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Model development for garment design assessing using DEMATEL

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Abstract. Various models for evaluating the best garment design have been developed, however most of them disregard interdependence among their elements. This study aims to develop comprehensive model that consist of intrinsic and extrinsic elements for assessing garment design schemes, and take into consideration of interrelation between its elements. The Decision-Making Trial and Evaluation Laboratory (DEMATEL) was utilized for analysing a relationship between the key components for assessing garment design. The research constructed the garment design evaluation framework that consider intrinsic and extrinsic elements and interdependence elements. The model can be used as a framework for evaluating garment design with some various advantages: considering interrelations between components and influences between elements.

1. Introduction

To meet consumer needs for design and aesthetics, garment designers must consider various factors in designing clothing such as garment trends, culture, social norms, time and place [1]. Designing a garment design in a garment industry in which the production process is mass production like Zara is one of the complex decision-making processes for a company. Choosing a combination of materials, colours, patterns for the right target consumers, and other attributes need to involve judgments from experts and garment designers. Therefore, developing a multi-attribute decision making approach to evaluate garment design plays an important role in the field of clothing, especially the garment industry.

　Some studies discussed how to evaluate garment design and it were mostly focus on elements and methods for assessing garment design. For example, Lin and Twu proposed eight evaluation elements within the framework of their decisions: themes, best seller modifications, new ideas, garment forecasting, garment events, opponent abilities, brand image, and product position [2]. Three elements - fabric, colour, and style - for analyzing garment design have been implemented in research of Goncu and Bayazit [1]. Harr suggested a series of different elements including time management, concepts, figure development, development of garment designs and interactions in images, rendering, image relationships, composition, quality, style, and presentation [3]. Kidd and Workman developed an evaluation model consisting of design creativity, aesthetic appeal, functionality, suitability and originality [4]. The elements discussed are intrinsic factors in garment design. On the other hand, Jones concentrated on extrinsic factors in garment design such as marketing when evaluating garment designs. The elements include the age of the consumer, gender, demography, lifestyle, physical characteristics, psychographics, social class, values and attitudes, economic conditions, and religion [5].

There are a number of studies that not only considered the elements in evaluating garment designs, but also developed approaches to choosing the ideal or best garment design alternative. Goncu and Bayazit used the AHP method [1]; Lin and Twu applied fuzzy AHP [2]; Lin compared AHP method with consistent fuzzy preference relation [6]; Lin used method of Fuzzy Delphi and Fuzzy AHP [7]; and Lin and Twu used Fuzzy AHP and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [2] . Generaly, these studies do not consider the existence of interdependencies or relationships between existing elements. Even though in the real world, mutual relations between elements are a necessity.

Table 1. State of the art of research on garment design

Research	Method	Objective
Goncu and Bayazit, 2007, [1]	AHP	Looking for garment trends
Dadashian et al., 2009, [8]	New hierarchical method	Quality assessment of textile products
Lin et al. [9]	Gray model	Prediction of garment colour trends
Lin and Twu, 2012, [2]	Combination of a fuzzy AHP and TOPSIS	Evaluate garment designs
Lin and Twu, 2012, [10]	Fuzzy AHP	Choose the best choice among garment trends
Lin, 2013, [7]	Fuzzy Delphi method and fuzzy AHP	Evaluate garment designs
Lin, 2014, [6]	Consistent fuzzy preference relation	Choose the best garment design

One important issue in the previous studies is that elements are assumed to be independent of each other. This means that there is no dependency or relationship between one element and other element. This independent situation does not reflect the real world situation. This condition motivates the author to conduct this study by developing a model for evaluating garment designs that considers the existence of interrelationships between groups and elements. Therefore, This study aims are: 1) to compile comprehensive elements for evaluating garment designs; 2) to develop a model for decision analysis that considers the interdependence between evaluation groups and the influence between the elements for assessing several garment scheme alternatives. In order to analize its relationship, this study implement DEMATEL.

