environment of borderless competition.

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Fuzzy Set's Logic Based Group's Social – Power Related Problems Resolution[1]

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Abstract

In this paper, the significance of concept of "power" and Fuzzy set's logics is explained briefly in introduction.

This paper presents the one-person system utilizing lewin legacy and field theory of Kenyon B. De greene in clearing the pave for future operations in Group Dynamics.

Firstly, concept of "power" by Locke, explained by M.Jacovides is explained by quoting his writing. Next the concepts of "Power" of Andrew Paul Ushenko explained by R.J.Rummel is also introduced by quoting his writing also.

Secondly, field theory and basic equation concerning base for group dynamical operation in future is explained.

Thirdly some topics about concepts of power, field theory, Kurt Lewin Legacy and other opinions of the presenter is extended.

In this, we can see Kurt Lewin's equation as a field theory. His "life spaces" and moving of points in Topological Spaces are also mentioned. Lastly, Kurt Lewin's social force, social equilibria, derived concepts of "power" as mentioned before, and the presenter's "Levels of power" is also mentioned

Fourthly, state of art of finding in Theory-like of the presenter is explained. Here, one person as the system is also explained by alluding "the limit of Euclid space. Next, the presenter's opinion

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[1] The Presenter would like to express sincere thanks to Prof. Iwai Sosuke, Prof.Katai Osamu and Prof. Nakamuta Kiyohiko my 3 teachers while the presenter was in IWAI Lab School of Engineering, Kyoto University while studying there from 1974 – 1981. Associate Prof. Wai Chamornmarn of Thammasat School of Business for fierce dissussion and Associate Professor Jay Wu, Ph.D. Associate Professor at the Shanghai University of Finance & Economics and Visiting Professor to Thammasat Business School for grateful comments. Lastly, presenter would like to thank Associate Professor Acharawan Ngamyarn of Thammasat business School for great help in running Factor Analysis in computer.

of why only "inward vector" and "outward vector" regard.? is mentioned briefly. What is "Balance" in classical field theory is also mentioned. Lastly, the preliminary limitation of presenter is concluded. That is the insufficient knowledges about sociological classical theory coming next to Talcott Parsons.

Fifthly, fuzzy set and its potential for conflict resolution is introduced in its database potentials and its basic concept of fuzzy set appropriate in modeling human – social affairs. In This section, some relations between dialectics philosophy to fuzzy is shortly indicated.

Sixthly, Case study of conflict of power in family is introduced with diagram from grouping data about problems and Factor Analysis of Intensity of Power based concerned causes' related phenomenon. Lastly, an example of Idea of fuzzy set's conflict resolution in family is picked up.

In conclusion, The drawback of expression of fuzzy set and fuzzy logic which might be that the x-axis must be increasing of decreasing discrete (non-parametric approach) or continuous entities is mentioned again (after mentioning in 6.1) Moreover, the realization of relationalism-like approach as Osamu Katai's works is indicated that it should be studied.

Keywords : Power, Fuzzy set, Locke, M.Jacovides, R.J. Rummel, A.P. UshenKo, Kurt Lewin, Field theory, Family, Conflict resolution, Eclid Space. Life Space

1. Introduction

In Thailand , conflicts by emotion are everywhere. In micro level, "people rift", in office, in family, in university, or macro level, in politics etc. everywhere they are prevalent. By this, the resolution by employing Fuzzy set and fuzzy logic approaches might be useful in some sense expecially in social psychology operation in politics.

In micro level of conflicts, wisdom and religions play great role. But in country level or other macro level, the system must be established in order to stabilize (maintain) the system or reduce the number of loss as much as possible. To this, Fuzzy set and Fuzzy logic might be appropriate because of the power of modeling the vagueness which is the intrinsic character of in-voluntary and voluntary character of people. Moreover, the vagueness in outcome of decision making in some cases might be preferred. The relaxation of mental by relaxing the rule or a little violationg of the rule can not be underestimated. Locally, "Mai Pen Lai" is best Thai people's mental.

Moreover, in Thailand expecially in Bangkok, the "striving for power" is everywhere, in family, in local social systems etc.

We, especially engineer and scientist, who operate social system academically, should clear the concept of "power".

So, the presenter would like to present preliminary presentation of "Fuzzy Set's Logic Based Group's Social – Power Related Problems Resoultion".

2. Concepts of "Power"

2.1 Concept of "Power" By Locke, Explained By M.Jacovides.

From the article of "Locke's Construction of the Idea of Power", written by Michael Jacovides, he suggests by inferring to Locke that "When changes and activites come to happen , the mind takes these data and infers "from what it has so constantly observed to have been, that the like changes will for the future be made, in the same things, by like agents, and by like ways" "After making this prediction, the mind considers in one thing the possibility of having any of its simple "Ideas" changed, and in another the possibility of making that change". (including action….Parenthesized by presenter). More elaboratingly, from the same article, Locke says that the product of the mind's construction is that it comes to consider "in one thing the "possibility" of having any of its simple Ideas changed, and in another the "possibility" of making that change and so comes by that Idea which we call Power". The same article also says that … "the idea of Power that Locke describes is the idea of a sort of possibility and they are not pushes, forces, or strivings."

2.2 concepts of "Power" Explained By R.J. Rummel.

From the article "Understanding Conflict And War : Vol.1 : The Dynamic Psychological Field, Chapter 5, The Field Of Power" 1975, by R.J. Rummel explains the followings. He infers significantly to philosopher Andrew Paul Ushenko's 1947 writings. R.J. Rummel says that,

"Ushenko's central philosophical concern is with the "dispositional" properties of objects, with their meaning and nature, and most important with their implications for understanding the mutual relations between person and reality.

R.J. Rummel says that ""dispositions" become a key concept for unlocking the nature of person and reality….. usually we focus on the manifestation of a disposition, and it is the manifestation of a disposition that interests us.

"It is actuality of our world that most interests us. It is Ushenko's contribution of focus instead on potentiality as opposed to actuality on the power of objects to be a specific manifestation, and …..We experience power as an imposition of causal compulsion and observe it as a mode of indeterminancy and in stability. Actuality is but a momentary meeting and cancellation of opposed tendencies."

"A Momentary settlement among conflicting powers or this actuality is but a perspective, a point of view. In essence the physical world is a power or potentiality, to be realized, on the scale of human perception and transaction ……."

R.J. Rummel also says that "power has direction, a bearing, and intensity". "It is therefore a vector. However, by vector Usheko does not mean a construct or a mathematical entity, he means an actual tendency that exists in reality……. An example adopted from Ushenko may make this clear. Consider a set of tiles, each a different shade of blue formed by mixing white with blue in increasing proportions, such as 1:5, 1:4, 1:3. Now, arrange these tiles in order from lightest of darkest blue. By our sense of color, these shades should show a clear progression. Psychologically we will note a missing shade as a gap, even if we had never seen the shade before, and we could even fill in what the shade should be. This gap is therefore a power, a tendency to be completed by a specific appearance. It is a psychological pressure toward resolution of the gap, toward balance; and this power has direction and the pressure to completion, a felt magnitude. To understand the directionality, consider that a shade of blue out of order would be spotted immediately and that there is only one shade of blue that can fill the gap."

The article also says the followings. …….. "these vectors are observable, as are the gaps in the blue tiles, and basically enable us to distinguish between the self and external reality. Experience consists of two kinds of vectors. There are inward vectors, comprising our experience of something bearing upon us, of an external pressure of compulsion to be sensed such as a crying baby, a dripping faucet, or a sudden clap of thunder. The second kind are outward vectors, consisting of our resistance to the external vectors and our practical judgment. Outward vectors give us our definitions and feelings of them. They are our manifestation of power to control reality. The inward and outward vectors are in dynamic balance and the point of the balance – a point of tension—defines the distinction between person and environment."

"These opposing vectors also enble us to understand the nature of the cognitive meaning and truth of statements or propositions. Words of concepts can only be understood in the context of a proposition which itself is an enactment of meaning, a disposition in dynamic tension. And this tension is a dynamic balance identical to that between self and the environment. There is in understanding the meaning of a proposition an outward vector consisting of one's expectation imbedded in the descriptive part of a proposition, and the inward vector which defines the verifying expectation concerning the proposition's reference. Both inward and outward vectors are powers; the balance between them defines belief. Doubt is the inequality in the strength of the vectors, where the outward expectation exceeds the inward verification; belief is an equal strength between the two. Then, a truth claim is dynamically equivalent to a pattern of balanced tension in the field of meanings."

"There is truth in art, in science, and in philosophy. These truths are all similar in being based on a real or objective tendencies, that is, on powers. In order to become public knowledge,

however, these powers must be made actual and discernible. Because power and actuality are different states of real being, the change from power to actuality must involve a transformation. The means of transformation is a perspective."

"In reality there is a complex of alternative and entwined powers—tendencies. Which of these powers is to be disentangled from the rest and actualized depends on the perspective brought to bear, for a perspective can present only one aspect at a time, and this is identical to separating and manifesting a specific power."

…. "For Ushenko. There is no reality beyond our perspective. There is only a complex of powers, each one a tendency to be made actual by means of a perspective."

3. Field Theory and Basic Equation of Kurt Lewin

3.1 Field Theory By Kenyon B. De Greene

From the article of "Field Theory as a Framework for the Computer Simulation Modeling of Complex Societal Systems", (no date of Publishing indicated) K. B. De Greene. says that "Field theory views the behavior of any system as being a function of the interaction of the system and a field of environmental forces."

3.2 Basic Equation of Kurt Lewin

Kurt Lewin was a leader of the institution studying " Group Dynamics" in Massachusetts Institue of Technology from 1944. His notorious proposal of basic equation is that the behavior of a person is function of that person (ality) and environment. What is more is The person (ality) is the function of environment. In summarizing, Behavior of a person

Be = F1 (Person, Environment)

Person = F2 (Environment)

As the result

Behavior of a person = F (Environment)

We should be noted here firstly that "environment" means the setting of topological attributes (Axes) defining the behavior of person in the same topolagical space. Secondly, Kurt Lewin uses the word "person" not "personality". Thirdly, he uses the word "life space" instead of "environment" which presenter tries to mean "concerned (relavant) or connected environment". And presenter also agrees on the points of view of R.J. Rummel in separating the various type of fields such as psychological field, field of social – psychology, field of power as such etd. Let presenter denotes that R.J. Rummels approach is quantitatively under Euclid space.

The presenter would like to express that, in some specific field, behavior of a person might be the shift of point in such field in the same topological "life space" or crossing the topological "life space". (See Diagram 1)

And the real objective of operating social system especially politics, should be focused on the balance of "powers" (in Ushenko and Locke's sense) not only the balance of "forces". In presenter opinion, "social forces" indicated in Kurt Lewin's "Frontiers in Group Dynamics : Concept, Method and Reality in Social Science : Social Equilibrium and Social Change", Human Relations 1947 are "powers" in Locke Ushenko and R.J. Rummels sense

It should be noted here also that Kurt Lewin uses the word "Equilibria" more than the word "balance" It might be lower level of power than In Ushenko's sense

4. Some Topics About Concepts of Power, Field Theory, Kurt Lewin Legacy and Other Opinions of the Presenter.

4.1 Kurt Lewin's Equation As a Field Theory

Kurt Lewin himself has stated that he is inspired in his work by Alfred Einstein. As mentioned before, "Field theory views the behavior of any system as being a function of the interaction of the system and a field of environment forces", we can say that, in taking personality as system or a person's status (state), the Kurt Lewin equation,

Behavior of a person = F (person, Environment)

would possess Field Theory approach, by taking person as such the "System".

4.2 Kurt Lewin's Life spaces and Moving of Points in Topological Spaces.

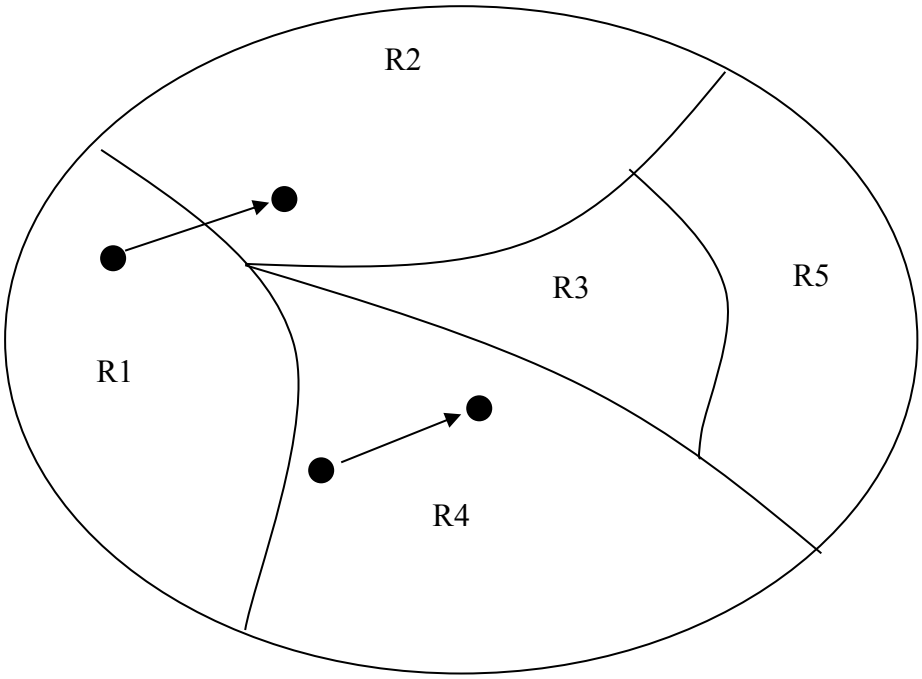

Diagram 1 Kurt Lewin's Life Space as Partly Illustrated by Iwai's Lab. Adapted by Presenter

R1, R2, R3, R4 and R5 are life spaces of a person in an relavant environment. (life spaces). These are represented as Euclid Topological Space. Each one possess the same number of dimensional attributes.

At one moment one posseses oneself status (state) represented as a point. The changing of point is simply called "Dynamical Changing"

The moving (shift) of points across life space or within life space may denote the behavior of a person such as "action" of a person, changing of emotion, changing of status (State) of a person etc. in some specific field. (for example Power Field, Social – Psychological Field, Psychological Field etc. as mentioned by R.J. Rummel)

4.3 Kurt Lewin's Social Force, Social Equilibria, Concept of Power and Presenter's "Levels of Power"

From "Frontiers in Group Dynamics : Concept, method and Reality in Social Science ; Social Equilibria and Social Change", Kurt Lewin, Human Relations 1947 1 : 5 content /1/1/5)

He says something about social force with example of "discrimination" problem. He uses "equilibria" of opposing social force".

The presenter would like to express that Kurt Lewin's opposing "social force" is opposing "inward power vector" and "outward power vector" in some sense. Usually, Ushenko and R.J. Rummel discerns "power" from its "manifestation". (push, force or striving). Kurt Lewin uses frequency uses disruption violence and like – happening as its "manifestation".

The reconciling idea might be that "power" has many "levels" into "hierarchical order", says "more deep or more shallow"

Ideally, it is already known that we should concern with also "deep contradiction of power" not only solving "manifested phenomena" or "current day by day problems" or as solution, we should solve them both at the same time.

5. State of Art of Finding in Theory–like : Only One Person as the system and a Limit of Euclid Space

5.1 Field Theory

As stated by K. Be Greene that "Field theory views the behavior of any system as being a function of the interaction of the system and a field of environmental forces" the presenter take only one person not a group of persons as concerned system in this sense. This is interpretation in view of presenter to Kurt Lewin basic equation which might relate to the "Theory of action" of Talcott Parsons and shils (a well known sociologist) stance.

In setting a system of one person, we interprete that other persons and other factor are environment as Kurt Lewin's basic equation.

Behavior of a person = F1 (person, Environment)

Person = F2 (Environment)

As the result

Behavior of a person = F (Environment)

If we treat other persons behavior and other factors as environment, a Euclid Space's topological behaviors could be illustrated with the whole system of person and environment as behavior of "Attribute Axes" and moving point in the space.

What should be noted is that, as R.J. Rummel's legacy , we have to separate many spaces such as space of Field of power space, Field of socio-psychological space, as such etc. Factor Analysis should be done and utilized to reduce the matrix' size, that is number of axes, and reinterprete the on coming axes in many times.

5.2 The Limit of Euclid space

At this R.J. Rummel Legacy, Osamu Katai's (also in Iwai Lab, both Osamu Katai and Iwai Sosuke is presenter's teacher) Leibnizian spactio – temporal fields, (utilizing Peirce's existential graph concepts) should be scrutinized seriously because, in this new expression of phenomenon, the philosophy of "relationalism" can be realized and we could illustrated comprehensively the "agents" ("entities") and the "predicate" ("action" or "activities" or "phenomenon's content") in the same space which Euclid space can not do easily.

More over, It can be in line with the philosophy of "Phenomenology" of Kant's legacy. (But in presenter opinion "heuristic approach" is still prevalent.)

5.3 Why Only "Inward vector' and "Outward Vector" Regard

In operation of the social system, the Factor Analysis like approaches (reducing the number of axes) are employed.

We can not always reduce the system into number of factor arbitrarily. But why only "Inward vector" and 'Outward Vector" concern? In very deep sub – sub system, it is convenient to employ dualism which will comprehend us. At this point Fuzzy set's philosophy emerges. This is mentioned in Osamu Katai's "last lecture" in Japanese at one temple in Kyoto City.

5.4 What is "Balance" in Classical Field Theory?

In Uclid Spaces expressing field Theory, if one attribute changes the

quantity the point in space will change crossing life-space or within the same life – space as mentioned before. At one moment , in R.J. Rummel's social – power space (field), the tendency of maintaining one person's power (one co-ordinate of axes) (Outward vector) against the other co-ordinates (Inward vector of environments) is the "Balance". It is the maintaining the form of equation.

The moving of person as a changing of state could be interpreted either "action", "emotional expression", "voluntary action", "committing violence" etc. Usually it can not be predicted precisely but we can accumulate the database of data unto more precise in predictive illustrated in Kurt Lewin's "hunband and wife affair" which is in article mentioned in 4.3

In conclusion , the ideal static balance can not be attained, because system is dymanical but rather good stability may be attained. One way of this is in Talcott Parson's approach is in AGIL – Shema. (See "Talcott Parsons' AGIL Schema – based system Identification of

Administrative Problems of North – East Vocational Education In Thailand", Surachai Tumtavitikul, Thammasat Business School, 2013)

5.5 The Preliminary Limitation of Presenter.

Presenter would like to be permited to confess that approach of advancement in sociology like Luhman's approach which utilizes the base component of "communication" not "orientation of action" as Talcott Parson and A Shils' classical "Theory of action", or "mutual interaction"-like legacies of Mead as such classical sociology and also the advancement in Kurt Lewin's Legacy are above presenter's state of art.

6. Fuzzy Set and Its Potential for Conflict Resolution

6.1 General description of fuzzy set and approaches for operating data for conflict Resolution

Fuzzy set is the expression form for the fuzzy phenomena in the world. Its character and philosophy posses great unbelievable deepness because it presents the world as non – dualism and is very appropriate to express human behavior which is fuzzy in nature. Thus its logic cannot be under – estimated in conflict resolution.

The drawback of this expression of Fuzzy set and Fuzzy logic might be that the x-axis must be increasing or decreasing discrete (non-parametric approach) or continuous entities.

In confessing, the presenter have not surveyed the new development of the state of art of x-axis by now.

They are 2 ways of operating the so called "conflict resolution approaches"

First, the operation of x-axis as discreate (non-parametric approach) or contionuous entities of increasing or decreasing entities.

The second, is the operation of nominal entities on x-axis which well know paper is "Modelling of Human Learning Behavior Through Inference by Analogy using Fuzzy set and Its Application to an Information Retrivel System", by Nakamura Kiyohiko (also the student of Iwai Lab some 38 years ago and now professor of Brain Science and Engineering of Tokyo Institute of Technology) In this second approach the learning of database tanks can be done which give clues to operation in Lewin – Style approach of "husband and wife" example mentioned in article in 4.3

Presenter will not mention the second approach but will instead mention the basic conflict Resolution Scheme. by utilizing fuzzy set and fuzzy logics approach.

6.2 Possibility of Fuzzy Set Logic To Conflict Resolution

Tantative mentioning of basic type of logics are

"And"

"Or"

"If A then B"

"And" is the combination of concepts. It gives one way of resolution type.

"Or" is the combination of concepts. It gives one way of resolution type.

"If A then B" is very interesting. Firstly, if we have Database of "If A then B", we may infer the new consequence B' from new A' or infer causal new A' from new consequence B'

It should be noted that these give power to the conflict resolution. The basic significance Fuzzy set still is the of power of expressing subjective ideas and human related phenomenon itself.

6.3 The further approach

The further approach should be done to converting the x-axis of increasing or decreasing discrete (non-parametric approach) or contionuous unto x-axis of nominal scale as Nakamura Kiyohiko approach which relates to database system in human –related phenomena.

This is very rough explaination of the presenter

6.4 Fuzzy Set and some Dialectics Philosophy

6.4.1 Fuzzy set as Embedded Contradiction Within One Unit.

In selecting appropriate x-axis entities, we might express the contradiction within one fuzzy set. That is the unification of contradiction.

6.4.2 The Resolution Between Contradictory Set

It might be done by using the logic of "And", "Or", "If A then B". Furthur study in this point should be done.

7. Case Study of conflict of Power in Family

7.1 Description of Case

In one Chiness descendent Christian family in Thailand. The family consists of one elder mother (85 years-old) and 3 sons. (each 62, 60, 59 years-old). Each of the sons have their own family. The mother lives with 60 years-old son which newly married with 53 years-old Chiness descendent Thai wife. (His first wife passed away 12 years ago with no children)

This second son possesses some nervous problem working as university researcher and goes to one Chinese Church every Sunday with his wife and old mother.

The Church society possesses great influence to whole family's members. It should be noted here that the 60 years-old son possess dependency character. The conflict arrives when the mother with strict character impacts the behavior of new wife. The Tensions arrive which cause nervous tensions within this 3 persons family (mother, son and newly wedded wife).

As a result, son and his newly wedded wife move to live in a near-by apartment and the son goes to see his mother everyday as a solution.

7.2 Result From Grouping Data About the Problems and Factor Analysis of Intensity of Power Based Concerned Causes' Related Phenomenon. (Diagram 2)

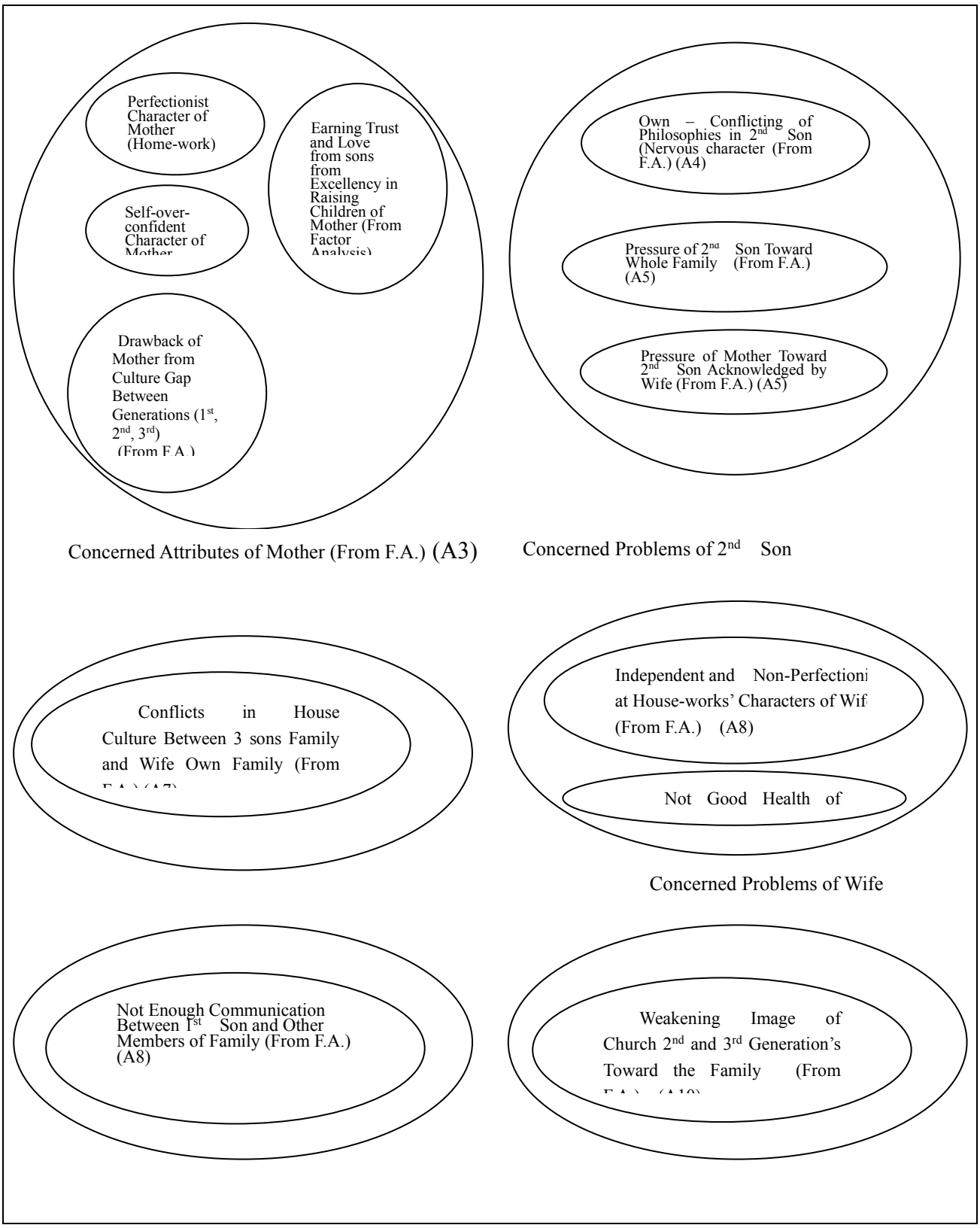

Diagram 2 Result From Grouping Data About the Problems and Factor Analysis of Intensity of Power Based Concerned Causes' Related Phenomenons.

7.3 An Example of Idea of Fuzzy Set's Conflict Resolution approach In Family

For an example, we take one contradiction in family. This is the habit of perfectionist in house-work of mother and habit of non-perfectionist in house-work of wife which could be the following set as an example.

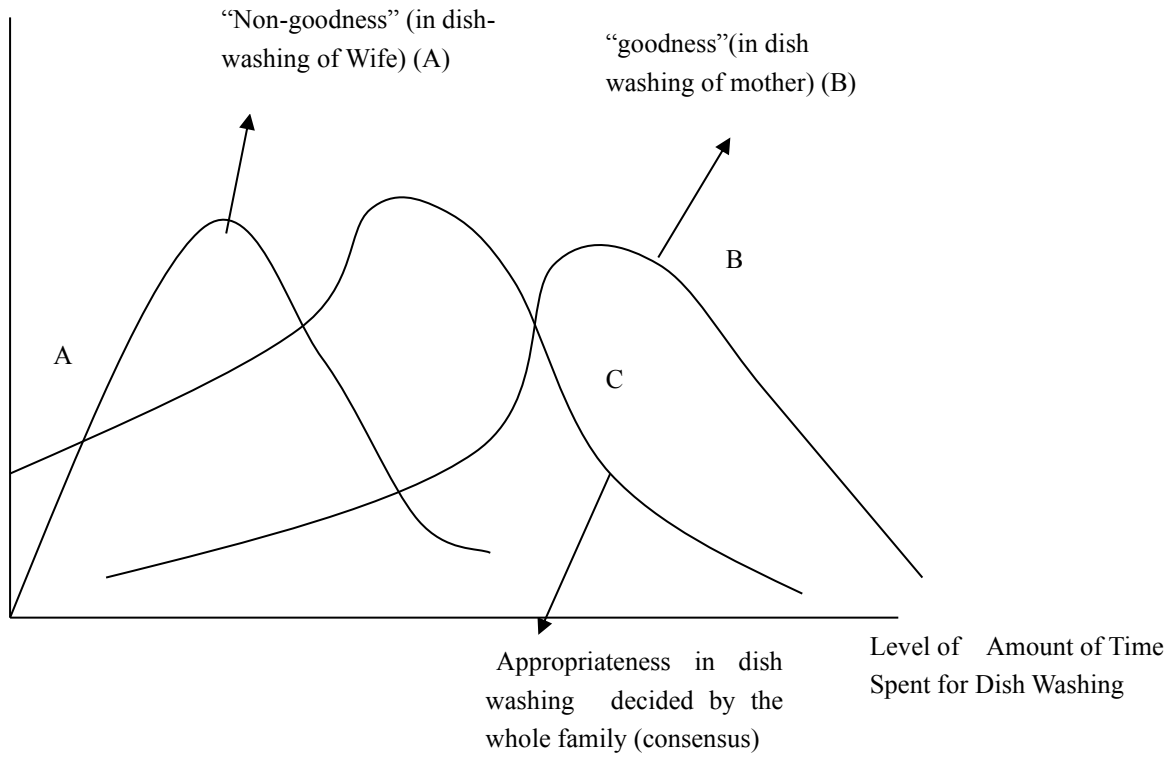

Diagram 3 Example of Conflict Resolution Approach

From precedent data, we can illustrate "If A then ~ C"., "If B then C", "If A or B then C" , " If ~ A and B then C" "If A then ~ C and ~ B" etc. as an examples. In these approach we could find the appropriate fuzzy set of appropriate time spent for dish-washing as resolution, such as Find new A' from database, find new C' from database, but we can not find new B from database because the mother is too old to change the habit.

8. Conclusion

In this writing the concept of "power" is firstly explained. Secondly, Field Theory and basic equation of Kurt Lewin and some topics about concepts of power, field theory, Kurt Lewin legacy and other opinions of the presenter are presented. Thirdly, state of art of finding in Theory-like : Only one person as the system and a limit of Euclid space is extended. Fourthly, Fuzzy set and its potential for conflict resolution is concluded. Finally, case study of conflict of

power in family and an example of idea of Fuzzy set's conflict resolution approach in family is explained.

In conclusion, Field Theory, Lewin Legacy and their relationship to concept of power and Fuzzy Logic in this paper could not be said successfully integrated and explained by the presenter. Kurt Lewin successor have said something about power. This should be studied further. The rule of fuzzy set and fuzzy logic posses great potentiality. The real definition of concept of power by fuzzy set should extended theorically above presenter's rough idea.

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Systematic Approach for Developing Innovative Business Models based on Morphological Matrix - Case Study of Grilled Chicken Shops

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Abstract

Nowadays, the research on developing innovative business models has attracting more attentions of academia and industry. However, there are few systematic methods on this research as the business model relates multi-disciplinary domain knowledge. Most of prior studies on developing business models only focused on conceptual or theoretical perspectives. In this paper, we proposed a systematic approach for developing innovative business models based on morphological matrix.

Firstly, we analyzed the situation of the focused business model elements to construct the dimensions of morphological matrix. Based on the dimensions and the kinds of instances in each dimension, many possible business model options were generated. Then cross-consistency assessment (CCA) was conducted to remove the business models with low possibilities and reserve the business models with high possibilities. Finally, to demonstrate the practical application of this proposed method, a case study of a grilled chicken shop was illustrated. The contribution of this paper is that it not only provides a systematic approach to develop and evaluate innovative business models but also can be readily employed in practices.

Keywords: Business Model, Morphological Analysis, Systematic Innovation, Cross-Consistency Assessment.

1. Introduction

Currently, the research issue on business model has attracted more and more attention of academia and industry (Timmers, 1998; Linder and Cantrel, 2000; Chesbrough & Rosenbloom, 2002; Osterwalder and Pigneur, 2005, Bouwman et al., 2008, Teece, 2010, Souchkov, 2007; Pereira & Caetano, 2015). The start-up research on business was initiated in 1990s, and it relates a wide range of multi-disciplinary knowledge. Moreover, the theoretical bases of economics or finance have not yet been established for business model (Teece, 2010). Therefore, most of prior studies only focused on the definition of the business model, definition or description of the necessary element in business

models and classification of business models. They almost concentrated in conceptual or theoretical perspective. Now, it still lacks systematic approach research methods to develop and evaluate innovative practical business models.

Morphological analysis method was developed by the Swiss astrophysicist and aerospace scientist, Fritz Zwicky (Zwicky, 1948). It is applicable to build and investigate multi-dimensional, non-quantified, complex problems including a total set of relations. Currently, this method has been applied to many disciplines such as engineering, design and management (Higgins, 1996; Yoon & Park, 2005; Kim et al., 2008; Hsiao et al., 2010).

Since the morphological analysis method is suitable for forming the combination of multiple dimensions instances, it is appropriate for combining some key business model elements to form various instances of innovative business models. Therefore, in this paper, we adopted the morphological analysis method to create the preliminary business model instances. The cross-consistency assessment (CCA) analysis was used to evaluate these instances and delete the business model instances in which there is at least one contradiction or low possibility between pair-wise elements. To illustrate the procedure of the proposed method, a case study on creating feasible business models for grilled chicken shops was demonstrated.

The rest of the paper is organized as follows. Section 2 describes the literature review on the development of business model and morphological analysis method. Section 3 illustrates the research methodology proposed in this paper. Section 4 demonstrates the case study and Section 5 is the conclusion.

2. Literature Review

Since the early 1990s, many scholars in various disciplines, such as economy, management, e-commerce and entrepreneurship, have participated in the researches of business models (Amit & Zott, 2001; Hedman & Kalling, 2003; Teece, 2010). However, due to the lack of rigorous theoretical bases, the early concepts of business model was discrete. This resulted in that most of scholars only had a vague cognition on this particular research (Linde and Cantrell , 2000). Currently, the researches and applications on business model own various perspectives and concepts. **Table 1** shows the some definitions of business model proposed by different scholars.

In **Table 1**, Osterwalder and Pigneur (2010) presented a more detailed but compact architecture, called Business Model Canvas. This architecture consists of nine elements in three constructs: interaction between customer and enterprise, internal management of enterprise and revenue/cost, respectively. **Figure 1** shows the business model canvas proposed by Osterwalder & Pigneur (2010) and **Table 2** shows the elements in the canvas.

Table 1. Some definitions of business model proposed by different scholars

Author(year)	Proposed Definition of Business Model
Timmers (1998)	A description of key components defining a business idea, including products and services, actors, roles, information, revenue, and benefits.
Linder and Cantrell (2000)	organization's core logic for creating value
Chesbrough and Rosenbloom (2002)	Logic for the way a business creates and captures value from new services or products.
Osterwalder and Pigneur (2005)	A conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm.
Bouwman et al. (2008)	A business model illustrates how a company or stakeholders aims to make financial benefits or network value and create consumer value from a specific service offering
Casadesus-Masanell and Ricart (2010)	An articulation of the logic, the data and other evidence that support a value proposition for the customer, and a viable structure of revenues and costs for the enterprise delivering that value
Osterwalder and Pigneur (2010)	A business model describes the rationale of how an organization creates, delivers, and captures value

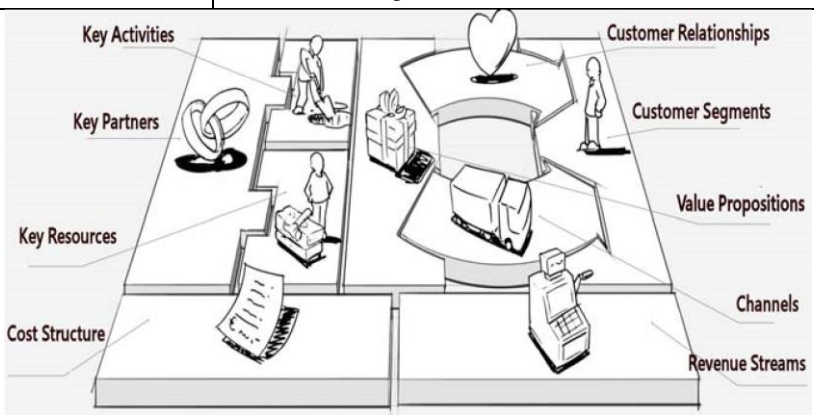

Figure 1. Business Model Canvas (reproduced from: Osterwalder and Pigneur, 2010)

Table 2. Definition of Each Element (or Block) in Business Model Canvas. (reproduced from: Osterwalder & Pigneur, 2010)

Component	Definition
Customer Segments	the different groups of people or organizations an enterprise aims to reach and serve
Value Propositions	the bundle of products and services that create value for a specific Customer Segment
Channels	how a company communicates with and reaches its Customer Segments to deliver a Value Proposition
Customer Relationships	the types of relationships a company establishes with specific Customer Segments
Key Resources	the most important assets required to make a business model work
Key Activities	the most important things a company must do to make its business model work
Key Partnerships	the network of suppliers and partners that make the business model work

Revenue Streams	the cash a company generates from each Customer Segment (costs must be subtracted from revenues to create earnings)
Cost Structure	all costs incurred to operate a business model

Morphological analysis is a practical method that the targeted subject is broken down into several dimensions, through which the subject can be described as comprehensively and detailed as possible (Wissema, 1976). The result after using morphological analysis method will generate many possible options. Therefore, it is necessary to delete some options which are contradictory or useless, i.e., to implement internally consistent assessment to reduce solution space. This evaluation means was said as cross-consistency assessment (CCA). The huge amounts of options can be reduced to a manageable number of options to examine.

3. Methodology

The systematic approach for developing innovative business models in this paper was shown in **Figure 2**. First, we analyze the situation of targeted problem and describe the business model elements based on business model canvas proposed by Osterwalder and Pigneur (2010)**.** Then we select focused elements of business model and assign the instances on each element.

Based on morphological analysis method, we can generate all possible business model options by combining the selected instances for each element. As the amount of all possible options is so huge, we need to conduct the internal consistency assessment to delete the business models with low feasibility and reserve the business models with high feasibility.

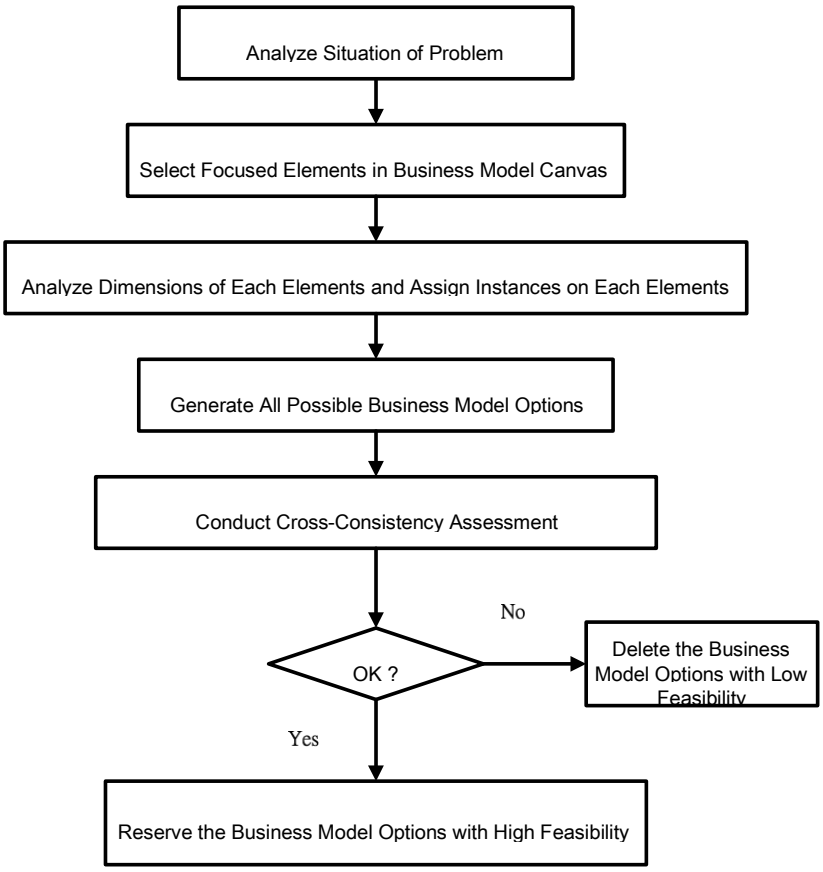

Figure 2. Systematic Approach for Developing Innovative Business Models in This Paper.

4. Case Study

To demonstrate the practical applicability of this proposed method, a case study on the development of a business model for grilled chicken shops was illustrated. As a business relates many affairs and stakeholders, we need to set the limit of the scope (image the scenario) to focus the targeted problem. The scenario was described as below:

Scenario: A grilled chicken shop was located in Taipei city in which there are many universities, business company and residence houses. In other words, the potential customers for the grilled chicken shop may include college students, office workers and housewife. The problem is: the boss of the grilled chicken shop was confused how to sell lunch for these potential customers with the combination of which channels and what kind of food types so that the business has higher successful possibility.

Based on the above-mentioned scenario, we found that there are three elements of business model canvas (Osterwalder & Pigneur, 2010) – customer segments, channels and value propositions in the problem. In this problem, we want to use morphological analysis method to solve this problem. To avoid too huge amounts of options resulted from the combination of many instances in these three dimensions (customer segments, channels and value propositions), we assigned a small amount of

instances of each dimension to form a morphological matrix as **Table 3** and set definition on each instances (in **Table 4**). There are 12 (2 × 3 × 2) kinds of business model options in this problem.

