4th International Conference of Fuzzy Information & Engineering

14-15 October 2010
Shomal University, Amol, Iran

# Fashion Design by Fuzzy TOPSIS

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**Abstract**
Choosing among the available cases to find the right attribute is the main goal in multi attribute decision making. The purpose of the present study is to design fashion on the basis of the selection of the best attributes which has been evaluated by fashion designers. In this approach patterns of the garments are formulated by a matrix and finally the experts draw the best attributes which involves the best criteria and the best coordinated elements of the dress. Then the patterns are compared with the best attributes according to the opinions of the experts and next they are ranked. Fuzzy sets are also used to draw the data which provide an ambiguous condition for the simulation of concepts which are matters of taste. The results showed that the proposed system was acceptable in fashion design.

**Keywords**: Fashion Design, Fuzzy TOPSIS, Multi attribute decision making

## 1. Introduction

Multi attribute decision making (MADM) is a method to find an attribute with the best criteria. There are two ways to do this i.e., AHP and TOPSIS. AHP refers to Analytic Hierarchy Process and TOPSIS refers to Technique for Order Preference by Similarity to Ideal Solution. The MADM model is used for selecting the best attribute from the available attributes. Hwang and Yoon developed a Technique for Order Preference by Similarity to Ideal Solution in 1981 (TOPSIS) [1]. The TOSIS method can help experts to evaluate some objects by determining the value of each criterion. In many cases, crisp data aren't efficient to model real life situations .So fuzzy TOPSIS method was applied in these cases, which was introduced by Chen and Hwang in 1992 [2]. There are some applications in fuzzy TOPSIS, for instance Application of TOPSIS in evaluating initial training aircraft under a fuzzy environment that was done by Tien-Chin Wang, Tsung-Han Chang in 2007 [3] and using fuzzy TOPSIS method for evaluating the competitive advantages of shopping websites by Chia-Chi Sun, Grace T.R. Lin in 2009[4] or Weapon selection using the AHP and TOPSIS methods under fuzzy environment in 2009 [5].
In designing patterns for clothes there are some elements, all of which should be fashionable so that a pattern seems fashionable. In this paper fuzzy TOPSIS for fashion design is introduced in which100 patterns should be ranked by expert's evaluation.

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## 2. TOPSIS Method

The basic principle is of TOPSIS is that the chosen alternative has the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution [1].This model usually is formulated by the matrix that has n alternatives , $A_1$ , $A_2$, $A_3$, . . ., $A_n$ and m criteria, $C_1$, $C_2$, . . ., $C_m$ looks like this

$$D = \begin{bmatrix} X_{11} & \cdots & X_{1m} \\ \vdots & \ddots & \vdots \\ X_{n1} & \cdots & X_{nm} \end{bmatrix} \quad (1)$$

The weighting vector W represents the importance of each criterion is in the form of

$w_j = [w_1, w_2 \ldots . w_m]$ j=1,2,….,m (2)

Then D must be normalized by this formula:

$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}}$ i=1,2,….,n j=1,2,….,m (3)

Then multiplication the columns of the normalized decision matrix by the associated weights defined as follow

$v_{ij} = w_j \times r_{ij}$ i=1,2,….,n j=1,2,….,m (4)

There is positive-ideal solution:

$A^* = \{v_1^*, v_2^*, \ldots . v_m^*,\}$ (5)

And negative-ideal solution:

$A^- = \{v_1^-, v_2^-, \ldots . v_m^-,\}$ (6)

The distance of existing alternatives from positive-ideal solution and negative-ideal solution must be obtained as follows:

$s_i^* = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^*)^2}$ i=1,2,….,n (7)

$s_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2}$ i=1,2,….,n (8)

The relative closeness to the ideal alternatives can be calculated as:

$$c_i^* = \frac{s_i^-}{s_i^* + s_i^-} \qquad 0 \leq c_i^* \leq 1 \qquad i=1,2,\ldots,n \tag{9}$$

And then preference order must be ranked. In fact it is chosen an alternative with the maximum $c_i^*$[1]

## 3. Fuzzy TOPSIS method

In this part, the fuzzy TOPSIS method is explained. In fuzzy TOPSIS method $X_{nm}$ and $w_j$ can be linguistic variables that are described by any form of fuzzy numbers [6]

$$\widetilde{x_{ij}} = (a_{ij}, b_{ij}, c_{ij}) \tag{10}$$

$$\widetilde{w_j} = (w_{j1}, w_{j2}, w_{j3}) \tag{11}$$

The normalized fuzzy decision matrix must be calculated as follows:

$$\tilde{R}=[\widetilde{r_{ij}}]_{n\times m} \tag{12}$$

$$\widetilde{r_{ij}}=\left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \qquad c_j^*=\max c_{ij} \tag{13}$$