DEMATEL can be used to identify a relationship of network structure, the level of interdependence, and a vital dimensions of a scheme [11]. DEMATEL was developed by The Battelle Memorial Institute through its Geneva Research Centre. The DEMATEL is useful tool for composing the interrelation between factor or elements in order to create the impact of a network relationship maps (NRM). Its NRM can visualize the structure of complicated causal relationships with matrices or diagraphs. By using the DEMATEL, the relation between elements and causal dimension of a complex system can be converted to a comprehensible structure model [11]. DEMATEL can identify the network relationship structure and vital influential component of a garment scheme can be obtained through implementing this method. The steps of DEMATEL are as follows [11].

Step 1. *Decide the initial average matrix by score*. The level of direct influence between components is calculated using a scale of 0 to 4. These numerical values can be calculated to be an average matrix, *A*, as follows:

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & & \vdots & & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & & \vdots & & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix} \qquad (1)$$

Step 2. *Decide the initial influence matrix.* The normalization of the average matrix, *A*, will produce the initial direct influence matrix, $X(X=[x_{ij}]_{nxn})$. Based on calculations of Formulas (2) and (3), can be obtained matrix *A*.

$$X = s.A \tag{2}$$

$$s = \min\left[1/max_i \sum_{j=1}^{n}|a_{ij}|, 1/max_j \sum_{i=1}^{n}|a_{ij}|\right] \tag{3}$$

Step 3. *Conclude the full influence matrix.* The indirect influence between different component can be decided by considering the powers of matrix *A*. An aggregation of the direct effect and all of the indirect effects will produce the total influence matrix, *T*, as formula (4).

$$T = X + X^2 + \dots + X^k = X(I-X)^{-1} \tag{4}$$

where $T=[x_{ij}]_{nxn}$ and $(I-X)(I-X)^{-1}=I$. Each row and column sum of total matrix *T* can be obtain after getting the total influence matrix.

$$r = (r_i)_{nx1} = \left[\sum_{j=1}^{n}t_{ij}\right]_{nx1}, c = (c_j)_{nx1} = \left[\sum_{i=1}^{n}t_{ij}\right]'_{1xn} \tag{5}$$

where the superscript ' indicates transpose.

Step 4. *Decide the network relation map.* This study implements a threshold value, α, to eliminate unimportant effect in full influence matrix *T*. If the elements' values in matrix *T* are less than α, then the values are zero. The α-cut step generates a new matrix, the α-cut total influence matrix, *T_α*. Therefore, the network will simpler.

$$T_{\propto} = \begin{bmatrix} t_{11}^{\propto} & \cdots & t_{1j}^{\propto} & \cdots & t_{1n}^{\propto} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{\propto} & \cdots & t_{ij}^{\propto} & \cdots & t_{in}^{\propto} \\ \vdots & & \vdots & & \vdots \\ t_{n1}^{\propto} & \cdots & t_{nj}^{\propto} & \cdots & t_{nn}^{\propto} \end{bmatrix} \tag{6}$$

After normalizing the α-cut total influence matrix, we obtain the network relation map based on the normalized matrix, *T_s*, as follows.

$$T_s = \begin{bmatrix} t_{11}^{\propto}/d_1 & \cdots & t_{1j}^{\propto}/d_1 & \cdots & t_{1n}^{\propto}/d_1 \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{\propto}/d_2 & \cdots & t_{ij}^{\propto}/d_2 & \cdots & t_{in}^{\propto}/d_2 \\ \vdots & & \vdots & & \vdots \\ t_{n1}^{\propto}/d_3 & \cdots & t_{nj}^{\propto}/d_3 & \cdots & t_{nn}^{\propto}/d_3 \end{bmatrix} = \begin{bmatrix} t_{11}^{s} & \cdots & t_{1j}^{s} & \cdots & t_{1n}^{s} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{s} & \cdots & t_{ij}^{s} & \cdots & t_{in}^{s} \\ \vdots & & \vdots & & \vdots \\ t_{n1}^{s} & \cdots & t_{nj}^{s} & \cdots & t_{nn}^{s} \end{bmatrix} \tag{7}$$

where $d_i = \sum_{j=1}^{n}t_{ij}^{\propto}$. $\tag{8}$

2. Method

This study uses a quantitative research approach where computation follows the computational algorithm method used, DEMATEL. DEMATEL is used to analyze interrelations between components of clothing design elements. The characteristics of DEMATEL which do not require a comparison of all elements against each of the other elements makes the analysis of the relationship between the elements simpler.