Table 3. Morphological Matrix for Business Model of Grilled Chicken Shops

Element of Business Model (Dimensions)	Instance 1	Instance 2	Instance 3
Dimension 1 -Value Proposition (V)	Healthy and Delicious Whole Chicken (V1)	Healthy and Delicious Set Meal (V2)	
Dimension 2 -Customer Segment (Cu)	Office Worker (Cu1)	House Wife (Cu2)	College Student (Cu3)
Dimension 3 -Channel (Ch)	Virtual Channel (Ch1)	Physical Channel (Ch2)	

Table 4. Description of Instances in the Elements of the Focused Elements

Elements in Business Model Canvas	Instance	Definition
Value Proposition	Healthy and Delicious Whole Chicken	A healthy and delicious grilled whole chickens with different flavors for customer's selection
	Healthy and Delicious Set Meal	A healthy and delicious set meal consists of a part of chicken (leg, wing or chest), rice, vegetable, and beverage.
Customer Segment	Office Worker	Employee who work in offices on daytime
	House Wife	Women married and stay home for household affairs
	College Student	Student who enrolls in university
Channel	Virtual Channel	Telephone, Email, Internet or Television shopping channel
	Physical Channel	Brick-and-mortar shops or stalls

Then we conducted the cross-consistency assessment (CCA) to evaluate the possibilities of all the business model options. During the assessment process, the signs indicating the comparability of pairs of conditions were assigned. Three signs are used in CCA: "H" means high possibility; "I": intermediate possibility; and "L": low possibility. **Table 5** shows the cross-consistency assessment for each pair-wise instances and **Table 6** shows the result of consistency evaluation for possible business model options. In **Table 6**, we found that seven options (options 2, 3, 5, 6, 8, 9, 11) contained low possibility (L) in them. Therefore, we delete these business models with low possibilities and remained 5 options (options 1, 4, 7, 10, 12). The reserved five feasible business models were shown in **Table 7**.

Table 5. Cross-Consistency Assessment for Each Pair-wise Instances

		V		**Cu**			**h**	
		V1	V2	Cu1	Cu2	Cu3	Ch1	Ch2
V	V1							

	V2							
Cu	Cu1	*I*	*H*					
	Cu2	*H*	*I*					
	Cu3	*L*	*H*					
Ch	Ch1	*I*	*H*	*H*	*L*	*L*		
	Ch2	*H*	*H*	*L*	*H*	*H*		

Legend: "V": Value Proposition; "Cu": Customer Segment; "Ch": Channel
"H": High Possibility; "I": Intermediate Possibility; "L": Low Possibility

Table 6. Result of Consistency Evaluation for Possible Business Model Options

Options of Business Model	Value Proposition	Customer Segment	Channel	Consistency Evaluation (Feasibility)
1 (V1-Cu1-Ch1)	Whole Chicken	Office Worker	Virtual Channel	*IIH*
2 (V1-Cu1-Ch2)	Whole Chicken	Office Worker	Physical Channel	*IHL (Low)*
3 (V1-Cu2-Ch1)	Whole Chicken	House Wife	Virtual Channel	*HIL (Low)*
4 (V1-Cu2-Ch2)	Whole Chicken	House Wife	Physical Channel	*HHH*
5 (V1-Cu3-Ch1)	Whole Chicken	College Student	Virtual Channel	*LIL (Low)*
6 (V1-Cu3-Ch2)	Whole Chicken	College Student	Physical Channel	*LHH (Low)*
7 (V2-Cu1-Ch1)	Set Meal	Office Worker	Virtual Channel	*HHH*
8 (V2-Cu1-Ch2)	Set Meal	Office Worker	Physical Channel	*HHL (Low)*
9 (V2-Cu2-Ch1)	Set Meal	House Wife	Virtual Channel	*IHL (Low)*
10 (V2-Cu2-Ch2)	Set Meal	House Wife	Physical Channel	*IHH*
11 (V2-Cu3-Ch1)	Set Meal	College Student	Virtual Channel	*HHL (Low)*
12 (V2-Cu3-Ch2)	Set Meal	College Student	Physical Channel	*HHH*

Table 7. Reserves Five Feasible Business Model Options

Alternatives of Business Model	Value Proposition	Customer Segment	Channel
1 (V1-Cu1-Ch1)	Whole Chicken	Office Worker	Virtual Channel
4 (V1-Cu2-Ch2)	Whole Chicken	House Wife	Physical Channel
7 (V2-Cu1-Ch1)	Set Meal	Office Worker	Virtual Channel
10 (V2-Cu2-Ch2)	Set Meal	House Wife	Physical Channel
12 (V2-Cu3-Ch2)	Set Meal	College Student	Physical Channel

5. Conclusion

In this paper, we proposed a systematic approach to create business model options with morphological analysis method. Moreover, a practical case study was demonstrated to show the detailed process and its applicability. The proposed method is generic and feasible for other similar cases. The contribution of this paper is that it not only provides a systematic approach to develop and evaluate innovative business models but also can be readily employed in practices.

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Algorithm for Work Improvement (AWI)

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Abstract

TRIZ is a powerful tool to create innovative solutions. It can be applied to product innovation, process innovation in different business environments. Continuous work improvement is almost a daily job of most of the organizations in order to confront tough competitions. Various methodologies have been invented in the past for continuous work improvement such as Six Sigma, Lean, TQM, etc. Most of these methodologies are powerful on the analytical side, for instance, Six Sigma. It has the methodology of comprehensive study of DMAIC (Define, Measure, Analyze, Improve, Control). However, how to "Improve" is not stated. TRIZ is therefore a good match to create innovative ideas for continuous work improvement to fill up this "I". An Algorithm for Work Improvement (AWI) based on TRIZ is thus developed. AWI selects and combines various basic tools of TRIZ to create work improvement innovative ideas. It can be applied to all types of organizations who are seeking work improvements opportunities.

Keywords: Contradictions, Functionality, Trimming, TRIZ, Work improvement

1. Introduction

In this business world, no matter what type of products or services they are offering, organizations are working hard to improve their products or their processes in order to meet the competitions. Continuous improvement is one of their key daily tasks to stay ahead to their competitors. They have to reduce costs, simplify products, and rationalize production processes to keep the leadership role in their business environment for survival. They are required not just to face the needs of the customers, solve their problems but also to delight them.

Theory of Inventive Problem Solving (TRIZ) is not simple. There are many tools being involved in the TRIZ theory. Users have encountered difficulties of choosing appropriate tools to drive fast and useful solutions. In view of this, a work algorithm named as Algorithm for Work Improvement (AWI) that adapts TRIZ tools for work improvement is proposed and presented in this paper.

In this paper, theoretical background of the selected TRIZ tools is firstly introduced. They include Functionality, Trimming, Ideality Thinking, Contradiction and Inventive Principles. An integrated

algorithm based on TRIZ using various tools is thus formed. Finally, a case study is presented to demonstrate the application of the Algorithm for Work Improvement (AWI)

2. Roadmap of the Algorithm for Work Improvement

The roadmap for work improvement by applying AWI is divided into seven steps using various TRIZ tools. Walk through the seven steps will guide the user to develop inventive solutions in a systematic manner.

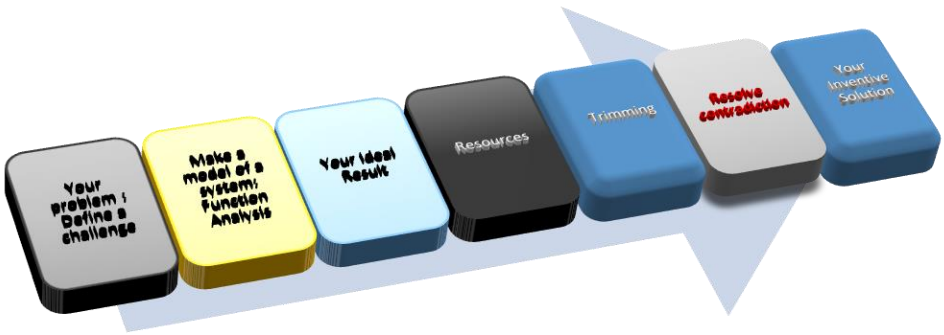

Fig 1: Roadmap for Work Improvement

- **Step 1: What is your challenge?**

How can you define your problem clearly in one statement? The best way to understand the challenge is to analyze the function of the system where you have the problem. What are the functions of the individual components of the system? Function Analysis (FA) tool is thus used. Walking through the function analysis, function advantages and disadvantages are identified which can lead to challenging actions at the later stages. Basically, function advantages will be kept but function disadvantages will be eliminated for improvement.

- **Step 2: What is your system?**

Can you make a model of your system that you have the problem? By understand the problem more deeply, build a function model of the system by using Function Modeling. The function model describes and classifies the functions, their usefulness and performance levels, and costs of the system and super-system components. After applying the function modeling step, a function model of the system is represented by a graphical form.

- **Step 3: What is your wish?**

What do you really want from the improvement? Ideality Thinking from TRIZ can open up our mind by thinking out of the box. It provides a thinking methodology towards Ideal Final Result from the view of the customers' wants. It also helps the user to avoid psychological inertia. In this step, a wish of the ideal solution is developed.

- **Step 4: What do you have?**

What resources do you have for the improvement? Resources for improvement are preferred to come from the system or super-system. Additional resources from outside are usually avoided. This thinking methodology encourages the users to utilize all the existing resources for improvement rather than seeking additional external resources.

- **Step 5: What can you simplify?**

Can you simplify your system by making it more simple? Improvement is usually related to reduction of costs, upgrading of quality, enhancement of efficiency, etc. All these actions could be achieved by using TRIZ Trimming tool. Trimming tool allows users to simplify the system by reducing components but yet maintaining the original useful functions of the system.

- **Step 6: What are the things stopping you?**

Is there anything stopping you to improve? Contradiction is defined as a conflict between two existing parameters of the system. This is the innate conflict stopping the system to achieve better results. After applying Contradiction Analysis, it allows users to re-formulate the system by describing a set of contradictions and leading to solutions by solving the conflicts.

- **Step 7: What are your inventive solutions?**

After analyzing the problem, simplifying the system, getting available resources, and identifying conflicts, 40 inventive principles of TRIZ are used to develop inventive solutions.

3. Demonstration of AWI- A Case Study of Tea Extractor

Tea extractor is a device to produce tea in a mass production process. The tea leaves are trapped by a screen. Hot water passes through the screen and hence tea solution is produced.

The problems of the system are:

Screen easily clogged and thus blocking tea solution

Tea leaves leaking to the product (i.e the tea solution)

Difficult to replace screen, too many screws and nuts

Potential risk of dropping screws into the product (i.e. the tea solution)

In order to under the system better, a function model of the tea extractor is developed.

The tea extractor system can be represented by a function model diagram

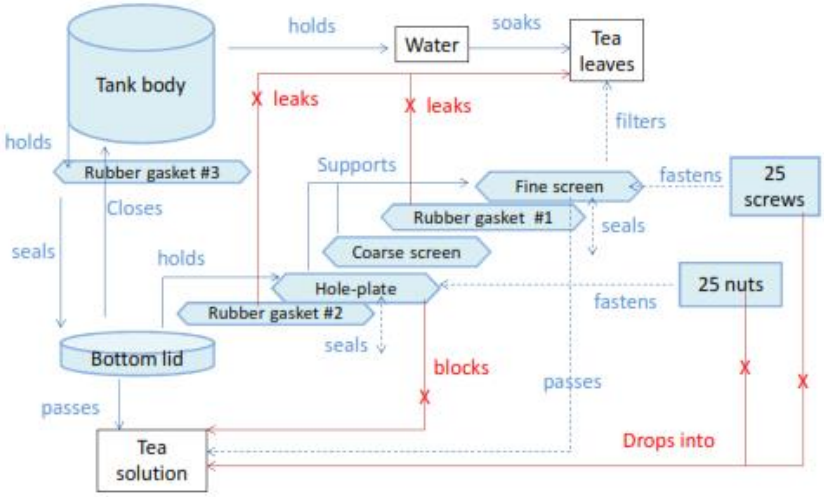

Fig 2; Function diagram of the tea extractor

The ideal outcomes to this case of the tea extractor are: no clogging of tea leaves, no tea leaves leaking to the tea solution, no risk of dropping screws into the product, greatly improve the efficiency of replacing the screen.

All the resources are found inside the system. No external resources are allowed to be used. However redesign of the extractor is allowed if needed.

The biggest disadvantage of the original system is the number of screws and nuts which would lead to the potential risk of dropping into the product, inefficiency of changeover. Trimming of the screws and nuts are thus proposed.

After the analysis of the system, four technical contradictions are identified.

1. System easily blocked by tea leaves (Area of non-moving object vs Strength)
2. Tea leaves leaking into the tea solution (Force vs Ease of operation)
3. Too much works for screen change-over (Ease of operation vs Force)
4. Potential of dropping screws and nuts to the product (Harmful side effects vs Force)

By solving the four contradictions, Inventive Principles are identified leading to the following innovative solutions to redesign the tea extractor.

- Stronger coarse screen
- Add support rods on the bottom cover
- Coarse screen with integrated gasket
- Replace fastening screws by using tank body with double gasket to pressure on the screens.

A new function model of the improved solution is developed:

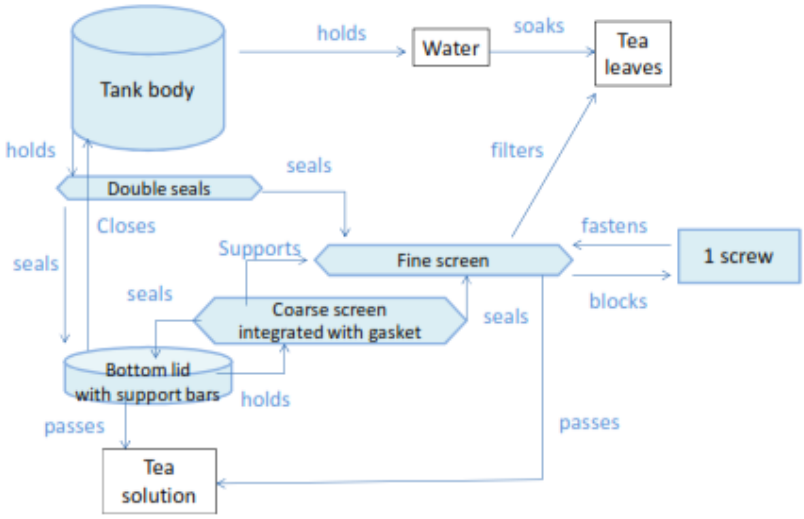

Fig 3: Function model of the improved design

Fig 4: Modified screen design

Result:

After the modification of the screen of the tea extractor, the following results are obtained.

- No tea leaves would leak to the product (tea solution).
- Screen would not be clogged anymore
- Efficiency of replacing the screen is much easier with the new design
- Potential of dropping the loosening screws into the product is eliminated.

4. Conclusion

Algorithm for Work Improvement (AWI) is a step-by-step methodology based on TRIZ to look for work improvement by innovative solutions. The seven-step approach allows the user to walk through the whole process in a systematic manner to generate innovative solutions. AWI is able to assist users to change the thinking process by deeply understanding the problem and the system, finding necessary resources, simplifying the system and resolving the conflicts. AWI has been demonstrated by the tea extractor case as a useful tool to lead to a big improvement of the tea production operation.

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Study on the System Boundary Function Analysis Method

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Abstract

This work proposed a systematic analysis method with theory and an application example. This method focuses on the contact interfaces between system and its surroundings and aimed at providing efficient thinking directions to analyze system rapidly and accurately. The concept of the System Boundary was presented and its characteristics were analyzed. The Su-Field Model of TRIZ was employed to describe functions on System Boundary. Components were classified with a classification strategy based on correlation level to functions on System Boundary. Then the System Boundary Function Analysis method (SBFA method, for short) was proposed. This method provides ideas and means for analyzing system and discovering problems. It also helps finding system contradictions or searching for beneficial resources. Finally, this method was used to provide a way of guiding thinking for bridging the gap between adjacent windows when using the 9-Windows tool. The distinct and precise thinking route of bridging gaps between windows was provided to verify the feasibility and efficiency of the SBFA method. The main contributions of this paper include: 1) proposing the concept of System Boundary and expounding the characteristics of the System Boundary; 2) proposing the SBFA method with a new perspective which paid specific attention to the System Boundary; 3) using the SBFA method for an application of the 9-Windows tool.

Keywords: System Boundary, Function Analysis, Su-Field Model, 9-Windows Tool.

1. Introduction

System analysis is the key procedure to find and solve problems. Only if having a clear and accurate understanding of the system, we can find out the key problems quickly, and then search for solution to optimize the system.

There were lots of researches on system analysis method, and different scholars put forward different methods from different perspectives to analyze system, such as the perspectives from functions, components, thinking and the cause-effect relationship. The

Function Analysis method and FAST model are two important systematic analysis methods from perspective of function. One of their advantage is that key problem of system can be found by analyzing system and its essential attribute, namely function. Wang et al. (Wang, 2006) introduced the concept of input constraint function. Substance, energy and information flow were regarded as products or by-products processed by the system. And they put forward the Function Analysis method based on a generalized process function and applied this method to concept design phase of a pigment filling machine. Kaufman (Kaufman, 2006) studied the FAST model which including explaining on how to set up and read the FAST model and how to use the FAST model to analyze functions of system. The system analysis method from the perspective of components is always used with the combination of trimming. It can make clear the system constitution, and simplify system component in order to reduce cost while improving the ideality of system. Sheu et al. (Sheu, 2013) used component analysis and trimming to analyze and improve the system from the perspective of subtraction rather than addition or replacement, and established a comprehensive trimming model for breakthrough problem solving. The system analysis method from the perspective of thinking such as the 9-Windows tool is conducted from two dimensions, i.e., time and system. Mann (Mann, 2007) studied the 9-Windows tool from different perspectives and dimensions, and stimulated users thinking a problem in different perspectives when using the 9-Windows tool. The system analysis method from perspective of the cause-effect relationship is used to find the root causes of problems by searching the cause of each effect, e.g., the fishbone method. Tan et al. (Tan, 2003) used the reverse fishbone method to determine functional elements by improving the way of establishing the fishbone diagram, and established the function model of existing products. The above methods provide ideas and methods for analyzing system. Using appropriate method for different systems can be efficient and convenient.

This paper intended to propose a method which provides ideas and thinking directions to analyze system from a new perspective by focusing on the relationship of system and its surroundings.

2. System Boundary

2.1 Attributes of System

According to the Free Dictionary, a System is defined as a group of interacting, interrelated, or interdependent elements forming a complex whole (Web dictionary, 2015). A system contains at least more than one element and those elements are associated with a well-organized topology relationship. Interactions between elements perform the partial functions, and all the partial functions perform the general function of system. As an organic combination, system possesses attributes like integrity, relevance and hierarchy(Von, 1987).

The integrity of system means that system has the integrate characteristic, i.e., the general function, which internal elements do not have. A function is defined as a necessary intent or casual action that is realized through the performance of a solution (Kaufman, 2006). Based on this definition, function is a collection of actions for specific purpose. The general function of system which the partial elements can not represent belongs to the whole system. The relevance of system means that system is connected with the surroundings and elements of the system are connected with each other orderly. The connection relationships are realized by functions. The hierarchy of system represents that components in the system are organized into successive ranks or grades with each level subordinate to the one above it. System is relative from macro to micro level. Widely, system and the surrounding components can form a bigger system, i.e., a supersystem. Narrowly, elements in the system which have an independent function can form a smaller system, i.e., a subsystem. These different systems have different scopes.

The scope of a system determines the amounts and types of elements of the system and their hierarchy and relationships. Different ranges of system contain different amounts and types of elements. The connection relationship of elements constructs the hierarchy of the system and reflects the complexity of system. Furthermore, the scope of the system defines the scope of primary concern and influences the analysis result. Therefore, the scope of system should be established before analyzing a system.

2.2 System Boundary

To analyze the relationship of a system and its surroundings, here we propose the concept of System Boundary. System Boundary is the contact interface between the system and its surroundings. On the System Boundary, substance flow, energy flow and information flow transfer via contacts and actions. System Boundary is an abstract term rather than a real edge of entity or an outer outline of a system. Using circle, rectangle or other scope lines to represent the System Boundary to help understanding easier, as shown in Figure 1.

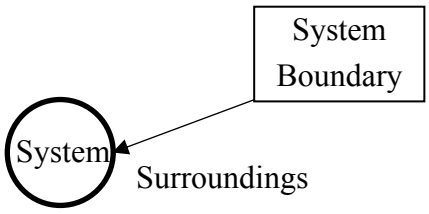


Figure 1. System Boundary

Elements from system and its surroundings contact with each other. The contact refers to not only a physical contact, but also some kind of correlation. The contacts perform actions and

the actions implement the correlation of system and its surroundings. As an interface, System Boundary carries multiple functions.

Linking the system and its surroundings, the System Boundary possesses its own characteristics: accompanying with the system, directivity of action, variety of function.

(a) The System Boundary changes with the changing of the system scope, i.e., accompanying with the system. For the current system, components of the system contact with components in its surroundings. Exactly, the contacts are on the System Boundary. Taking a subsystem as the current system, it would have its own System Boundary. The same for a subsystem.

(b) The actions on the System Boundary are directional. Substance flow, energy flow and information flow export from the system to the surroundings via the System Boundary. In this way, the system acts upon the surroundings. Conversely, Substance flow, energy flow and information flow import from the surrounding into the inside of system via the System Boundary, i.e., the surroundings acts upon the system.

(c) The amounts and types of function are various on the System Boundary. For the surroundings, the general function and auxiliary functions of the system conduct on the System Boundary. For the system, the influences of surroundings realize via the System Boundary.

Therefore, the System Boundary is also an attribute of system.

3. Description of Function on the System Boundary

3.1 Function Expressing in TRIZ

In TRIZ, function is used to describe the effect of actions. Basically, functions are actions between two components. The function carrier acts upon the object of the function and modifies a parameter(s) of the object. A parameter describes an inherent property of the object(e.g., weight, length, volume) (San, 2009). In terms of the graphic expressing, the function carrier is represented by a rectangular outline while the object of the function is represented by an oval outline. The action is expressed as an arrow, as shown in Figure 2.

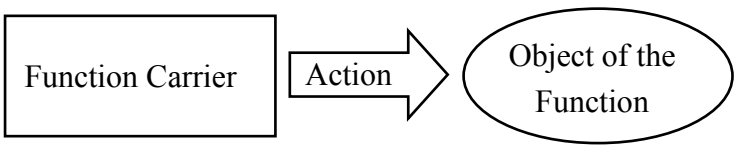


Figure 2. Graphic Expressing of Function

The function carrier and the object of the function are components which are objects consisting of Substances and/or Fields. Additionally, the existing conditions of a function include two key points: 1) the function carrier interacts with the function receiver; 2) parameters of the object are changed (or are maintained) through the interaction.

Based on the performance level of the actions, functions are classified to two types, namely Useful Function and Harmful Function. Furthermore, Useful Function is subdivided to adequate level, insufficient level, and excessive level. Different performance levels of actions are expressed by different kinds of arrow symbol, as shown in Figure 3.

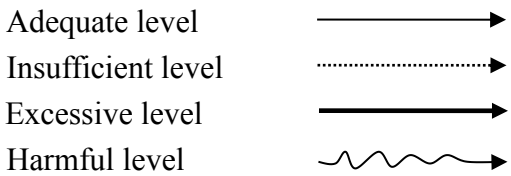


Figure 3. Expression of Different Performance Levels of Action

3.2 Function Description on the System Boundary

Contemporary physics views the world around us as consisting of substances interacting with each other by means of fields (Terninko, 1996). The actions or means of accomplishing the action is called a Field (Terninko,1998). Substance is an object with rest mass while Field is an object without rest mass that transfers an interaction between Substances.

Based on TRIZ, the Su-Field is devoted to describe the realization of a function. The Su-Field Model shown in Figure 4 is a minimum system in which a set of substances interacting with each other by means of fields which are generated by the substances (Belski, 2007). Substances here can be any level of complexity. They can be single components or complex systems. The Field, which is often some kind of energy, provides space, force, or reaction to generate an effect. The form of field indicates not only physical field, but also chemical field, biological field, and so on. Each function on the System Boundary is corresponded to a Su-Field Model. The two substances are elements from the system and its surroundings respectively. The field between two substances is the root cause of effect as well as the key point to analyze the functions on the System Boundary.

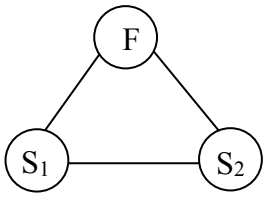


Figure 4. Su-Field Model

The Su-Field Model can explain and express the three essential elements of function. More than that, it can also analyze the performance level of function on the System Boundary to find some existing problems and contradictions of the system. Therefore, the Su-Field Model is employed to describe the functions on the System Boundary.

4. System Boundary Function Analysis Method Based on the Su-Field Model

4.1 Strategy of Components Classification

According to the description of function on the System Boundary, the substances in the Su-Field Model are composed of both components coming from the system and the surroundings respectively. Components which are involved in the realization of functions on the System Boundary are different from other components in the system. Accordingly, a component classification strategy is put forward based on the correlation to functions on System Boundary, as shown in Figure 5. The components shown as black circles in Figure 5 are highly correlated to functions on the System Boundary, called the near-system-boundary components (NSBCs, for short). The NSBCs in the system are adjacent to System Boundary. The other ones shown as the white circles in Figure 5 are less correlated to functions on System Boundary, called far-system-boundary components (FSBCs, for short).

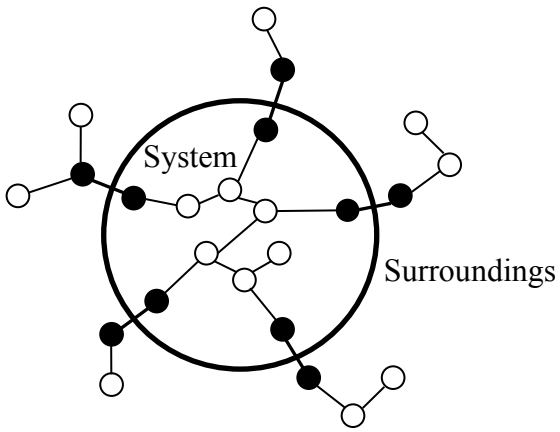


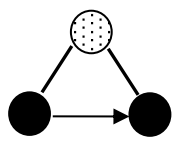
Figure 5. Schematic Plot of Components Classification

According to this classification strategy, the two substances of the Su-Field Model on the System Boundary are both NSBCs. Therefore, it means paying close attention to the actions between NSBCs while analyzing the Su-Field Model on System Boundary.

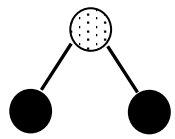
4.2 Su-Field Analysis of the System Boundary

Su-Field Analysis is a TRIZ analytical tool for modeling problems related to existing technological systems(Terninko,1998). A function on the System Boundary depicted by Su-Field Model is researched by analyzing relationships among the three essential elements of the Su-Field Model, i.e., one NSBC of the system and another NSBC of the surroundings and the Field between them.

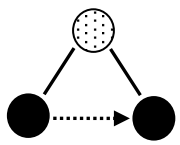
Based on the performance level of the function, the Su-Field Model is classified to four types, which are the application complete model, incomplete model, ineffective complete model and harmful complete model, as shown in Figure 6.



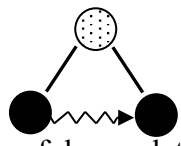
(a) Application complete model



(b) Incomplete model



(c) Ineffective complete model



(d) Harmful complete model

Figure 6. Different Types of Su-Field Model

Once the Su-Field Model of each function on the System Boundary is established, the type of Su-Field Model can be judged by analyzing the performance level of the function. According to different types of Su-Field Models, the system can be improved by using tools such as the 76 standard solutions or trimming. For the incomplete model, substances/fields are added to make the model complete. Once the model is complete, we can evaluate the effects by judging the effects belong to effective, ineffective or harmful. Then, we can determine the type of model. For the ineffective complete model, the effect can be enhanced by enhancing the field or other means. For the harmful complete model, it can be improved by weakening the harmful effects or other means.

4.3 System Boundary Function Analysis Method

System Boundary Function Analysis method (SBFA method, for short) focuses on the NSBCs from the system and its surroundings and analyzes the functions on the System Boundary, so that key problems or contradictions in the systems as well as beneficial resources can be discovered rapidly and accurately. No matter how complexity the system is, this method begins with the defining of the system scope and concentrates on the System Boundary directly. Ignoring a large amount of FSBCs, the NSBCs are focused on. Consequently, we can analyze the system rapidly and improve the efficiency of analysis.

Based on the hierarchy of system and System Boundary accompanying with the system, there are different hierarchies of subsystems in the system and their System Boundaries. Therefore, the SBFA method can be used not only to build a correlation between system and its surroundings to analyze the system, but also to analyze the internal system gradually. The specific procedure of the SBFA method is shown in Figure 7.

(a) **Step 1.** Identifying the scope of system. Based on System Boundary accompanying with the system, in order to define the System Boundary, the scope of system should be certain.

(b) **Step 2.** Analyzing the NSBCs in the system. Firstly, Judging which components in system contact with components in the surroundings. Once the components in system have contact relationship with components in the surroundings, identifying these components to be NSBCs. And the contacts are on the System Boundary. The components analysis contributes to clarify the connection relationship among components near the System Boundary and understand the system deeply. The result of this step is to list the components inventory and draw the connecting diagram of components. Components contacting with each other are connected through a short line, as shown in Figure 8.

(c) **Step 3.** Analyzing the contact relationship based on Fig.8. The aim of this step is to understand three issues step by step: Firstly, how many contacts interfaces existing on the System Boundary. For example, there may be one system component contacts with more than one component in the surroundings. Accordingly, more than one contact interface should be identified for this component. Then, each interface should be analyzed one by one. Secondly, the contact type, e.g., visible geometry contact, invisible contact, or micro level of contact should be judged. Finally, analyzing effects generated by contacts. There is at least one effect on each contact interface. Functions on all contact interfaces form the functions on the System Boundary.

(d) **Step 4.** Establishing Su-Field Models of all the functions on the System Boundary. The NSBCs play the role of Substances. The Field is derived from interaction between substances. As a result, functions on the System Boundary are represented by the Su-Field Model.

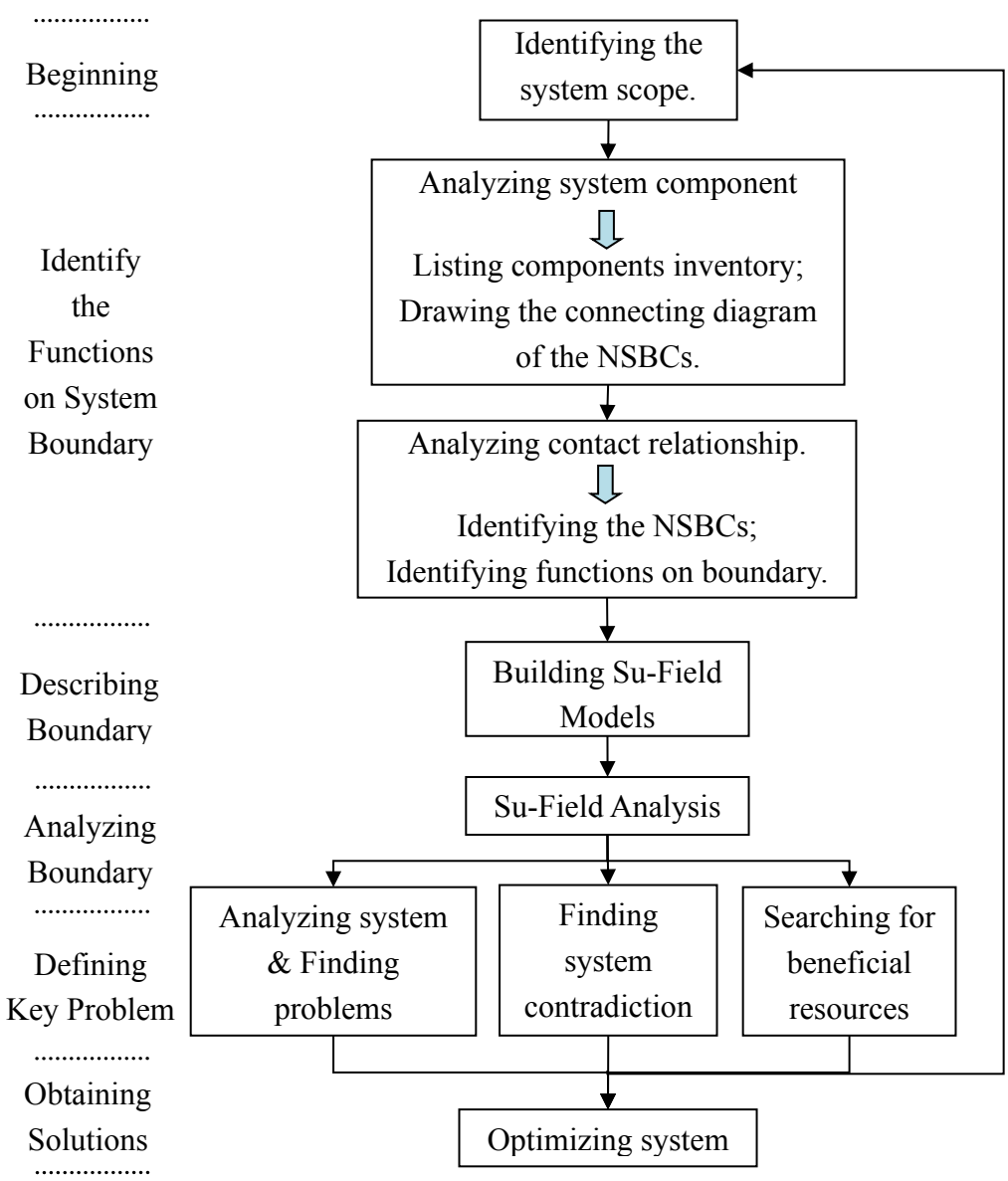


Figure 7. Process of System Boundary Function Analysis Method

(e) **Step 5.** Analyzing the performance level of functions based on the Su-Field Analysis. For each Su-Field Model, it needs to judge the performance levels of actions, i.e., adequate level, harmful level, insufficient level, or excessive level. If the performance level is not a normal level, analyzing the cause leading to an harmful, insufficient or excessive effect. Then, it should be analyzed that which substance or which field is the root cause. At last, the problems or contradictions of system can be found.

(f) **Step 6.** Optimizing system. After finding the problems or contradictions, various solutions such as the 76 standard solutions or trimming can be involved to optimize the system.

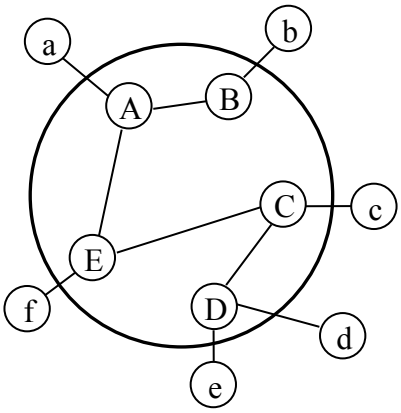


Figure 8. Diagram of Connecting NSBCs

5. Application Research of the 9-Windows Tool Based on the System Boundary Function Analysis Method

5.1 Gaps of 9-Windows

The 9-Windows tool is a classic systematic thinking method in TRIZ (Han, 2014). Figure 9 shows the graphic presentation of the 9-Windows tool. The 9 windows are organized through two dimensions, i.e., time dimension and system dimension. Comparing to the traditional one system thinking mode, the 9-Windows tool increases more thinking perspectives and is more comprehensive. The advantage of this tool is to guide users to analyze the relationship between the center system and other systems in the adjacent windows. It can analyze the system deeply from both system and time dimensions.

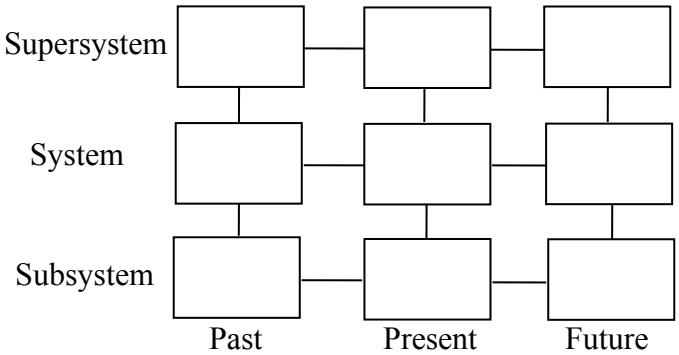


Figure 9. 9-Windows Diagram

In system dimension, there are three system hierarchies including the supersystem, system and subsystem, users can transcend the current system to pay close attention to a broader or

narrower scope. In time dimension, there are three time states including the past, present and future of a system. it can activate users to form a dynamic and developing thinking mode.

When facing a problem, our brain are likely to immediately conjure up the image of a most intuitive system as the thinking origin. It is the system in the center window. However, the system in other windows are still fuzzy. Therefore, it is necessary to find a method to guide users bridging the gaps between adjacent windows when using the 9-Windows tool.

Usually, users judge the scope of the supersystem and subsystem depending on their own subjective consciousness. However, it is difficult to definitely define the supersystem or the subsystem. For example, as the scope of supersystem could be infinite, it would be a problem that how to define the boundary of the supersystem appropriately. It is a leaping thinking. Additionally, the past and the future of system are two vague concepts relatively. The choice of the time span is another problem if crossing from the current system to the past system. It is hard to choose the time span, e.g., one hour or one year. Here is still a very leaping thinking. In brief, users always feel confused when using the 9-Windows tool because they bridging the gap between adjacent windows depending on their own mindset randomly. So far, there is a lack of principles or methods to guide users going to adjacent windows around the center window.

5.2 Bridging the Gaps by Using the System Boundary Function Analysis Method

According to the above analysis, we propose the application procedure of the 9-Windows tool by bridging the gaps based on the SBFA method. Figure 10 shows the main strategy of bridging the gaps between the windows. Since there are more than one Su-Field Model on the System Boundary, each Su-Field Model is an action unit. For each Su-Field Model, the strategy can be used to bridge the gap between adjacent windows.

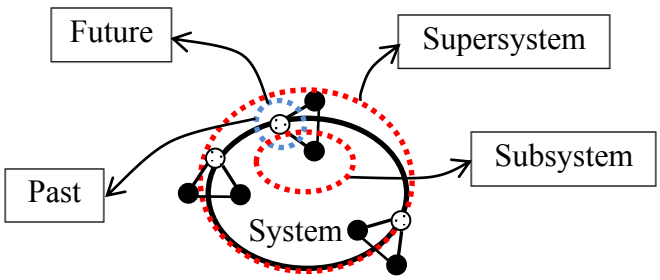


Figure 10. Strategy of Bridging the Gaps

Firstly, the scope of system is defined as the one which is migrated to our minds naturally. At this point, the start point of thinking is located in the center window. For an example, the pen is chosen as the current system in the center window naturally when we face the problem that it could not be used to write smoothly.

In system dimension, the SBFA method is used to analyze connections between the system and the supersystem. The strategy of bridging the gap of windows in system dimension includes:

(a) According to the result of the function analysis of the System Boundary, selecting the NSBCs of the surroundings and previous system, e.g., the paper and the pen, to structure a new system. So, the bridging the gap from the center window to the above supersystem window is realized.

(b) Selecting a subsystem which includes the NSBCs of previous system as a new system, e.g., a refill with the nib. So, the bridging the gap from the center window to the below subsystem window is realized.

As for a system, users can define various new systems upwards or downwards according to the needs of analysis. And then users analyze the new system using the SBFA method iteratively. As a consequence, the purpose of analyzing system comprehensively can be reached.

In time dimension, there are three states of a system. The present of the system is a system station which is at the time when the problem exists. For the certain system, the time attribute of the action in the Su-Field Model is conducive to bridge the gaps between the windows. Therefore, this paper provides a strategy to realize windows spanning in time dimension according to the time attributes of actions. The strategy of bridging the gaps of windows in time dimension includes:

(a) Using the SBFA method to the current system and establishing the Su-Field Models on the System Boundary.

(b) Then, considering the time period of actions for each Su-Field Model. Analyzing that the system was in which station before the realization of actions, i.e., the past of system. Accordingly, realizing the bridging the gap from the center window to the left window.

(c) Similarly, analyzing that the system is in which station after the realization of the action, i.e., the future of system. Accordingly, realizing the bridging the gap from the center window to the right window.

The key point of this application procedure of the 9-Windows tool is to analyze functions on the System Boundary. By analyzing the Su-Field Models, on the one hand, association of components can be analyzed synthetically. Moreover, we can find problems through the analysis of the System Boundary so as to optimize the system.

The application of the SBFA method when using the 9-Windows tool supplies an operational strategy to guide bridging the gaps between windows. Meanwhile, the feasibility and efficiency of the SBFA method is verified.

6. Conclusions

(1) This research proposed the concept of the System Boundary and expounded its characteristics. As a contact interface, System Boundary is the transmission channel of the substance flow, energy flow and information flow. It is significant to pay more attentions to the System Boundary when analyzing a system.

(2) The components classification strategy was proposed based on the correlation level to functions on the System Boundary. The system components were classified to two types, namely the NSBCs and the FSBCs. The NSBCs become the specific components group which we focus on.

(3) This research proposed the System Boundary Function Analysis method aimed at analyzing system quickly and accurately. The System Boundary is the key target for analysis and we can grab this target quickly according to the proposed procedure. This method is used to look for problems of system, find system contradictions, and search for serviceable resources.

(4) The SBFA method was used to guide bridging the gap between adjacent windows when using the 9-Windows tool. The feasibility and efficiency of this method were verified.

7. Acknowledgements

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TRIZ and Lean Methodologies in an Industry of Air handling and Ventilation

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Abstract

In a globalized world, organizations have been forced to innovate in search of new management techniques, due to limitations of traditional management models. To survive in a highly competitive market, organizations seek to differentiate themselves from the competition through the use of new management methods for increasing the efficiency of internal processes.

