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Application of Modified DIPA Method to Explore Mutual Influence Relationship Between Technical Fields and Functional Fields of LED Projection Light

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Keywords: LED projection light, modified DEMATEL, modified IPA, modified DIPA, patent analysis

ABSTRACT

The paper integrates the modified DEMATEL and the modified IPA to develop an innovative decision-making method — modified DIPA. Then the modified DIPA is attached with technical/functional matrix to make an overall analysis of the mutual influence relationship between technical fields and functional fields of LED projection light. Through this method and according to the size of normalized numerical values of the functional fields corresponding to the technical fields in the technical/functional matrix of LED projection light, the paper respectively determines the final combinations of technical fields and functional fields for prioritized improvement and minor improvement. The combinations of technical fields and functional fields for prioritized improvement and minor improvement finally determined by the paper respectively are the combination of B. base structure technique and c. heat dissipation increase, as well as the combination of F. light source framework configuration technique and a. structural stability enhancement.

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INTRODUCTION

Steigerwald et al. (2002) mentioned the use of tricolor to make full-color signals, such as traffic light and slogan. At the beginning LED light mainly served as indicator light. The energy consumed was very low, and the heat produced was also less, without creating excessively high temperature to the module. Jung et al. (2012) explored in their studies optimization of cooling effect and weight of radial heat dissipation fin. They made comparison between plate-fin heat sink and pin-fin heat sink. Regarding LED projection light, Liu et al. (2012) developed a patent, which was a miniature LED projection light for illuminating decoration. It contained a support stand and a lamp body. The lamp body, mounted on the support stand, contained a substrate, an illuminating object installed on one side of the support stand opposite to the substrate, a condenser extended from the edge of the substrate, and a chamber that is co-shared by the condenser and the substrate, open in single direction, and provided for placement of the illuminating object. Besides, the patent of Huang and Hsien (2013) was a structural design of a heat-dissipation lamp holder of LED projection light. Its parts mainly contained a heat-dissipation pipe, a set of heat-dissipation fins, a heat-dissipation tray and a lamp shade.

Besides, focusing on the related Taiwanese patents, Chinese patents, American patents and EU patents of LED projection light, the paper collects over 100 related patents.

Decision-making trial and evaluation laboratory (DEMATEL) was a method developed by Battelle Memorial Institute of Geneva, Switzerland from 1972 to 1976 for Science and Human Affairs Program. At that time the purpose of using DEMATEL was to study complicated and difficult problems, such as race, starvation, environmental protection and energy (Fontela and Gabus, 1976), Tzeng et al. (2007) mentioned that the main function and

characteristic of DEMATEL were that through observation of the degree of influence between paired criteria, and subsequently, through calculation by matrix and its mathematics-related theory, the cause-effect relationship among all criteria could be acquired. The numbers in the matrix and the influential network relation map (INRM) expressed the strength of mutual influence relationship and cause-effect relationship among different criteria in order to find out the core problems and improvement direction of the complicated issues. Also because of this characteristic of DEMATEL, in recent years DEMATEL has been started to be applied to the areas of corporate planning and decision-making as well as urban planning design.

Martilla and James (1977) used importance-performance analysis (IPA) to conduct empirical research of 14 service attributes provided by a certain car manufacturer. Through question nairesurvey of customers, the means of scores of importance and performance of different attributes were achieved from the questionnaire survey to draw a two-dimensional matrix framework, which was called importance-performance analysis (IPA) coordinate chart. Through the 4 quadrants on the chart, representing different physical meanings respectively, analysis was carried out. The chart provides a reference for the proprietors in the later days to make adjustment and improvement of part of their strategies. Huan and Beaman (2005) indicated that IPA method did not belong to a kind of quantitative decision-making tool. It could only perform preliminary analysis, but could not be used to make final decision.

COMBINATION OF TECHNICAL/FUNCTIONAL MATRIX OF PATENTS AND MODIFIED DEMATEL TO EXPLORE MUTUAL INFLUENCE RELATIONSHIP BETWEEN TECHNICAL FIELDS AND FUNCTIONAL FIELDS OF LED PROJECTION LIGHT

Establishment Procedure of Techniques and Functions of LED Projection Light

The paper establishes technical/functional matrix of LED projection light by combining engineering knowledge with the technical expansion chart of LED projection light. First of all, the paper defines the 1st-layer technical fields of LED projection light. The 1st-layer technical fields are:(1) overall support structure technique of LED projection light; (2) heat dissipation structure technique of LED projection light; and (3) light source main body structure technique of LED projection light. After that, the paper preliminarilye stablishes the 1st-layer and 2nd-layer technical/functional matrix.