Ten experts were selected to give their perceptions of the interactions between the elements and the assessment of several design alternatives. The selection of experts is based on non-probability sampling techniques, namely purposive sampling [12]. These experts were drawn from academics and practitioners that have experience and competence on garment design, pattern making, garment assessment, textile, garment mass production, garment trend, garment forecasting, marketing, and customized garment product designs.

3. Result and Discussion

3.1. Group and Element
This study successfully developed the garment design evaluation model that considers intrinsic and extrinsic factors in the garment design process. The model consists of groups and elements. The essential group in evaluating garment designs consist of creation (innovation), mode (style), tone (colour), marketing, and textile (fabric). Each group has two elements (see Table 2).

Table 2. The objective, group, and element of the garment design evaluation model.

Objective	Group	Element
Evaluating garment design alternatives.	Creation	1. garment forecast
		2. freshly concept
	Mode	1. suitability of the style
		2. mix and match with other garments
	Tone	1. daily use hormony
		2. body type and skin colour
	Marketing	1. customer understanding
		2. customer lifestyle
	Textile	1. ease of care
		2. textile motif

3.2. DEMATEL based Network Relations Map
Average matrix (A) derived from expert judgment must be obtained first as in Table 3. The result of calculation matrix A is then used to find out the matrix of direct influence (D) value.

Table 3. Matrix A

Group	Creation	Mode	Tone	Marketing	Textile
Creation	0	3	2.5	2.4	2.2
Mode	2.8	0	2.7	2.3	2.5
Tone	2.6	2.3	0	1.9	1.9
Marketing	2.6	2.7	2.5	0	1.9
Textile	2.1	2.4	2.4	2	0

By using formula of $X = s.A$, the matrix D can be obtained (see Table 4).

Table 4. The matrix D

Group	Creation	Mode	Tone	Marketing	Textile
Creation	0	0.3	0.2	0.2	0.2
Mode	0.3	0	0.3	0.2	0.2

Tone	0.3	0.2	0	0.2	0.2
Marketing	0.3	0.3	0.2	0	0.2
Textile	0.2	0.2	0.2	0.2	0

The formula (4) was implemented to get the matrix of total direct-influence, T (see Table 5).

Table 5. The matrix T

Group	Creation	Mode	Tone	Marketing	Textile
Creation	2.3	2.6	2.5	2.3	2.2
Mode	2.6	2.4	2.6	2.3	2.2
Tone	2.3	2.3	2.6	1.9	1.9
Marketing	2.5	2.5	2.5	1.9	2
Textile	2.3	2.3	2.3	1.9	1.8

Based on Table 5, the DEMATEL succesfully deliver an important information that among groups and elements for assessing garment design have interrelation. Matrix T inform level of influence from each group. In other words, we can know which group has highest influnce to other. Hence, a decision maker should take it into consideration when evaluating designs of garment. In order to minimize the effects that are not too significant, the threshold value in the matrix T is set at 2. Therefore, only among marketing-tone-and textile have one-direction of relation from marketing to other element. It means that the interrelations between these element were inconsequential. On the other hand, creation, mode, and tone are influence each other. This study showed creation is the most dominan group, followed by mode and tone. This finding suggest to designer and decision maker in garment design compony must pay more attention on creation's elements first, then others. It is because creation give more affect to other.

4. Conclusion

This research has succeeded in producing a model for analyzing alternatives of garment design. This model consists of intrinsic and extrinsic component in carrying out garment designs. Intrinsic component consists of creation, tone, mode and fabric. While extrinsic component includes matters that related to marketing. In addition, this study produced a framework that considered the relationships between groups and elements where this was not considered by other studies. Through this model, designer or decision maker in the garment company can use the results and suggestions in this study to support their daily work.

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