The implementation of fundamentals and techniques of *Lean* methodology, together with the concepts and analytical tools of TRIZ methodology, can help organizations continuously improve search in all functional areas, finding more creative and innovative solutions.

Improvement of the organization of the warehouse and inventory management, in a metalworking company, was established as the main goal of the study. The analysis made to the current situation of the company and the solutions to the problems identified were based on some techniques and analytical tools of *Lean* methodologies and TRIZ.

The main problems were related to the organization of storage, working areas and administrative problems leading to waste of resources.. The solutions have emerged through the application of the main TRIZ techniques together with various Lean methodology analytical tools recent theories: 5 S, visual control and Standard Work.

The implementation of Lean-TRIZ solutions had a very positive impact, with results in improving the organization of the warehouse.

Keyword TRIZ, Lean, Warehouse Management.

1 Introduction

The present work aimed to study of the management of a warehouse in a metalworking industry of Air Handling and Ventilation (industrial unit situated in Vila Franca de Xira (Povos), Portugal).

The study focused on the analysis of the maintenance management of a warehouse in particular the organization and managing inventory. The elaboration of proposals aimed at increase efficiency and to improve the organization.

Lean and TRIZ methodologies were the main elements of the study. The implementation of the methodology involves the application of several techniques in order to identify technical and administrative problems leading to waste of resources. Identifying the problems it was possible to seek solutions to them and to provide solutions that reduce or eliminate waste those found.

For the organization of the warehouse was implemented 5S, with the application of actions related to space and material management. During the implementation of these actions audits were developed in this way it was possible to verify that the actions taken were effective in the organization. With the implementation of the 5 senses there was an improvement of 65% of effectiveness. Another Lean tools were applied during this study as Visual Control and Standard Work.

2 Lean Methodology

The beginning of the Lean production had its origin in Japan, within Toyota automobile construction company, by Taiichi Ohno in 1940. The Toyota Production System (TPS) was based on desire to produce a continuous-flow process, in which did not depend on long production runs to be efficient (Melton, 2005).

In the opposite way, in the Western world where the mass production, initially developed by Henry Ford, was based around the planning of material requirements and complex computer systems. This production method was based on producing with a high volume of stock (Melton, 2005).

When Taiichi Ohno began to build the foundations of Lean production, he began by examining the production systems used in the West, which in his opinion had two failures (Holweg, 2007):

(1) The first failure was that the production of high batches would result in excessive inventories, This would make that they increase capital costs and the warehouse space.

(2) The second failure consisted in the inability to adapt to customer preferences for greater product diversity.

His main concerns were mainly the reduction of the cost of production through the elimination of waste (Holweg, 2007).

The Lean philosophy is based on the implementation of several tool that aid in the identification of existing waste and improvement solutions in a production system.

3 Analyses and Implementation of TRIZ and Lean Tool

3.1 Implementation of Lean tools

For the organization of the warehouse was implemented 5S, with the application of actions related to space and material management. During the implementation of these actions audits were developed in this way it was possible to verify that the actions taken were effective in the organization. With the implementation of the 5 senses there was an improvement of 65% of effectiveness.

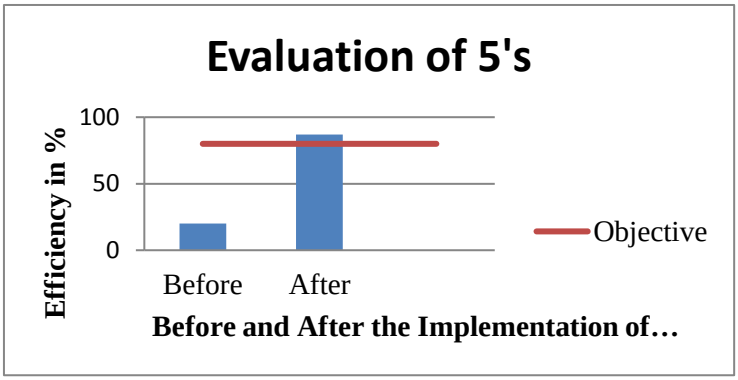

Figure 1 - Performance evaluation of the implementation of Improvement Actions

Other Lean tools that are related to the 5S were applied during this study like Visual Control and Standard Work.

3.2 Implementation of TRIZ tools

3.2.1 Expand Existing Su-Field Model to a Chain

The company to make the control and management of stocks using ERP software called Alidata, to integrated management of all products. In this system software constraints have been identified, for example:

The limit of users on the same server, this is limited to 20 users to work simultaneously.

The software is slow to perform certain operations that should be fast because the functional point of view is not demanding, such as the stocks of consultations.

Researching and identified the contradictions of this system it was decided to apply the Substance-Field Analysis tool. Identifying S1 substance as the product description, S2 substance as the product consultation and finally, as the F field we have the ERP software used for data storage. So it is possible to produce a substance-field model, which is an inefficient system (Figure 2).

For the resolution of the contradictions found, an expansion for a chain system was made (figure

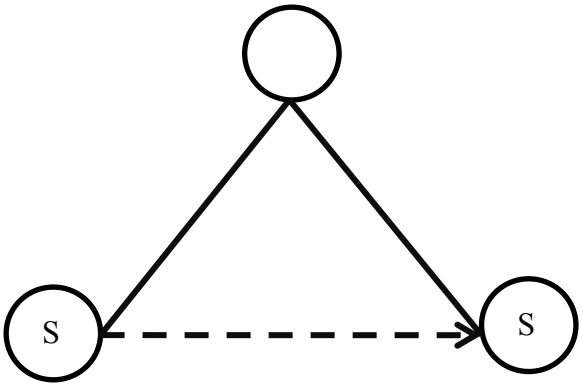

Figure 2 - Inefficient system

3). In this new system we have:

- S1 product settings;
- F2 field is the Database (Cod Alidata);
- S3 is the intermediate query ERP software products;
- F2 field corresponding to an internal database where the information is stored for reference, who was created for solution;
- S2 substance as the product consultation.

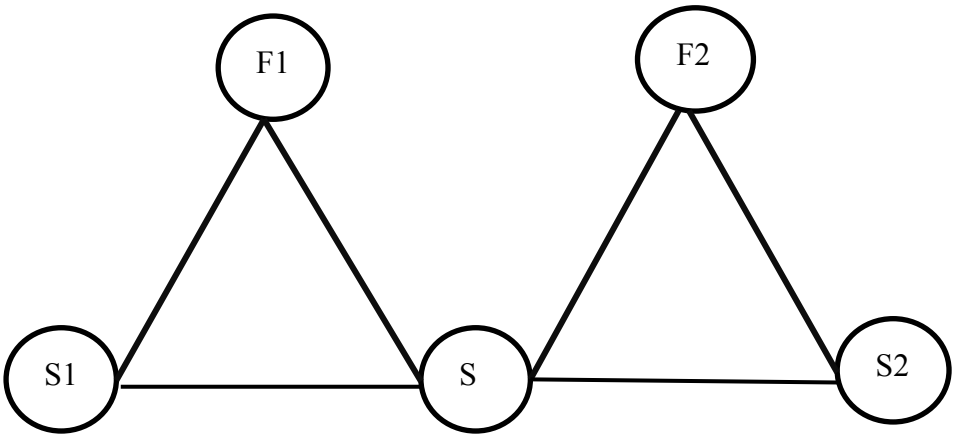

Figure 3 - Efficient system in a chain

In this case, it was found that expanding the system can develop a more efficient product query. And with this query engine, which is the internal server of the company, it is possible to research products. After development of this system it was possible to solve the above obstacles.

The creation of the database allowed an improvement in product demand as:

- Pictures of the products association;
- Set a product key;
- Set the reference;
- Designate a product (definition of the type of product);
- Know what the discontinued products;
- Define the size (not applied in some cases);
- Stocks of Inquiry;
- Codes suspension.

In Figure 4 shows some fields developed in the database for existing query in Alidata Cod.

IMAGEM	CHAVE	REFERENCIA	DESIGNACAO	TAMANHO1	COR	TAMANHO	SUSPENSA
Arra	ACESSUTAMONO_SC_ST	ACESSUTAMONO	ACESSÓRIO UTA (MONO)	-	SC	ST	N
Arra	ACTANTIGOS_SC_ST	ACTANTIGOS	ACTUADORES ANTIGOS - SEM REFERÊNCIA NO ?SISTEMA	-	SC	ST	N
	AMORT.PES0_SC_ST	AMORT.PES0	AMORTECEDOR PÉ 160kgs REFª. S 00	-	SC	ST	N
	AMORT.PES00_SC_ST	AMORT.PES00	AMORTECEDOR PÉ 160kgs REFª. S 00	-	SC	ST	N

Figure 4 - Database

This base can be configured where it is always necessary to innovate in order to seek the best solution.

3.2.2 Change Existing Field to Reduce or Eliminate Harmful Impact

One of the problems identified was the lack of accounting and control the material in storage. Because of the absence of that control, it was found that existed several disruptions of stock from external suppliers. Most external needs was not reported in a timely manner from suppliers. This is a factor that affects directly, delivery times of products produced and that can lead to non-compliance with the customer. In this system it was identified:

- S1 as the production manager;
- S2 as the external purchasing manager;
- F as the exchange information on stock purchases and required for the production.

This makes it easier to produce a substance-field model where it was found that the system was inefficient (Figure 5).

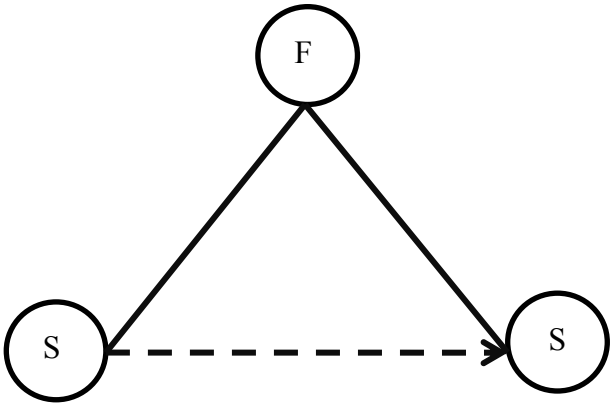

Figure 5 - Inefficient system

In this case, it was found that it was necessary to change the substance S1, where it verifies the source of the problem. Changing the S1 substance by a warehouse manager S1'(Figure 6).

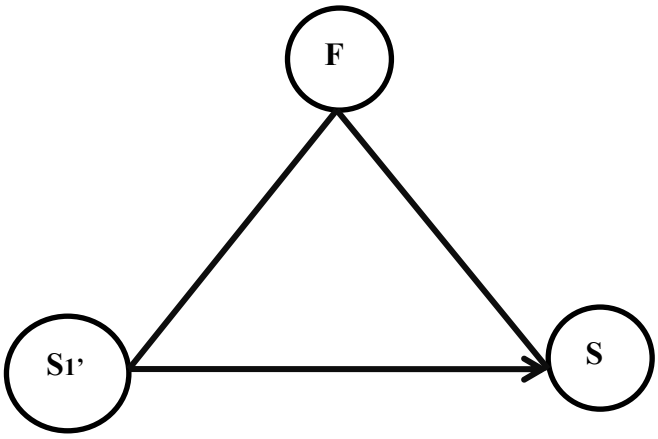

Figure.6 - Efficient system

These changes reduced the problem of disruptions of stock and make a systematic control of all the products in stock. Information began to be reported more quickly and to flow better from a warehouse manager for the purchasing manager. Although it was made successful replacement, the production manager continued to be necessary to report the failure of a given type of material that does not pass through the warehouse, as in the case of some screws and certain insulating tapes.

It was possible to determine the arrival times of suppliers material, avoid breakage of future stock and reduce the internal stocks.

3.2.3 Complete an Incomplete Su-Field Model

Following the replacement of the field mentioned above it was able to identify defect products and incomplete orders by the suppliers. In this system it was identified:

- S1 as non-compliant foreign products;
- S2 as the Purchasing Manager and external product complaints.

In this case, an incomplete system was identified, which was not reported to the supplier defects or incomplete orders (Figure 6).

Figure 6 – Incomplete system

In this case, it was found that it was necessary to add a field F, the store manager, allowing the connection between S1 substance which is non-conforming products and S2 external substance which is the shop manager and product claims external (figure 7).

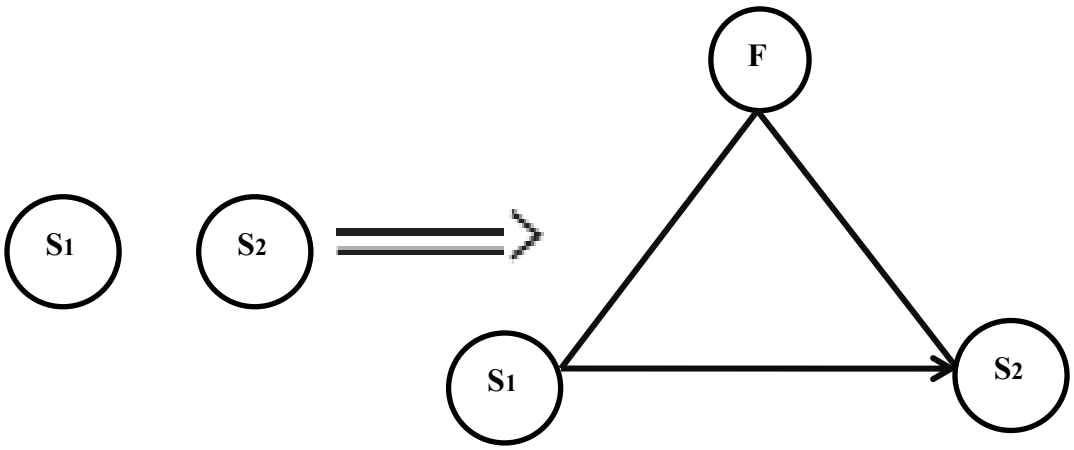

Figure 7 – Complete system

The solution to this problem is to have a field that reports the non-compliance information to the Purchasing Manager. For this purpose, it was considered the warehouse manager was the missing element for this link to work.

So the warehouse manager was responsible for reporting defects and incomplete orders to shopping manager.

From the introduction of this field several problems found with suppliers:

- Fans did not come with instructions;
- Orders that did not come complete (example: pressure switches box with units less);
- Non-compliant products.

3.2.4 Contradiction Matrix

The material management of the warehouse there was operators withdrawing material from the warehouse and sometimes could not reach register. Registration should be done ERP software was

slow but as the operators were not for lack of time and the program's complexity, so this process is discontinued. As a consequence it was found that there was persistent problems, such as excess of certain products by changing manufacturing processes have become somewhat worn. On the other hand, there was a frequent rupture of stock material that is currently most widely used in production.

One of the initial goals was to increase the stock control without leading to significant investment taking advantage of existing resources. Knowing the factors that negatively affected the implementation of this particular system as the time spent in picking, it was verified that the TRIZ would be an interesting methodology to apply because of their ability to solve problems analyzed the processes to improve and contradictions.

For this we applied the contradictions Matrix tool.

In the new system is intended to achieve an improvement in (24) loss of information but involves having a technical contradiction will worsen (25) Waste of time. It can be seen that at the intersection of the parameters 24 and 25 affords the principles of the invention 24, 26, 28 and 32.

Of these four principles identified, only two of them is that they were considered with the potential to solve the problem.

24) Introduction of a new intermediate device. Any connection between the code and the product database on the computer.

32) Computer system for organizing colors database.

One solution was to introduce in the system a barcode reader (optical device), as shown in Figure 8.

Figure.8 - Optical reader

This device allows us to select the product and this automatically becomes available in the system. After being made the product selection, the system is available an item that allows us to select the amount of material out of the storage of each product and thus automatically update the stock.

For a better visualization and simplification of the system, the selected products acquire a green color and change to the top positions on the list. Unselected codes were blocked with a red color and were on the list.

4 Conclusions

The implementation of Lean tools in conjunction with the resolution of technical and administrative problems TRIZ, is a promising solution to achieve significant improvements in the effectiveness and efficiency of the processes carried out by company. Given that, the tools associated with TRIZ and Lean can have an important contribution to the growth of the company and to establish a significant position in the market where it operates. The methodologies trend was significantly driven, either directly or indirectly, in the search for solutions to the process improvement.

It is important that companies apply tools like Lean and complementary to the TRIZ methodology to reduce waste and solve the contradictions that may arise. Thus the application of methodologies narrowly allowed analyzing and resolving administrative and technical contradictions that allowed an improvement in the organization of the warehouse and contributed to the management of it

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The Capability Level Evaluate Index of Agribusiness Electronic Commerce

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Abstract

More and more Agribusiness enters the field of electronic commerce with the popularity of internet. In order to promote the healthy development of Agribusiness, and to provide an intuitive method for Agribusiness to understand its electronic commerce capability, a method that can evaluate the electronic commerce capability of an enterprise accurately seems really important. In this essay, a four-dimensional capability maturity evaluation system model has been established to suffice this kind of need. This evaluation system can evaluate an enterprise with a specific value, and provide feasibility proposal for enterprise which can develop circularly. This essay describes this model's scheme and design, how to use the index system to evaluate an enterprise and develop the enterprise circularly. At the end of this essay, a case that uses this index system has been provided. Besides that, some advice for further research has been provided.

Keywords: The capability level evaluate index, Agribusiness electronic commerce, evaluation system model

1 Introduction

With the rises and popularity of the internet, and the development of the computer technologies, the transmission of information steps over the limit of time and space and into a world of information. Then, a new industry has emerged, electronic commerce (e-commerce), which produces and develops in this age. A new vitality is injected into the internet economy because of the e-commerce, and the economic globalization has been promoted to some extent. Consequently, e-commerce has attracted extensive attention of the world.

Out of China, early, APEC raised “APEC Blueprint for Action on Electronic Commerce” in 1998. At the same time, OECD also proposed “A Global Action Plan for Electronic Commerce” and other related issues. Accept these, WTO and other important international economic organization raised various issues to promote the development of e-commerce.

In China, E-commerce transactions keep increasing rapidly. In the period of the eleventh five-year plan, E-commerce transactions increase nearly 2.5 times. In 2011, E-commerce transactions reached 5.77 trillion overall, an increase of 28.3%. At the same time, the proportion of retail turnover in E-commerce is also rising, reaching 4.9% in 2011. The number of online shopping is also increasing rapidly, according to the latest data released by CNNIC, China's online shopping users reached 242 million as of December 2012, online shopping utilization increased to 42.9%.

All of these show that the E-commerce has played an important role in the world economy and trade. It has great significance for the development of related industries to keep a correct understanding and evaluation of E-commerce. Therefore, the E-commerce maturity evaluation is worthy of attention.

Early in 1987, Carnegie Mellon Software Engineering Institute, which was funded to establish by U.S. Department of Defense, had published a technique report about Capability Maturity Model for Software (CMM) and a methodology that is seen as evaluating the process maturity of defense-contract contractors. CMM contains 5 levels, 18 process areas, 52 goals, and over 300 key practices. In 2000, Cisco proposed E-commerce level assessment. This method is a quantitative evaluation method which is based on a four-category index system (including leader, management, the capability and technical of business). Each category of index system is composed by 57 specific indicators. In 2012 Yilei Pei, Wanxin Xue, Chunyu Yang and Yong Su published small and medium agricultural enterprises E-commerce maturity research in Anhui Agricultural Sciences. In this issue the concept of small and medium agricultural enterprises E-commerce maturity was proposed, index system for small and medium agricultural enterprises E-commerce maturity was established. The index system contains four first-level indicators, followed by 11 second-level indicators. The weights of the indicators were decided by AHP to build the model of comprehensive evaluation of E- commerce in small and medium agricultural enterprises.

China, as a large agricultural country, has great development in the agricultural E-commerce recently. It has a certain significance to promote Agribusiness E-commerce according to set a proper evaluation of Agribusiness E-commerce maturity and recognize its disability and obtain an explicit target.

2 Construction of Index System

The purpose of agribusiness E-commerce maturity evaluation is to provide advice and suggestions to agribusiness E-commerce. Therefore, agribusiness E-commerce should be established from related aspects. There are specific indicators for agribusiness E-commerce maturity evaluation, like internet business strategy, IT Governance, process management, performance and so on. According to the unified evaluation criteria and evaluation method, an objectively evaluation about agribusiness E-commerce maturity could be concluded. Agribusiness E-commerce could also influence the operation management of their websites. So it's necessary to evaluate their capabilities.

2.1 The overall framework

The model is built around three main elements: leverage areas, key domains, and critical variables.

Leverage areas are composed by key domains, while the key domains are composed by the critical variables. Leverage areas are internet business strategy, internet business IT governance, internet business process management, and internet business performance. Internet business strategy decides the superstructure, internet business IT governance is the base of an E-commerce enterprise, internet business process management connects the enterprise as an entirety, and internet business performance is the core of an enterprise. Leverage areas contain 12 key domains, like enterprise architecture, human capital, and organizational atmosphere and so on. Key domains are composed by 33 critical variables, like architecture system program, architecture strategic planning, and business model design and so on. Key domains and critical variables reflect the purpose and content of the high-level areas.

Table 1. The overall framework of the index system

Leverage areas	Key domains	Critical variables	Explanation of critical variables	Weights of critical variables
Internet business strategy	enterprise architecture	architecture system program	There is a organization structure with specific position and responsibility	0.3
		architecture Strategic Planning	Design enterprise architecture related to business vision based on understanding the internal and external atmosphere of the website to improve site performance.	0.4
		business model design	There is a program applies to variety of situation, and this program coordinates with the atmosphere.	0.3
	human capital	Qualification management	Ensure the human available to support internet business foundation	0.35
		Recruitment and retention	The ability the recruited staff have matches the ability the cooperate needs.	0.35
		Staff training and development	There is a Training and education programs for site staff to ensure Career Development	0.3
	organizational atmosphere	Senior planning capacity	How E-commerce strategy senior managers formulated matches Business Vision	0.35
		Middle execution capability	Degree of utilization of IT and human capital of middle managers, and the degree of implementation of the strategy of economic resources.	0.3

		Staff cohesion	The degree of enterprise between employees for the development of cooperate	0.35
IT govern	IT Infrastruct	Hardware and software	If there is Infrastructure for Online Services and its	0.3

ance	ure	facilities	extent.	
		Network technology architecture	The level of Technical architecture to support E-commerce, including Applications, technology, networking, security and data	0.4
		Network Security	Whether the Hardware and software systems of the system and the database are protected, the Degree of protection and the capability of the system works reliable	0.3
	IT Managem ent	IT Strategic Planning	Plan and build a Appropriate IT strategy to make it create new business opportunities	0.35
		Standardizati on Technical Application	The use of Basic technology that Compliance with external standards(Laws, regulations, and other relevant rules) and Internal standards(Cultural ideas cooperate advocated)	0.35
		Technical Resources Exploitation	The capability a cooperate Enhance business efficiency through developing and intervening Website technology and resources	0.3
	IT Service	The service level of consulting desk	Whether there is a Advisory Desk to help customers, and whether there is a Standard Practice	0.35

		Emergency service procedure	Whether there is Programs and procedures for emergencies, and its continuous improvement	0.3
		Facility operation and maintenance	There is a program to manage and maintain Infrastructure that supports related function, and its efficiency	0.35
internet busines	Quality and Safety	Quality of service	There is a Quality Management System based in	0.3
s process manag ement		system	quality of serves and can Continuous Improve, and its Degree of perfection	
		Business Process Monitoring	There is Monitoring mechanisms of Business Process and its degree of perfection	0.4
		Electronic Payment Security	The degree of site safety in the transaction process	0.3
	Customer Relationsh ip	Customer Information System	There is a Mechanism to Capture and store customer information, and to Measure, evaluate and acquire information about Service efficiency of customers' feedback.	0.35
		Network Promotions	Do Promotional activities through the internet	0.35
		Personalized service	The ability to provide personalized services for different customers	0.3
	Performan ce Managem ent	Online services convenient level	How difficult customers acquire Effective Services rapidly through the internet	0.35

		Control of costs and benefits	there are a series of goals and weights and measures to control the costs and benefits of e-commerce	0.3
		Logistics and distribution efficiency	The efficiency of enterprise logistics and distribution system, evaluate from the time, quality and other aspects	0.35
internet business performance	Output performance	Network sales	Corporate get revenue through network sites	0.55
		Internet sales margins	the net rate business sales through network	0.45
	Operation	Customer	how customer satisfied with	0.6
	al performance	Satisfaction	products and services of internet sales	
		Channel efficiency	the time saving rate network channels trading transactions than traditional channels	0.4
	Strategic Performance	Online market position	he ranking of similar market size and market share	0.5
		Corporate profit structure	Network operating profit accounted for the proportion of the total profits of the enterprise	0.5

2.2 Capability level measurement

This issue divides the capability level into five grades; they are Initial Capability, Developing Capability, Defined Capability, Managed Capability, Optimization level [1]. Below is the specific explanation:

a. Initial capability: the enterprise doesn't have any ability to handle the internet business and matters in internet business are treated as Individual circumstances, seeming separate and passive. However, the matters have been realized to be solved.
b. Developing capability: the enterprise has Basic capabilities to handle internet business, and there is a set of modes to solve the matters existed in the enterprise. Different people can use the same mode to solve the similar matters, but the staff doesn't have any formal training about this mode, which doesn't have been separated. c. Defined capability: the enterprise certain ability to deal with the internet business, and

have a straightforward mode to solve matters. This mode has spread in the enterprise. Furthermore, this mode is more relative to the matters existed, and there is formal training to support this mode.

d. Managed capability: the enterprise has higher ability to deal with the internet business. There is a supervision and management mechanism in this enterprise. It also has emergencies when inefficient situations appear. Simultaneously, related standards and guidelines have been established and widespread in the enterprise.

Optimization level: the enterprise has very high ability to have internet business. Procedures, mechanisms, standards and guidelines related to the key domain have reached the best condition. The contents key domain contains can improve continuously, and can work with other related domain.

(1) Critical variables capability level measurement

Capability of each key domain is an attribute. It measures the degree of readiness of each level to support enterprise development. Simultaneously, its capability level could be measured by critical variety capability.

Each critical variety capability level is measured by 7 dimensions; they are visibility, manpower training, organizational communication, procedures and practices, compliance of standards and specifications, tools and automation support, contribution of staff. Information is collected through questionnaires. Assessors provide data through the finished questionnaire designed based on the assessment dimensions of critical variables. Below is the description of each critical variables capability level.

Table 2. The description of the capability level

Capability level	description
1	When formulating the business vision, the cooperate management doesn't consider the internet business
	……
2	Enterprise high senior management take business commerce into account of the business vision.
	companies have the IT strategy to meet the operational needs
	……
3	Enterprise define and adjusted internet business strategy according to the company's business situations and the IT strategy
	Enterprise have plan to execute internet business strategy and IT strategic plan
	senior management have proposals about internet business and IT strategy, and communicate with corporate employees
	……
4	Senior managers can monitor and control internet business strategy and IT strategy
	……
5	Plans and policies on business and IT strategy are updated frequently, and consider the information performance indicators, suppliers and other business organizations have information exchange
	PE ratio and related results of organizing and implementing internet business strategy are taken into the internet business strategy and IT strategy process
	……

(2) Key domain capability level measurement

Critical variables capability level can be estimated after obtaining the data. Weighting each critical variable and the results is the capability level of key domain. Below is the formula.

$$CL(KD) = \sum CL_{CV_i} \times W_i$$

CL means capability level, KD means key domain, CV means critical level, and W means weight, i=1, 2,3,4,5.

Each weight of critical variables is decided by expert consultation. The weight of each critical variable is in table 1.

Assign different weights to different critical variables, because all critical variables are important but not the same important. For example, critical variable Recruitment and retention and Staff training and development in human capital, how a staff's capability match the capacity the enterprise requirements will determine the post-training costs, so recruitment and retention should have a higher weight.

Table 3. The requirements of the maturity level

Leverage areas	Key domains	Maturity level				
		level1：initial	Level 2：developing	Level 3：defined	Level 4：managed	Level 5：optimization
Internet business strategy	enterprise architecture				3	4
	human capital				3	4
	organizational atmosphere		2	3	4	5
IT governance	IT Infrastructure		2	3	4	5
	IT Management			3	4	5
	IT Service		2	3	4	5
internet business process management	Quality and Safety			3	4	5
	Customer Relationship		2	3	4	5
	Performance Management		2	3	4	5

internet business performance	Output performance			3	4	5
	Operational performance			3	4	5
	Strategic Performance				3	4

Each enterprise can be treated like the initial level. If an enterprise wishes to acquire level 2, then key domain organizational atmosphere, IT Infrastructure, IT Service, Customer Relationship and Performance Management need to reach level 2.

2.3 Capability Maturity score

After comparing with table 3 to acquire the capability level of the enterprise, a capability maturity score can be obtained to facilitate horizontal comparison between companies. After obtaining the level of each key domain of the enterprise, each key domain can be further assigned a certain weight according to the importance of it to calculate the score of each leverage area. Below is the specific way to weight.

$$S(LD) = \sum (ML_{KD_i} \times W_i)$$

S means the score of leverage area, LD means leverage area, ML mean maturity level, KD means key domain, W means the weight, i=1. 2. 3 .4. 5.

Table 4 shows a set of weights of key domain.

Table 4. A set of weight of key domain

Leverage areas	Key domains	weight
Internet business strategy	enterprise architecture	0.3
	human capital	0.35
	organizational atmosphere	0.35
IT governance	IT Infrastructure	0.4
	IT Management	0.3
	IT Service	0.3
internet business process management	Quality and Safety	0.35
	Customer Relationship	0.35
	Performance Management	0.3

internet business performance	Output performance	0.3
	Operational performance	0.35
	Strategic Performance	0.35

Every leverage area's statue is the same, so after calculating the score of leverage, simply, the average can obtained the capability maturity of each enterprise.

$$SC\ (CO) = \sum S_{LD_i} \div 4$$

SC means the score of the company, CO means company, S means the score of the leverage area, LD means the leverage area, i=1.2.3.4.5.

3 Agribusiness internet business maturity comprehensive evaluation

As can be seen from the above description, the maturity assessment model is a circulation improve model. Therefore, it has a set of workflow of circulation improve.

3.1 Participants of this model

Participants of the model means all objects involved during the maturity evaluation process.

a. Assessment team

To evaluate an enterprise fairly and impartially, an assessment team composed by multiplayer is needed. Assessment team generally consists of senior corporate executives, outside experts and corporate grassroots staff.

Senior management of the enterprise is the makers of internet business strategy of the enterprise. They have a comprehensive understanding about the development of the enterprise, so the evaluation about the field of strategy can be more accurate. Outside experts have relevant expertise, so the evaluation about the field of internet business technology can be more accurate. And corporate grassroots staff is the Specific performer of internet business strategy, so the evaluation about the field of internet business implementation can be more accurate.

Assessment team is the user of the model, and the provider of the model's data.

b. evaluation method and evaluation model

Evaluation method is the usage of the model, it describes how the assessment team to use the evaluation model to evaluate maturity. Evaluation model is the model constructed in chapter 3.

c. evaluation tools

After evaluating by using the model, the data obtained should be processed, and evaluation tools exposure to such a function.

Collect the evaluation tools and process the assessment information. The resulting information can provide a reference for improving the assessment model.

Simultaneously, it feedbacks the information to assessment team to obtain a maturity level of the enterprise.

d. The results of the evaluation and improvement program

The result of the evaluation is the maturity level determined by the assessment team. Improvement program emerges during the evaluation based on the evaluation model and the evaluation level. Enterprise compliance this improvement program improve internet business, and then it can upgrade maturity level rapidly.

Improvement program reflects the model is a circulation improve model mentioned above. Enterprise improves internet business maturity by using this improvement program, and then a new improvement program produces.

e. enterprise

Enterprise is the one being evaluated. After assessment team produce an evaluation result and improvement program, enterprise obtains this result and program to improvement continuously.

3.2 Improved circulation specify

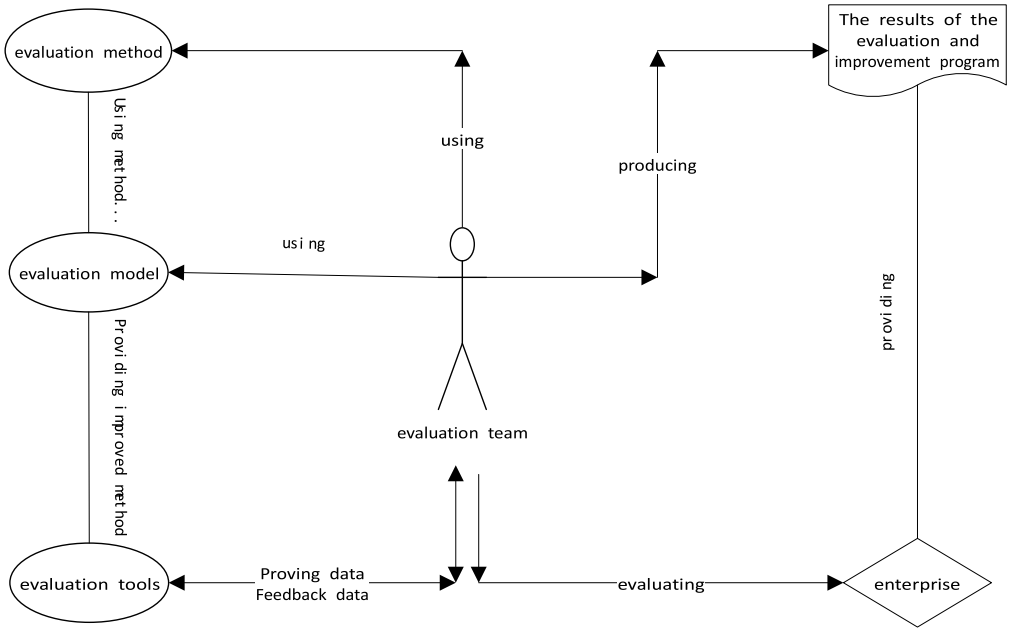
Firstly, assessment team provides the raw data by filling in the questionnaire according to critical variables. Secondly, the assessment team analyzes and organizes the data by using the evaluation tools. Thirdly, evaluation tools weigh the critical variables by using the formula mentioned in 2.2 and feedback it to the assessment team. Assessment team can adjust the model according to the evaluation result.

Assessment team produces a result and an improvement program to enterprise for improved circulation. The advantage of combining the result and the improvement

roadmap is that when an enterprise acquires its maturity, it can be aware of which field inadequate by using the result. For example, an enterprise is in level 2, and all the key domains reach the demand of level 3 except quality and safety, this roadmap provides the direction for the enterprise to improve internet business.

After the round of assessments, enterprise obtains the result and the improvement program, and the next round of assessment can be conducted.

Figure 1. Map of the improved cycle.



3.3 Application of the model

After designing the evaluation system, we choose a certain enterprise to evaluate its capability maturity by using this evaluation system.

Key domains	Score
enterprise architecture	2
human capital	1
organizational atmosphere	2
IT Infrastructure	2
IT Management	2
IT Service	2
Quality and Safety	3
Customer Relationship	2
Performance Management	3
Output performance	2
Operational performance	2
Strategic Performance	1

We can see this enterprise is in level 2 by comparing with the table above. At the same time, the enterprise is now just entering the Capability Maturity level 2. The only key domains reaching level 3 are quality and safety and performance management. However, the capability maturity level 3 requires organization atmosphere, human capital, IT infrastructure, IT management, IT service, quality and safety, customer relationship, performance management, output performance and operational performance reach level 3. Most key domains of this enterprise haven't met the needs. So if the enterprise wants to reach level 3, it should improve all key domains except quality and safety, and performance management.

We can obtain the data that the internet business strategy score of this enterprise 1.75, internet business IT governance is 2, internet business process management is 2.65, internet business performance is 1.65. Finally, we can get the capability maturity score of this enterprise, 2.68.

4 Summaries

In this issue, we studied capability maturity evaluation and related contents. We Summarized an index system which suits the agribusiness capability maturity evaluation, established a capability maturity evaluation model. This issue focuses on the establishment of the Capability Maturity Evaluation Model, including establishing index system, the evaluation method of key domain and critical variables, the determine of the index weight, the evaluation method of internet business maturity, and the description of improve circulation.

In this issue, however, we proposed index system and model about agribusiness internet business capability maturity evaluation, but there are still some researches that haven't been achieved. Below are the further researches.

Achieve Information Technology of the evaluation. This evaluation system can use the human only, the workload is heavy and the task is cumbersome. If we can use a more intelligent method like writing a set of procedure, it could save a lot of time.

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Innovation Model for Integrating the Logistics Service - Cases of Free Economic Pilot Zone in Taiwan

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Abstract

The world moves from the industrial economy to the networked and digital economy. The government and enterprises of Taiwan have already faced serious challenges of protecting their positions and interests. In the face of global economic and trade liberalization, Taiwan's establishment of the free economic pilot zone (FEPZ) is going into the second phase, which is also the focus of the government's economic policy in the beginning of 2015. This study tries to explore the innovation model for integrating the back-end suppliers and frond-end manufactures by the logistics service providers. This research applies the case study methodology for data collection and analysis. The major forms of innovation in logistics services include multi-unit organization, new combinations of services, customer as co-producer, technological innovations. Through information service advantage, the intelligent logistics services will be able to build an e-commerce platform and expand the scale and depth of processing in the business model. To fully satisfy the increasing requirements of customers for one-stop service, the logistics service providers have taken initiatives to broaden the scope of their services. The logistics service providers can differentiate their products and/or services through service innovation.

Keywords: Business model, Free Economic Pilot Zone, Intelligent logistics service, Service innovation.

1. Introduction

The world moves from the industrial economy to the networked and digital economy. Taiwanese government and enterprises have already faced serious challenges of protecting their positions and interests. The special regulations for the FEPZ of Taiwan in two phases are responding to the global trend to liberalize the business environment and to open up domestic markets. It had been entered to the second phase, which is also the focus of the government's economic policy at the beginning of 2015.

Taiwan starts up six "Free Economic Pilot Zones", which aim to attract foreign capital to the investment-starved island and also to familiarize a protectionist public with the concept of free trade, of increasing importance to the island. During the last decade, there has been an

explosive increase in both international trade and foreign direct investment, and many markets are now truly global. If the FEPZ can be succeed, the trade liberalization that goods can freely import, produce, and export without the intervention of neither the customs supervision and control nor tariffs can be fulfilled too.

The core concept of the free economic pilot zones (FEPZ) is to loosen regulations and innovate systems within the zones. Therefore, logistics service providers (LSPs) have to provide a better service for their customers in FEPZ. For 3PLs seeking high value service opportunities in the growing competitive 3PL outsourcing markets, developing innovation competence has become a very important, however, challenging strategic goal (Halldorsson and Skjott-Larsen 2004). Service innovations can enhance customer value and increase brand loyalty. In addition, innovation is also a critical factor for sustainable development. This is the best way for Taiwan LSPs to boost their business growth with internationalized, liberalized and advanced technological innovations.

This study uses the service innovation technique to build up the service chain for Taiwan FEPZ's industrial supply chain in exploring the innovation model for integrating the back-end supplier and frond-end manufactures by the LSPs in FEPZ. The case study methodology is applied for data collection and analysis. The major forms of innovation in logistics services include multi-unit organization, new combinations of services, customer as co-producer, technological innovations.

This paper is arranged as follows. Section 2 provides a brief summary of the recent logistics studies in the FEPZ by paying particular attention to the service innovation resulting in better performance among participating firms. We outline the shift in trade regime that have increased the relative attractiveness of FEPZ programs in Asia. Section 3 illustrates the summary of the research methodology and the sample firms. The case study results was presented in Section 4. In Section 5, we examine the policy implications of this study for Taiwan that have incorporated FEPZ as an integral component of the development strategy.

2. Literature Review

2.1 The role of 3PL in FEPZ

Trade competition among East Asian countries is extremely tough as these countries compete over speed in signing free-trade agreements and establishing free-trade zones. Wong and Chu (1984) examined the general concept of free zones, which includes different types of developments ranging from customs-bonded warehouses/factories, export processing zones (EPZs) and special economic zones (SEZs) to free ports or comprehensive free trade zones. They found common problems encountered by the Asian zones included inadequate infrastructure provision, social problems due to the high percentage of female workers and the exploitation of the indigenous labour force, inefficient government administration and low standards of management, vulnerability to changing conditions in the world economy as well

as competition among themselves because of similar products and markets. Logistic management is one of the key success factors of a supply chain system in FEPZ. Therefore, the 3PL have to overcome the common problem and develop a innovative service for their customers to gain the business in FEPZ.

Sargent, and Matthews (2008) examined how China's success as a EPZ supplier to the United States was shaping the evolution of Mexico's maquiladoras. Chinese competition is clearly only one factor influencing maquila performance. In this study, they examined the characteristics of surviving and non-surviving plants to determine if maquila losses were concentrated in low-, medium-, or high-quality segments. They found that larger maquilas and plants producing auto parts enjoyed lower mortality rates. Controlling for these two factors, they found no statistically significant relationship between the use of technology-intensive production systems, just-in-time inventory practices, total quality management, attractive human resource management practices, and maquila survival. Rather than commodity manufacturing, Rocio Ruiz (2005) proposed that maquiladoras now competed on the basis of the efficient use of technology, speed to market, flexibility, supply chain efficiency, short delivery times, product diversification, and through the ability to design, innovate, and create knowledge.