As previous mention, after defining the 1st-layer technical fields of LED projection light, we startusing important words and International Patent Classification (IPC) codes of the related patents to conduct mass collection of the related patents. Based on these searched patents, a term and word segmentation system of patent semantic analysis is employed to conduct analysis of the key technical words, part/components words and functional words, and calculate the normalized numerical values of different keywords. The highly correlated technical word clusters and functional word clusters of patents are categorized as the word cluster of technical fields and word cluster of functional fields. Employing the concept of synonym, the paper establishes the word cluster of important technical words and part/component word cluster of different 1st-layer technical fields and 2nd-layer technical field of the related patents of LED projection light.

Subsequently, these word clusters are compared by modified cosine similarity. The 2nd-layer technical fields and functional fields of each 1st-layer technical field are defined by artificial classification, and a 1st-layer and 2nd-layer technical/functional matrix is established. And the 1st-layer and 2nd-layer technical/functional matrix of the related Chinese and English patents of LED projection light as well as the patent numbers of the related Chinese and English patents can be obtained. The 1st-layer and 2nd-layer technical fields and functional fields of the related patents of LED projection light are outlined as follows.

The 1st-layer technical fields of LED projection light patents are divided into 3 kinds: (1) overall support structure technique; (2) heat dissipation structure technique of lamp; and (3) light source main body structure technique.

The 2nd-layer technical fields of the overall support structure technical field of LED light on the 1st layer can also be divided into 2 kinds: (1) support stand design technique; and (2) base structure technique. The 2nd-layer technical fields of heat dissipation structure technique of LED light on the 1st layer can also be divided into 2 kinds: (1) fin design technique; and (2) heat conduction structure technique. The 2nd-layer technical fields of the light source main body structure technique of LED light on the 1st layer can also be divided into 3 kinds: (1) lampshade design technique; and (2) light source framework configuration technique; and (3) electronic component control technique.

The functional fields of LED projection light

patents are divided into 7 kinds: (1) structural stability enhancement; (2) increase of convenience for use; (3) heat dissipation increase; (4) cost reduction, quality improvement and life extension; (5) illumination strength enhancement; (6) light source adjustability; and (7) electricity supply and power-saving.

This paper also establishes the functional word cluster of different functional fields of the related patents of LED projection light. If new patents are added, the internal information of the technical/functional matrix and the related word clusters can be improved continuously.

Modified DEMATEL

Taking traditional DEMATEL as the foundation, the paper applies a new decision-making method — modified DEMATEL analysis method to calculate the proportion of the normalized numerical values of the patent technical words being repeated or having the same definitions between one technical field and another technical field in the patent-related technical fields. The calculated proportion can serve as a reference for judging the degree of mutual influence between two technical fields. The degree of mutual influence between different technical fields (or functional fields) is a value of 0~4; and the physical meanings respectively representing 0, 1, 2, 3 and 4 are “no influence,” “low influence,” “medium influence,” “great influence” and “extremely great influence.”

Regarding the detailed calculation process of modified DEMATEL, it has 6 steps as follows:

1, Define different technical fields and judge the mutual relationship among them.
2. Establish direct relation matrix.
3. Establish normalized direct relation matrix X.
4. Establish total influence matrix T.
5.Through total influence matrix, calculate D_i and R_j values, and calculate the degree of prominence $(D_i + R_j)$and the degree of relation $(D_i\text{-}R_j)$.

Total influence matrix $T = [t_{ij}]$. Let t_{ij}(i，j=1,2,…,n) be the elements in T, representing the degree of influence of criterion i on criterion j.

D_i denotes the total value of rows.

$$D_i = \sum_{j=1}^{n} t_{ij} \text{(i=1,2,…,n)} \quad (1)$$

R_j denotes the total value of columns.

$$R_j = \sum_{i=1}^{n} t_{ij} \text{(j=1,2,…,n)} \quad (2)$$

6.Causal Diagram

The degree of prominence and the degree of relation calculated in Step 5 are drawn as a causal diagram. The degree of prominence and the degree of relation of each technical field (or functional field) are taken as coordinates and drawn on a diagram. Through the two straight lines of the mean of the degree of prominence (D_i+R_j) and the degree of relation $(D_i\text{-}R_j)$ being zero, the relationship diagram is divided into 4quadrants. This relation diagram is called causal diagram. Through distribution of different technical fields (or functional fields) in the causal diagram, the cause-effect relationship and degree of prominence of this technical fields (or functional fields) can be analyzed, and the physical meanings that the various quadrants of this diagram represent respectively can be explained, as shown in Figure 1.

