Fuzzy Sets Applied for Product Selection based on Customer Preferences

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Abstract: Selection process to decide purchasing of a product is a very important process especially on the increasing of competitiveness among products. Many factors are put into consideration such as packaging, reliability, appearance, after sales price, facility, accessories, and so on. Consumer ratings of each of these factors are different ant it is stated as customer's preference. Mostly customer's preferences are stated in linguistic terms, for solving this conditions, fuzzy sets can be applied. The solutions of such a problem is discussed in this paper. An illustrative example, selection of university by candidate students, is presented to show how the problems can be solved using fuzzy sets approach. The results showed that difference preferences on the attributes of the university will yield different decision of the university selected.

1 INTRODUCTION

Product selection is a part of customer satisfaction. A customer tries to select the best product which is reflected by many attributes such as quality of a product, price of product, availability of the product, and the variety of a product. Indeed, customer satisfaction can be measured by the customer's response to the fulfillment of the suitability of the expected preferences (Kim et al., 2004). Consumers must choose products from so many products available based on the proximity of the desired preferences. Thus, the customer satisfaction can be reflected based on the level of preference achieved. On product selection, a customer provides preferences on each attribute which are regularly expressed in a cryptic, relative, and generally expressed in linguistic terms. In this condition, various fuzzy techniques can be applied.

2 LITERATURE REVIEW

Research on fuzzy satisfaction has been conducted by many researchers. Using the analytical hierarchy process and fuzzy set theory, Liu (1995) in his paper focus on customer satisfaction. Whilst, Kuo (1996), in order to measure customer's satisfaction level by applied a fuzzy neural network in general with a back propagation learning model.

There are many membership function can be applied to solve information in linguistic terms, such as the triangular membership function, rectangular membership function, and trapezoidal membership function. Among all, the one of the most frequently used is triangular membership function as shown in the following Figure 1.

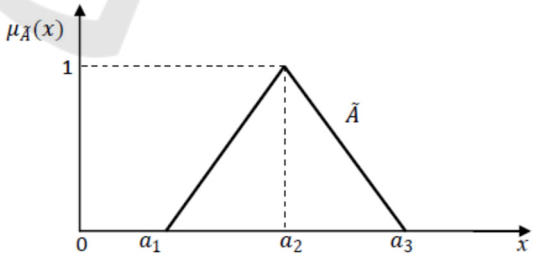

Figure 1: Triangular Fuzzy Number.

where,

$$\mu_{\tilde{A}}(x) = \begin{cases} \dfrac{x - a_1}{a_2 - a_1}; & a_1 \le x \le a_2 \\ \dfrac{a_3 - x}{a_3 - a_2}; & a_2 \le x \le a_3 \\ 0 \text{ ; others} \end{cases}$$

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Hanif et al. (2010) mentioned factors affecting customer satisfaction. While Jamali (2007) focused on customer satisfaction at a public private partnership. In fuzzy area, Wang (1997) applied fuzzy outranking method for conceptual design evaluation.

3 FUZZY SETS APPLIED

To solve the problem of product selection where costumer's preferences are stated in linguistic terms, Barajas & Agard (2011) can be applied with the following steps.

Step 1: Identify the market and technical evaluation of products
Step 2: Prioritize the general features
Step 3: Consider customer's preference
Step 4: Select the product

Barajas & Agard (2011) proposed a method to evaluate the features that are the best and closest to the customer's preferences. Furthermore, based on the definition of standard deviation, they proposed a Fuzzy Indifference Degree (FID) with the best choice corresponds to the smallest FID of the set of products at issue. The following equation is a way to measure of the degree of indifference between the product features and the customer preferences:

$$FID_i = \sqrt{\frac{\sum_{j=1}^{m}\left[R\left(A_{ij}, B_{jk}\right) - 0.5\right]^2}{m-1}} \quad (1)$$

where:

$R\left(A_{ij}, B_{jk}\right)$ is a notation about the fuzzy preference relation between A_{ij} and B_{jk}

The set $A_{ij} = \{a_{11}, a_{12}, \dots, a_{nm}\}$ is features (j) for product (i) for all $i = 1,2,\dots,n$ and for all $j = 1,2,\dots,m$, and

$B_{jk} = \{b_1, b_2, \dots, b_{mp}\}$ is the set of features (j) for customer (k) for all $j = 1,2,\dots,m$ and for all $k = 1,2,\dots,p$.

m is the number of attributes.

Then, the following expression is the best product (i) for customer (k) is determined by applying *equation 1*:

$$BP_k = \min\{FID_1, FID_2, \dots, FID_i\} \quad (2)$$

where BP_k is the best product alternative for customer (k).

To calculate the indifference between fuzzy numbers is as follows:

Let A and B be two fuzzy numbers with convex and normal properties. In this case, there are two possibilities, i.e. the indifference and the dominance between them. The indifference area is an area of overlap between fuzzy numbers A and B (intersection between A and B), as depicted in Figure 2.

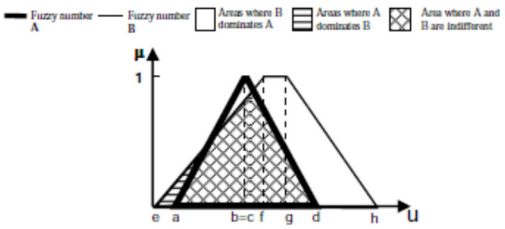

Figure 2: Dominance and indifference between A and B.

To calculate the non-overlap areas, it is used the Hamming distance as follows:

$$D(A, B \mid S) = \int_{u \in S} |\mu_A(u) - \mu_B(u)| du \quad (3)$$

$$S = \Re, D(A, B \mid \Re) = D\ (A, B) \quad (4)$$

4 AN ILUSTRATIVE EXAMPLE

In selection of university, a candidate student decides five attributes to be considered including tuition fee, university image, facility, graduate quality, and research quality. There are four universities can be selected by a candidate student, i.e. University A, B, C, and D. There are three candidate students to select the best universities for them.