2.2 Service innovation in supply chain network

Both supply chain and manufacturing network researches are focused on the value network by using different approaches. Manufacturing networks theory stems from the operations management field whereas the logistics management perspective dominates supply chain theory. Supply chains research from the logistics perspective tends to analyze the network as an external network with facilities owned by different organizations. Logistics research furthermore sets out from its roots in physical distribution and materials management and focuses on the links between the nodes, whereas manufacturing network research tends to focus on the (manufacturing) nodes themselves. Rudberga, Olhagerb (2003) illustrated these different points of view as Figure 1. Based on such concept, we treat the supply chain network cover the differenent firms across FEPZ operations.

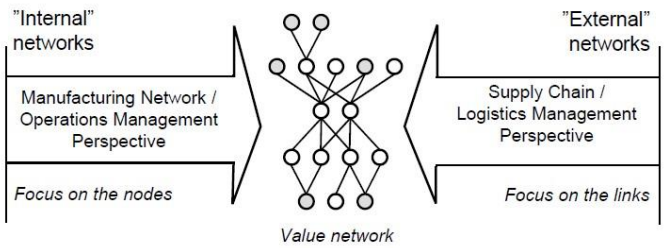

Figure 1. Different points of view on the value network

Cui, Su and Hertz (2009) investigated several international multiple case comparison on the innovation of 3PLs in Northern Europe and Greater China. They revealed new insights to the innovation of 3PLs. In their earlier work, it was found that 3PLs possessed strong intension to innovate to deliver high value to their customers in many business dimensions and thus

created their own value. In their later studies (Cui et al., 2012), they looked at the factors that drived or detered 3PLs from innovation and the performance of 3PL innovations. The findings showed that successful 3PL innovations could bring substantial tangible and intangible advantages to the supply chain partners. Su, Cui & Hertz (2012) developed a 3PL innovation competence model that depicted six key innovation capabilities for a 3PL innovation competence. These six key innovation capabilities included new value creation, external relationships, jobs-to-be-done, organizational transition, multi-faceted dimensional service offerings, and supply chain performance. So, the innovation is a critical issue for 3PL to enhance their service capability and competence in the FEPZ business.

Innovation forms in services are multi-faceted. Van der Aa and Eflring (2002) showed how large the innovation field could be in services that included multi-unit organization, new combinations of services, customer as co-producer, and technological innovations. A summary of this study by Van der Aa & Elfring (2002) found three different processes of innovation where (1) the development of multi-unit organizations, where the simultaneous production and consumption limits the growth of the business in any one location, with a balance between standardization and customization. For the multi-unit organization three supporting processes are relevant: the standardization of the service management system; making the service concept explicit; and a certain amount of experimentation connected with internal benchmarking; (2) new combinations of services – such as organizing linkages between services, creating transparency in the service offering, and the cross selling of the various elements in order to customize the service bundle; and (3) the customer as coproducer, "where innovation through co-production with clients is supported by motivating the clients and integrating them into the delivery process of the service firm. The application of information technology can also play an important part in creating and supporting new forms of co-makership" (Van der Aa & Elfring, 2002).

The nature of Asia's trade is changing and becoming more efficient due to its recent rapid growth. In particular, the information and communication technology (ICT) revolution has generated increased trade in ICT products and outsourced services, and the application of information technology in many public and private supply chain collaborations, as well as greater migration of highly skilled professionals within and across the regions (Hummels, 2009). The connectivity for goods flowing within Asia or between Asia and other regions must be gradually enhanced to ensure reliable, better, and faster movement of cargo. So, we consider the ICT is an important technological innovations factor for the logistics firm. This paper use the four multi-facet of a 3PL innovation model and assess the 3PL innovation competence for the case study.

2.3 Shop onsite and Factory offsite in the FEPZs

FEPZs are different from conventional "Export Processing Zones" or "Science Parks". FEPZs focusing on economic deregulation and institutional innovation. For international goods owners (including Mainland China, Hong Kong, and Macau) engaging in goods storage or

simple processing in FEPZs, 100% of the export and 10% of the domestic sale will enjoy business income tax exemption. Enterprises are encouraged to import key technology, intellectual property or capital so as to promote cross-border cooperation. Industries with clear physical location will be piloted within physical zone areas and linked with companies outside the zones via a "shop onsite, factory offsite" operation model (see Figure 2). Industries unsuitable for being confined to physical zone areas will be conducted at designated trial-points, with loosened pilot operation scope and separate-grade management.

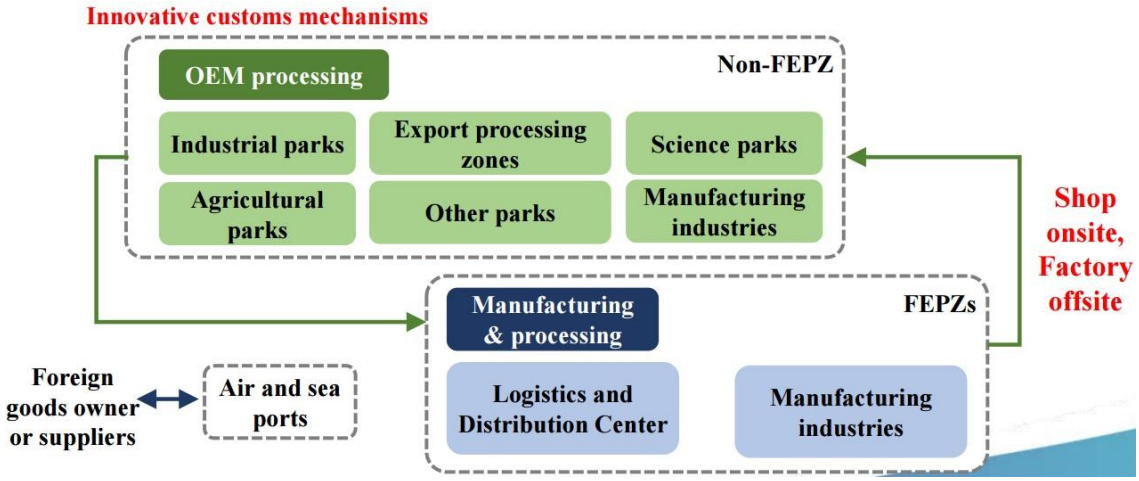

Figure 2. Shop onsite and Factory offsite

(Source: National Development Council, Taiwan, 2014)

3. Case Study Method

This research applies the case study methodology for data collection and analysis. Three companies were interviewed for business strategy/service innovation data gathering and comparison by designed questionnaire. We assess the innovation competence of three 3PLs, i.e. Company A, B, and C, via in-depth interviews. One senior executive from each firm, who possesses the experience and knowledge of the logistics innovation specific to that firm, was chosen to fill out the questionnaire for the four innovation capabilities of the 3PL innovation competence.

In this paper, we investigate three cases that run their business in Taiwan FEPZ (see Table 1). Company A is a forwarder who provides import and logistic service for automobile companies. Company B is an equipment manufacture who import and produce equipments for semiconductor industry. Company C is a forwarder agency who provides export and logistic service for B2C companies to export their products.

Table 1. Background of case companies

Individual company	Company profile	Service location	Global operation	Features of service innovation
Company A	Established for 45 years, is one of the largest custom declaration company	Branches in Keelung, Kaohsiun, Taichung, office in the Taoyuan airport, locations at customs of Taipei and Keelung passed AEO's validation	Provide declaration, logistics, and services on information system. Cooperation with international carriers including England, Japan, Indonesian. Hong Kong, Korean and Malaysia	♦Innovative information platform ♦Information connection between declaration and customer's ERP system ♦Information platform integrating declaration and warehousing service ♦Provide the custoemers complete solution with third-party
Company B	Capital: 18.8 billions NTD Employee in Taiwan: 700	Over 60 offices in 16 countries. Locations in Holland, Taiwan and USA. 4 service locations at Linkou, Hsinchu, Taichung, Tainan. Passed AEO's validation .	Required equipment for foreign and domestic clients and second hand equipment from clients	♦Outsourcing business process operations through thrid-party to increase efficiency ♦Subcontract and acquire other resources from clients ♦Ungent repair and maintenance services
Company C	Established over 10 years. Capital: 20 millions NTD Employee: 61	With increasing dealers over 200 over the world, including Locations in FETZ of Taoyuan and Keelung Passed AEO's validation	Passed five AEO's validations for import/export, manufacturing, warehousing, forwarder, and declaration services. Obtaining recommendation from international manufacturers, large shipping companies, and agents.	♦Innovative information platform ♦Port stationed process professional knowledge ♦Connecting to information system of e-business network in providing immediate information ♦Information platform to integrate declaration and warehousing services ♦Providing ocean/air freight and logistics service

4. Operation Model Analysis of Case Companies

The establishment of FEPZ in Taiwan aims to provide international firms or customers tax-free zone for establishing their business units. They can cooperate with high-tech companies located in industrial zone or science park or small and medium enterprise located around Taiwan to utilize their production technology and provide service for back-end supply. Based on the concept of "store in the front, factory in the back" as shown in Figure 2, this study chooses three cases in the Port of Keelung (case A and case C) and Taoyuan International Airport (case B and case C) as service innovation cases of supply chain.

Service-provider's service innovation will improve business performance by reducing cost and increasing customer loyalty. To fully satisfy the increasing requirements of customers for one-stop services, many logistics service providers have taken initiatives to broaden the scope of their services. The logistics service providers can differentiate their products and/or services through service innovation. Table 2 shows different service innovation of three cases. Their operation models are shown as Figure 3-5.

Table 2. Service innovation of three cases

	Company A	Company B	Company C
Multi-unit organization	♦ ERP connection between customs and domestic clients ♦ Integrated custom declaration platform, to resolve shrinking declaration industry ♦ Cooperation between warehousing and transportation supply to make declaration service more professional and easy ♦ Commission of products declaration change with domestic economy ♦ Cooperate with information industry to establish information platform ♦ AEO validation	♦ Free trade zone simple processing ♦ Contract free trade zone storage business to private sector ♦ Government policy ♦ Geographic location ♦ Complete infrastructure construction, stable economic growth rate ♦ Complete IC industry supply chain ♦ Cooperation from correlated industry ♦ AEO validation	♦ Providing warehousing service within FEPZ ♦ Providing ocean/ air freight service within FEPZ ♦ Connection foreign e-business through distribution center ♦ Cooperation with foreign dealer, domestic dealer and supply ♦ Custom controls products in storage through audit program from government ♦ AEO validation

New combination of services	♦ Connection between information platform and ERP system of	♦ Providing urgent repair and maintenance model	♦ Besides general transportation declaration, also
	domestic clients ♦ Outsourcing custom declaration industry ♦ Share information platform with competitors ♦ First hand billing and second hand billing use platform to exchange information ♦ Connection in custom declaration system and clients information system	to handle the busienss of semiconductor equipment that sold it to the front end firms of the process, while recovering the disused old machine sold to customer in the past. ♦ Transportation cooperation	provides professional consulting service ♦ Contract ocean and air freight ♦ Information system to integrate domestic and foreign clients ♦ Shipping fee quote, tax inquiry, and online import form services with e-business ♦ Goods warehousing service
Customer as co-worker	♦ Relationship between custom declaration competitors ♦ Provides clients independent information system, customization information platform ♦ Connection for PDI center information system ♦ Control import vehicles and more accurate information through connections between information systems	♦ Site service ♦ Outsourcing non-core business ♦ Cooperation in educational training ♦ Cooperation between material and production ♦ Company policy cooperation ♦ Seeking cooperation between supply and dealer ♦ Adjustment period	♦ Share website information, connect added value platform ♦ Bonded advantage of Port that brings customers tax relief on goods ♦ Packing and transportation service

Technological innovation	• Innovative information system • Experienced custom declaration • Innovative custom declaration • Professional IT technicians	• Transportation equipment and advantage in international trade • Professional technicians	• Innovative information platform • Professional knowledge of FEPZ flow • Provide most update information through e-business • Use information platform to integrate declaration and storage service

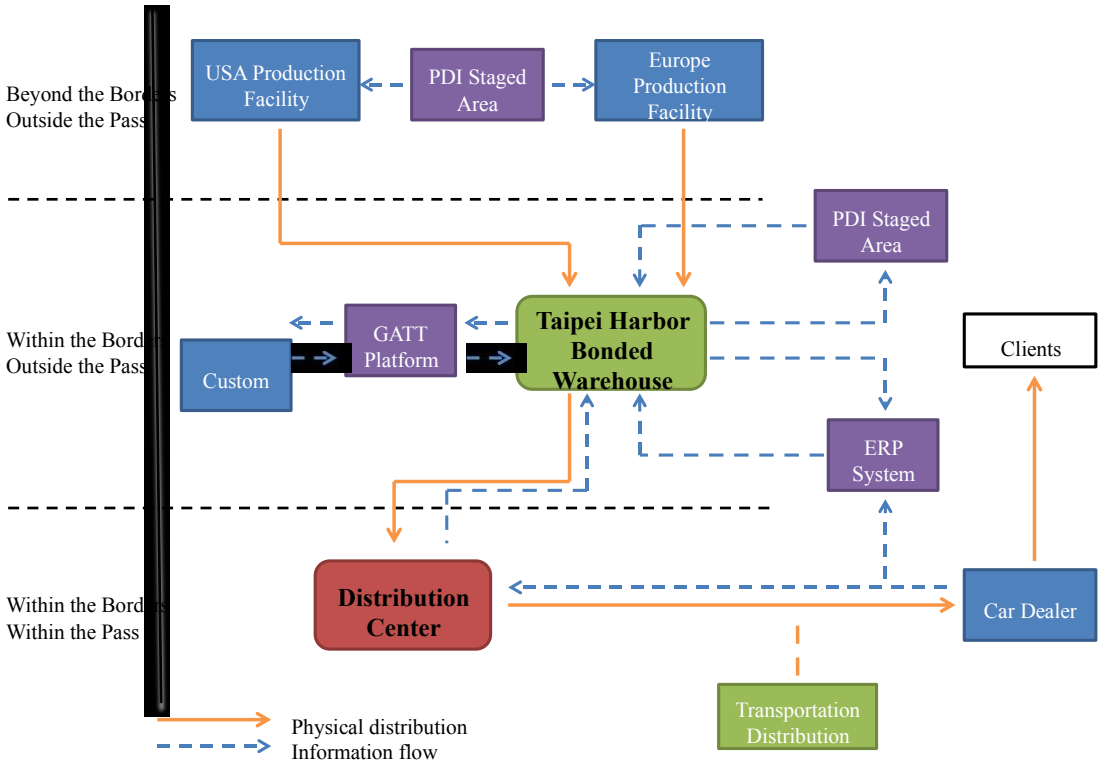

Figure 3. Logistic flow of Company A

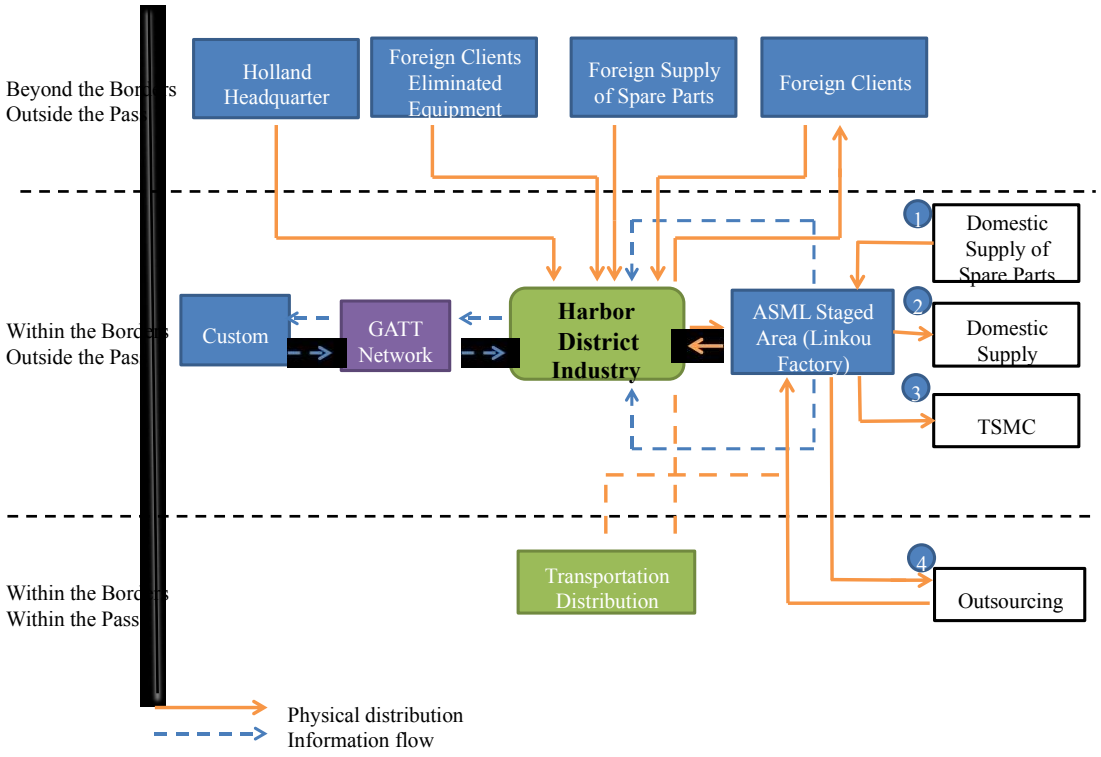

Figure 4. Logistic flow of Company B

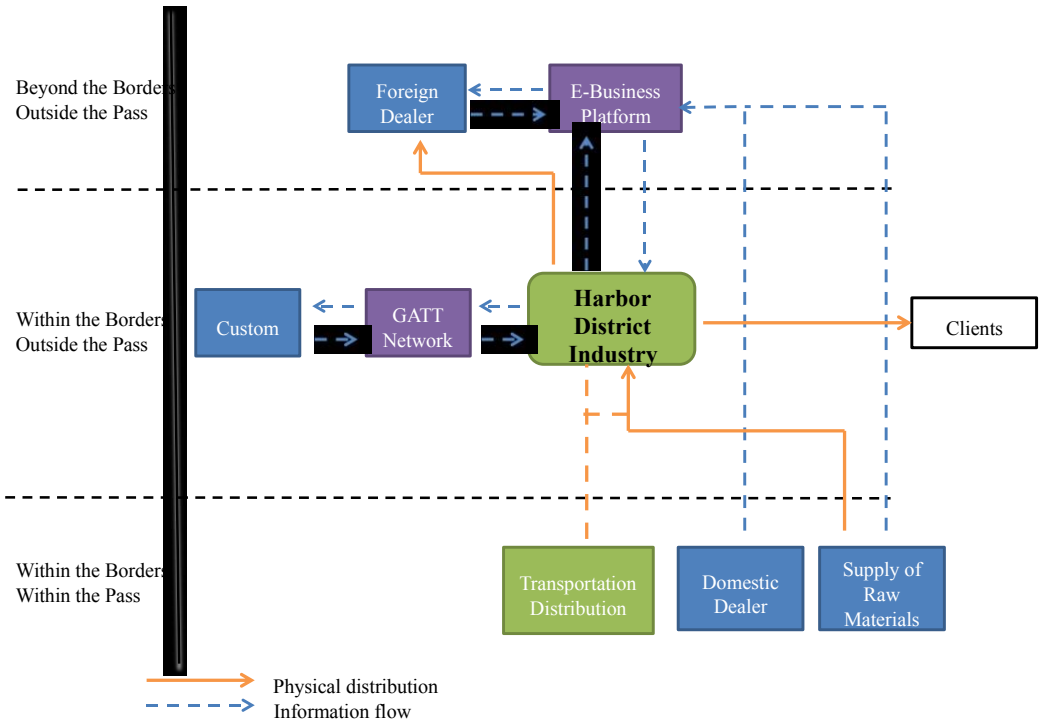

Figure 5. Logistic flow of Company C

5. Conclusion

A company combines with other customs brokers to provide an convenient B2B and B2G customs system. B company, the equipment provider, combines with the information platform of DHL to provide the fast maintenance service for its downstream semiconductor customers. C company, without large capital scale, provide well B2C logistic distribution system within FEPZ with its professional logistics service to expand the oversea sales. Based on the comprehensive analysis of three cases, developing information platform to integrate upstream and downstream information is an important part for 3PL providing integrated service.

3PL plays an important integration role in building up upstream and downstrem partnership. The firms can outsource generalized logistics work to logistics providers. 3PS can also make use of the location superiority within FEPZ and exploit service innovation model to link the goods flow inside and outside the FEPZ, so as to provide the global competence for expanding Taiwan trade.

Acknowledgement

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Preliminary study on TRIZ Implementation Model and Case Study

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Abstract

Innovation is the most frequent used terms recently. As a quality professional, we do not only solve problem for continuous improvement, but also to select innovative solutions to achieve higher value. Therefore, TRIZ, so called creative thinking for engineers, is a handy tool for quality professionals for the above purpose. In this paper, a systematic implementation of TRIZ approach is proposed as an organizational innovation model, as well as, one success small project as a case study to be discussed.

Keywords: Systematic Innovation, Organizational Innovation Model, TRIZ implementation, TRIZ Tool Application.

1. Introduction

The Theory of Inventive Problem Solving (TRIZ) was developed in the former Soviet Union by Genrich S. Altshuller (1926-1998) who studied 200,000 patents and selected 40,000 patents as representing the most effective solutions from 1946 to 1948 (Terninko J. etal., 1998). He found that evolution of an engineering system is not a random event, but governed by certain patterns. Altshuller's key finding and developments included:

A) Technical Contradictions:

- 40 Inventive Principles
- 39 Engineering Parameters

B) Physical Contradictions:

- Four Separation Principles

C) Ideality

D) Algorithm of Inventive Problem Solving (ARIZ)

In Hong Kong, I had attended MATRIZ Certification Level 1 Training on 19, 20, 26 & 27 April 2013 which organized by Institute of Systematic Innovation, Hong Kong (ISIHK). In this MATRIZ Level 1 course, TRIZ techniques are included "The Nine Windows", "Ideality and Ideal Final Result", "Function Analysis", "Cause Effect Chain Analysis", "Trimming", "Technical and Physical Contradiction" and "40 Inventive Principles". The whole MATRIZ training road map is showed in Figure 1. Then I found that TRIZ could offer to a quality practitioner a more systematic approach to quality problem solving. However, there is no systematic implementation framework for organization to apply TRIZ tools step by step. Therefore, I try to propose a TRIZ Implementation Model for Technology Support Centre in Hong Kong Science and Technology as preliminary study.

2. Methodology

Based on the TQM implementation framework (Chin, 2000), it has four main sections and the foundation section is "Organizing", and the two pillars, which form its structure, are the use of "Systems and Techniques" and "Measurement and Feedback". "Changing the Culture" is the fourth section that must be considered at all stages. This framework has 22-step guideline for facilitating TQM adoption through Awareness – Preparation – Implementation phases. Throughout the entire process, the parties involved "Top Management", "Steering Committee Members", "Departments and Project Teams", as well as, "External Consultants".

The TRIZ implementation roadmap is modification of the TQM implementation framework as 20-step guideline which is developed to facilitate the TRIZ adoption through the "Awareness," "Preparation," "Implementation" and "Validation" phases, respectively. Throughout the execution of the TRIZ implementation roadmap, top management, TRIZ committee members, TRIZ promotion work group members, users, and external experts, are being involved as deemed appropriate. A stepwise implementation guideline of TRIZ is proposed. It is developed based on the PDCA approach, under which different responsibilities and the key tasks of parties can be defined, as stated in Table 1. (Lai, Lotto K.H., 2014)

Based on MATRIZ Level 1 course, TRIZ tools application sequence is mainly focused on Problem Identification as follows.

Tool 1 – Multi-screen Thinking (The Nine Windows)

Tool 2 – Ideal Final Result (IFR)

(IFR = All useful effects or functions / All harmful effects or functions)

Tool 3 – Functional Analysis (FA)

(Component & Interaction Analysis and Function Modeling)

Tool 4 – Cause and Effect Chain Analysis (CECA)

Tool 5 – Trimming

Tool 6 – Technical Contradictions

(39 Engineering Parameters & 40 Inventive Principles)

This TRIZ implementation model is also considered Mr. Heungyeol Na (TRIZ Expert / Senior Engineer, Samsung Mobile Display, Korea) 7 Tips for adoption of TRIZ in 2013:

Tip 1 - Try to make CEO to be assured of TRIZ

Tip 2 - Organize TRIZ Promotion Team

Tip 3 - Draw project with Top-down style at the early stage of TRIZ introduction

Tip 4- Choose the TRIZ method which has the problem solving process

Tip 5 - Be carry out TRIZ training course; starting with CEO

Tip 6 - Give Incentive to Internal TRIZ Expert who has TRIZ Level

Tip 7 - Collaborate with other tools which can compensate deficiencies of TRIZ

3. HKSTP Case Study

Hong Kong Science & Technology Parks Corporation (HKSTP) is a statutory body, which established in May 2001, dedicated to building a vibrant innovation and technology ecosystem to connect stakeholders, nurture technology talents, facilitate collaboration, and catalyse innovations to deliver social and economic benefits to Hong Kong and the region.

Technology Support Centre (TSC) of Hong Kong Science and Technology Parks Corporation has implementing the TRIZ implementation framework. Ten members were selected to attend MATRIZ Certification Level 1 Training on 14, 15, 21 & 22 March 2014

and formed TRIZ promotion team (named TSC TRIZ Team – 3T) in order to solve different technical problems / projects.

The first project named "Enhancement of IC sample amount and balance the Metal Tray weight". The procedure of reliability test is to put IC devices inside the holes of each metal tray which then stacked up in the environmental chamber. The test conditions are -65°C to 150 ^{o}C, 15 mins dwell time and 1000 cycles. The maximum capacity of chamber (loading) is upto 2kg. The existing setting is showed in Figure 2.

After nine windows exercise, we still focus on "Present" and "System & Sub-system". Then the Ideal Final Result (IFR) is identified as followings:

i) Zero weight for sample holder

ii) Hold large amount of IC samples

iii) Fix IC samples orientation

iv) Simply, No side effect and No cost, as well as, satisfied customer requirement.

We perform Function Analysis (FA) and the function model is created with Trimming (Rule – C) in Figure 3.

The key disadvantage is identified as heavy weight of metal tray by using "Cause and Effect Chain Analysis (CECA)".

We selected related Engineering parameters and group with different contraction pair using IF…THEN…BUT statement. Finally, we identify the most frequency Inventive Principles (IPs) which are IP 1 – Segmentation and IP 15 – Dynamic Parts.

The solutions are mainly considered two Inventive Principles and details show as follows

Ip 1 – Segmentation

Divide an object or system into independent parts

Make an object or system easy to disassemble

Increase the degree of fragmentation or segmentation*

Ip 15 – Dynamic Parts

Allow (or design) the characteristics of an object, external environment, or process to change to be optimal or to find an optimal operation condition.*

Divide an object or system into parts capable of movement relative to each other.

If an object (or process) is rigid or inflexible, make it movable or adaptive.

The final metal tray is separated from large one to small six places and reduces the weight of each tray. Moreover, the orientation hole is re-designed. The comparison of original metal tray and final metal tray is showed in Figure 4 and its parameter comparison is recorded below. The result is found to be enhanced about 3 times of original one!

Items	**Original Metal Tray (Parameters)**	**New Metal Tray (Parameters)**
Dimension of original holder and new holder (Length, Width and Height)	15cm*18.5cm*0.5cm	5cm*7cm*0.25cm
Weight of original holder and new holder	390g	52g
Number of sample held	270pcs	150pcs
How much of total sample could be handled per time in the oven?	270pcs*2 tray(per basket)*2 basket(per oven)= **1080pcs(of samples)**	150pcs*12 tray(per basket)*2 basket(per oven)= **3600pcs(of samples)**

4. Conclusion

Overview the above cases, top management support, adequate training and knowledge, as well as Resource are well recognized as key sources of TRIZ project success. Moreover, Function Analysis could help us to focus the problem and Trimming assist us to simplify the system and then the Final Idea Result to be our innovation hints. There is no systematic way for innovation. However, Samsung Mobile Display to use TRIZ for Product Innovation seems very successful. Therefore, this preliminary study using 20 steps TRIZ Implementation Framework for Organization Innovation is proposed.

Lastly, I would like to quote the Chinese old saying "Poor force to change, Change become success" (窮則變，變則通). In my own word, it describes as "Innovation is for Survival" (變則生，不變亡).

Acknowledgement: I would like to thank the TSC management support and TSC TRIZ Team (3T) members' effort for their help and provision of the necessary facility support.

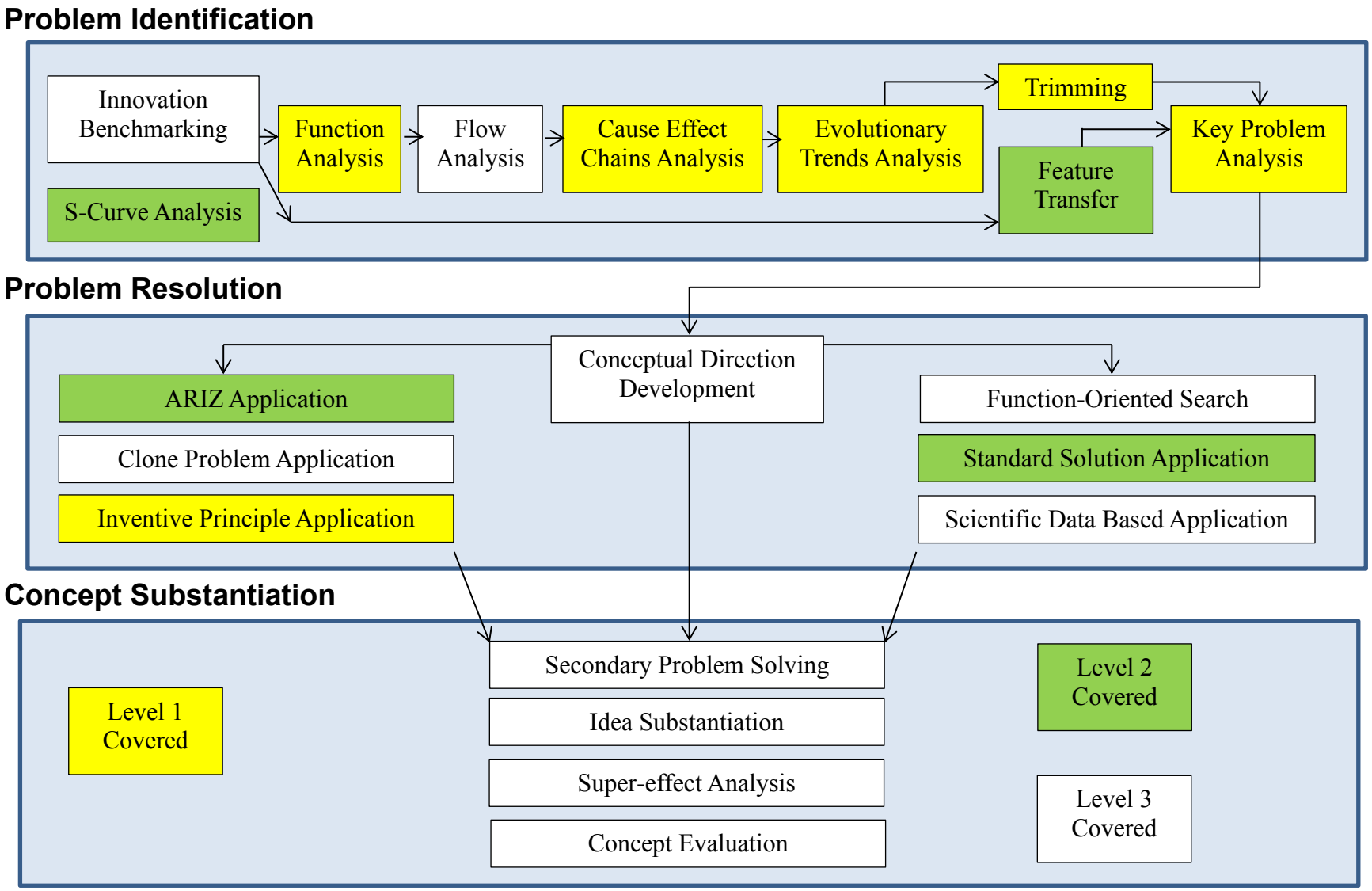

Fig. 1 – Roadmap of TRIZ Training

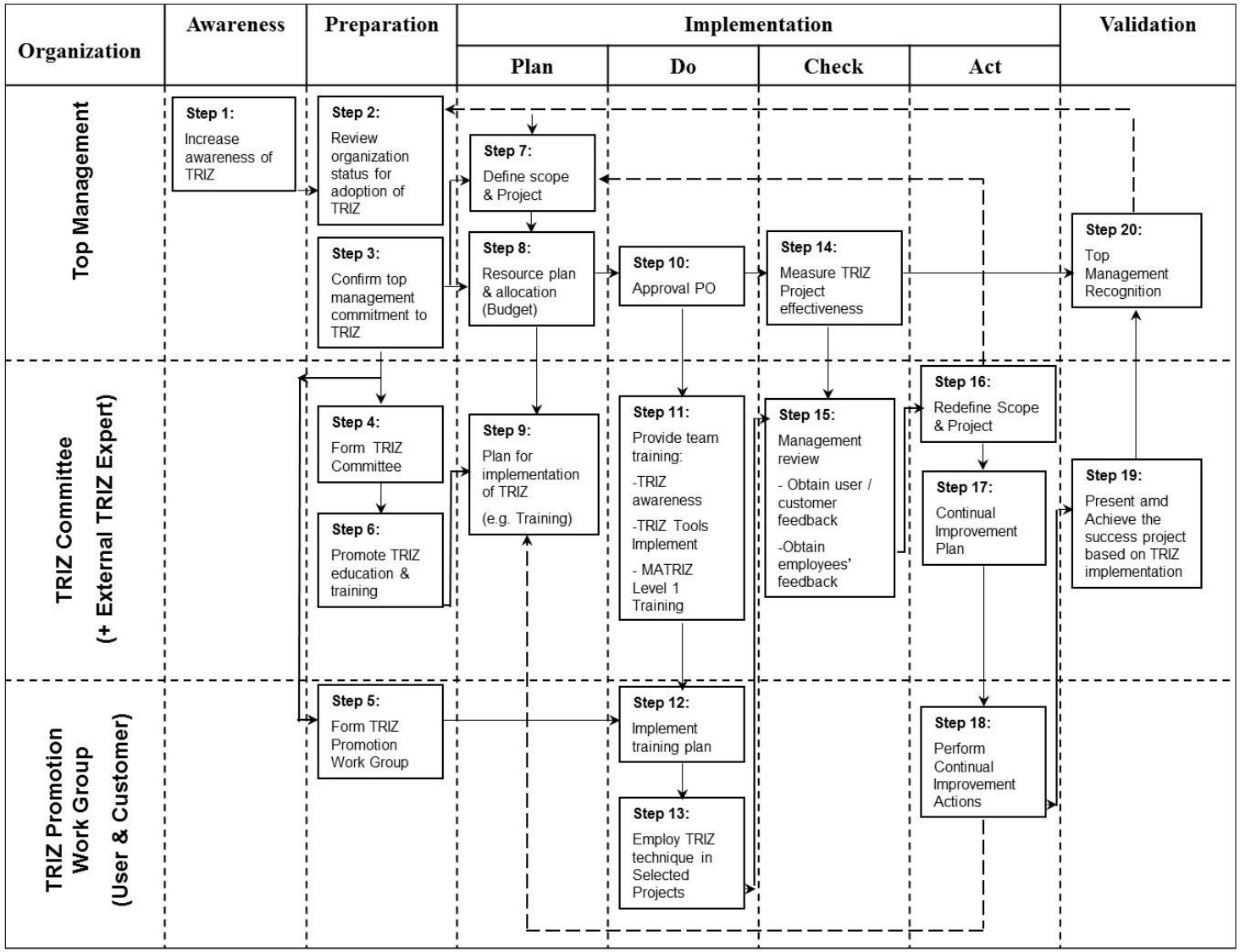

Table 1 – Roadmap of TRIZ implementation (Lai, Lotto K.H., 2014)

	ER	OL	TM	BA	HS	CA	SU	CI	RI	LO	Total
Ip 1 – Segmentation	**1**		**1**		**1**	**1**		**1**			**5**
Ip 3 – Local Quality										1	1
Ip 4 – Symmetry Change			1								1
Ip 10 – Preliminary Action	1										1
Ip 15 – Dynamic Parts						**1**		**1**		**1**	**3**
Ip 16 - Partial or Excessive Actions						1					1
Ip 18 – Mechanical Vibration			1	1							2
Ip 19 – Periodic Action				1							1
Ip 27 – Cheap Disposables					1					1	2
Ip 28 – Mechanical Interaction										1	1
Ip 29 – Pneumatics and Hydraulics	1				1						2
Ip 33 – Homogeneity			1								1
Ip 34 – Discarding and Recovering						1					1
Ip 35 – Parameter Changes	1				1						2
Ip 36 – Phase Transitions				1							1
Ip 40 – Composite Materials				1							1

Table 2 – Identified Inventive Principles (IPs) Frequency Table

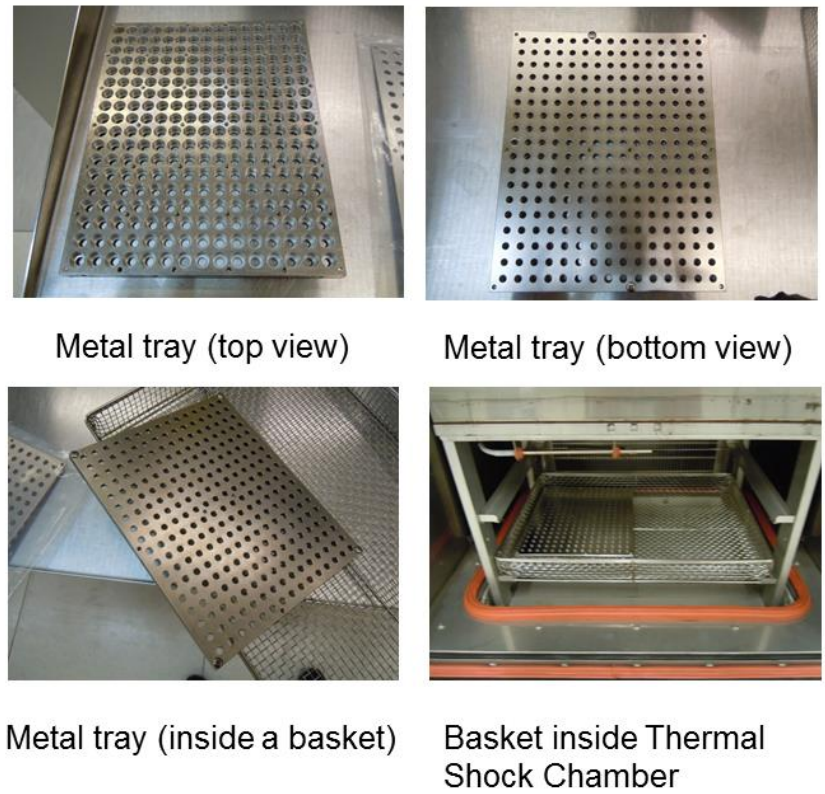

Fig. 2 – Metal Tray for enhancement

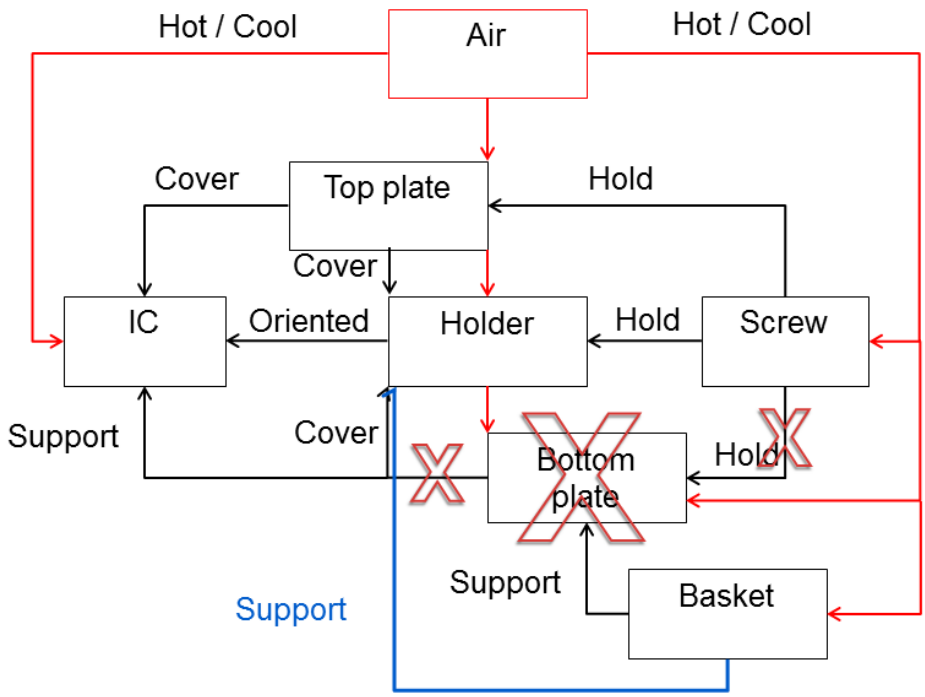

Fig. 3 – Function Model of Metal Tray (Trimming – Rule C)

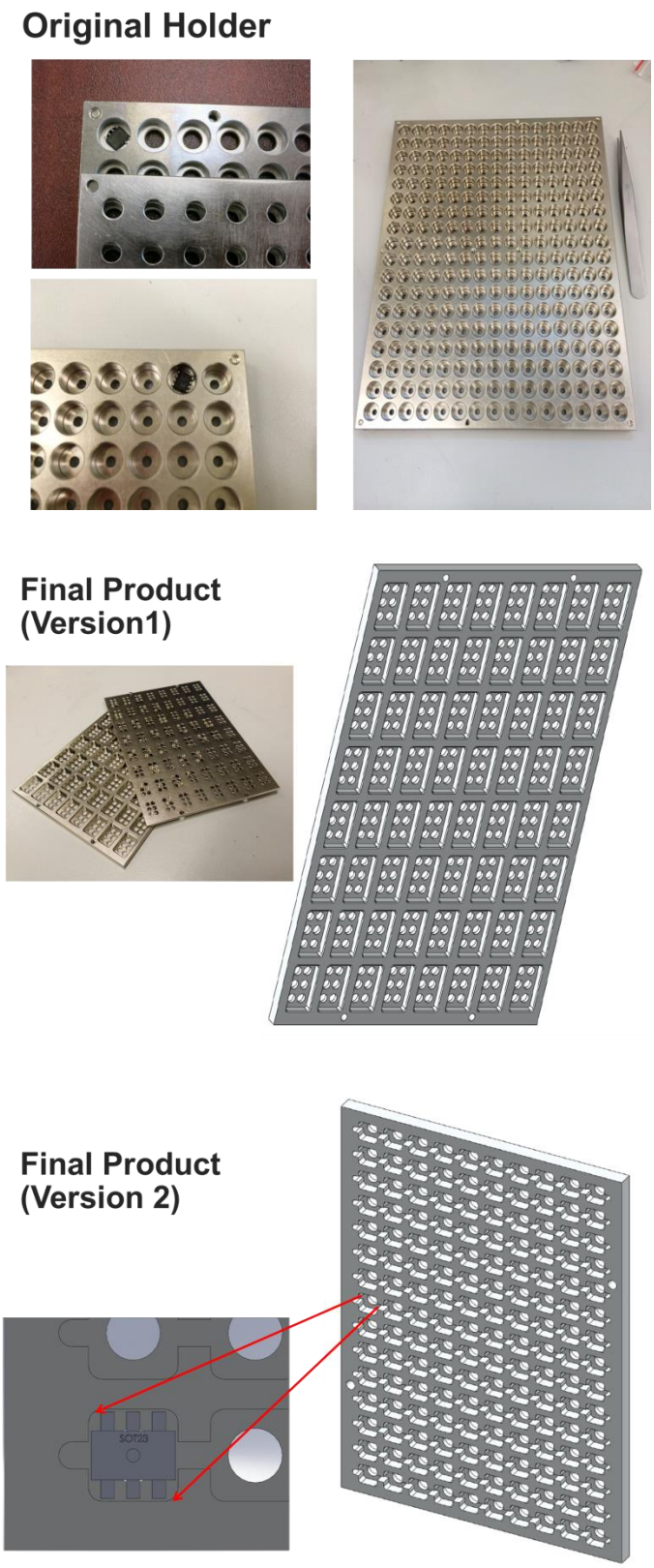

Fig. 4 – The comparison of original metal tray and final metal tray

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Innovative Automation Equipment of Laser Cladding

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Abstract

This paper presents the development and automation of the innovative laser cladding equipment. The need of control parameter as overlapping, number of clads, deposition rate, laser power and powder feeder rate are very import in the process and they influence the mechanical proprieties and durability of the coatings. With the automation of the process is possible guarantee the quality of the product. To achieve the objective of this work it is necessary to survey all electrical, electronic and mechanical components of the constituent systems. The laser cladding layout and the process must be very well studied to be developed, the automation and optimization. A program with graphic interface was develop in C# language to allow control simultaneously the main components of the tree systems: laser, powder feeder and system position XYZ. So, with only one program was possible control and define all the parameters of the process and of the equipment. So, was possible obtain different chemical compositions in one sample keeping the same process control parameters, varying linearly the mass flow rate from two metallic materials in synchronization with the translation movement of XY table.