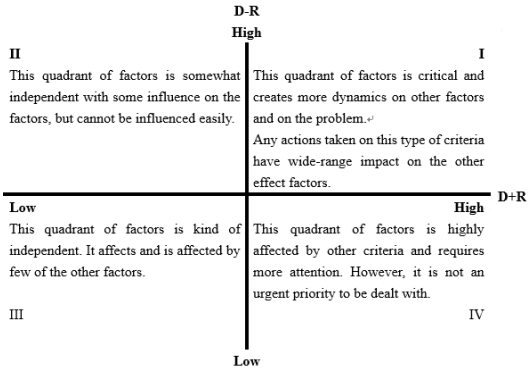

Figure 1 Physical meanings of 4 quadrants in causal diagram

Calculation Process of Technical Fields of LED Projection Light by Modified DEMATEL

Using term and word segmentation system, the paper selects 7 most important technical fields from hundreds of the patent fact sheets. According to the related patents, the appearance frequency of the related technical words in the related patents and each technical field is divided by the total number of words in the related patent fact sheets. The paper calculates the normalized numerical values of each technical field of LED projection light, as shown in equation (3).

$$\frac{\text{Appearance frequency of the related technical words in each technical field}}{\text{Total number of words in the related patent fact sheets}} = \text{Normalized numerical value of each technical field} \quad (3)$$

Using term and word segmentation system, the paper selects 7 most important technical fields from hundreds of patent fact sheets. According to the total number of words in the patent fact sheets and the appearance frequency of the related technical words of each technical field, the normalized numerical values are calculated.

[Step 1] Define the technical fields and judge the irmutual influence relationship.

According to the technical words and normalized numerical values possessed by different technical fields, and through equation (4), find the proportion of the normalized numerical value of a technical field in another

major technical field, and establish a matrix of the proportion of normalized numerical values among 7 technical fields. The calculation results are shown in Table 1.

$$\frac{\text{Sum of normalized numerical values, being repeated or having the same definitions, of another technical field appeared in major technical field}}{\text{Total normalized numerical values of major technical field}} = \text{Proportion of normalized numerical value} \quad (4)$$

For example, the total normalized numerical value ratio of the technical field of B. base structure technique, being repeated or having the same definitions, in the technical field of A. support stand design technique is 0.3389(33.89%), which is just a normalized numerical value ratio. Using this calculation method, the normalized numerical value ratio of other technical fields can be sequentially calculated

Table 1 Matrix of normalized numerical value ratios of 7 technical fields of LED projection light

	A.	B.	C.	D.	E.	F.	G.
A.	100.00%	35.32%	7.55%	7.34%	18.86%	19.70%	10.80%
B.	33.89%	100.00%	12.70%	19.41%	9.90%	12.11%	8.30%
C.	5.51%	5.40%	100.00%	44.01%	8.40%	23.88%	11.92%
D.	2.96%	10.07%	60.62%	100.00%	26.89%	11.62%	11.66%
E.	7.11%	17.72%	8.92%	12.81%	100.00%	18.42%	18.97%
F	13.46%	3.85%	19.67%	22.56%	31.75%	100.00%	20.95%
G.	12.07%	11.50%	10.75%	7.06%	23.81%	11.97%	100.00%

[Step 2] Establish direct relation matrix Z.

From the normalized numerical value ratios of the technical fields of LED projection light in Table 1, we can evaluate and determine the degree of mutual influence of 0~4 among different technical fields, as shown in Table 2. In Table 2, the normalized numerical value ratio of technical fields is 0~4% and expressed as 0, indicating “no influence”; the normalized numerical value ratio of technical fields is 4~12% and expressed as 1, indicating “low influence”; the normalized numerical value ratio of technical fields is 12~20% and expressed as 2, indicating “medium influence”; the normalized numerical value ratio of technical fields is 20~28% and expressed as 3, indicating “great influence ”;and the normalized numerical value ratio of technical fields is above 28% and expressed as 4, indicating “extremely great influence”.

From Table 2, the strength of influence of different technical fields is acquired. Furthermore, a table of the strength of influence of different technical fields of LED projection light is established, as shown in Table 3.

The contents below show the establishment process of Table 3. For example, when “D. heat conduction structure technique” is the major, “D. heat conduction structure technique” and “D. heat conduction structure technique” are actually the same technical field, so that it is set to be 0, i.e. no influence. Besides, the normalized numerical value ratio for “A. support stand design technique” to affect “D. heat conduction structure technique” is 7.34% in Table 1, so that the strength is 1 as shown in Table 2 and Table 3.