Weighted normalized fuzzy decision matrix is defined as:

$$\tilde{v}_{ij}=\widetilde{w}_j \times \widetilde{r_{ij}} \tag{14}$$

Also the positive-ideal solution and negative-ideal solution are shown respectively.

$$\widetilde{v_j^*}=(1,1,1) \tag{15}$$

$$\widetilde{v_j^-}=(0,0,0) \tag{16}$$

As mentioned before, the distance of existing alternatives from positive-ideal solution and negative-ideal solution are obtained as follows:

$$s_i^*=\sum_{j=1}^{m} d(\tilde{v}_{ij}, \widetilde{v_j^*}) \tag{17}$$

$$s_i^- = \sum_{j=1}^{m} d(\tilde{v}_{ij}, \widetilde{v_j^-}) \quad (18)$$

And the relative closeness to the ideal alternatives can be calculated as:

$$c_i^* = \frac{s_i^-}{s_i^* + s_i^-} \qquad 0 \leq c_i^* \leq 1 \quad (19)$$

And then preference order must be ranked. In fact it is chosen an alternative with the maximum $c_i^*$

## 4. Case study

In this part the fuzzy TOPSIS method was applied to fashion design. In fact the fuzzy TOPSIS method is used to rank some dress patterns from. 100 patterns of women dresses with different elements of collar, sleeve, skirt, belt, button and pocket were to be ranked from the simplest to the most fashionable. So there were 100 collars, 100 sleeves, 100 skirts, etc. Each element had a code to be recognized and could be assigned to 5 groups to be fashionable or simple that was shown in Table1. Table 2 shows the fuzzy decision matrix of six alternatives or pattern dresses. Each criterion weight in linguistic term is shown in Table 3.

**Table1. Definitions of linguistic variables and membership function to be fashionable**

| | | |
|---|---|---|
| **Very low** | **(1, 1,3)** | ***VL*** |
| **Low** | **(2, 3,4)** | ***L*** |
| **Medium** | **(3, 4, 5)** | ***M*** |
| **High** | **(4, 5,6)** | ***H*** |
| **Very high** | **(5, 6,6)** | ***VH*** |

**Table2. The fuzzy decision matrix of six alternatives or pattern dresses**

| C / A | collar | sleeve | skirt | belt | button | pocket |
|---|---|---|---|---|---|---|
| **Pattern1** | ***VL*** | ***G*** | ***VG*** | ***M*** | ***M*** | ***H*** |
| **Pattern2** | ***G*** | ***VP*** | ***M*** | ***VH*** | ***M*** | ***VH*** |
| **Pattern3** | ***L*** | ***M*** | ***VL*** | ***L*** | ***L*** | ***VL*** |
| **Pattern4** | ***M*** | ***M*** | ***M*** | ***L*** | ***VL*** | ***L*** |
| **Pattern5** | ***VL*** | ***VL*** | ***VH*** | ***VH*** | ***M*** | ***M*** |
| **Pattern6** | ***VH*** | ***M*** | ***M*** | ***H*** | ***VL*** | ***M*** |

**Table3. Each criterion weight in linguistic term**

| | |
|---|---|
| **Collar** | ***VH*** |
| **Sleeve** | ***M*** |
| **Skirt** | ***VH*** |
| **Belt** | ***L*** |
| **Button** | ***VL*** |
| **Pocket** | ***L*** |

For each pattern dress, the membership function of its elements which mark the pattern as fashionable is found, because all the elements were assigned to 5 groups, as it was mentioned in Table1, and the each criterion weight is distinct. So for 100 patterns the normalized fuzzy

decision matrix was indentified. Then it was multiplied by the weight vectors. Then for each pattern, the distance of pattern from positive-ideal solution and negative-ideal solution was obtained. After that the ranking of 100 patterns was done from the simplest to the most fashion.

## 5. Conclusion

In some cases in real life determination of the exact value is difficult. In this paper, the fuzzy definition was applied to determine if a pattern is fashionable or not. So the fuzzy TOPSIS method was used to rank patterns based on their elements. In fact if the elements of a pattern are fashionable, the pattern itself is fashionable too. The result of the system compared to the expert fashion design was acceptable.

## 6. References

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