Keywords: Automation, Innovation, Laser Cladding, Graphic Interface, Laser IPG YLR.

1. Introduction

Laser cladding is a technique to enhance a surface protection with an addiction of fine clads of similar or dissimilar material. This process will increase surface mechanical properties as hardness, wear and corrosion resistance (Navas et al., 2005) in mechanical components subject to adverse working condition such aggressive environment, high thermal cycles and exposure to corrosive

gases (Capello et al., 2005) for prolonged periods of time. It also increases their lifetime (Costa & Vilar, 2009).

These indicated features are due to reduced dilution between the substrate and the alloy coating, so, the high mechanical properties of the coating are preserved (Farnia et al., 2012; Komvopoulos & Nagarathnam, 1990; Schneider, 1998; Navas et al., 2005; Vilar, 1998). However, the increase of mechanical properties of the surface layer is not only due to the metallurgical characteristics of the coating, but also by the result of thermal cycles applied. The high heating and cooling rates that occur during the process result in a grain refinement (Schneider, 1998; Li et al., 2004).

Laser cladding is used in large industries like repairing of dies and molds (Dianbing, 2014; Jhavar et al., 2013; Navas et al., 2005; Shaoke, 2014); repairing marine engine crankshaft (Torims et al., 2015); coal industry, repairing of shearer pick (Che et al., 2014), repairing of aero-engines components (Wang & Lin, 2014), continuous caster, repairing of lateral rolls (Ray et al., 2014) and other industrial applications.

This work has, as main objective, the automation of laser cladding equipment from Laser Laboratory of the Lisbon University, used by the Center of Physics and Engineering of Advanced Materials - CeFEMA. In this paper was developed a control process to optimize the simultaneous use of the: three linear guides OWIS, laser IPG YLR and PLASMA-TECHNIK powder feeder. This automation is necessary because the control of process parameters process are crucial in the quality of coating obtained (Lin, 2015).

2. Laser cladding setup

For the XYZ positioning system the authors used the layout shown in Figure 1. In this setup the sample is positioned by the XY guides and the laser focus is done by vertical guide Z.

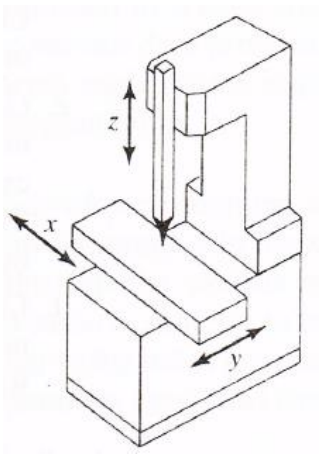

Figure 1. Configuration used for linear guides (Groover, 2007).

In Figure 2 can be observed the layout of the X, Y and Z guides and lateral nozzle of the cladding equipment used as study object of this work.

For addition of metallic powders to the molten pool was implemented a lateral nozzle configuration (in red on Figure 2). This lateral nozzle has an internal diameter of 1.2 mm and a length of 200 mm in order to minimize the divergence of the powders flow when these are injected into the molten pool increasing the efficiency.

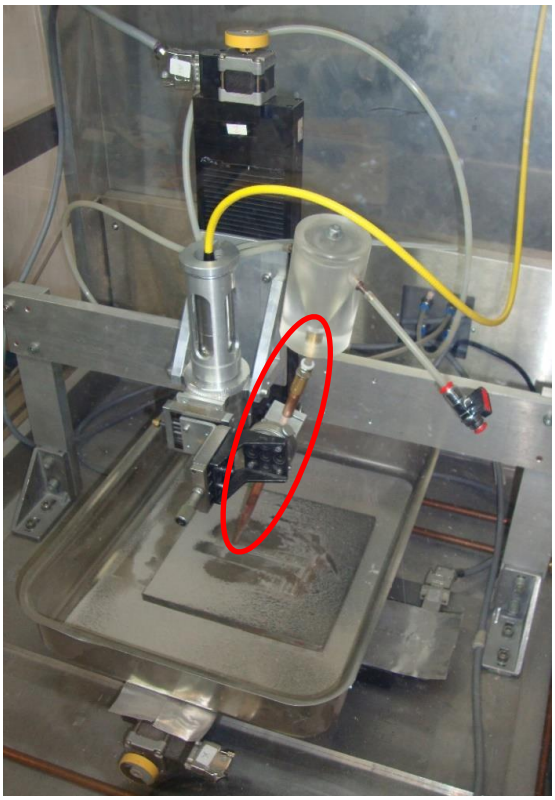

Figure 2. Layout of the guides and lateral nozzle of the cladding equipment.

Through two manual linear guides, the incidence of powders flow to molten pool is positioned in X and Y. By manual rotary guide, the angle of incidence of the powders flow can be adjusted. Thus, the position of the flow powders to molten pool is made with precision.

3. Process automation

The principal components of the cladding process are three linear guides, 300W power laser and powder feeder. These three components must be controlled simultaneously. In Figure3, is shown the control scheme of the laser cladding equipment controlled by a personal computer.

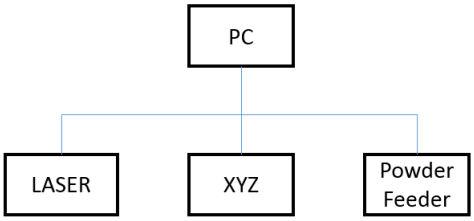

Figure 3. Control scheme of the equipment.

For the automation of laser cladding equipment, is needed to understand the external control of the laser (Figure 4 a)), the linear guides, as well as the powder feeder (Figure 4 b)). The guides X, Y and Z, lateral nozzle, and the sample must be inside of the glove box (Figure 4 c)) for protecting the sample in an inert atmosphere during the deposition process.

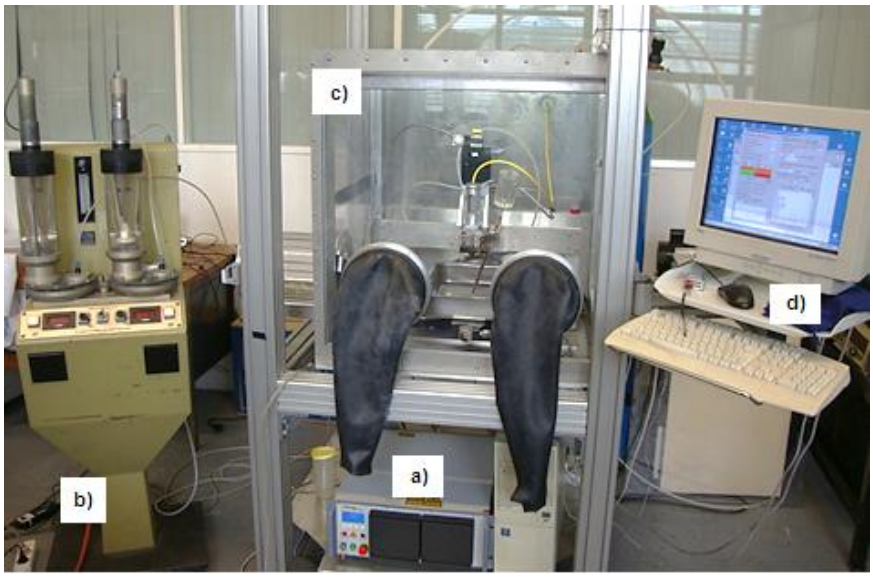

Figure 4. Equipment used in laser cladding process: a) Laser IPG YLR 200; b) PLASMA-TECHNIK powder feeder c) glove box; d) personal computer.

The laser IPG YLR 200 AC is a fiber laser that can be controlled by RS-232 interface, as shown in Figure 5, through configuration and control commands defined by the fabricator. In this interface are used three lines, RxD, TxD and GND, of a DB9 cable. This RS-232 interface used a baud rate of 57600, 8 data bits, 1 stop bit and is not used parity bit nor flow control. In order to verify that the laser receives the command sent, the laser generates a response which consists of the echoed back command.

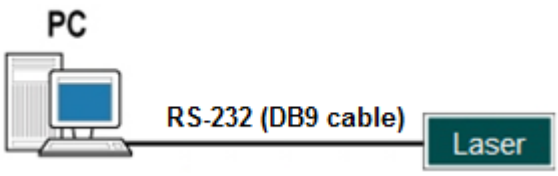

Figure 5. Control scheme of the equipment.

As has been said before, in this laser cladding equipment are used three motorized linear guides LTM.80-150 of OWIS (Figure 6). This guides have bipolar motors which are controlled by Microstep Controller SM30 card of OWIS that is inserted into the computer's motherboard. The list of control functions of driver SM30 card was implemented on programs to control sample dislocations on X and Y axes and laser focus position, on Z axe.

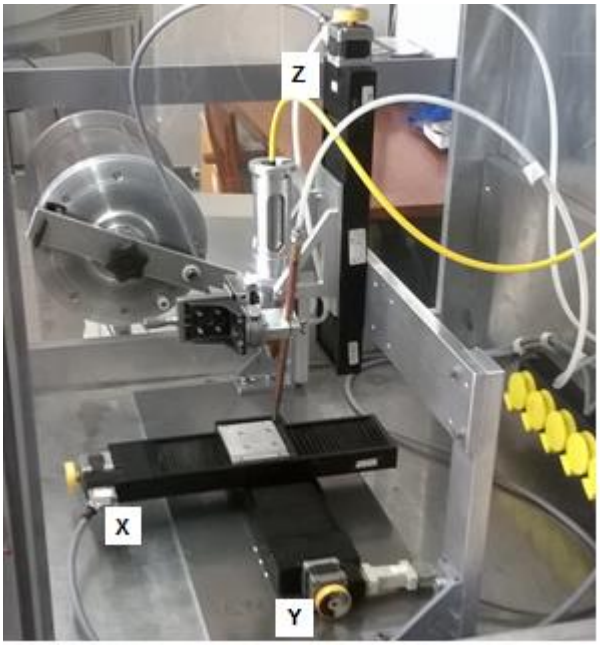

Figure 6. Motorized positioning system.

In the control of powder feeder it was used an Arduino Nano (Arduino, 2015) that receives control instructions through USB from the control program developed. This Arduino communicates through I^2C with the digital analog converter (DAC) MAX518 (Maxim Integrated Products, 2002) which generates two analog signals. These two analog signals are amplified by the LM2904 AMPOP (Texas Instruments Incorporated, 2015) to range 0 to 10 V to set the mass flow rate of the two powder feeder channels.

The TD62783 driver (Toshiba, 1998), drives powder feeder's control relays, by amplifying Arduino's logical level outputs. Each channel could source up to 500 mA; 50 V maximum output. In this application, each output drives a 24V - 1600 Ohm coil relay (15mA). So, powder feeder's channels 1 and 2, can be turned on and off by the computer.

4. Graphical interface

The control program was developed in Microsoft Visual Studio Express in C#. As shown in Figure 7, the graphical interface enables the user to define the main process parameters such as the length, number and spacing between coats, the deposition rate, the laser power and mass flow of powders injected into the molten pool.

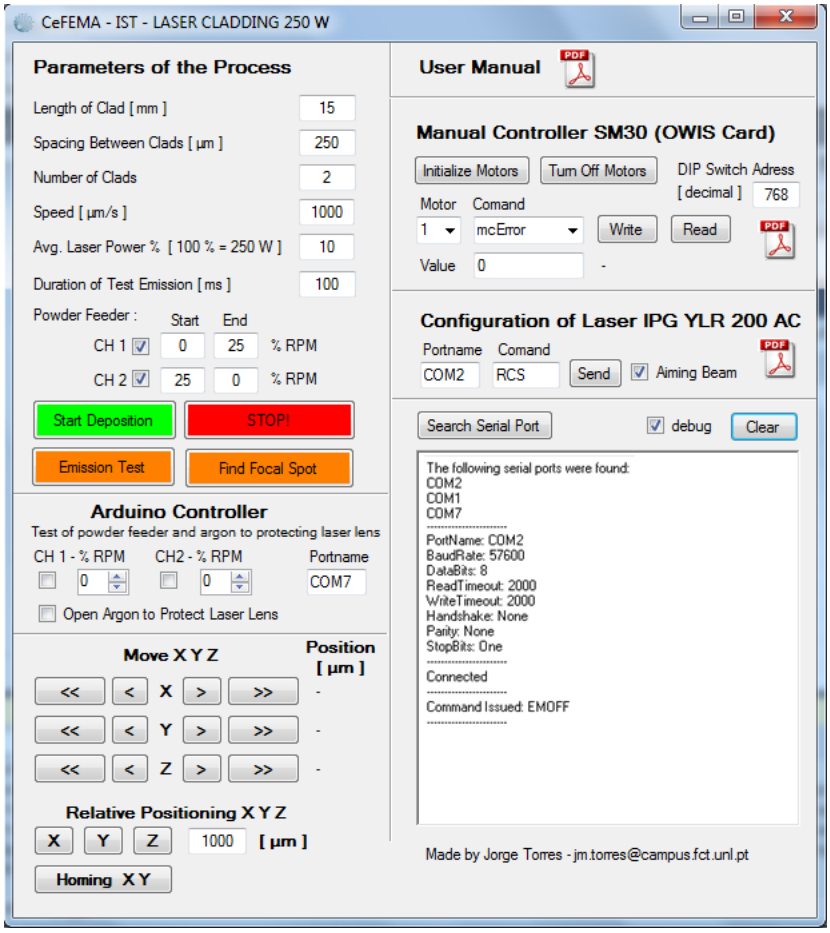

Figure 7. Graphical interface for control of laser cladding equipment.

In this control program the three guides, the laser and the powder feeder are controlled by threads. These threads have the advantage of allowing these devices to be controlled simultaneously, and it also avoids blocking the graphical interface. This graphic interface allows the user: move X, Y and Z with different speeds; do the homing XY; move each axis in a distance in microns; and testing the radiation emission with specified power and duration; open argon to protect laser lens; test the turn on/off powder feeder and set mass flow rate; and turn on/off aiming beam of the laser.

In order to study different alloys of two materials A and B, these have to be introduced into the powder feed's container (channel 1 and channel 2), and the process control routine developed allows varies linearly the mass flow rate from the two metallic materials in synchronization with the translation movement of XY table. Therefore, with a single coat it is possible to study the different alloy percentages (with different chemical composition) produced, as showed in Figure 8. Therefore with this technology is possible to study the obtained samples of different alloys and its mechanical properties and durability.

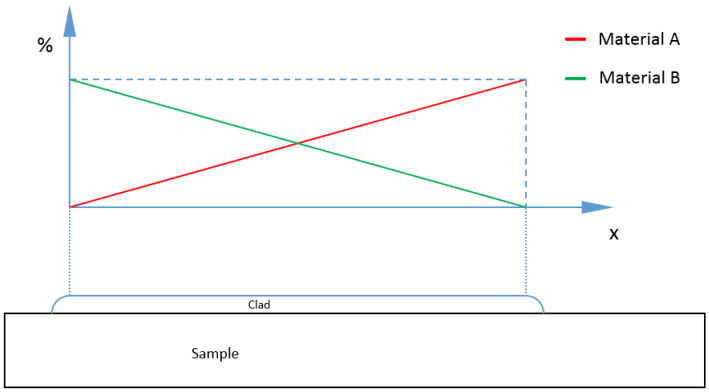

Figure 8. Variation of the mass flow during the coating.

5. Conclusion

Development, automation and optimization of laser cladding equipment of the Center of Physics and Engineering of Advanced Materials – CeFEMA, allows controlling the main components simultaneously and efficiently. With only one program was possible control all the parameters of the process and of the equipment. This process automation allows the user to set different parameters such as length, spacing and number of clads, the deposition rate, laser power and powder feeder rate. This technology is very important to obtain different alloys in same samples with same process control parameters to study phase diagram. By controlling the fabrication parameter it is possible to study its influence in the mechanical proprieties and in the durability of the coating obtained.

Controlling the parameter of fabrication it is possible study its influence in the mechanical proprieties and the durability of the coating obtained.

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Research on the Search Process of Technology Opportunities Based on Disruptive Innovation

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Abstract

Disruptive innovation (DI) is an effective approach of innovative design. If enterprises can use the DI successfully, they can compete with the product that have already occupied the market, and even replace them. This paper describes the concept of DI, and explains the occurrence period of DI through the theory of technology evolution. DI can be divided into two ways: new-market DI and low-end DI. Based on DI, the search process of technological opportunities for both kinds of DI was studied and concrete steps were obtained. Finally a case of desk lamp was given to verify the search process of technological opportunities.

Keywords: disruptive innovation, low-end DI, new-market DI, technology evolution, the search process of technological opportunities

1. Introduction and Literature Review

The concept of disruptive Innovation was proposed by Christensen in his book" The innovator's dilemma, when new technologies cause great firms to fail" for the first time in 1997. It is a kind of theory of technological innovation that established in the continuous improvement process. DI is a innovation activity that mainly used to attract special consumption group such as low-end users or new users. It introduces different features from mainstream products. After DI, the product can reduce its performance in one or a few aspects. Generally speaking, it has the characteristics such as low cost, small size, simple structure and so on. Even the poor performance in early time, the DI products can get a firm foothold in non-mainstream market and is likely to replace the products of mainstream market after development. A successful DI can meet the customer's demand, and provide additional features at the same time. Usually, these additional features of the product is are: small, light, low cost, feature-rich, easy to use, high reliability, high efficiency, low energy consumption. DI is important for enterprises, therefore, the research about search process of technology opportunities for disruptive innovation is necessary.

Technology has been in constant evolution. A large number of studies show that any products or technologies are similar to biological systems and it is regular. The success of new technology or new product depends on whether it follows the general rule of technology evolution.

Since disruptive innovation put forward, the scholars study it constantly. Govindarajan & Kopalle[1] introduced the high-end DI and put forward a general measure of DI. Erwin D [2] used the disruptive technology to examine some key issues which affect the technological change on firms and industries, and studied the relationship between them. His purpose was to encourage further researches of disruptive technology. Bharat R[3] tried to integrate one or more disruptive innovation, and find out whether the result can affect new and existing markets. Lin C P[4] summarized three kinds of market encroachment mode and got a more comprehensive understanding of disruptive innovation theory. Philipp K[5] studied the disruptive innovation based on past and current conditions. He put forward the "disruptive susceptibility" and developed a theoretical framework to evaluate.

2. The technology opportunities in the process of technology evolution

The ultimate goal of technology evolution is to achieve the ideal final result. Every step of technology evolution is the result of inventors' efforts. As a whole, the inventors is not controllable, they work in a random state. While the studies show that the invention was accepted until it followed the logic of technology evolution. Thus, the technology evolution follows the certain evolution routes. Although the routes of technology evolution are not unique and there are bifurcations, all the directions of the routes of technology evolution towards to ideal final result. Therefore, we can take the initiative to perform technology forecasting if we master the routes of technology evolution. Learning all the routes of technology evolution from the past, we can find a common characteristic: the inventors studied the existing technology and summarized the historical experience and conclusions of technology evolution, then, according to the ultimate goal of technology evolution, they applied the result for technology forecasting. However, there are some limitations about the existing forecasting methods. They are only able to forecast the technology route mutations on the same S curve. For the technology route mutations on different S curves, the existing methods are almost ineffective. While , with the rapid development of the global economy, the market competition is becoming increasingly fierce, effective technological innovations usually belong to the latter one, which requires us to seize the technology opportunities in the process of technological evolution.

Technology evolution process can be represented by S curve. To forecast the technology route mutations on different S curves, we need to understand the state of some certain points in the process of technology evolution. Classify these points from different technology evolution directions, and different technology evolution directions correspond to different innovation categories. As it shown in figure 1, innovation can be divided into three categories: incremental innovation, radical innovation and disruptive innovation.

In the figure 2[6], the point B to C occurs on the same S curve which belongs to the incremental innovation. Incremental innovation has a strong dependence on the evolutionary routes. Technology evolution bifurcation from point B to C is commonly called Incremental Bifurcation (IB).

Point C to D occurs on two adjacent S curves which belong to the radical innovation. Point C represents that the product has been developed to the limit state, and the corresponding technology cannot be improved. However the existing technologies now cannot meet the demand of the market. That's why we need technology innovation. Technology evolution bifurcation from point C to D is commonly called Radical Bifurcation (RB)。

Disruptive innovation can be divided into two ways. One way is the bifurcation from point B to A, and this bifurcated approach can be called Reverse Trajectory Bifurcation (RTB). RBT means the short-term backward of technology evolution, and the bifurcation belongs to low-end DI. The other way is the bifurcation from point B to E, and this bifurcated approach can be called Transfer Trajectory Bifurcations (TTB), and the bifurcation belongs to new-market DI.

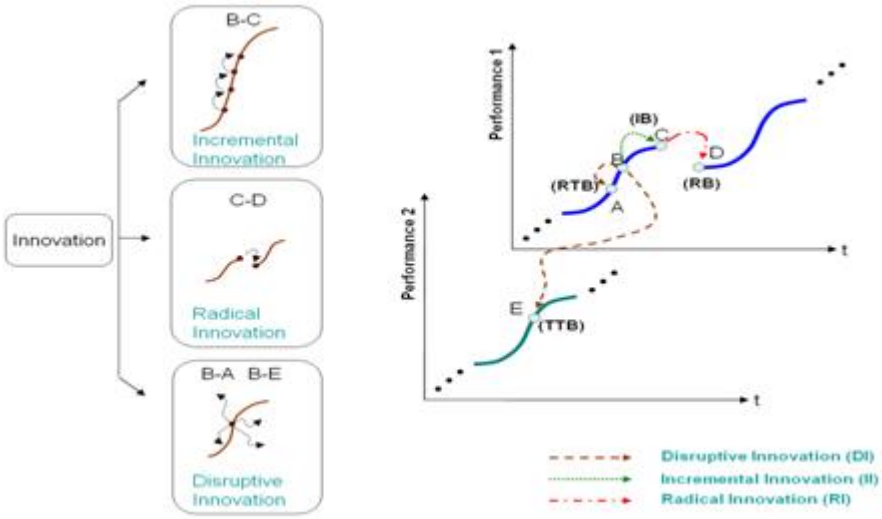

Fig.1 Technological Evolution Bifurcations

For effective technical innovation, disruptive innovation is necessary. We need to implement the technology opportunities search to achieve the goal of low costs and high competitiveness.

3. The process model of technology opportunities search based on DI

3.1 The process of technology opportunities search of NDI

New-market DI is mainly aimed at "zero consumer market", and the purpose is to attract potential users that have different values about the product's properties. Before the emergence of new-market DI, the enterprises cannot obtain some results or accomplish something due to the limitation of environment, capital or technology. Therefore, the enterprise can either give up or hire professionals to finish the work[7].

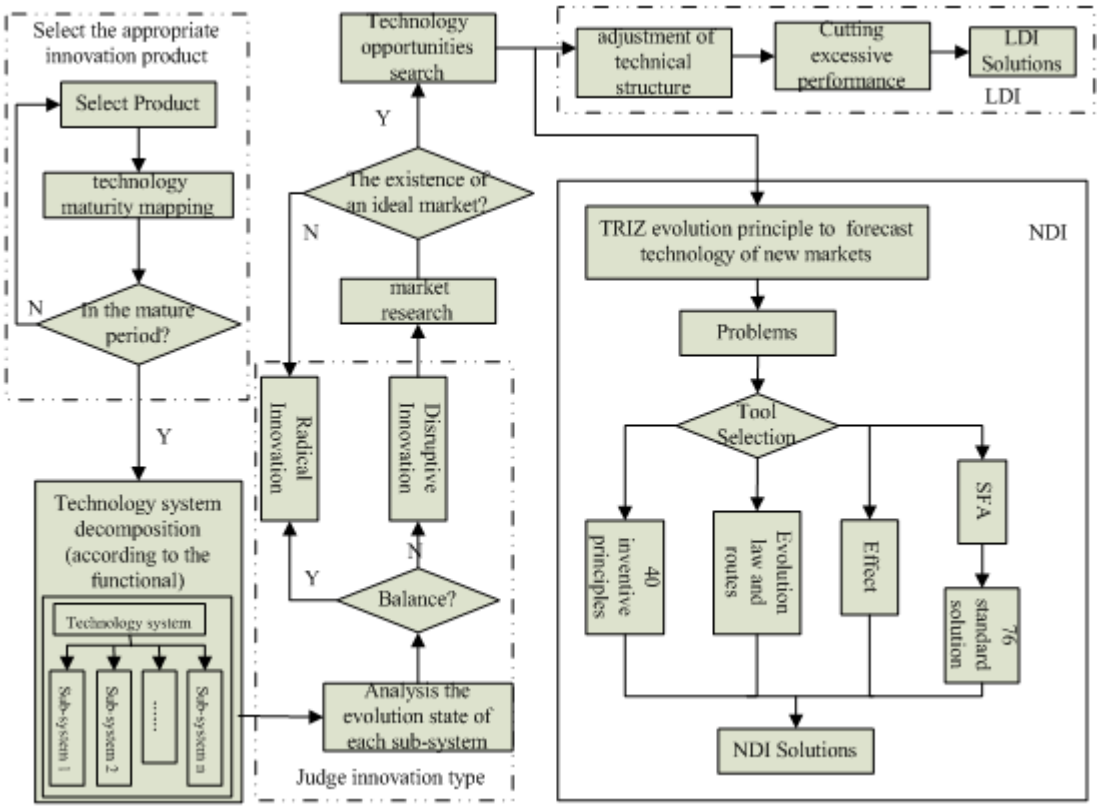

Fig.2 Implementation process model of disruptive innovation

Figure 2 is a implementation process model of disruptive innovation where shows the process of new-market DI. Specific steps are as follows:

Step 1: Choose the right innovative products. DI happens in the mature period of the S curve. So choosing a product is to judge its maturity of technology. And the product only in the mature period can meet the requirements of DI. Otherwise, it should be re-selected.

Step 2: Decompose the technology system of the selected product. The technology system of product is composed of subsystems. Each subsystem that has a complete system structure after the decomposition of the technology system can be analyzed as a complete technical system. This step is the key step.

Step 3: Determine the innovation type of the technology system. Technological opportunities of DI are due to the excessive evolution of product performances and new market demands. To analyze the evolution state of each subsystem, radar map is available to judge whether the evolution state of subsystem balance. If balance, radical innovation can be proceeded, if unbalanced, there are technology opportunities to use DI.

Step 4: Market research. For the technology systems which have DI opportunities, we need a market assessment survey. Determine whether there are ideal markets. If there is a new market, NDI

can proceed; if there is a low-end market, LDI can proceed; while if there is no market, radical innovation is the only way to proceed.

Step 5: technical opportunities search. By TRIZ evolution principle [8] and the constraints, we can forecast the potential technologies of new market.

1. Collect the early data about the subsystem that we want to improve its performance by searching the patent database. And summarize the data about the number of patents, the average grade of patents, the number of patents to make up for deficiencies, and the number of patents to reduce the cost.
2. Depicting the evolution trajectory and fitting with TRIZ evolution route. According to the data in Step 1, we can draw the corresponding graph and compare with TRIZ evolution routes.
3. If the curve is consistent with the TRIZ evolution routes, it means that the early evolution is based on the TRIZ evolution routes, so we can forecast the future evolution.
4. If the curve isn't consistent with the TRIZ evolution routes, we need to determine the technology evolution routes of new-market DI through constraints. The constraints are: simple, green, convenient, strengthen DNS, ITES function and Adding auxiliary function.

Step 6: Using TRIZ tools to solve problems. Problems in the forecasting process can be solved through conflict theory, 76 standard solutions, effects and technology evolution law.

Step 7: Get NDI solutions.

3.2 The process of technology opportunities search of LDI

The innovation research of mainstream market is always based on users' interest. As the product matured, the evolution of each technology has reached their limit, users are satisfied, the evolution of the product is gradually replaced by price, so that part of the performance of the product is over to meet. For some non-mainstream market users, they are more willing to buy a product at lower prices and relatively poor performance (quality assurance). And if there is a product not only can meet the basic needs but also at a lower price, some low-end users will be attracted. This is LDI[9].

Figure 2 is also shows the process of low-end DI. Specific steps are as follows:

Step 1 to step 4 are the same with the implementation process of NDI.

Step 5: Technical opportunities search. The main purpose of NDI is to reduce the cost of the product. According to its constraint-- cost-effective, technology opportunities search is proceed. For example, in the process of mobile phone evolution, the mainstream technology is calling. In recent years, the emergence of smart phone can not only ensure the quality of the calls, but also strengthen

the function of entertainments. For some elderly people, their mobile phones are just used to call, they don't chat or surf the Internet on mobile phone. So they prefer a common mobile phone that has a cheap price and has no extra functions except calling rather than a smart phone. These people are low-end users, so the mobile phone has chance to LDI.

Step 6: Adjustment of technology structure. In the presence of low-end market, the technology structure can be adjusted. For some non-mainstream market users, we can reduce excessive performance to meet the basic needs of users. We also can improve existing technologies to reduce costs.

Step 7: Get LDI solutions.

4. Case Study: disruptive innovation of desk lamp

As seen from figure 3, it is the verification search process of technological opportunities.

Step 1: Decompose the technology system of desk lamp and analysis of the constraints, we can get 8 parameters: light, stability, support, lampshade, economy energy, operability, portability respectively and material.

Step 2: Analyze the 8 parameters, determine the mainstream technologies are light and lampshade, the other 6 parameters are the assistive technologies.

Step 3: Determine the 8 parameters conform to which kind of disruptive innovations. The parameters light, stability, support, economy energy, operability, portability respectively can use NDI, and the last one: material can use LDI

Step 4: DI and get the NDI results and LDI results.

For the subsystem of light, increase the auxiliary functions according to the search process of technology opportunities is a good idea. The general illumination lighting can be innovated to a kind of light that can protect eyes. The light is soft and can reduce the eye fatigue. For the subsystem of stability, the constraint—convenient can be used here. The common base can be innovated to a clip base so that the lamp can be placed anywhere you want. For the subsystem of support, the constraint—convenient can be used here too. The common holder can be innovated to gimbals, and you can adjust the height and direction of the lamp. For the constraint parameter of operability, the constraint—convenient can also be used here. NDI product through touching switch brings great convenience to users. Combine the results can get a new lamp, as it shown in figure 3a.

For the subsystem of lampshade，increase the auxiliary functions according to the search process of technology opportunities guide us to use decorative lampshade, as shown in figure 3b.

For the constraint parameter of economy energy，based on the condition: green, the new product uses solar energy. For the constraint parameter of portability, the NDI based on the condition--simple and convenience can get the result about folding lamp and it can save space effectively. The combination of these results is a solar-powered folding table lamp shown in Figure 3c.

For the constraint parameter of material, in accordance with the purpose of reducing costs, the new product can use plastic shell as a result of low-end DI , as shown in Figure 3d.

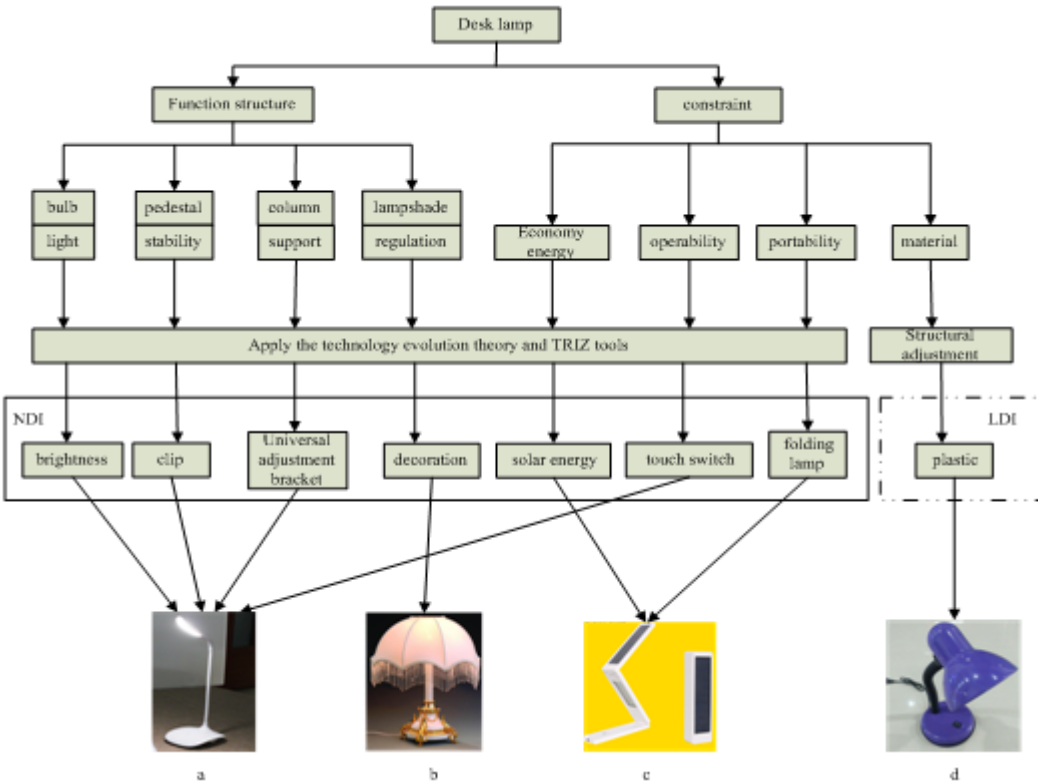

Fig 3 disruptive innovation of desk lamp

5. Conclusion

DI is an effective innovation method. In this paper, we introduce two ways of disruptive innovation and their steps simply. The search process of technology opportunities is one of the steps that described in detail. The desk lamp as an example to verify the process gets the new-market ID results and low-end DI results, which make users realizing the importance of DI and the search process of technology opportunities. There are still some shortcomings in this paper, more detailed process needs further research.

6. Acknowledgement

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The process of function-structure mapping driven by CAI technique

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Abstract

In the process of product function - structure mapping, several function - structure model, that is direct mapping, function - behavior - structure model, function - effect - structural mode. But the conflicts may arise between the conceptual structures, or conceptual structure cannot fully meet the design needs. Designers need to rely on their own experience to improve and innovation. Based on this fact, the method of function - structure mapping driven by computer-aided innovation (CAI) technology is put forward. At the same time, the application process to assist designers to complete the entire function – structure mapping is provided, and finally the desired structure is obtained. As an illustration, an innovation design of the transporting girder vehicle case study shows the application of the process.

Keywords: function – structure, CAI, conceptual structure, desired structure, TRIZ tools

1. Introduction

In conceptual design, firstly, designers determine the functional requirements by describing the functional requirement. Then according to the function – structure mapping [1], to find the solution of functional units, the one can obtain the conceptual structure. What's the more important, which integrates the all conceptual structure is the initial solution in the conceptual design. That is product principle structure model. In the process of obtaining the solution of function, this is the key to build the functions-structure mapping mechanism.

Therefore, scholars made a lot of search about obtaining function – structure mode. People obtain some model. Such as the function – structure directly mapping, function– principle – structure model, functional-effects-structure model. But their information is not completion and may be appear at lacking the bridge. Meanwhile their expression is too abstract.

Traditional computer focused on geometric design. It is not in line with the trend of the information age. In recent years, there is emerged a computer-aided which can assist building functions-structure mapping by establishing a bridge to relate the functions base and structure base. But this computer-aided technology can't perfectly complete the innovation. And some structures take place the function conflict. According to the reasons, this paper supports function-structure mapping driven by CAI technique. Its advantage has a strong the knowledge database, which can build the functions base and structure base. What's the most important reason, the CAI owns a strong technology, which can assist to solve some solutions, and realize the structure innovations.

2. Build the function – structure ontology base

2.1 Function ontology

In order to specification and limit the function space, function ontology which bases on Ontological principle defines conceptual vocabulary of the function space, So effectively sharing knowledge, and to achieve functional knowledge "reusable." Application the functional concept, function ontology can make designers to the better understand the design requirements and reasoning effectively in the function space. Which is function information model, flow ontology, operation ontology [2], function - behavior mode and function decomposing mode common expresses function ontology. Functional motion is divided branch, guide, connection, control, transformation, supply, determine and support in the operation ontology, which can express every process in the technology system and form the standard Verbs to describe function.

And they can provide sufficient semantic information to support different levels of product knowledge representation. From the form of the input and output, flow ontology is divided into material, energy and signals, which are object flows of physical operation and form the standard nouns to describe function by detailing them. And they can provide sufficient semantic information to support different levels of product knowledge representation. By composing of function verbs and nouns, people make sure primary function. Through different verb and flow combine, they can be composed of standard functional groups.

2.2 Building function - structure mapping model base on TRIZ

Axiomatic design emphasizes the zigzag mapping from top to down between functional domain structural domain. By this process of change, product is judged the rationality and optimality. Axiomatic design is the powerful methods and tools for assisting functional decomposition and function - structure mapping, which supports measurable evaluation criteria of design. Axiomatic design can confirm the best plan in the sub-layer function-structure mapping process and easy to control sub-function Particle Size, which can obtain the optimal design plan to satisfy the function by adjusting the design parameters. The method applies to improve the design of existing products, but also for new product design. Therefore, which resolve function of the product and build function – structure model introduces the theory of axiomatic design in the article.

2.2.1 Application for inventive principle

G.S.Altshuller proposes 40 the inventive principle by analyzing the patent analysis in the world. The inventive principle aims at technical conflict of engineering, which isn't the problem compromise, but to resolve conflicts from the nature of the problem. In the invention principle knowledge base of the CAI [3], their information includes serial number, name, explain and invention principle case database, etc. Due to the inventive principles can change several aspects of objects function, structure, time, etc, so in addition to containing the above basic information, they imply physical behavior information.

In order to conveniently search and match for case, the invention principle case database and function should contact. According to the function type, every case must be classified. At the same time, every case should confirm the function and express function model. In the cases, their need regulate components and interaction type among component.

The effect knowledge base includes serial number, name, explain, case base and functional behavior information, etc, which is basically the same with the invention principle knowledge base. In order to connect the invention principle and components, and convenient for analyzing systems and the selecting schemes, that behavior information expression use the same expression way with the invention principle. Therefore Scientific effect knowledge base includes serial number, name, explain, case base and function, function and flow.