In this way, for “A. support stand design technique”; “B. base structure technique”,“C. fin design technique”,“ D. heat conduction structure technique”, “E. lampshade design technique”,“F. light source framework configuration technique” and “G. electronic component control technique”, a table of the strength of influence of different technical fields of LED projection light can be achieved, as shown in Table 3.

Table 2 Percentage of the degree of influence among different technical fields of LED projection light

Degree of influence (0~4)	Percentage (%)
0 – No influence	0~4%
1 – Low influence	4%～12%
2 – Medium influence	12%～20%
3 – Great influence	20%～28%
4 – Extremely great influence	Above 28%

Table 3 Table of the strength of influence of different technical fields of LED projection light

	A. Support stand design technique	B. Base structure technique	C. Fin design technique	D. Heat conduction structure technique	E. Lampshade design technique	F. LED light source framework configura-tion technique	G. Electronic component control technique
A. Support stand design technique	0	4	1	1	2	2	1
B. Base structure technique	4	0	2	2	1	2	1
C. Fin design technique	1	1	0	4	1	3	1
D. Heat conduction structure technique	0	1	4	0	3	1	1
E. Lampshade design technique	1	2	1	2	0	2	2
F. LED light source framework configure-tion technique	2	0	2	3	4	0	3
G. Electronic component control technique	2	1	1	1	3	1	0

The strength of influence of different technical fields of LED projection light in Table 3 can be expressed in the form of a matrix, establishing a direct relation matrix Z as follows:

Direct relation matrix

$$Z=\begin{bmatrix}0&4&1&1&2&2&1\\4&0&2&2&1&2&1\\1&1&0&4&1&3&1\\0&1&4&0&3&1&1\\1&1&1&2&0&2&2\\2&2&2&3&4&0&3\\2&1&1&1&3&1&0\end{bmatrix}$$

[Step 3] Establish normalized direct relation matrix.

After that, normalize the direct relation matrix obtained in [Step 2]. For matrix Z in the above step, and using equation (2), the maximum value S for the sum of total value of rows and total value of columns is found to be 14. Divide the matrix "Z" by 14, obtaining the normalized direct relation matrix "X" as follows.

$$\mathbf{S}=\left(\max_{1\le i\le n}\sum_{j=1}^{n}Z_{ij}\ ,\ \max_{1\le j\le n}\sum_{i=1}^{n}Z_{ij}\right)$$
$$=2+2+3+4+3=14$$

Then, normalized direct relation matrix $\mathrm{X}=\frac{\mathrm{Z}}{\mathrm{S}}$ can be calculated.

[Step 4] Establish total influence matrix.

After calculation of matrix, find the total influence matrix T of LED projection light, and the result of T can be calculated as follows:

$\boldsymbol{T}=\boldsymbol{X}(I-\boldsymbol{X})^{-1}$, where I denotes the unit matrix, and X denotes the normalized direct relation matrix.

[Step 5] Calculate the degree of prominence and the degree of relation.

Based on the value of total relation influence matrix T, and using equations (5) and (6), calculate the total value of rows D_i and total value of columns R_j, and calculate the D_i+R_j value and D_i-R_j value, with their results shown in Table 4.

D_i is total value of rows ,

$$D_i=\sum_{j=1}^{n}t_{ij}\ (i=1,2,\cdots,n) \quad (5)$$

R_j is total value of columns ,

$$R_j=\sum_{i=1}^{n}t_{ij}\ (j=1,2,\cdots,n) \quad (6)$$

[Step 6] Draw a causal diagram.

After that, draw a causal diagram based on Table 4. According to (D_i+R_j, D_i-R_j), draw the 7 technical fields on the coordinate axes. Through the mean 7.227 of the degree of prominence ($D_i + R_j$), draw a vertical axis. Divide the causal diagram into 4 quadrants, as shown in Figure 2. The technical fields existed in each quadrant are as follows.

The mean of the degree of prominence is the mean of D_i+R_j value of different technical fields:

(6.835+6.952+7.369+7.558+7.857+7.968+6.049)/7=7.227

Table 4 Total value of rows D_i, total value of columnsR_j, D_i+R_j value and D_i-R_j value of 7 items of LED projection light

Technical field	Total value of rows D_i	Total value of columns R_j	$D_i + R_j$	$D_i - R_j$
A.	3.728	3.108	6.835	0.62
B.	3.984	2.968	6.952	1.015
C.	3.655	3.715	7.369	-0.06
D.	3.279	4.279	7.558	-1
E.	3.325	4.531	7.857	-1.206
F.	4.346	3.622	7.968	0.723
G.	2.978	3.071	6.049	-0.093

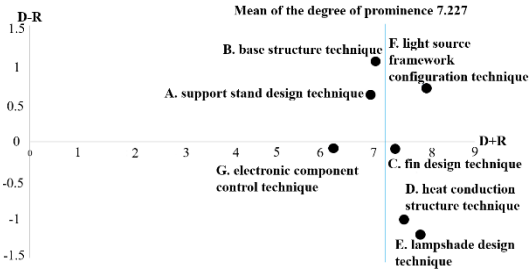

Figure 2 Causal diagram of the most important technical fields of 7 items of LED projection light

From Figure 2, it is known that when LED projection light is discussed in terms of its 7 technical fields, the LED light source framework configuration technique existed in the 1st quadrant is the core technique. The technical fields of A. support stand design technique and B. base structure techniqueexisted in the 2nd quadrant as well as G. electronic component control technique existed in the 3rd quadrant are the more independent technical fields. The technical fields of C. fin design technique, D. heat conduction structure technique and E. lampshade design technique existed in the 4th quadrant are the technical fields that can be most easily influenced by other technical fields.

Application Process of Modified DEMATEL to Functional Fields of LED Projection Light

Using term and word segmentation system, the paper summarizes 7 most important functional fields from hundreds of the related patent fact sheets.Divide the appearance frequency of the related functional words of each functional field of the related patents by the total number of words in the related patent fact sheets. The normalized numerical value of each

functional field is calculated. Then, apply modified DEMATEL to calculation process of functional fields of LED projection light as follows. The calculation steps is the same as the calculation steps of modified DEMETAL of technical fields.

Finally, based on the value of total relation influence matrix T, and using equations (1) and (2), calculate the total value of rows D_i and total value of columns R_j, and also calculate the D_i+R_j value and D_i-R_j value.

After that, draw a causal diagram. According to ($D_i + R_j$, $D_i - R_j$), draw the 7 functional fields on the coordinate axes. Through the mean 5.896 of the degree of prominence ($D_i + R_j$), draw a vertical axis. Divide the causal diagram into 4 quadrants, as shown in Figure 3.

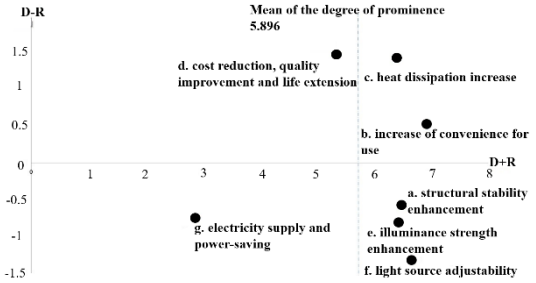

Figure 3 Causal diagram of 7 functional fields of LED projection light

RESEARCH APPROACH OF MODIFIED IPA

Traditional importance-performance analysis (IPA) is a method for evaluation of the related attributes of the products and services provided by proprietors. Due to its complete and comprehensible theory, its convenience for use, and its clear and explicit results, the scope of IPA application is rather extensive, such as tourism, home delivery service, etc.

Different from the traditional IPA that uses the way of questionnaire survey and achieves the means of different attributes through the designed scoring criteria of questionnaire, the modified IPA, based on the paper, explores the mutual influence relationship between technical fields and functional fields of technical/functional matrix of patents. Therefore, first of all, term and word segmentation system has to be used to define important technical words of different technical fields and important functional words of different functional fields, and calculate the normalized numerical values of different important technical words and different important functional words. Furthermore, they are added up, achieving total normalized numerical values of different technical fields and total normalized numerical values of different functional fields.

The paper proposes that the technical fields of the technical/functional matrix of the related patents of LED projection light are the important techniques that have to be considered during research and development (R&D) of patents. Therefore, their importance is equivalent to that of the traditional IPA. For functional fields, the degree of functional improvement is proposed to be made for the related patents. Users' performance is equivalent to that of traditional IPA. Thus, according to the size of normalized numerical values of different technical fields, the paper gives key criteria for importance. According to the size of normalized numerical values of different functional fields, the paper gives key criteria for performance.