The framework of the effect knowledge base is shown in Figure 1 and Figure 2.

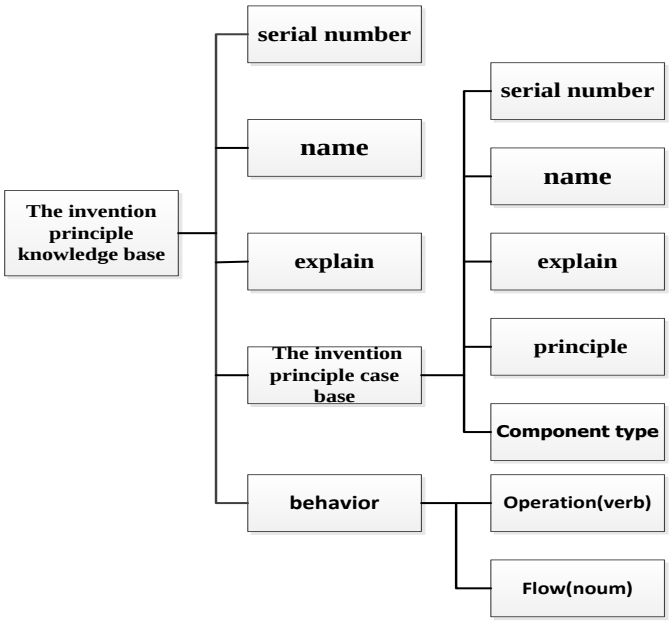


Figure 1. The invention principle knowledge base framework

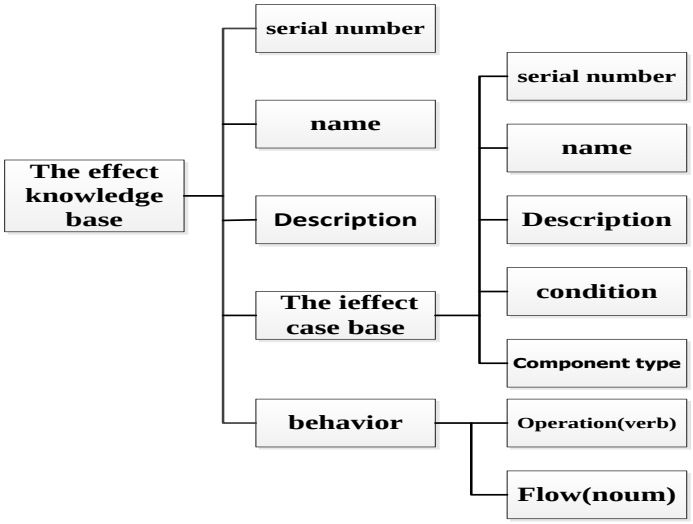


Figure 2. The effect knowledge base framework

2.3 Build function – structure base

In the function – structure mapping ontology base, firstly, it introduces the invention principle and the effect. So that they form function –the invention principle– structure mode and function –the effect– structure mode. At the same time, by describing function and building ontology database, which introduce concept of ontology, they make standardization between function and structure. Its purpose is that The method of function description convert describing the nature of object from describing the attribute and purpose of thing, which can expand the function category. Furthermore, Establishing function - structure mapping mechanism, which compose searching mechanism in the function – structure mapping ontology base how to select components by the mapping relation.

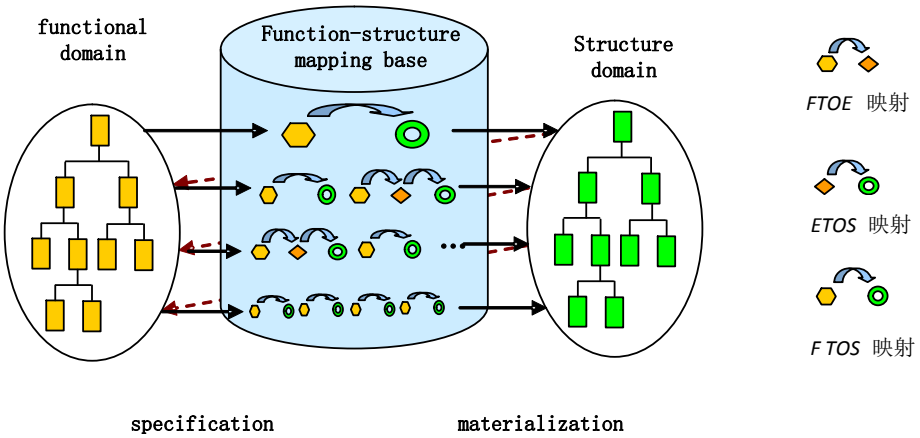


Figure 3. **The function-structure mapping model**

In the tortuous mapping process, Firstly, to make functions standardization, they are the function ontology. Then the designers find the corresponding structure ontology in the function – structure mapping ontology base according to the mapping relation. Finally, the structure ontology is improved.

There is to design structure. If designers cannot find the structure by searching the function, they can find from the bridge who are the inventive principle and the effect. Then the designers find the corresponding structure ontology by the CAI base. That is indirect mapping, as shown in the Figure 3.

3. Function-structure mapping process driven by CAI technique [5]

3.1 Mechanism of the general function unit analysis

The solution to the general function unit is easy to be obtained. For example, existing components and subsystems are possible to be the solution of this function unit. Or the designer proposes physical principle and physical structure of this function unit based on experience. For this type of function unit, the structure solution was carried out by adopting the bottom up method based on similar the function – structure mapping. The designer retrieves the mapping case in the designing case base starting from the known components or structures, supports the solving of similar feature matching design problem based on CBR method and therefore obtains the required structure.

In the conceptual design, some solutions of the general function unit can't match to the appropriate case by retrieving its similar feature and requires to be designed using principles and laws by adopting the form of IF<condition>THEN<choose corresponding technical tools>. Namely, the solution is obtained adopting CAI technical tools. If there existing function coupling, namely technique conflict or physical conflict, it’s necessary to be solved choosing the invention principle or the separation principle. If the function needs to be improved, we can choose the standard solving. If a new operating principle is needed, we can choose effect to solve according to the functional requirements and obtain corresponding scheme applying CAI tools.

3.2 Mechanism of the difficult function unit analysis

There is a mapping between the function units and the effects. As long as the input and output are similar quantities, this effect may be a kind of principle solution of the function unit. Or the effect chain formed by the organic combination of several effects may be a kind of principle solution of the function unit. If it is a solution of the difficult function unit, it is the target effect chain. The simplest case of the target effect chain is that single effect achieves a function unit. Several target effect chains may all achieve a function unit. Therefore, the mapping relation is one-to-many between principle solution of the function unit and the target effect chain. The target effect chain [2] is converted into the structural concept of the products, which ready to develop. In order to select the structure to achieve this effect, there is searching the instances. There is the instances base of the effect – structure in the inventionTool3.0 of the structure combination mould. The mapping relation is many-to-many between the effect and the structure. The structure concept can be designed according to the chain structure which is converted the effect chain into. Therefore, in the design process, firstly, the designer input keywords who describe the pre-interpretation of the difficult function unit or the initial solution. By the keywords, the system can automatic match all the effect and find the target effect. This process is supported the effect base, which is key. Secondly, the effect chains combination module are associated and controlled. They form the target effect chain. At last, the product structure can be obtained by the

mapping case between the effect and the structure. The effect – structure mapping theory based on effect is showed in Figure 4.

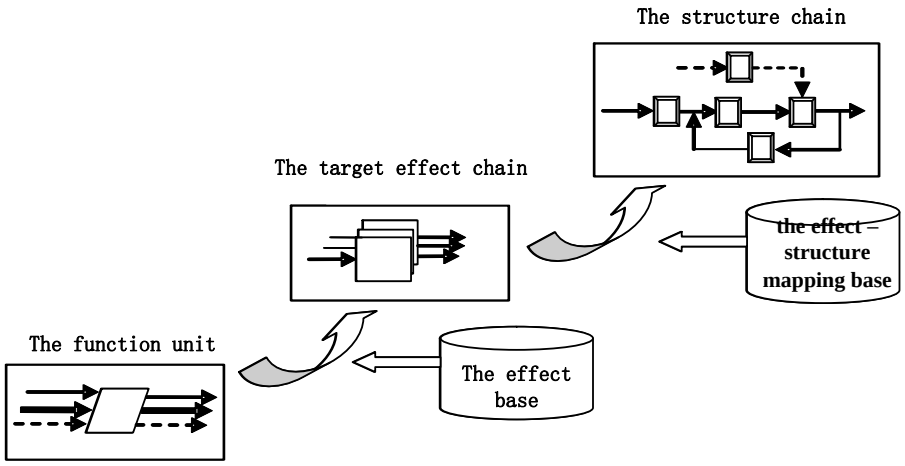


Figure 4. **The function – structure mapping principle based on the effect**

3.3 The process of function – structure mapping based on CAI

The main stages are as follow.

Step 1: to obtain the functional requirement, and the restricted condition.

Find the function units, query the attribute data and the functional information.

Step 2: Searching the knowledge base and obtain the structure obtain the structure of functional feature similar. If you can't obtain the matching structure or obtain a similar instance prototype, then step 3 continues.

Step 3: confirm the CAI tools

The CAI tools are used to optimization the similar structure. If there're the coupling functions, also named technical conflicts or physical conflict, the separation principle or the principles invention is chosen to solve. If the function needs to be improved, the standard solution can help work out. If a new principle is required, the effects are selected according to the functional requirement. Improve the searched structure by using one or several CAI tools and then get the required structure. If there're no needed structures, then step 4 continues.

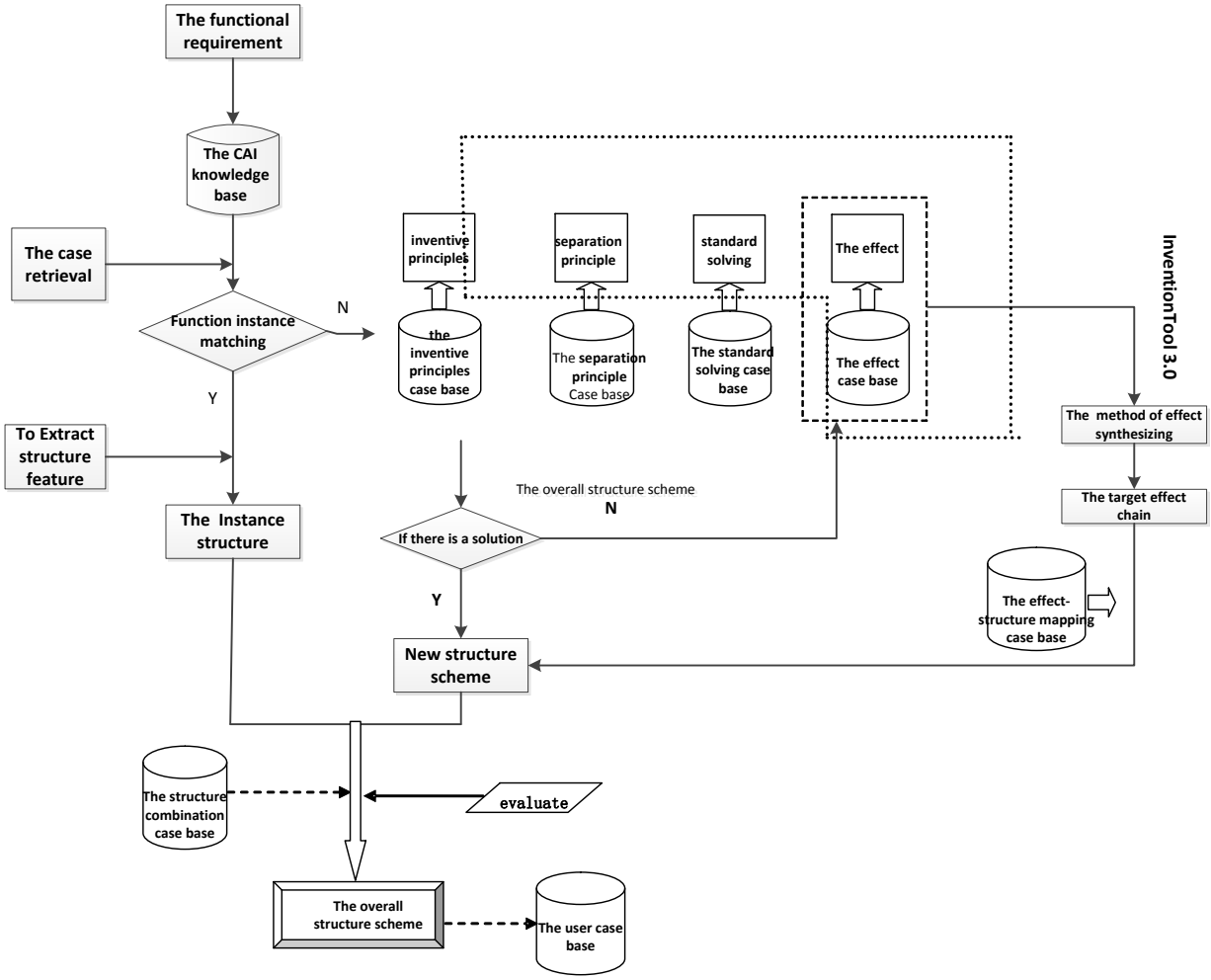


Figure 5. The function – structure mapping process

Step 4: make use of the effect algorithm

The solutions to the difficult function units are very vary in the solution to the general function units above. To input the keywords that they can possible describe the expected solution or the original solution of difficult function units and find the target effect chain. Finally, get the required structure. By solving the difficult function units can get the more innovative product and is the core of the new conception in the process of product concept design.

Step 5: the general structure scheme

Repeat all the above steps to complete the mapping process to solve all of the functions. The retrieved instances aren't full match with the required function. They need to recompose and adjust the instances so that they can achieve the constraints requirements.

4. Build the principle structure of transporting girder vehicle by CAI technique

According to the analysis, the beam is enough length, so it walks step by step. So the pushed beam device is contact with the entail, sometime the one needs rely on the transporting girder vehicle.

So there is the function coupling and we can apply the Physical contradiction. we can find time separation and corresponding to the inventive principle what are No.9 reaction, No.10 Pre-Operational and so on. According to the analysis, No.10 is adopted.

In the all levels solution of the structure process be involve the concrete technology, this is as follow.

- Instances are match according to the similar feature

  DP_{211} the power product: derive the beam go head

  DP_{22} the guide device: guide the beam go head

  $DP_1$the transport vehicle: transport beam from the factory to the workplace.

- Instances are match according to the CAI technology

  DP_{212} the control device: control the beam pushed

  DP_{23} the support structure: support the beam push.

  Because it is a simple structure, it don't required using the difficult function unit.

  According to the axiomatic design, build the Figure 6.

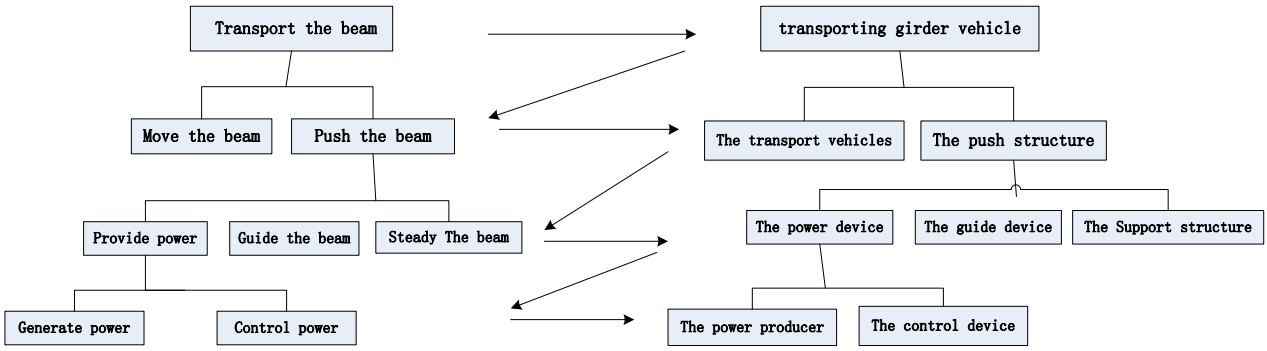
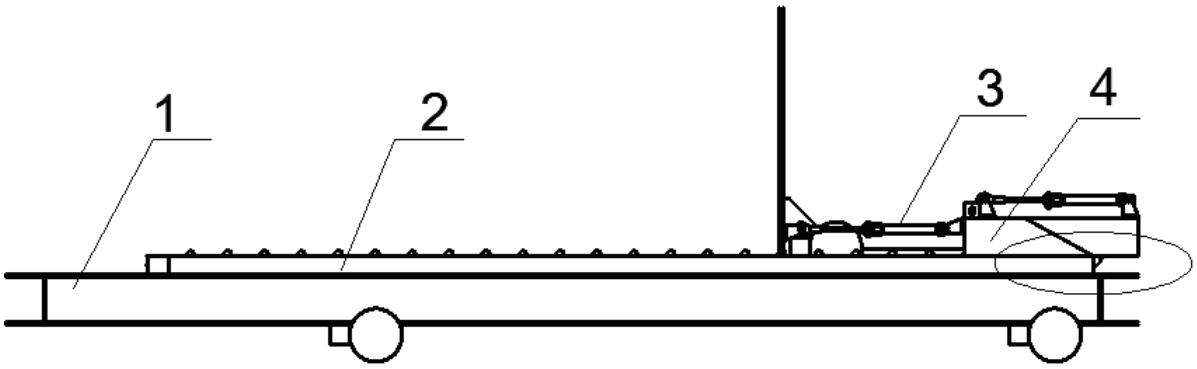


Figure 6. The function – structure mapping of the beam

Table 1. Relations between structure components and its DPs of the beam, drive mode, joint mod

	Structural component	Drive way
DP_1 the transport vehicle	general vehicle	motor-driven
DP_{22} the guide device	trajectory	
DP_{23} the support structure	wedge block	aerodynamic
DP_{211} the power product	hydraulic cylinder(multigroup)	aerodynamic
DP_{212} the control device	neck	



1 DP_1 the transport vehicle
2 DP_{212} the control device
3 DP_{211} the power product
4 DP_{23} the support structure

Figure 7. Principle schematic structural model sketch

▪Conclusion

This article introduces that basing on the CAI technology builds the function – structure mapping model and supply a procedure. In this process, It makes full use of the CAI knowledge and the CAI tools to rapidly and perfectly complete building the function – structure mapping. But this article is not enough full. Some details are required being perfect.

▪Acknowledgment

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Using TRIZ for Failure Analysis and Problem Solving in New Product Introduction

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Abstract

In this study, TRIZ theory and tools for analysis and problem-solving techniques applied to LCD TV speaker of product failure analysis and problem solving. Its problems include low resonance frequency (fo) high, the voice coil hit T-Yoke produce noise, etc., by this systematic analysis process to identify major issues, using TRIZ tools to find concept solutions, for fo problem, produce 48 concept solution, for noise, produce 49 concept solutions. After the integration of a similar concept solution, it comes out 9 solutions for fo problem, 8 solutions for noise problem, supplemented by Platts matrix (Pugh Matrix) to select and integrate to get the optimal solution concept, the optimal solution concept validation -fo high last question: T-Yoke and washers are not same high design. Voice coil hit T-Yoke generates noise problem: 2 layer 4-layer voice coil wire change. These two concepts exegesis experiments, positive results are obtained.

The contribution of this study include: (1) to solve the fo high problem about the cost of failure can be reduced 144,000USD; and (2) the impact of T-Yoke resolve speaker voice coil produces noise quality problems can be reduced to about 72,000USD failure costs.

Keywords: TRIZ, systemic innovation, problem solving, functional analysis, conflict analysis, problem-solving guidelines, LCD TV product problem solving, the speaker, the lowest resonance frequency (fo), Loudspeaker

應用萃智手法於新產品導入失效分析與解決

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摘要

本研究利用萃智理論及其工具進行分析與解題手法應用於 LCD TV 揚聲器的產品失效問題分析與解決。其問題包含最低共振頻點（Lowest Resonance Frequency; fo）高、音圈(Voice Coil)撞擊 T 鐵（T-Yoke）產生的異音等，藉由此系統化的分析流程找出主要的問題，利用萃智工具找出問題解答，fo 高問題部分產生 48 個概念解，異音問題部分產生 49 個概念解，經整合類似的概念解，fo 高部分產生 9 個概念解，異音部分產生 8 個概念解，輔以普氏矩陣（Pugh Matrix）選擇並整合得到最適概念解，最後驗證最適概念解-fo 高問題：T 鐵與華司不等高設計。音圈撞擊 T 鐵產生異音問題：2 層音圈線改 4 層。上述 2 個概念解經實驗，皆得到正向結果。

本研究貢獻包含：(1) 解決揚聲器的最低共振頻點(fo)的問題，約可減少 144,000USD 的失敗成本；(2) 解決揚聲器音圈撞擊 T 鐵產生異音的品質問題，約可減少 72,000USD 的失敗成本。

關鍵字：萃智（TRIZ）、系統性創新、問題解決、功能分析、衝突分析、解題指引、LCD TV 產品問題解決、揚聲器、最低共振頻點（fo）、揚聲器異音

1. 緒論

1.1 研究背景與動機

失效分析與問題解決在新產品導入階段扮演一個非常重要的角色，因為在新產品導入階段能盡量發現問題，進而分析與提供解決方案，後續進入量產，發生問題的機會將會大幅降低，也能減少後續因品質問題而產生的失敗成本。

目前企業界解決問題的方法大多以過往經驗法則加上試誤法(Try and Error Method)進行。由於有解決問題時間的壓力，因此只要將問題的症狀解決，就認為已解決問題，經由這樣的方式解決，殊不知頭痛醫頭，腳痛醫腳的方式，表面上看似解決，實際上可能非最佳解，後續可能還會衍生出副許多作用，造成另一個問題，這樣的解決方式，無法為企業帶來實質上的利益。

也因為上述原因，讓身為公司品質解決問題的人員，希望透過一套系統性的方法，進行問題解決。萃智（Theory of Inventive Problem Solving; TRIZ）為一個創新解題的方法，透過 TRIZ 分析問題的工具（功能分析 Function Analysis; FA、因果鏈分析 Cause-Effect Chain Analysis; CECA…），快速且有系統性找出核心問題，並藉由解決工具（Sol. Direction、Trends、Trimming…）進行解題，因此，本研究希望透過 TRIZ 理論及工具解決個案公司的新產品設計階段時發生的品質不良狀況，揚聲器是電視（TV）的主要零件之一，在設計階段也是主要關注點之一，故選擇利用 TRIZ 的理論解決個案公司新產品階段時發生的揚聲器最低共振頻點(fo)、異音等品質問題，期許協助個案公司解決問題。同時也希望透過該 TRIZ 理論能發現揚聲器創新的概念解。

1.2 研究目的

TRIZ 理論本身是一套哲學概念，利用此概念衍生出方法及工具，並透過對人的心理慣性進行改造，改變人對事物不同以往的經驗或習慣，進而對事物產生多種不同的角度進行觀察，以求得問題改善或重新設計較佳的產品。

本研究主要在實際運用萃智理論進行個案公司實際發生揚聲器零件品質問題進行分析，針對問題本身，找出核心問題，運用整合性 TRIZ 發明性問題解題流程中的不同解題工具提供解答，以解決品質問題。

2. 文獻探討

2.1 系統化問題解決流程

根據 許棟梁、蔡雲方(2014) 整合性系統創新問題解決流程，如圖 2.1 所示。將 TRIZ 問

題解決流程與 KT 式理性思考法之工具整合為 6 個階段，階段 0、「狀況評估」，階段 1、「問題定義」，階段 2、「問題分析」，階段 3、「解答產生」，階段 4、「解答選擇與整合」，階段 5、「解答驗證」，如圖 2.1。

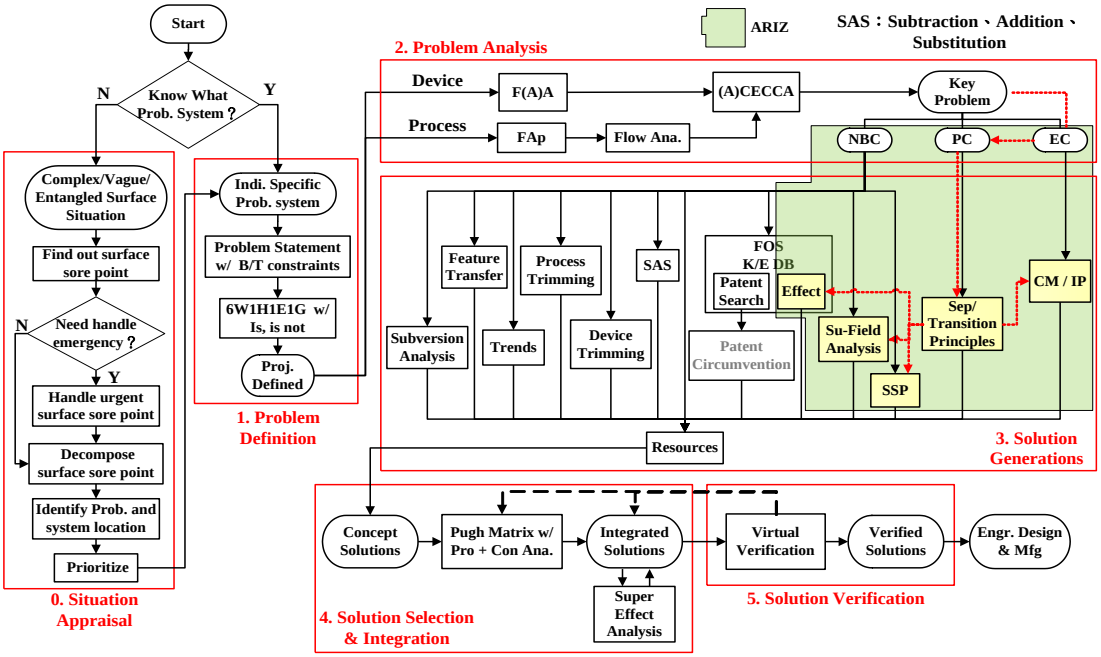


圖 2.1 整合性系統創新問題解決流程(資料來源：許棟樑、蔡雲方，2014)

2.2 狀況評估

一般的問題解決系統中並不常見，針對複雜且模糊的表徵狀況而訂做的一套系統性的步驟與問句提問，其目的為找出問題癥結點（失效處）及所在的失效系統，進而擬定處理優先順序，使我們能有效率的解決問題。

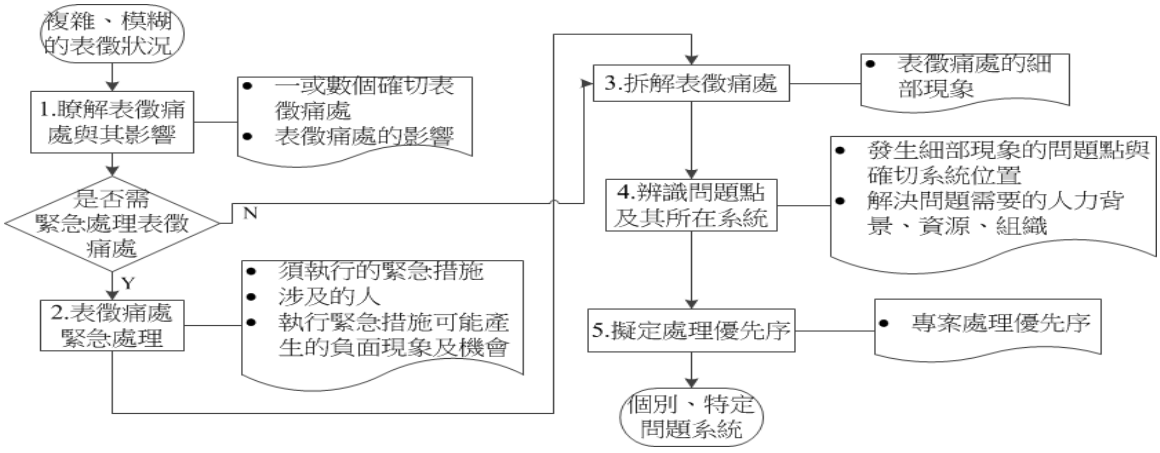


圖 2.2 狀況評估流程

2.3 問題定義

主要目的是瞭解正確的問題，同時界定問題的範圍，即藉由瞭解系統結構及運作方式，是否有企業、技術限制，配合 6W1H1E1G 的問答方式以釐清問題，清楚瞭解問題現象，並引導改善方向，訂定專案目標。

2.4 問題分析工具

功能屬性分析(Function Attribute Analysis, FAA)，目的為幫助使用者找到負面功能，並找到系統中潛在的核心問題。經由定義系統元件的功能與元件間和外界環境之交互作用進行系統的分析，如圖 2.3 所示。

屬性因果衝突鏈分析(Attribute Cause Effect Chain Contradiction Analysis, ACECCA)主要是功能就是屬性的改變或維持，所有元件的不利現象均與其元件與周邊元件屬性相關，因此藉由元件及周邊元件屬性作為思考媒介的方式來辨識不利點，以目標不利點（Target Disadvantage）的受害元件（Object）為起始中心元件，經由探討其屬性是否造成當前中心元件之不利點，同時一併探討其周邊元件的屬性，一層一層的往下挖掘其其不利點，反覆的將不利點視為當前的目標不利點，其元件為受害元件的方式，直至辨識完成找出關鍵不利點（Key Disadvantage）。

2.1 解答產生工具

衝突矩陣/發明原則(Contradiction Matrix /Inventive Principles; CM/IP)，主要用來解決當改善一參數(Improve)，而會使另一參數惡化(Worsen)之工程衝突問題，利用改善方與惡化方之工程參數，並透過其相對應之 40 發明原則 (Inventive Principles) 作為可能解決衝突之觸發解 (Trigger solution)。

分離原則與系統轉移(Separation/Transition Principles)，主要用來解決物理衝突，分離原則包含空間分離、時間分離、系統層級分離、關聯分離與參數分離，藉此五種分離方式來產生解答，而系統轉移是透過將系統於目前運作情境轉換至另一情境來化解衝突，其分為轉至超系統、轉至子系統、轉至替代系統與轉至負系統等四種情形來產生解答。

功能導向搜尋(Function-Oriented Search; FOS)，其主要思想是把一個已經存在的技術或是科技，應用在一個需要創新問題解決方案的科學領域或工程。功能導向搜索是利用三大概念：1.定義功能 2.找到該功能之領先領域 3.全球知識網路(Simon 2005)。為了提升功能導向之解題成功機率，許棟樑(2011)提出其搜尋的 8 步驟：

1. Identify the key problem to be solved.
2. Articulate the specific function to be performance.
3. Formulate the required parameters.(Attribute)
4. Generalize the function.
5. Identify technology & leading industry that performance a similar function in related and non-related industries.(option)
6. Conduct search for relevant technologies/product process.
7. Select the technology that is most suitable to perform the desired function based on your requirements and constraints.
8. Identify and solve the secondary problem required to adapt and implement the selected technology.

物(質)場分析(Su-Field Analysis)，將系統之問題點中，物質及場之間的互動關係呈現出來。許棟樑、楊岳崙(2011)根據 Belski (2007)之理論，加以修改提出之解題步驟，讓人更容易理解，步驟為：

1. 列出問題點包含的所有物質與場。
2. 畫出系統的物質場關係圖。
3. 選擇適當的規則
4. 利用不同場的種類 MeTh-ChEM-ON-AB，機械場、熱場、化學場、電場、磁場、光場、核子場、
   聲場與生物場，來解決問題。
5. 選擇/整合可行的解答。

減加換法(Subtraction-Addition-Substitution; SAS)，主要透過分析工具所找到之元件間負面功能關係，針對元件與功能利用「增加」、「替換」、及「削減」三種方式，幫助使用者觸發解答。

元件修剪設計(Device Trimming)為一刪除某特定元件之工具，是以減少元件的方式來進行創新，可重新分派系統或超系統中有用的功能。藉由減少元件與簡化系統來改善系統，能刪除對系統有負面影響之功能、減少成本、降低複雜性、同時提升良率與產出、並且朝向理想性，讓系統在最簡單的產品結構與最低成本下滿足顧客預期的需求。根據許棟樑、林芸蔓(2010)整理修剪規則(Trimming Rules)一共有六個，幫助使用者欲刪除目前功能提供者(Current Carrier)時，如何尋找新的功能提供者(New Carrier)或刪除功能。而修剪效力由大到小依序為 Trimming Rule A、X、B、C、D、E，依修剪效力並搭配雙迴圈之修剪流程(Trimming Process)進行修剪計

畫(Trimming Plan)。

演化趨勢的目的除解決問題，亦可預測系統發展，Mann(2002)提出 37 個演化趨勢，是以 35 個 Technology Evolution Trends 為依據，加入行銷的演化趨勢，並將趨勢分為空間(Space)、時間(Time)、介面(Interface)三個構面。許棟樑、呂宗興(2012)整合 GEN3 與 Darrell Mann 兩大演化趨勢，及建立演化趨勢各階段之功能屬性；邱聖家(2013) 建立演化趨勢之案例資料庫，利用相關之屬性與功能，以相似性比對過去案例的解答，作為觸發問題的解答。

2.2 解答選擇與整合工具

根據許棟樑、李曉真(2013)發展之解答評估手法-普氏矩陣(Pugh Matrix)，是由 Stuart Pugh 於 1981 年所提出的概念選擇方法，其目的是能將概念的數目快速侷限在最小數量且最適概念，並提供概念的整合及改善。概念篩選方分成二階段：概念篩選（Concept Screening）階段及概念評比（Concept Scoring）階段。

2.3 解答驗證工具

虛擬驗證(Virtual Verification)為許棟樑、李曉真(2013)參考限制理論中未來樹的概念所發展出的一套驗證手法，採用「目標達成」的方式，在進行解題前定義解決問題的目標，再利用放入概念解答於因果衝突鏈分析中關鍵問題之處，以嚴謹的因果關係推論進行反推，進而評估所得概念解答是否達成預期理想目標，並找出執行時可能發生的不良效應，以預見未來避免風險的產生。

實做驗證，利用 DOE 實驗進行實驗驗證。

3. 研究方法

3.1 整合性系統化問題解決流程

本研究的問題解題流程，總共分為五階段，(1)問題定義 (2) 問題分析 (3) 解答產生 (4) 解答選擇與整合 (5) 解答驗證，如圖 3.1 所示。

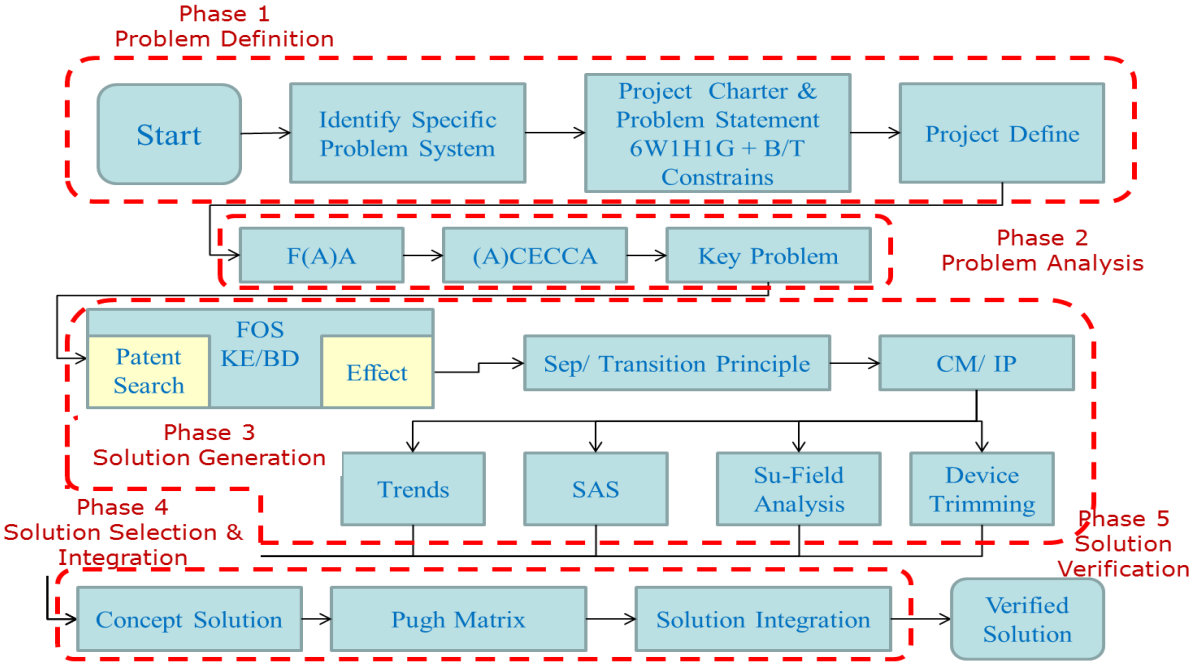


圖 3.1 整合性系統化問題解決流程

3.2 問題定義階段

利用 6W1H 1E1G(What, When, Where, Why, Who, What to do, How, Extent, Goal)描述表，幫助使用者清楚描述現象，以釐清表徵問題，並引導改善方向以訂定確切的專案目標，如表 3.1。

表 3.1 6W1H1E1G 描述表

描述發生問題之情況。下列問題幫助你考慮到各個構面，但**請勿逐項回答**，**應以順暢易懂的方式說明問題狀況** 以利於讀者了解問題: 1. What problem? 有什麼問題/需求/機會/痛處？ 2. When was it happen? 在什麼時候發生的？ 3. Where is it found?在哪些 發現/產生 此問題？ 4. Why? 為何會發生? Or 為何要做此問題? 5. Who? 哪些人受到影響？誰引起的? 6. How was it happen. 問題如何發生 7. What to do? 要做甚麼 **輔以圖示說明問題狀況。必要時可加頁說明。**	
專題目標: (Specific Project Objectives. Itemize)	

3.3 問題分析階段

針對實體系統問題，可以利用功能屬性分析，透過元件分析與功能關係分析，幫助我們辨識系統元件間功能關係，並以功能模型繪製，清楚瞭解有害功能，如圖 3.2。

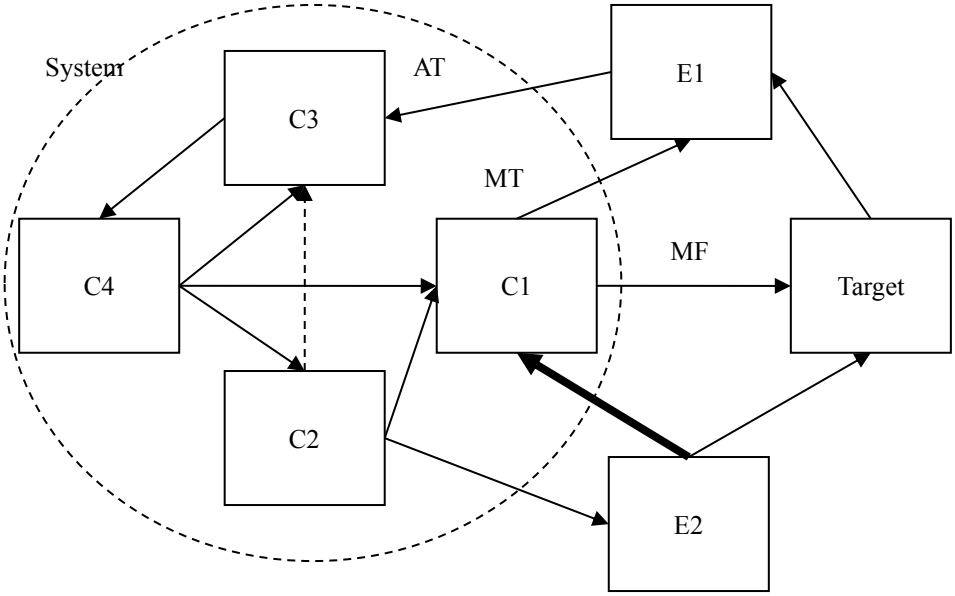


圖 3.2 功能模型示意圖（許棟樑, 2007）

藉由功能屬性分析找出目標不利點後，再利用基於屬性的因果衝突鏈分析（許棟樑、蔡雲方 2014)，進行因果關係之探索，以辨識核心關鍵不利點，由於功能就是屬性的改變或維持，因此，所有元件之不利現象均與其屬性或其周邊元件之屬性相關，流程如圖 3.3。

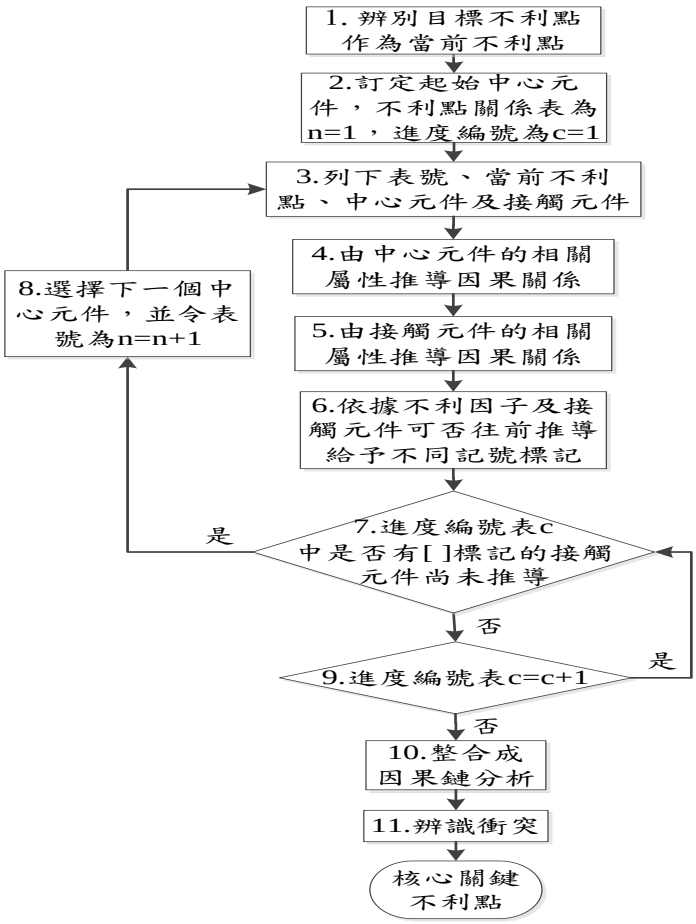


圖 3.3 辨識因果關係之流程圖

以目標不利點(Target disadvantage)的受害元件(Object)為起始中心元件開始，藉其與其接觸元件屬性探討是否可能造成當前不利點，並反覆地將不利點視為當前不利點，其受害元件視為中心元件，利用不利點關係表一步一步探索更深層的不利現象，直至辨識完成並找出關鍵不利點，如表 3.3。