Key criteria of technical fields and functional fields are explained as follows:

1. Key criteria of importance of technical fields:

(1) "extremely important": 4 points
(2) "important": 3 points
(3) "slightly important": 2 points
(4) "not important": 1 point

2. Key criteria of performance of functional fields:

(1) "excellent": 4 points
(2) "good": 3 points
(3) "fair": 2 points
(4) "poor": 1 point

After that, according to the normalized numerical values of technical fields and functional fields, the means of the sum of their normalized numerical values is calculated in order to define the key criteria of scoring range. Then, through the means, the intersection between the vertical axis and the horizontal axis is defined, and 4 quadrants are divided, and "IPA coordinate chart" is drawn. Finally, pairwise comparison is made between individual technical field and functional field. The results of pairwise comparison are drawn in the 4 quadrants of the chart.

The paper explores the distribution of different technical fields and different functional fields of LED projection light in the modified IPA coordinate chart as follows:

(1) Calculate the normalized numerical values of different technical fields and different functional fields.

Through term and word segmentation system, calculate the normalized numerical values of 7technical fields and 7 functional fields of LED projection light, and the acquired results.

(2) Determine the key criteria of scoring range of the normalized numerical values of different technical fields and different functional fields

After observing the scoring range of the

normalized numerical values of different technical fields and different functional fields of LED projection light, determine the importance values of technical fields and performance values of functional fields and the sconing range of theur normalized numerical values, as shown in Table 5 and Table 6.

Table 5 Importance values and performance values of technical fields and functional fields and the scoring range of their normalized numerical values

Technical field		Functional field	
Importance value	Scoring range	Performance value	Scoring range
2	Below 0.0075	2	Below 0.002
3	0.0075~0.009	3	0.002~0.003
4	Above 0.009	4	Above 0.003

Table 6 Importance values and performance values of different technical fields and functional fields

(a) Importance values of different technical fields

Technical field	Importance value
A. support stand design technique	4
B. base structure technique	4
C. fin design technique	3
D. heat conduction structure technique	2
E. lampshade design technique	2
F. light source framework configuration technique	3
G. electronic component control technique	4

(b) Performance values of different functional fields

Functional field	Performance value
a. structural stability enhancement	3
b. increase of convenience for use	4
c. heat dissipation increase	3
d. cost reduction, quality improvement and life extension	4
e. illumination strength enhancement	3
f. light source adjustability	3
g. electricity supply and power-saving	2

(3) Calculate the means of importance values of different technical fields and performance values of different functional fields and draw a coordinate chart of relationship analysis between importance of different technical fields and performance of different functional fields.

After adding up the importance values of different technical fields and performance values different functional fields, find their means respectively. The mean of importance value of different technical fields and the mean of performance values different functional fields are both 3.14. The mean of both of them is the central point of the vertical axis and horizontal axis, so that 4 quadrants are divided. Draw a "coordinate chart of relationship analysis between importance of different technical fields and performance of different functional fields". After pairwise comparison is made for the importance values of different technical fields and the performance values of different functional fields, draw them on the "coordinate chart of relationship analysis between importance of different technical fields and performance of different functional fields" to achieve the analysis results, as shown in Figure 4. As seen from Figure 4, the technical fields of A. support stand design technique, B. base structure technique and G. electronic component control technique are matched with the functional fields of a. structural stability enhancement, c. heat dissipation increase, e. illuminance strength increase, f. light source adjustability and g. electricity supply and power-saving, and located in the 2nd quadrant. It implies that patent engineers can take into consideration improvement of the technical fields of A. support stand design technique, B. base structure technique and G. electronic component control technique, in order to increase the functionality of product. This quadrant belongs to the part of prioritized improvement.

The technical fields of C. fin design technique, D. heat conduction structure technique, E. lampshade design technique and F. light source framework configuration technique are respectively paired with the functional fields of a. structural stability enhancement, c. heat dissipation increase, e. illumination strength enhancement; f. light source adjustability and g. electricity supply and power-saving, and located in the 3rd quadrant. It implies that patent engineers can take into consideration improvement of the technical fields of C. fin design technique, D. heat conduction structure technique, E. lampshade design technique and F. light source framework configuration technique, in order to increase the functionality of product and enhance the functionality of the entire product. This quadrant belongs to the part of minor improvement.

As to the 1st quadrant and the 4th quadrant, since the performance of the functional fields possessed by the technical fields is quite good, it is not required to make improvement particularly for these two parts.

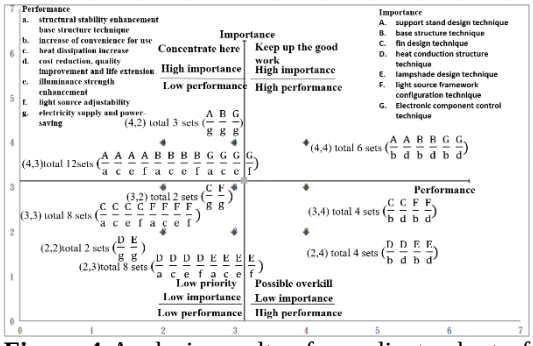

Figure 4 Analysis results of coordinate chart of relationship analysis between importance of different technical fields and performance of different functional fields

COMBINATION OF TECHNICAL/FUNCTIONAL MATRIX OF PATENTS WITH THE MODIFIED DIPA TO EXPLORE MUTUAL INFLUENCE RELATIONSHIP BETWEEN TECHNICAL FIELDS AND FUNCTIONAL FIELDS OF LED PROJECTION LIGHT

Modified DIPA

DIPA, finally used by the paper, is to combine (a) coordinate chart of relationship analysis between importance of different technical fields and performance of different functional fields, as shown in Figure 5, (b) causal diagram of technical fields, as shown in Figure 2, (c) causal diagram of functional fields, as shown in Figure 3, and (d) technical/functional matrix of LED projection light, concerning the technical fields and functional fields of the related patents of LED projection light, to make an overall exploration of the mutual influence between different technical fields and different functional fields, and also find the pairwise combination of the technical fields and functional fields for prioritized improvement and minor improvement. The related method and procedure are explained below.

DIPA is applied to exploration and analysis of the technical fields and functional fields of LED projection light, which can be divided into two parts:

(1) The 2nd quadrant of coordinate chart of relationship analysis between importance of technical fields and performance of functional fields is compared to the causal diagram of technical fields and the number of the related patents of technical/functional matrix for exploration

As seen from Figure 5, the technical fields of A. support stand design technique, B. base structure technique and G. electronic component control technique are matched with the functional fields of a. structural stability enhancement, c. heat dissipation increase, e. illumination strength enhancement and f. light source adjustability, located in the 2nd quadrant.

From Figure 2, it can be seen that A. support stand design technique and B. base structure technique are independent technical fields, which would influence other techniques but would not be easily influenced by them. Therefore, A. support stand design technique and B. base structure technique can be considered to be listed as the technical fields for prioritized improvement. The technical field of G. electronic component control technique is a technical field located in the 3rd quadrant and is the most independent one or is least influenced by other techniques. Therefore, this item is not listed as a selected item for improvement.

After that, from the causal diagram of the part of functions in Figure 3, it can be seen that c. heat dissipation increase is located in the 1st quadrant. Since the functional fields located in this quadrant are core functional fields, many of the changes would cause more influence on the functional fields of other quadrants. Therefore, the functional field of c. heat dissipation increase can be listed as a functional field for prioritized improvement.

Finally, from the technical/functional matrix of LED projection light, it also finds that B. base structure technique and the functional fields of c. heat dissipation has the less number of the corresponding related patents. It implies that patent engineers can make breakthrough of the selected technical fields so as to enhance the performance of the overall functionality of the product.

Summing up the above, it is suggested that the combination of B. base structure technique and the function of c. heat dissipation increase can serve as a part for prioritized improvement.

(2) The 3rd quadrant of coordinate chart of relationship analysis between importance of technical fields and performance of functional fields is compared to the causal diagrams and the technical/functional matrix for exploration

As seen from Figure 4, the technical fields of C. fin design technique, D. heat conduction structure technique, E. lampshade design technique and F. light source framework configuration technique are matched with the functional fields of a. structural stability enhancement, c. heat dissipation increase, e. illumination strength enhancement, f. light source adjustability and g. electricity supply and power-saving. The pairwise combinations are located in the 3rd quadrant.

From the causal diagram of technical fields in Figure 2, it can be seen that F. light source

framework configuration technique is located in the 1st quadrant. Since the technical field located in this quadrant is a core technique, its changes would cause more influence on the functional fields of other quadrants. Therefore, the technical field of F. light source framework configuration technique can be listed as a technical field for minor improvement. And the technical fields of C. fin design technique, D. heat conduction structure technique and E. lampshade design technique are located in the 4th quadrant. Since the technical fields in this quadrant can be very easily influenced by other technical fields, they need more attention but do not need prioritized handling. Anyway the technical fields in this quadrant can still be considered to be listed as the technical fields for minor improvement.