表 3.3 不利點關係表

不利點關係表#{n}

中心元件：{當前不利點中受害元件/之前表中的接觸元件}	當前不利點：{目標不利點或當前中心元件不利點，可為數個}
中心元件	因果關係
{同上}	{任一當前不利點}←{中心元件不利因子 1}、{中心元件不利因子 2}； {中心元件不利因子 1}←{中心元件不利因子 3*}
接觸元件	因果關係
{與中心元件接觸的元件}	{任一當前不利點}←{[接觸元件不利因子 1]}； {中心元件不利因子 2}←{接觸元件不利因子 2*}、{[接觸元件不利因子 3]}
…	…←…

最後將找到的不利點依因果前後關係進行因果衝突鏈分析，如圖 3.6。

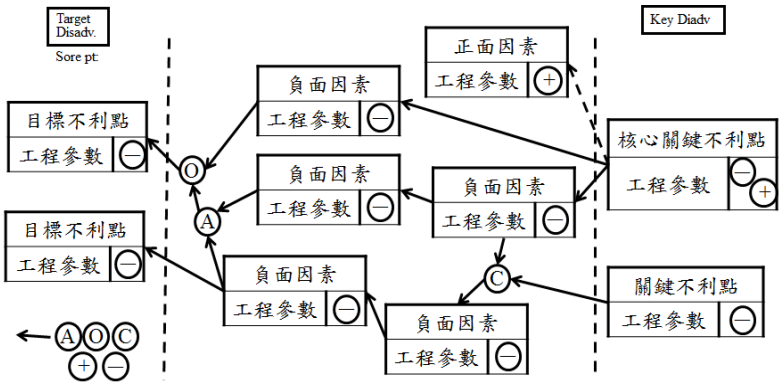


圖 3.4 因果衝突鏈分析圖(許棟樑、蔡旻志，2010)

將衝突整理成衝突家族，以利後續解答產生工具使用，如表 3.4。

表 3.4 衝突家族表

ID	[IF] 物理衝突@(-)	[THEN] 欲改善的因素 (-→+)	[BUT] 惡化的因素(+→-)
	(+)		

3.4 解答產生階段

以「工程衝突」觀點解題：

- **功能導向搜尋(FOS)**—將問題分析至底層其物理、化學之現象，透過搜尋其他領域已有且已成功植入之技術，轉移至適用於待解決問題之方法，如表 3.5。

表 3.5 功能導向搜尋表 (許棟樑、楊岳崙，2011)

Project Title:

1. Key problem to be solved	
2. Specific key function	
3. Required parameter/Attr. (value ranges)	
4. Generalized function (Func/attr. key words;)	Generic: Expanded:
5. ID Possible technologies & Leading industry	Tech: Industry: [can be left blank if not sure]
6. Search in: - Function DB - (Attribute DB) - Patent DB	Effect DB http://www.triz.co.uk http://www.triz.co.kr/TRIZ/frame.html Goldfire software; http://function.creax.com/ Patent Search web sites - http://patft.uspto.gov/ (USA patents) http://ep.espacenet.com/ (European patents) http://www.google.com/patents (free) http://www.freepatentsonline.com/ (free) http://www.runride.com/patent/pat_info_all.asp (Taiwan+Japan+China Patents) http://twp.apipa.org.tw/default.asp (Taiwanese Patents) http://www.patent.org.tw/ & http://www.twpat.com/webpat/ http://www.ipdl.ncipi.go.jp/homepg_e.ipdl 日本特許廳

功能導向搜尋中，其包括兩種方式，首先是利用效應，藉由解決問題的需求功能/屬性，

轉成通用功能/屬性的方式，利用通用功能/屬性於現有科學效應知識庫中查詢，逐一檢視效應並思考可能的特定解決方法以作為解答，並整理在表 3.6 與表 3.7 中。

表 3.6 功能-效應搜尋表

Original Function		Basic Function	
Effect(s)			
Specific Approach			Diagram of specific idea.
			DB Source:

表 3.7 屬性-效應搜尋表

Original Attribute Change		Basic Attribute Change	
Effect(s)			
Specific Approach			Diagram of specific idea.
			DB Source:

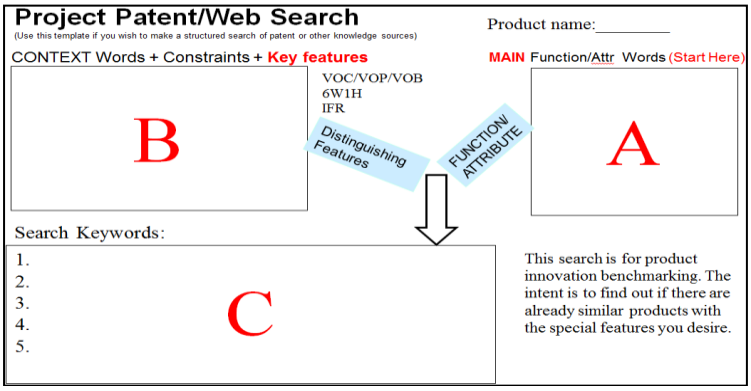
- **專利搜尋**
  - 從龐大的專利數量中有效搜尋有用的專利，如圖 3.5，會藉由區域 A「Function/Attribute」與區域 B「Context」兩個維度來聚焦搜尋符合需求的專利，而區域 C「Search Commands」則為觸發解。
  - 

圖 3.5 專利搜尋圖

- **分離原則/系統轉移(Separation /Transition Principles)**—從屬性因果鏈衝突分析（ACECCA）中找出的物理衝突，可用分離原則來找出觸發解，假設使用者問題中之物理衝突為 P，「+P」指物理衝突朝正向發展，「-P」指物理衝突朝負向發展，並利用問句詢問，是否能在不同要求+P/-P 之情況下滿足不利點。 其情況包含 (1)空間分離(Separation in Space)、(2)時間/時機分離(Separation in Time)、(3)系統與元件分離(Separation between System and Parts)以及(4)參數分離(Separation between Parameters)，如表 3.8。
-

表 3.8 分離原則表

為了目標 1 (O_1)，*參數 P* 必須_____(+P)；但 為了目標 2(O_2)，*參數 P* 必須_____(–P)

問句	回答	概念解答
何處我需要 +P： 何處我需要 –P：		
何時我需要 +P： 何時我需要 –P：		
是否 +P 或 –P 可被分至不同的系統層級？		

O_1=fn1(X1, X2, X3,…) O_2=fn2(Y1, Y2, Y3,…) 是否+ P 和–P 能被分配至分離的參數？[↑↓—]	回答： {O_1=fn1(X1, X2, X3,…)} {O_2=fn2(Y1, Y2, Y3,…)}
概念解答：	

而系統轉移將現有系統中的衝突，利用超系統、子系統、替代系統及負系統逐一帶入每一問句的X-element位置，以思考如何達成問句所述的情況，進而產生解決的方法以化解衝突。如表 3.9。

表 3.9 系統轉移表

為了目標 1 (O_1)，*參數 P* 必須_____(+P)；但 為了目標 2(O_2)，*參數 P* 必須_____(–P)

問句： 如何使[X-element]幫助我達到[O_1]在[–P]的情況下？ 如何使[X-element]幫助我達到[O_2]在[+P]的情況下？ 如何使[X-element]幫助我達到[O_1]與[O_2]？	
系統：	主要功能：
超系統：	替代系統：
子系統：	負系統：
解答：	

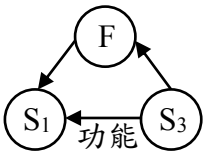
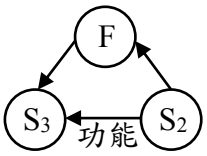
- **衝突矩陣/發明原則(CM/IP)—**現有運作模式下，要改善目標參數（績效）;什麼參數會惡化現有運作模式下，什麼參數會阻礙我改善目標參數
將會影響現有模式的的缺點的工程參數填入惡化欄（A 區域），將能改善目標的工程參數填入改善欄（B 區域），依據惡化方與改善方參數相對應之發明原則填入 C 區域。如表 3.10

表 3.10 衝突矩陣表

在現有的運作模式(原理)下: (羅列一個家族的衝突) System: IF _____，THEN_____，BUT_____ Classical ( ) / Matrix + 【】	
Worsen / Improve	A
B	C

- **物(質)場分析(Su-field Analysis)—**建構一個執行功能的物質-場的三角模型，藉此瞭解系統的基本運作方式，利用 6 個解題規則及 9 個場構成的表格，透過替換物質或場的方式，得到改善後的新物質與場，以求得特殊概念解答，如下表 3.11 所示。

表 3.11 規則 1 物(質)場分析表

規則 1	場	Chk	解答模型
	Me	✓	
	Th		
	Ch		
	E		
	M		
	O		
	N		
	A		

	B		

- **元件修剪設計(Device Trimming)**—以達到減少元件為目的，將有用功能重新分配至其他元件上，然後將某特定元件消除，利用元件修剪規劃表(Trimming Plan)，如表 3.12，與 6 項修剪規則 Trimming Rules A、X、B、C、D、E 進行修剪設計。

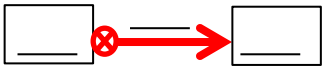
表 3.12 元件修剪規劃表

功能提供者	功能	目標元件	修剪規則	新功能提供者	修剪問句	解決此修剪工作項的方法

- **減加換法(SAS)**—SAS 是以問句的方式引導使用者分析關鍵衝突的解決方法，依照問句來推論出關鍵衝突的觸發解。如表 3.13。

表 3.13 減加換表

系統：
問題點：



	增加	替換	削減
工具(Tool)			
目標(Object)			
功能(Func.)			

- **演化趨勢(Trend)**—利用演化趨勢表格，配合相似性演化趨勢軟體，以得到可以解決問題的解答。將演化趨勢中目前階段標示為綠色，而辨識出之期望階段標示為黃色，並寫出具體之解決方案，如表 3.14。

表 3.14 演化趨勢表

系統：　　目前階段　　觸發階段

演化趨勢	演化趨勢階段				解決方案描述

3.5 解答選擇與整合階段

利用過濾/評估矩陣(Pugh Matrix)進行兩階段的概念解評估，以選出對使用者最適之解答方案。

首先初步篩選以快速粗略方式來篩選較差的解答，如表 3.24。

表 3.24 初步篩選/評估矩陣

初步篩選	概念解				
評估準則	A	B	C	D	E
技術可行性					
技術發展性					
…					
…					
“+”的總數					
“0”的總數					
“-”的總數					
總分					
排名					
是否繼續?					

再以二次篩選利用評估準則與權重，仔細評估初步篩選後之解答，利用權重值*評分=加權分數，求得加權後的總分；進行加權後所得總分之概念解排序，並進行第二階段的解答整合，選擇總分為最高分者為最佳概念解答，，如表 3.25。

表 3.25 二次篩選/評估矩陣

二次篩選	概念解		
	A	B	C

評估準則	權重	評分	加權分數	評分	加權分數	評分	加權分數
技術可行性							
技術發展性							
…							
總分							

3.6 解答驗證階段

進行 DOE 實驗，驗證概念解的可行性。

4. 案例驗證

4.1 揚聲器最低共振頻點（fo）高失效問題

液晶（LCD）電視生產工廠，揚聲器為元件之一，其供應商品質不良 fo 高約 40%，其製程簡述如下圖 4.1。

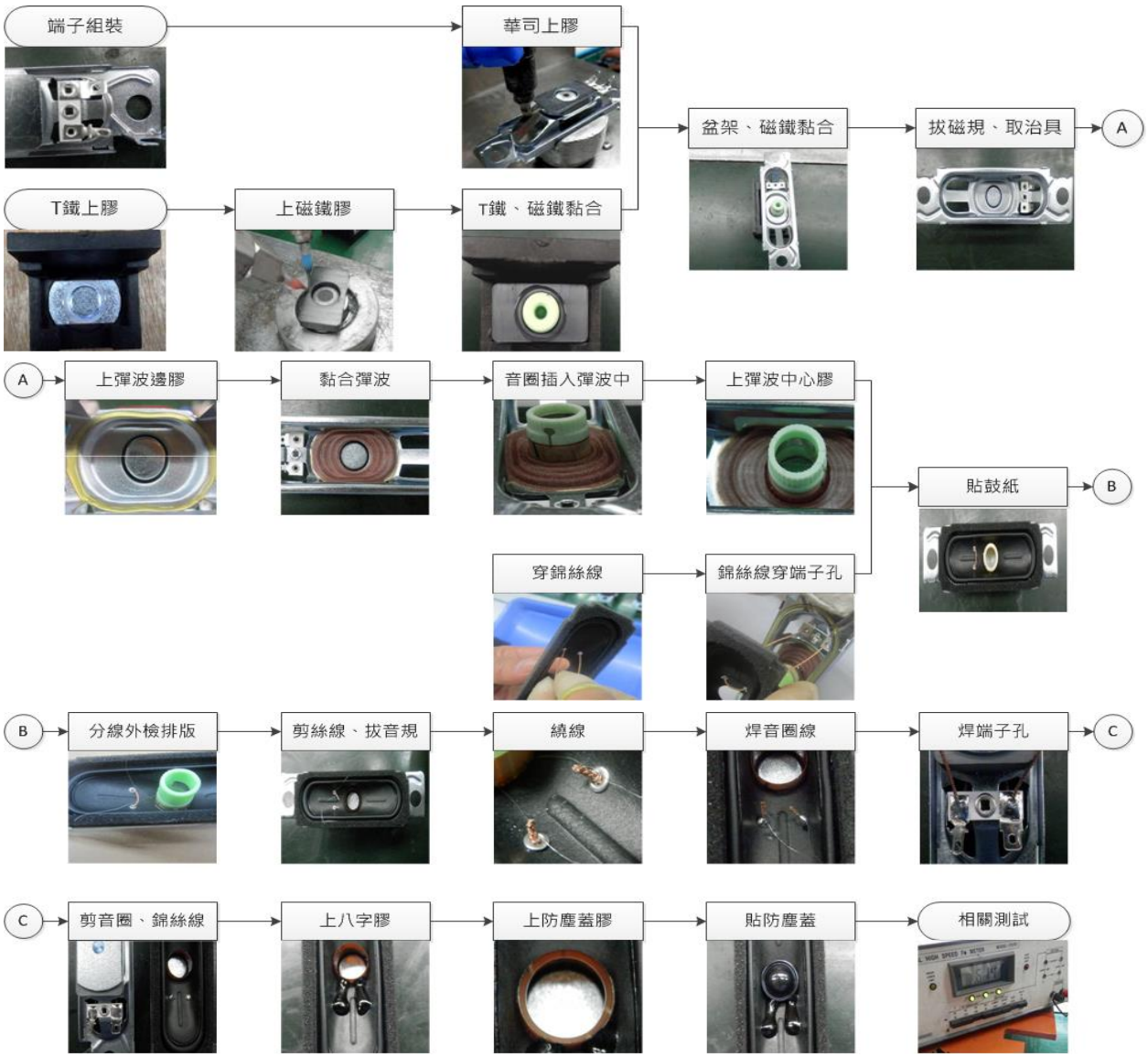


圖 4.1 揚聲器製作流程

揚聲器原理：揚聲器是由電磁鐵、線圈、喇叭薄膜組成。揚聲器把電流頻率轉化為聲音。換句話說，喇叭之所以會發聲，是因為電流訊號與磁鐵產生交互作用，進而帶動磁場中的音圈作動，與音圈黏在一起的振膜便跟著前後震動而壓縮空氣產生音波。

4.1.1 案例問題定義

本案例欲解決問題為揚聲器最低共振頻點（fo）高，利用 6W1H 1E1G 問題描述表描述表清楚描述現象，以釐清表徵問題，並引導改善方向以訂定確切的專案目標，如表 4.1。

表 4.1 fo 問題描述表

描述發生問題之情況。下列問題幫助你考慮到各個構面，但**請勿逐項回答**，**應以順暢易懂的方式說明問題狀況** 以利於讀者了解問題: 1. What problem? 有什麼問題/需求/機會/痛處？(sore point) 2. When was it happen? 在什麼時候發生的？ 3. Where is it found?在哪些 發現/產生 此問題？ 4. Why? 為何會發生? Or 為何要做此問題? 5. Who? 哪些人受到影響？誰引起的? 6. How was it happen. 問題如何發生 7. What to do? 要做甚麼 **輔以圖示說明問題狀況。必要時可加頁說明。**	**設計階段，揚聲器單體低音不足:** 因喇叭供應商提供品質不穩定的喇叭，個案公司生產組裝時喇叭完成後進行 *fo* (喇叭最低共振頻率)測試，發現 fo 大於 300Hz，反應供應商進行改善。供應商不良率約 12%。
專題目標: (Specific Project Objectives. Itemize)	喇叭(扬声器)最低共振頻點(fo)的改善 Fo＜300Hz

4.1.2 案例問題分析

利用 FA 分析系統元件間之功能關係。本案例之問題系統為揚聲器系統，將系統向下拆解至元件層級，系統之主要功能(Main Function)為鼓紙推動空氣進而產生聲音。藉由功能關係分析後繪製出功能模型如圖 4.2。

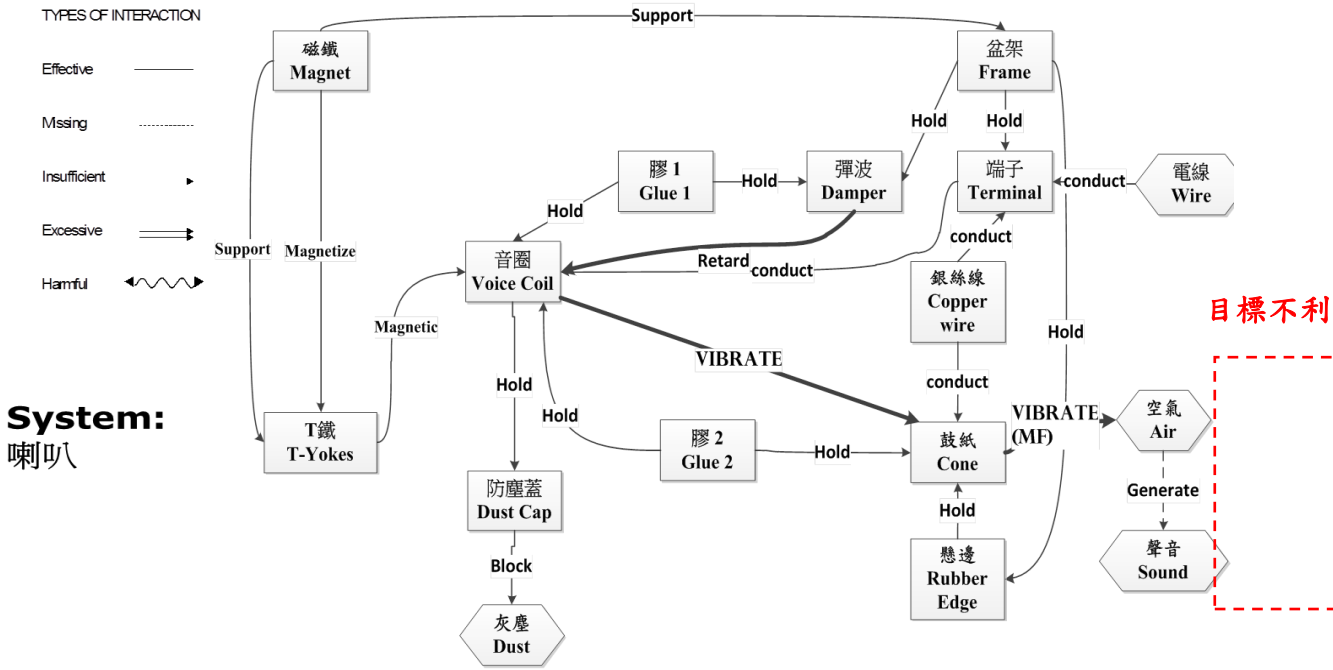


圖 4.2 揚聲器功能模型

再利用 ACECCA 從目標不利點「fo 高」，經過不利點關係表辨識因果關係，如表 4.2 至 4.5，最後所得到的因果衝突鏈，如圖 4.3。

表 4.2 低音不足(*fo* 高)不利點關係表 1

不利點關係表#1

不利點：低音不足 （*fo* 高）		
中心元件	相關屬性	因果關係

Cone	重量、韌性、順性、硬度、密度	低音不足（*fo* 較高）←鼓紙 *fo* 較高 鼓紙 *fo* 較高← 重量輕、順性小* 重量輕←密度小*、體積小 體積小←厚度薄*、面積小*
接觸元件	相關屬性	因果關係
Glue2	比重、重量	低音不足（*fo* 較高）←中心膠 2 重量輕
Copper Wire	N/A	N/A
Rubber Edge	順性、硬度	低音不足（*fo* 較高）← 懸邊 fo 高 懸邊 fo 高←順性小*、硬度大*、懸邊較厚*
Air	濕度	低音不足（*fo* 較高）← 空氣濕度低*

表 4.3 低音不足(*fo* 高)不利點關係表 2

不利點關係表#2

不利點：中心膠 2 重量輕		
中心元件	相關屬性	因果關係
Glue2	比重、重量	中心膠 2 重量輕←比重輕*、塗量少*
接觸元件	相關屬性	因果關係
Voice Coil	N/A	N/A
Cone	N/A	N/A

表 4.4 低音不足(*fo* 高)不利點關係表 3

不利點關係表#3

不利點：低音不足 （*fo* 高）		
中心元件	相關屬性	因果關係
Voice Coil	重量、長度、頻率	低音不足（*fo* 較高）←音圈震動頻率快 音圈震動頻率快←音圈重量較輕 音圈重量較輕← 線圈直徑小*、線圈長度短*
接觸元件	相關屬性	因果關係
Glue 1	比重、重量	低音不足（*fo* 較高）←中心膠 1 重量輕
Glue2	比重、重量	低音不足（*fo* 較高）←中心膠 2 重量輕
Dust Cap	重量、面積、厚度	低音不足（*fo* 較高）←防塵蓋較輕 防塵蓋較輕←面積小*、厚度薄*
T-Yokes	N/A	N/A
Terminal	N/A	N/A

表 4.5 低音不足(*fo* 高)不利點關係表 4

不利點關係表#4

不利點：低音不足 （*fo* 高）		
中心元件	相關屬性	因果關係
Damper	硬度、厚度、面積、形狀	低音不足 （*fo* 高）←彈波重量輕、彈波硬度較硬、彈波波紋淺 彈波重量輕←厚度薄*、面積小* 彈波硬度硬←含浸膠水濃度高* 彈波波紋淺←面積小*
接觸元件	相關屬性	因果關係
Glue1	黏性、耐熱性、比重、固成分	低音不足 （*fo* 高）←中心膠 1 重量輕 中心膠 1 重量輕←比重輕*、塗量少*
Frame	N/A	N/A

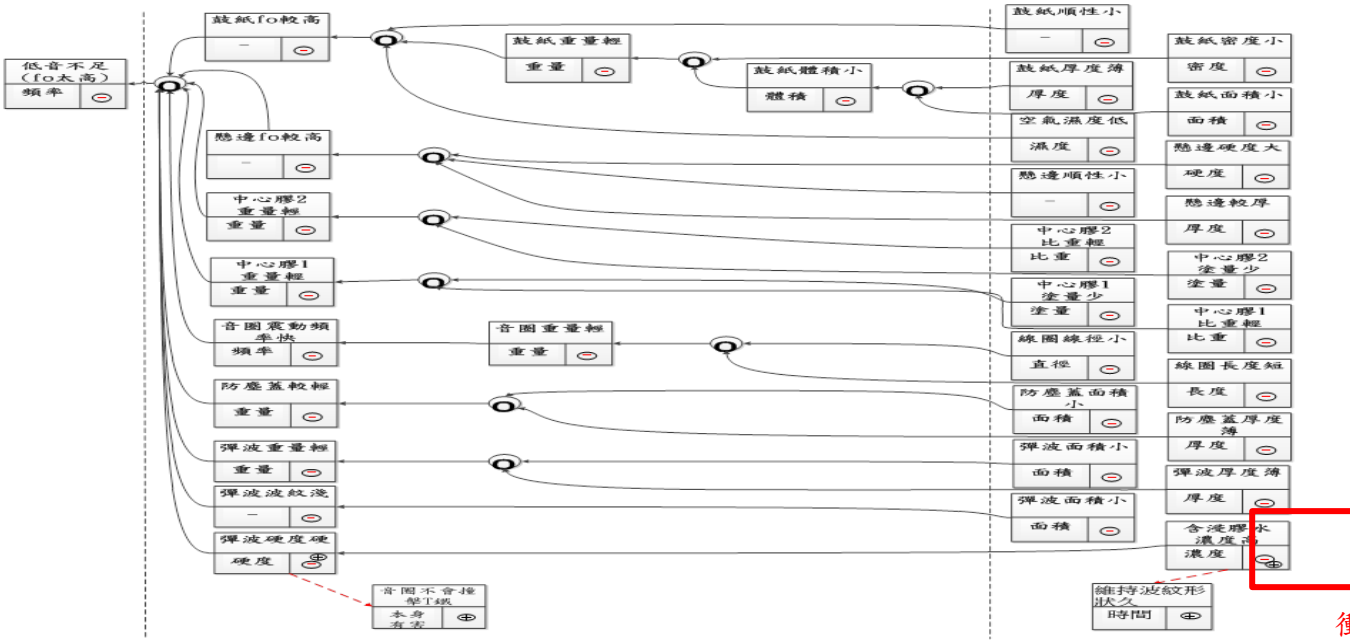


圖 4.3 fo 高問題因果衝突鏈分析圖

以衝突點開始往目標不利點前進，將所涉及的因果關係整理成衝突家族，如表 4.6。

表 4.6 fo 高問題衝突家族表

ID	物理衝突[IF]	欲改善負面因素[THEN]	惡化的正面因素[BUT]
1	含浸膠水濃度低	彈波較軟	波紋形狀維持時間減少
		Fo 低	

4.1.3 案例解答產生

- **功能導向搜尋**

依關鍵問題「fo 高」，思考欲解決問題之需求功能「fo 低」、「體積小」，並一般化成關鍵字「產生聲音」、「推動空氣」。利用效應知識庫查詢所得到之效應有「**Crank Mechanism**」、「**Electromagnetic induction**」，可分別依這兩種方式得到解決 fo 高的概念如圖 4.4- 4.5。

「**Crank Mechanism**」**效應**-利用凸輪機構帶動鼓紙震動空氣，產生聲音。由於震動行程可以加長，因此 fo 可以較低。如圖 4. 4。

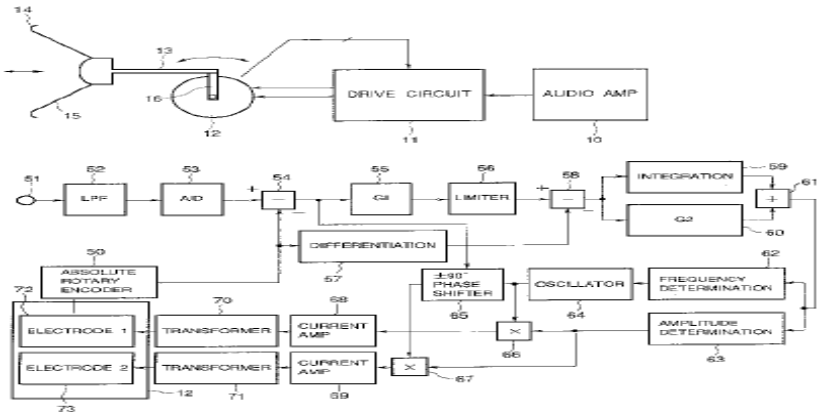


圖 4.4 超音波馬達推動鼓紙(US 專利 US 6384550 B1)

「**Electromagnetic induction**」**效應**-在鼓紙下緣背面塗上一層磁性物質，及線路 pattern，藉由電流改變，使鼓紙與磁鐵產生相吸、相斥作用，達到鼓紙震動空氣的目的。

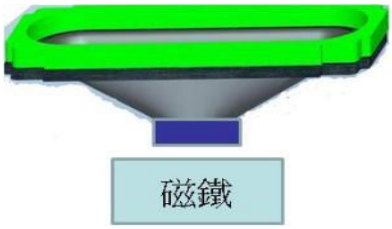


圖 4.5 磁鐵&電流作用推動鼓紙

另根據需求功能/屬性及 Context 組合成搜尋的關鍵字搜尋專利，如圖 4.6，搜尋結果如表 4.7。

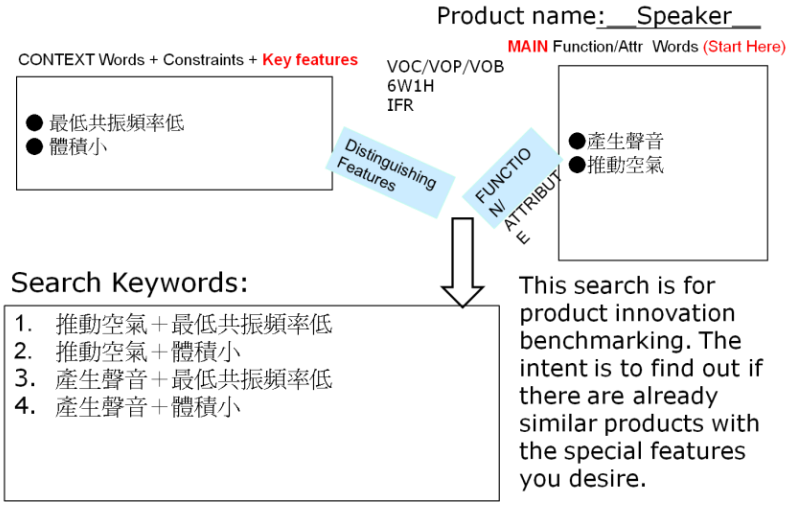


圖 4.6 fo 高問題專利搜尋

表 4.7 專利搜尋結果

#	Source	Patent #	Key Func./Attr.	Key Ideas
1	中華民國專利	TW M447647U1	揚聲器結構改良	彈波設置在音圈內部，彈波一端定位於定位件與華司間，彈波另一端由鼓紙、懸邊與音圈頂端進行三點定位，將彈波定位於懸邊與音圈頂端，避免彈波震動時掉落，又能增加低音表現。如圖 4.6。

2	US 專利	WO 2012/080912 A2	An audio Driver	● 懸邊黏在磁鐵和 T 鐵 及鼓紙。 ● 沒有彈波 ● 音圈並非黏在鼓紙中心點，而是黏在鼓紙周邊。如圖 4.7。

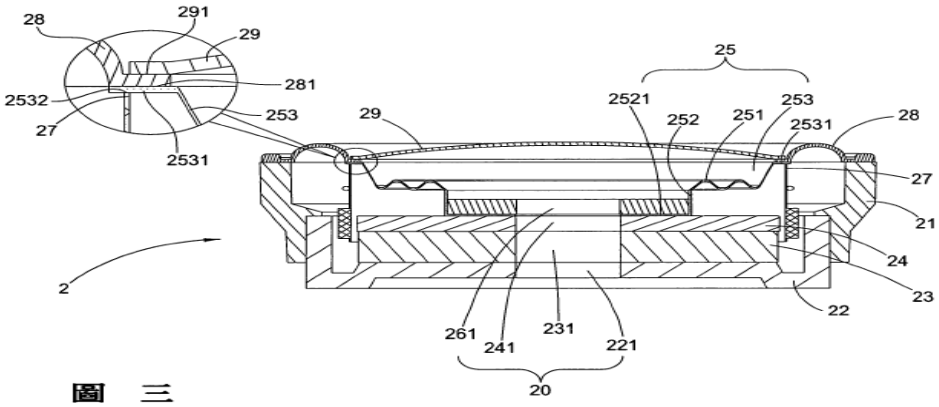


圖 4.6 彈波設計於音圈內

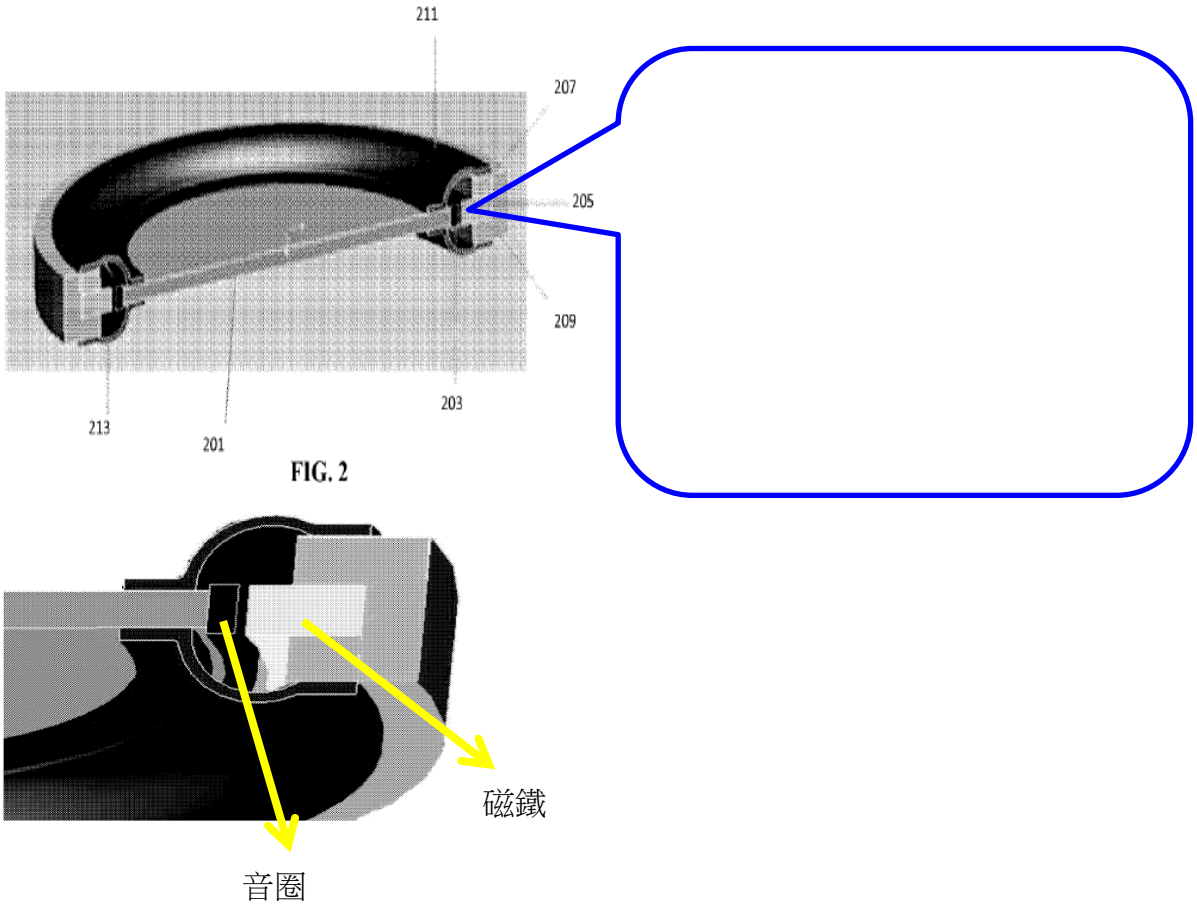


圖 4.7 雙懸邊替代彈波

- **分離原則/系統轉移**

根據衝突家族可知欲改善物理衝突為「維持彈波波紋形狀久，含浸膠水濃度需要高，但為

了使 fo 低，含浸膠水濃度需要低」，使用系統轉移得到的解答如表 4.9

表 4.9 fo 高問題系統轉移表

為了維持彈波波紋形狀久(O_1)，含浸膠水濃度必須高(+P)；但是
為了 fo 低(O_2)，含浸膠水濃度 必須低(–P)

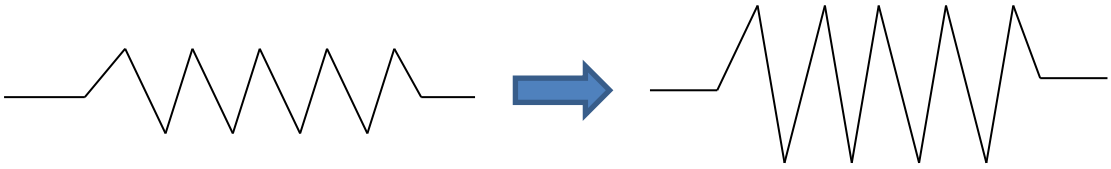
問句： 如何使[X-element]幫助我達到[維持彈波波紋形狀久]且在[濃度低]的情況下？ 如何使[X-element]幫助我達到[fo 低]且在[濃度高]的情況下？ 如何使[X-element]幫助我達到[維持彈波波紋形狀久]與[fo 低]？	
系統：揚聲器　　主要功能：產生聲音	
超系統：空氣、電、磁場	替代系統：N/A
子系統：樹脂、布料	負系統：N/A
概念解答： 彈波面積加大（波紋摺數加深），含浸膠水濃度維持不變 。 	

圖 4.8 彈波面積(摺數)加大加深

- **物(質)場分析**

初始物質場模型，如圖 4.9，有兩個問題，故在此分別利用 6 項規則與 9 個場進行解題。

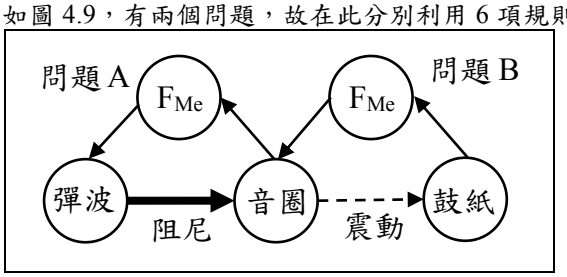
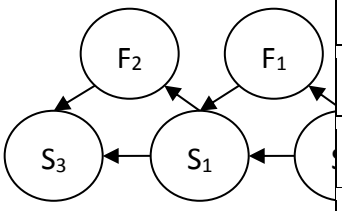
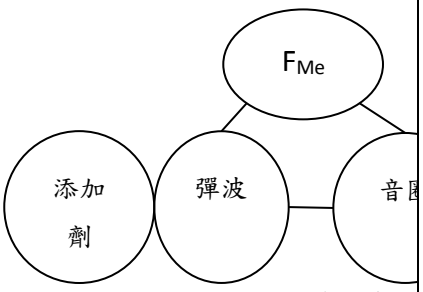
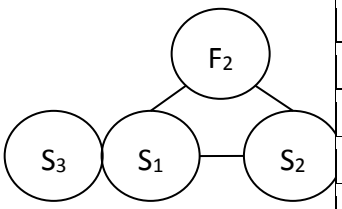


圖 4.9 初始物質場模型

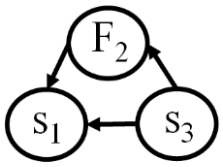
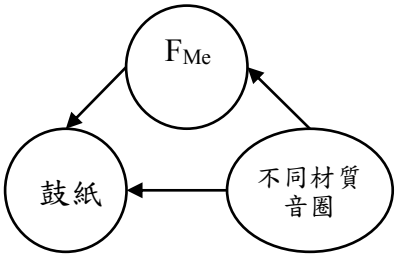
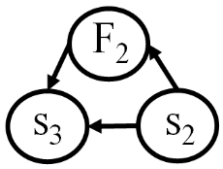
問題 A. 彈波阻尼作用太多，導致音圈上下震動距離不足，造成 fo 偏高， 規則 2 找出可行解答，如表 4.10。

表 4.10 彈波阻尼作用多物(質)場分析 Rule 3

規則 3	場	Chk	解答模型
	M	✓	
	T		
	C		
	E		
	M		
	O		
	N		加入軟化劑，使彈波阻尼作用減緩，增加音圈移動距離
	A		
	B		