After that, from the causal diagram of functional fields shown in Figure 3, it can be seen that c. heat dissipation increase is in the 1st quadrant. Since the functional field located in this quadrant is more important, its changes would cause more influence on the functional fields of other quadrants. Therefore, the functional field of c. heat dissipation increase can be listed as a functional field for minor improvement.

From the technical/functional matrix of LED projection light, it also finds that F. light source framework configuration technique and the functional fields of a. structural stability enhancement has the less number of the corresponding related patents.

Summing up the above, it is suggested that the technical field of F. light source framework configuration technique and the functional field of a. structural stability enhancement can be paired to serve as a part for minor improvement.

CONCLUSIONS

After discussion of the above results is made, the paper has made 3 conclusions as follows:

(1) The modified importance-performance analysis (modified IPA) developed by the paper is to draw the paired combinations of technical fields and functional fields on the coordinate chart of relationship analysis between importance of technical fields and performance of functional fields. This result is applied to analysis of the mutual influence relationship between techniques and functions. However, since this method is not a quantitative tool, it can only be applied to preliminary analysis. Therefore, other research approaches have to be attached to it so as to make further analysis. The paper combines the modified IPA with the technical/functional matrix and the causal diagrams of the modified DEMATEL for analysis.

(2) Regarding DIPA proposed by the paper, this method compares the causal diagram of the modified DEMATEL to the coordinate chart of modified IPA and the technical/functional matrix. Furthermore, the paper analyzes the mutual influence relationship between different technical fields and different functional fields, and then determines the final combinations of technical fields and functional fields for prioritized improvement and minor improvement. Therefore, this research approach can be provided to patent engineers as a reference in making patent analysis.

(3) According to the above method, the pairwise combinations of technical fields and functional fields of LED projection light for prioritized improvement and minor improvement finally determined by the paper are: combination of the technical field of B. base structure technique and the functional field of c. heat dissipation increase, being the part considered for prioritized improvement, as well as combination of the technical field of F. light source framework configuration technique and the functional field of a. structural stability enhancement, being the part considered for minor improvement.

REFERENCES

Fontela, E., Gabus, A., “The DEMATEL observer,” Battelle Geneva Research Center, Switzerland Geneva (1976).

Huan, T.C. and Beaman, J.G., “Importance performance analysis: The need to bridge solitudes for its effective use.” Paper presented at the Eleventh Canadian Congress on Leisure Research Hosted by Malaspina University-College, Nanaimo, B.C. 17-20, May 2005.

Huang, T.H, Hsien, I.L, Lamp Holder of LED Projection Lamp, American patent, US8585249B2 (2013).

Jang, D., Yu, S.H., and Lee, K.S., “Multidisciplinary Optimization of a Pin-fin Radial Heat Sink for LED Lighting Applications,” International Journal of Heat and Mass Transfer, Vol.55, Issue 4,pp.515-521 (2012).

Liu, Y.H , Liu, S.P, Miniaturized LED projection lamp for illuminating ornament, Taiwan patent, M440395 (2012).

Martilla, J.A. and James, J.C., “Importance-Performance Analysis” Journal of Marketing, Vol.41, No. 1, pp.77-79 (1977).

Steigerwald, D.A., Bhat, J.C., Collins, and D., Fletcher, R.M., Holcomb, M.O., Ludowise, M.J., Martin, P.S., and Rudaz, S.L. “Illumination with Solid State Lighting Technology,” IEEE Journal on Selected Topics in Quantum Electronics, Vol.8, Issue 2, pp.310-320 (2002).

Tzeng, G.H., Chiang, C.H., and Li, C.W.,“Evaluating intertwined effects ine-learning programs: A novel hybrid MCDM model based on FactorAnalysis and DEMATEL,” Expert Systems with Applications Vol.32, No. 4, pp.1028-1044 (2007).

結合修正式 IPA 與修正式 DEMATEL 之修正式 DIPA 探討 LED 投射燈之技術與功能的改善項目及改善結果

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摘要

本研究將修正式 DEMATEL 與修正式 IPA 整合，開發出一套創新的決策方法－修正式 DIPA，並配合技術／功能矩陣針對 LED 投射燈之技術領域與功能領域之間的相互關係進行整體性的分析。透過此套方法並依據 LED 投射燈之技術／功能矩陣中一技術領域對應一功能領域之常態化數值的大小，分別決定出最後優先改善與次要改善之技術領域與功能領域之組合。而本研究最後所決定之優先改善與次要改善之技術領域與功能領域分別為 B. 底座結構技術與 c. 增加散熱性之組合，及 F. 燈源架構配置技術與 a. 提高結構定性之組合。