問題 B. 音圈震動鼓紙的距離不足，造成 fo 偏高，分別於 Rule 1 找出可行解答，如表 4.11。

表 4.11 音圈距離不足物(質)場分析 Rule 1

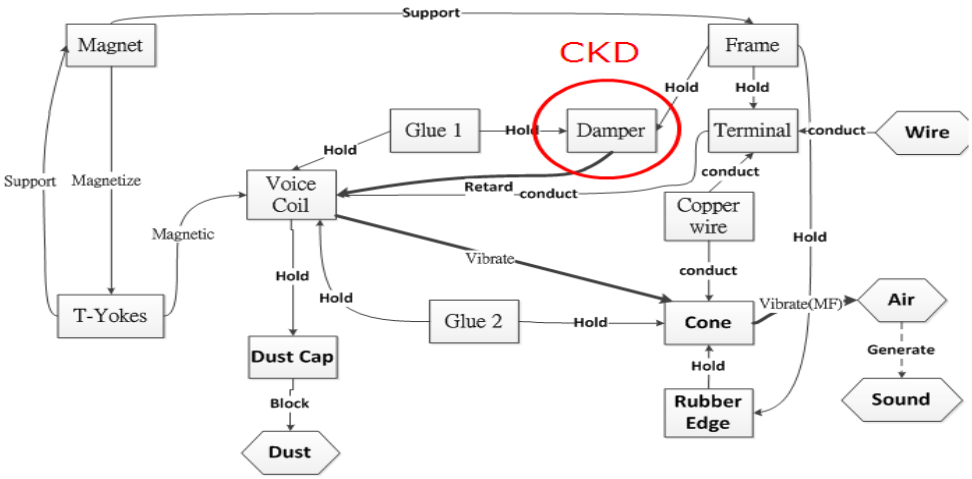
規則 1	場	Chk	解答模型
	Me	✓	
	Th		
	Ch		
	E		
	M		
	O		
	N		換另一種較重的音圈管材質，增加音圈震動行程
	A		
	B		

- **修剪設計**

從 ACECCA 找出主要不利點元件，先進行修剪，下表為元件修剪優先序辨識表，如表 4-12。

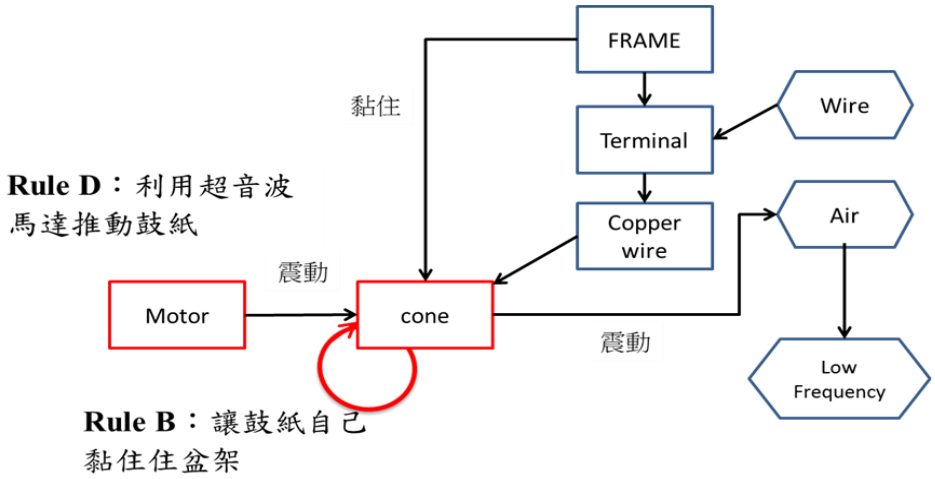
表 4-12 元件修剪優先序辨識表

Trimming Priorities
1. 彈波 2. 音圈 3. 懸邊



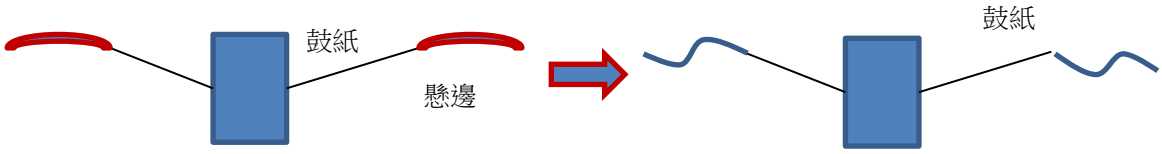
依據修剪規則效力大小依序(Trimming Rules A、X、B、C、D、E)以彈波為目標進行修剪，解題方案一，得到下表 4.13。

表 4.13 最終修剪模型



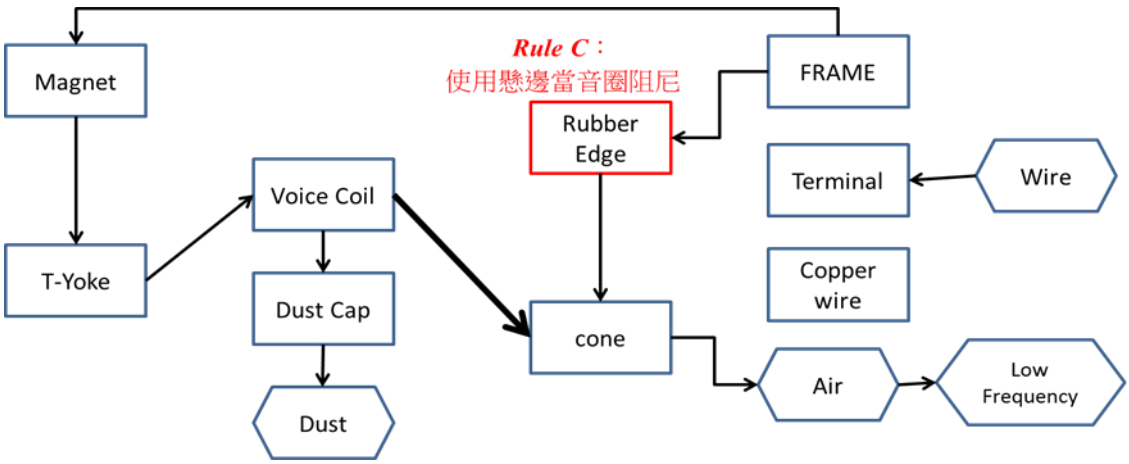
經由 Rule D 找出概念解為利用超音波馬達推動鼓紙，如表 4.13。經由 Rule B 找出的概念解為鼓紙自己本身黏住盆架，如下表 4.14。

表 4.14 以鼓紙替代懸邊



解題方案二，如表 4.15。

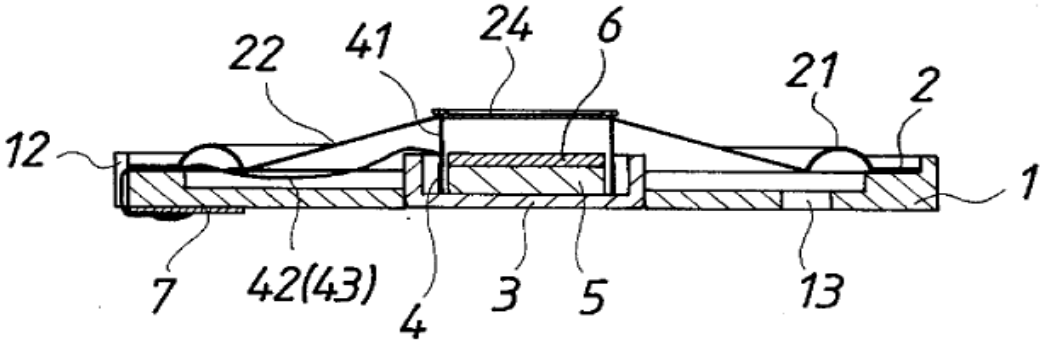
表 4.15 最終修剪模型



從修剪設計工具找到的概念解，修剪彈波---無彈波揚聲器的概念引入專利搜尋，所得結果如下表 4.16。

4.16 無彈波專利搜尋表

#	Source	Patent #/ Effect	Key Function/ Attribute	Key Ideas	Attachment
1	ROC 專利	Gn-438185	無彈波之超薄揚聲器	使振動膜表層之環形面呈向外凸出狀，藉此反向改變即可令振動膜之彈性大幅提昇，從而能省略彈波元件設置，避免戰空間，縮減揚聲器厚度，並可獲得音量提高及音質特別優異之效果。	結構如圖 4.10



第二圖

圖 4.10 無彈波揚聲器

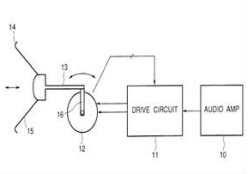
- **概念解集合**

將上述解答工具所產生的概念解，整合如下表 4.17。

表 4.17 最低共振頻率(fo)概念解彙整表

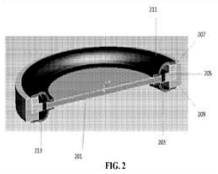
概念解1

以超音波馬達推動鼓紙



概念解4

以雙懸邊替代彈波

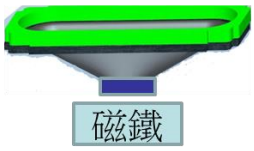


概念解7

換另一種較重的音圈管材質

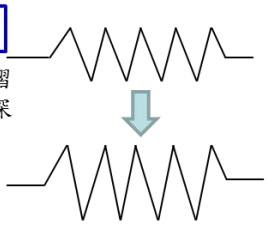
概念解2

鼓紙背面鍍上線路pattern及磁性物質



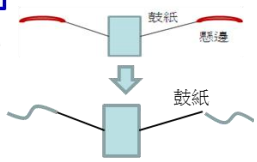
概念解5

彈波面積(摺數)加大加深



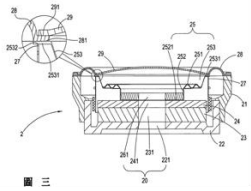
概念解8

以鼓紙替代懸邊



概念解3

彈波設計在音圈內部

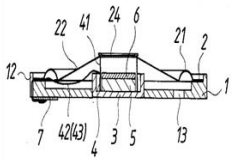


概念解6

彈波硬度放軟，音圈重量減輕

概念解9

無彈波揚聲器



4.1.4 案例解答選擇與整合

- **解答評估-普氏矩陣**

針對本案例之系統，增加評估準則「製程方便性」與「成本」進行初步評估，並以概念解 5「彈波面積加大」做為評估基準，其篩選結果如表 4.18。

表 4.18 概念解初步篩選

(初次篩選)	概念解答							
評估準則	**1**	**2**	**3**	**4**	**5**	**6**	**8**	**9**
技術可行性	-	-	-	-	0	0	-	+
技術發展性	+	-	0	0	0	0	0	0
易製造度	-	-	-	-	0	+	-	+
構造簡單性	+	+	0	+	0	0	+	0
成本	- -	0	-	- -	0	0	0	0
“+”的總數	2	1	0	1	0	1	0	1
“0”的總數	0	1	2	1	5	4	5	4
“–”的總數	-4	-3	-3	-4	0	0	0	0
總分	-2	-2	-3	-3	0	1	-1	2
排名								
是否繼續?					Y	Y		Y

篩選前三名結果說明如下：

概念解 5：彈波面積加大（波紋摺數加深），含浸膠水濃度維持不變 。

概念解 6：彈波硬度放軟，音圈重量減輕，達到 fo 低的目標。

概念解 9：換另一種較重的音圈管材質，增加音圈震動行程。

接著針對初次篩選整合後的三個概念解進行二次篩選，加入評估準則「維修性」、「創新性」，如表 4.19。

搭配 T 鐵與華司 高度差進行驗證

表 4.19 概念解二次篩選

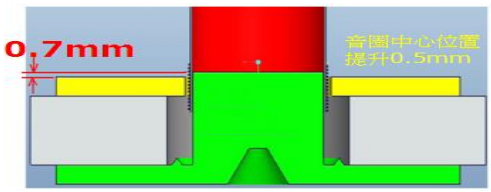
(二次篩選)		概念解答					
		5. 彈波面積（摺數）加大		6. 彈波硬度放軟，音圈重量減輕		9. 無彈波撞聲器	
評估準則	權重	評分	加權分數	評分	加權分數	評分	加權分數
成本低	30%	2	0.9	3	0.6	1	0.3
構造簡單性	25%	3	0.75	3	0.75	4	1
易製造性	20%	3	0.6	3	0.6	2	0.4
維修性	15%	3	0.45	3	0.45	3	0.45
創新性	10%	3	0.3	3	0.3	4	0.4
總分	100%		2.7		3		2.55
排序			2		1		3

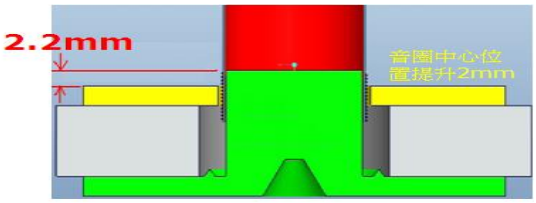
得到概念解-彈波硬度放軟，音圈重量減輕與音圈撞擊 T 鐵所產生異音的概念解-T 鐵高於華司面，使磁鐵磁力線做不均勻的分佈，防止音圈撞擊 T 鐵，結合兩者的概念解，使的 fo 能降低，又能防止防止音圈撞擊 T 鐵所產生的異音進行實驗驗證。

4.1.5 案例解答驗證

進行 DOE 實驗如下：

原設計以 T 鐵高於華司 0.2mm，實驗則以 Low 0.7mm 和 High 2.2mm 進行。





進行重置實驗 1 次、每個 Run 重複量測 2 次、中心點 0 個，執行 2^2 x 2 = 8 次實驗，實驗數據如表 4.20。

表 4.20 實驗數據收集 (直交表)

标准序	运行序	中心点	区組	W & T 高度差	彈波偏位	fo
5	1	1	1	0.7	0.6	230
2	2	1	1	2.2	0.6	225
3	3	1	1	0.7	0.9	185
4	4	1	1	2.2	0.9	178
1	5	1	1	0.7	0.6	235
7	6	1	1	0.7	0.9	180
8	7	1	1	2.2	0.9	183
6	8	1	1	2.2	0.6	240

實驗數據如 fo 欄位，可得到一個趨勢，彈波偏位越大，則 fo 相對低，約 180Hz，與華司

與 T 鐵高度差沒太大相關。
總結：根據上述的 DOE 實驗，彈波偏位為 0.9 時可得到約 fo 為 180Hz，低於規格 300Hz。

4.2 音圈撞擊 T 鐵產生異音失效問題

4.2.1 案例問題定義

本案例欲解決問題為揚聲器音圈撞擊 T 鐵產生異音問題，利用 6W1H 1E1G 問題描述表描述表清楚描述現象，以釐清表徵問題，並引導改善方向以訂定確切的專案目標，如表 4.21。

表 4.21 異音問題描述表

描述發生問題之情況。下列問題幫助你考慮到各個構面，但**請勿逐項回答**，**應以順暢易懂的方式說明問題狀況** 以利於讀者了解問題: 1. What problem? 有什麼問題/需求/機會/痛處？(sore point) 2. When was it happen? 在什麼時候發生的？ 3. Where is it found?在哪些 發現/產生 此問題？ 4. Why? 為何會發生? Or 為何要做此問題? 5. Who? 哪些人受到影響？誰引起的? 6. How was it happen. 問題如何發生 7. What to do? 要做甚麼 **輔以圖示說明問題狀況。必要時可加頁說明。**	**廠商反饋電視揚聲器有異音** 因喇叭供應商提供品質不穩定的喇叭，TPV 生產組裝時喇叭完成後進行測試，發生揚聲器異音，經查驗結果，為音圈 T 撞擊鐵時產生的聲音，要求廠商進行改善。
專題目標: (Specific Project Objectives. Itemize)	揚聲器音圈撞擊 T 鐵的改善

4.2.2 案例問題分析

利用 FA 分析系統元件間之功能關係。本案例之問題系統為揚聲器系統，將系統向下拆解至元件層級。彈波抑制音圈不足，導致音圈移動行程過長，撞擊 T 鐵產生撞擊異音。藉由功能關係分析後繪製出功能模型如圖 4.11。

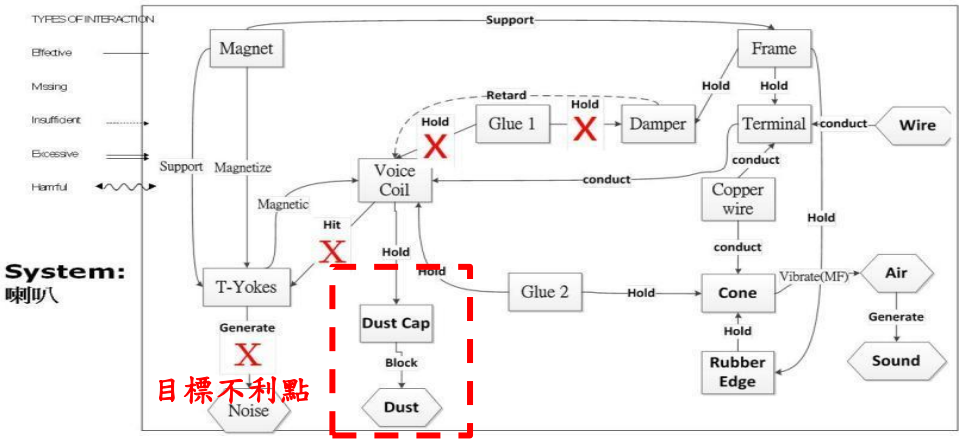


圖 4.11 異音功能屬性分析圖

再利用 ACECCA 從目標不利點「異音」，經過不利點關係表辨識因果關係，如表 4.22 至 4.26，最後所得到的因果衝突鏈，如圖 4.12。

表 4.22 T 鐵(T-Yokes) 不利點關係表 1

不利點關係表#1

不利點：異音		
中心元件	相關屬性	因果關係

T-Yokes	音頻範圍	音異←音圈撞擊 T 鐵
接觸元件	相關屬性	因果關係
Voice Coil	N/A	N/A
Magnet	N/A	N/A
Noise	N/A	N/A

表 4.23 音圈(Voice Coil)不利點關係表 2

不利點關係表#2

不利點：音圈撞擊 T 鐵		
中心元件	相關屬性	因果關係
Voice Coil	長度、重量	音圈撞擊 T 鐵←音圈長度長*、音圈重量重、音圈震動行程長 音圈重量重←線圈線徑大*、線圈長度長* 音圈震動行程長←彈波阻尼作用差
接觸元件	相關屬性	因果關係
T-Yokes	N/A	N/A
Glue1	黏性、耐熱性、比重、固成分	音圈撞擊 T 鐵←中心膠 1 與音圈剝離
Glue2	黏性、耐熱性、比重、固成分	音圈撞擊 T 鐵←中心膠 2 與音圈剝離
Dust Cap	N/A	N/A
Terminal	N/A	N/A

表 4.24 彈波（Damper）不利點關係表 3

不利點關係表#3

不利點：彈波阻尼作用差		
中心元件	相關屬性	因果關係
Damper	硬度、厚度、重量、面積	彈波阻尼作用差←彈波硬度較軟 彈波硬度較軟←彈波布較薄*、含浸膠水濃度低*
接觸元件	相關屬性	因果關係
Glue1	黏性、耐熱性、比重、固成分	中心膠 1 與彈波剝離←中心膠變質 中心膠變質←中心膠混合比例錯誤*、音圈溫度過高*
Frame	N/A	N/A

表 4.25 中心膠 1（Glue 1）不利點關係表 4

不利點關係表#4

不利點：中心膠 1 與音圈剝離		
中心元件	相關屬性	因果關係
Glue1	黏性、耐熱性、比重、固成分	中心膠 1 與音圈剝離←中心膠變質 中心膠變質←中心膠混合比例錯誤*、音圈溫度過高*
接觸元件	相關屬性	因果關係
Voice Coil	N/A	N/A
Damper	N/A	N/A

表 4.26 中心膠 2（Glue 2）不利點關係表 5

不利點關係表#5

不利點：中心膠 2 與音圈剝離		
中心元件	相關屬性	因果關係
Glue2	黏性、耐熱性、比重、固成分	中心膠 2 與音圈剝離←中心膠變質 中心膠變質←中心膠混合比例錯誤*、音圈溫度過高*
接觸元件	相關屬性	因果關係
Voice Coil	N/A	N/A
Cone	N/A	N/A

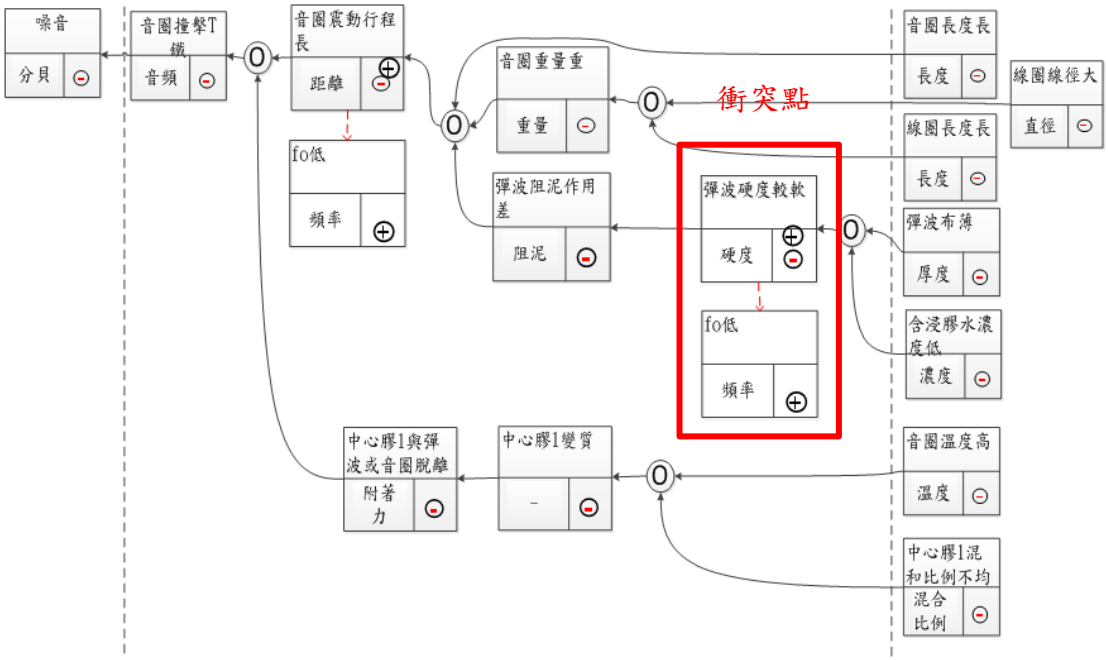


圖 4.12 異音屬性因果衝突鏈

以衝突點開始往目標不利點前進，將所涉及的因果關係整理成衝突家族，如表 4.27。

表 4.27 異音衝突家族

ID	物理衝突[IF]	欲改善負面因素[THEN]	惡化的正面因素[BUT]

1	彈波較硬	彈波阻尼作用好	fo 高
		音圈震動行程短	
		音圈不會撞擊 T 鐵	

4.2.3 案例解答產生

- **功能導向搜尋**

依關鍵問題「異音」，思考欲解決問題之需求功能「音圈不可撞擊 T 鐵」、「體積小」，並一般化成關鍵字「產生聲音」、「推動空氣」。利用效應知識庫查詢所得到之效應有「Electric field」，可分別依這兩種方式得到解決 異音高的概念。

「Electric field」效應-利用凸輪機構帶動鼓紙震動空氣，產生聲音。由於沒有音圈及 T 鐵，因此加害者和受害者皆消失，因此可以解決音圈撞擊 T 鐵的噪音。如圖 4.13。

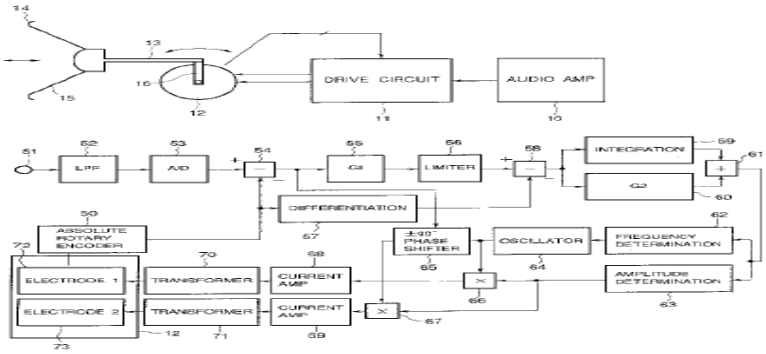


圖 4.13 超音波馬達推動鼓紙(US 專利 US6384550 B1)

另根據需求功能/屬性及 Context 組合成搜尋的關鍵字搜尋專利，如圖 4.6，搜尋結果如表 4.7。

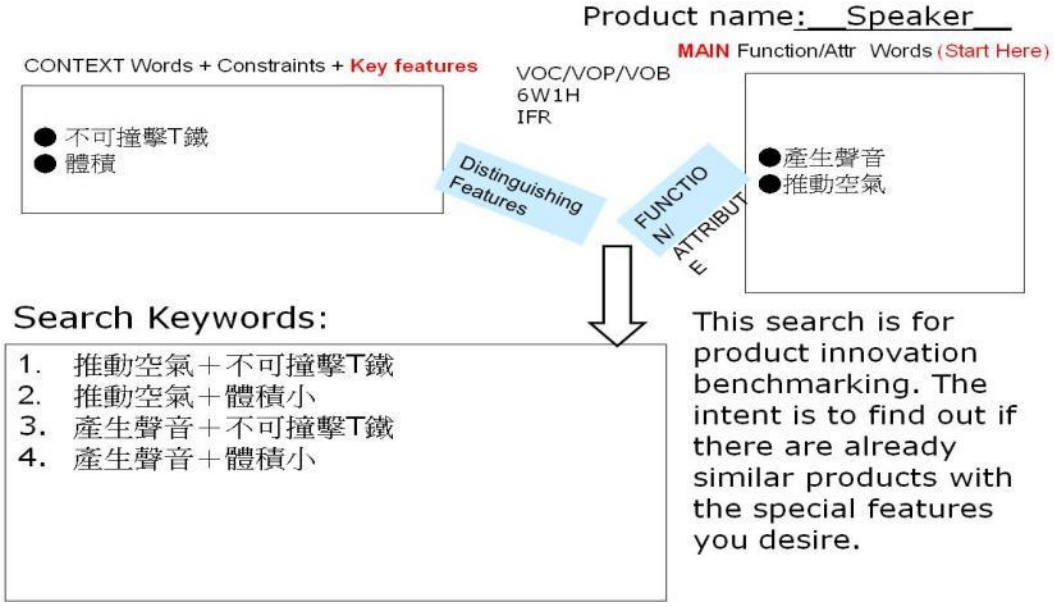


圖 4.14 異音問題專利搜尋

表 4.28 異音問題專利搜尋彙整表

#	Source	Patent #	Key Func./Attr.	Key Ideas
1	中華民國專利	201136331	動磁式揚聲器裝置	將左右 2 磁性元件固定在左右 2 側殼體，利用磁力線形成相吸、相斥作用，帶動殼體，震動空氣，產生聲音。沒有鼓紙、喇叭框架、彈波。該裝置尺寸不受結構形侷限，也可為迷你耳塞式大小。

				如圖 4.15。
2	US 專利	TW M399561U1	喇叭緩衝裝置	基於喇叭單體有限的高度及空間，用彈性緩衝體替代彈波，使振膜作動時不會偏移而碰撞到內部元件，且可承受更大的輸入電壓，提供更高的靈敏度及音質

將左右 2 磁性元件固定在左右 2 側殼體，利用磁力線形成相吸、相斥作用，帶動殼體，震動空氣，產生聲音。沒有鼓紙、喇叭框架、彈波。因此，能解決音圈撞擊 T 鐵的異音。如圖 4.15。

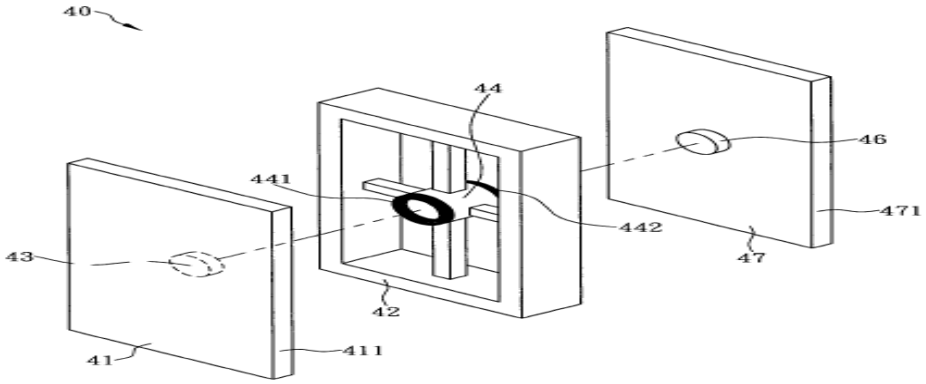


圖 4.15 動磁式揚聲器裝置

基於喇叭單體有限的高度及空間，用彈性緩衝體替代彈波，使振膜作動時不會偏移而碰撞到內部元件，且可承受更大的輸入電壓，提供更高的靈敏度及音質。如圖 4.16。

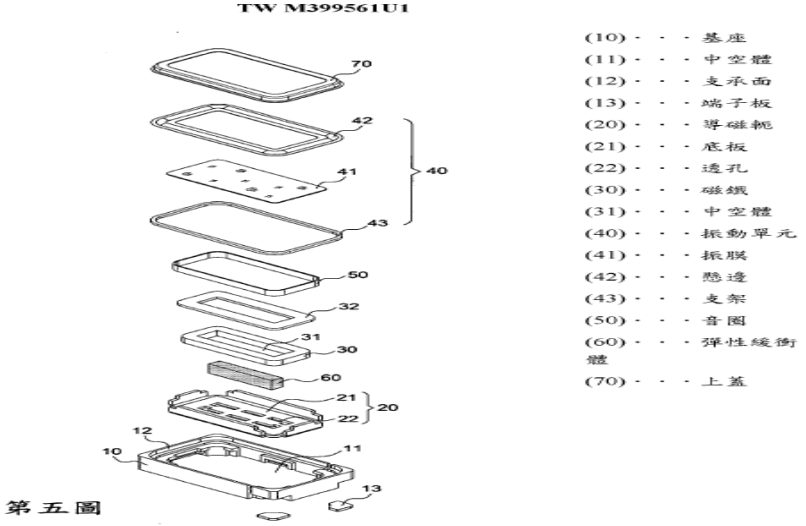


圖 4.16 喇叭緩衝裝置

- **分離原則/系統轉移**

根據衝突家族可知欲改善物理衝突為「彈波阻尼作用佳，彈波硬度必須硬，但為了使 fo 低，彈波硬度 必須軟」，使用系統轉移得到的解答如表 4.29

表 4.29 異音系統轉移表

為了彈波阻尼作用佳(O_1)，彈波硬度必須硬(+P)；但是
為了 fo 低(O_2)，彈波硬度 必須軟(–P)

問句： 如何使[X-element]幫助我達到[彈波阻尼作用佳]且在[硬度軟]的情況下？ 如何使[X-element]幫助我達到[fo 低]且在[硬度高]的情況下？ 如何使[X-element]幫助我達到[彈波阻尼作用佳]與[fo 低]？	
系統：揚聲器　　主要功能：產生聲音	
超系統：空氣、電、磁場	替代系統：N/A

子系統：鼓紙、懸邊	負系統：N/A

概念解答：

使 T 鐵與華司(washer)有高度差，磁力線做不均勻的分佈，防止音圈撞擊 T 鐵。

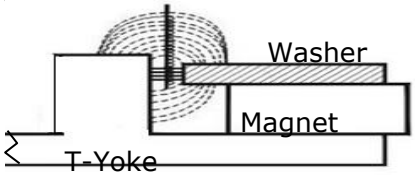


圖 4.17 T 鐵與華司(washer)有高度差

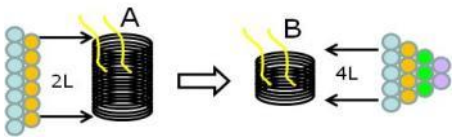
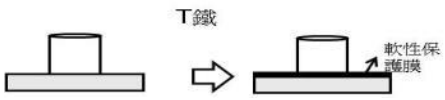
- 衝突矩陣/發明原則（CM/IP）

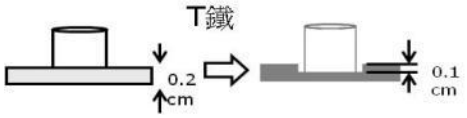
根據衝突矩陣/發明原則的模式化：IF 彈波較硬, THEN 彈波阻泥作用好, BUT fo 高，找出衝突參數，並進而找出發明原則，如表 4.30。產生觸發解如表 4.31。

表 4.30 異音衝突矩陣/發明原則

	(21)功率 [18] Power	(9)速度 [14] Speed
(10)力量 [15] Force/ Torque	(2)分離/抽出 (26)複製 (35)參數改變/屬性轉換 (36)相的轉變 [15]動態化/動態性 [19]週期性的作用	(13)另一方向/反相 (15)動態化/動態性 (19)週期性的作用 (28)取代機械系統
(11)壓力或應力 [19]Stress or Pressure	(10)預先作用 (22)將有害變成有益 (35)參數改變/屬性轉換 [3]局部品質 [30]彈性膜和薄膜	(6)多功能/萬用性 (18)機械震動 (38)使用強氧化劑 (40)複合材料 [14]球形/體，曲率 [28]取代機械系統

表 4.31 異音衝突矩陣/發明原則概念解彙總表

Generic Solution	Specific Solution	Remark/ Insert Diagram
[30]彈性膜和薄膜	Ceramic Foam(泡沫陶瓷)：音圈管材料改成泡沫陶瓷，當產生撞擊時，泡沫陶瓷產生吸音效果，減少異音	概念解 5-音圈管材料改成泡沫陶瓷
(1) 分割	音圈長度不變， 2L(雙層)音圈變 4L(4 層)，降低音圈撞擊 T 鐵的機率	 圖 4.18 2L 音圈變 4L 音圈
(24)中間介質	在 T 鐵表層增加軟性材料	 圖 4.19 T 鐵表層增加軟性材料

(3)局部品質	挖深 T 鐵使成凹槽	 圖 4.20 挖深 T 鐵周圍

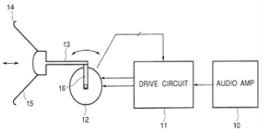
● 概念解集合

將上述解答工具所產生的概念解，整合如下表 4.32。

表 4.32 異音概念解彙整表

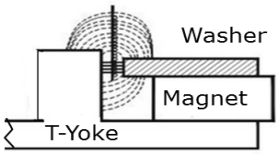
概念解1

以超音波馬達推動鼓紙



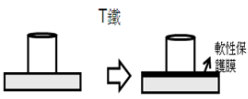
概念解4

T鐵與華司高度差



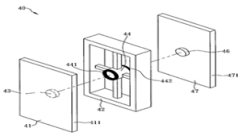
概念解7

T鐵表層增加軟性材料



概念解2

磁性元件帶動殼體，無撞擊T鐵異音

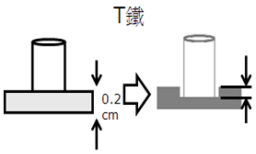


概念解5

音圈管材料改成泡沫陶瓷

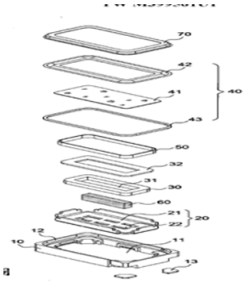
概念解8

挖深T鐵周圍



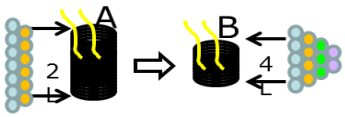
概念解3

彈性緩衝體替代彈波



概念解6

2L音圈變4L音圈



4.2.4 案例解答選擇與整合

● **解答評估-普氏矩陣**

針對本案例之系統，增加評估準則「製程方便性」與「成本」進行初步評估，並以概念解 4「T 鐵與華司高度差」做為評估基準，其篩選結果如表 4.33。

表 4.33 概念解初步篩選

(初次篩選)	概念解答							
評估準則	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
技術可行性	-	-	0	0	-	+	+	0
技術發展性	+	+	0	0	0	0	0	0
易製造度	-	-	0	0	0	+	0	-
構造簡單性	+	+	-	0	0	+	0	0
成本	- -	-	-	0	-	+	-	0
“+”的總數	1	1	0	0	0	4	1	0
“0”的總數	2	1	3	0	2	1	3	4

“–”的總數	-4	-3	-2	0	-2	0	-1	-1
總分	-3	-2	-2	0	-2	4	0	-1
排名						1		
是否繼續?				Y		Y	Y	

篩選前三名結果說明如下：
概念解 5：彈波面積加大（波紋摺數加深），含浸膠水濃度維持不變 。
概念解 6：加入軟化劑，使彈波阻尼作用減緩，增加音圈移動距離，藉以降低 fo。
概念解 9：換另一種較重的音圈管材質，增加音圈震動行程。

接著針對初次篩選整合後的三個概念解進行二次篩選，加入評估準則「維修性」、「創新性」，如表 4.34。

表 4.34 概念解二次篩選

(二次篩選)		概念解答					
		4. T 鐵凹+華司與 T 鐵不等面設計		6. 2L 變 4L 音圈		7. T 鐵表層增加軟性材料	
評估準則	**權重**	評分	加權分數	評分	加權分數	評分	加權分數
成本低	30%	3	0.9	4	1.2	2	0.6
構造簡單性	25%	3	0.75	3	0.75	2	0.5
易製造性	20%	3	0.6	3	0.6	2	0.4
維修性	15%	3	0.45	3	0.45	4	0.6
創新性	10%	3	0.3	3	0.3	3	0.3
總分	100%		3		3.3		2.4
排序					1		

4.2.5 案例解答驗證

實驗對象：概念解 6-音圈長度不變，音圈雙層變四層
實驗說明：
本實驗驗證總線圈長度不變之下，將其原本 2 圈（2L）線圈變成 4 圈(4L)線圈，其線圈高度縮減為 1 半，換言之 2L 的底部到 T 鐵底部為 4mm，修改成 4L 的線圈時，線圈底部到 T 鐵底部為 5mm，多出 1mm 的餘裕度。如圖 4-33。驗證修改成 4L 後，音圈是否還會打底，產生異音。

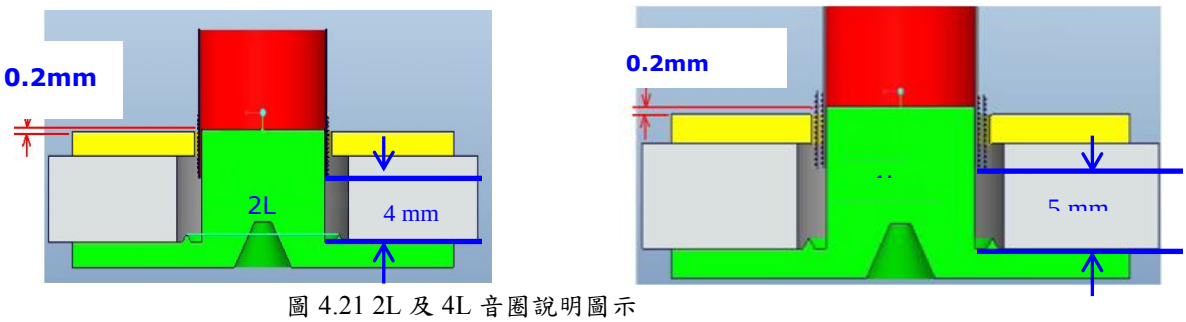


圖 4.21 2L 及 4L 音圈說明圖示

實驗數據收集：
收集 30 組衝程數據，並填入下表 4.35 中。

表 4.35 實驗數據收集表

NO	衝程距離	NO	衝程距離	NO	衝程距離
1	3.8	11	3.7	21	3.9

2	4.3	12	4	22	4.2
3	3.9	13	4.1	23	3.8
4	3.9	14	3.9	24	3.9
5	4	15	3.6	25	3.8
6	3.9	16	3.8	26	3.9
7	3.8	17	4	27	4.2
8	3.7	18	3.9	28	3.8
9	4.4	19	3.8	29	3.9
10	4.3	20	4.3	30	4

单样本 T: 衝程距離

mu = 4 与 < 4 的检验

变量	N	平均值	平均值标准差	标准误	95% 上限	T	P
衝程距離	30	3.9500	0.1996	0.0364	4.0119	-1.37	0.090

单样本 T: 衝程距離

mu = 5 与 < 5 的检验

变量	N	平均值	平均值标准差	标准误	95% 上限	T	P
衝程距離	30	3.9500	0.1996	0.0364	4.0119	-28.82	0.0

結論：以數據 P Vaule 來看音圈衝程距離 5mm 較音圈衝程距離 4mm 來的顯著，即提升音圈高度距離 1mm，可以避免音圈撞擊 T 鐵底部產生異音。

5. 結論與貢獻

本研究運用萃智（TRIZ）理論及方法進行品質問題解決，主要是採五階段，（1）問題定義 (2) 問題分析 (3) 解答產生 (4) 解答選擇與整合 (5) 解答驗證 及萃智 8 工具進行問題解決，找出可行概念解，大幅提升實際投入工程設計可能性。

本研究以揚聲器發生在個案公司之品質問題為例---最低共振頻點（fo）高及音圈撞擊 T 鐵所產生的異音，進行揚聲器品質改善，運用萃智工具找出概念解，不同的工具所找出的概念解可能會有雷同，可以整合在一起。最後進行驗證的部分有二個，其一、調整彈波硬度使其順性大些，加以使 T 鐵高於華司面（不等面設計），其二、音圈的長度不變，圈數由 2L 變為 4L，其結果皆為正向。

本研究主要貢獻如下：

1. 對個案公司或是供應商找出揚聲器的最低共振頻點(f0)的改善概念解。

財務效益
獲得利益為 A)預估年度銷售量：80 萬台 B)預估改善幅度（降低不良率）：12% C)預估每台節省（創造）金額：1.5 USD A x B x C = 144,000 USD

對個案公司或是供應商找出揚聲器音圈撞擊 T 鐵的異音改善概念解。

財務效益
獲得利益為 A)預估年度銷售量：80 萬台 B)預估改善幅度（降低不良率）：6% C)預估每台節省（創造）金額：1.5 USD A x B x C = 72,000 USD

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