4.1 The Evaluation of University's Attributes

The attribute's values for each university are shown in Table 1-4 and Figure 3-6.

Table 1: Attribute's Value for University "A".

Attribute	Fuzzy Number	Value
A_1: Tuition Fee	Triangular	[0,2,2,4]
A_2: University Image	Rectangular	[2,2,8,8
A_3: Facility	Trapezoidal	[1,3,6,8]
A_4: Graduate Quality	Triangular	[2,5,5,8]
A_5: Research Quality	Trapezoidal	[3,6,9,10]

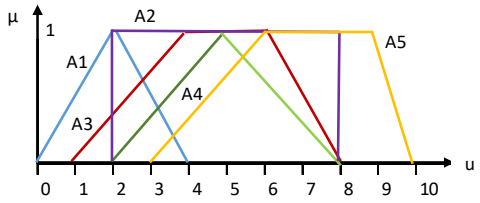

Figure 3: Attribute's Value for University "A".

Table 2: Attribute's Value for University "B".

Attribute	Fuzzy Number	Value
A_1: Tuition Fee	Trapezoidal	[5,7,8,10]
A_2: University Image	Triangular	[4,6,6,8]
A_3: Facility	Rectangular	[4,4,8,8]
A_4: Graduate Quality	Triangular	[1,3,3,5]
A_5: Research Quality	Trapezoidal	[0,2,5,6]

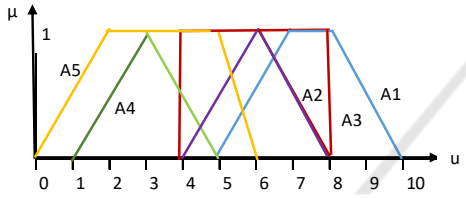

Figure 4: Attribute's Value for University "B".

Table 3: Attribute's Value for University "C".

Attribute	Fuzzy Number	Value
A_1: Tuition Fee	Trapezoidal	[0,2,4,6]
A_2: University Image	Triangular	[5,7,7,9]
A_3: Facility	Rectangular	[4,4,7,7]
A_4: Graduate Quality	Triangular	[4,6,6,8]
A_5: Research Quality	Triangular	[2,5,5,6]

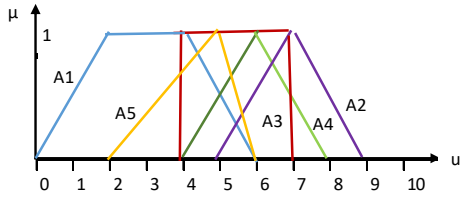

Figure 5: Attribute's Value for University "C".

Table 4: Attribute's Value for University "D".

Attribute	Fuzzy Number	Value
A_1: Tuition Fee	Trapezoidal	[5,6,8,9]
A_2: University Image	Triangular	[0,3,3,6]
A_3: Facility	Trapezoidal	[1,4,8,10]
A_4: Graduate Quality	Rectangular	[4,4,9,9]
A_5: Research Quality	Triangular	[3,5,5,7]

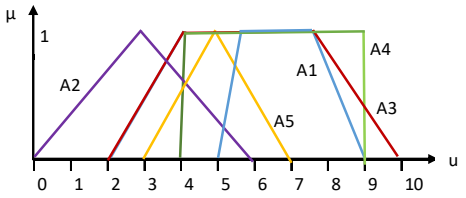

Figure 6: Attribute's Value for University "D".

4.2 General Prioritization of Attributes

Prioritization of attributes, it is assumed as depicted in Figure 7.

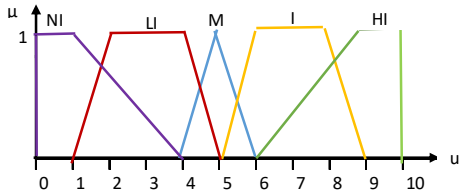

Figure 7: Definition of General Attribute Prioritization.

Based on Figure 7, five different levels are defined in linguistic terms as follows:

- HI reflects "highly important" and it indicates with [6 9 10 10],
- I reflects "important" and it indicates with [5 6 8 9],
- M reflects "a medium importance" and it indicates with [4 5 5 6],
- LI reflects s "of low importance" and it indicates with [1 2 4 5],
- NI reflects "not important" and it indicates with [0 0 1 4].

4.3 Consideration of Customer's Preference

There are three candidate students who have different preference on each attribute as shown in Table 5.

Table 5: Candidate Student's Preferences on Attribute

Attribute	Attribute preferences for Candidate Student (C_k)		
	C_1	C_2	C_3
A_1: Tuition Fee	LI	I	M
A_2: University Image	HI	HI	I
A_3: Facility	M	LI	I
A_4: Graduate Quality	HI	I	HI
A_5: Research Quality	I	M	HI

Note:
HI (Highly Important), I (Important), M (Medium), LI (Low Important), NI (Not Important)

Table 5 presents a candidate student's feature preferences. It shows, candidate student 1 states that university image and graduate quality are highly important attributes, research quality is important, facility is an attribute with a medium level of preference, and tuition fee is an attribute with low importance. For candidate student 2, university image is a highly important attribute, tuition fee and graduate quality are two important attributes, research quality is also an attribute with a medium level of preference, and facility is an attribute of low importance. For candidate student 3, both graduate quality and research quality are highly important attributes, university image and facility are important, and tuition fee is a medium level of preference.

4.4 University Selection Procedure

The process of university selection is started to attain the relation of fuzzy preference between university's features and candidate student's preferences.

By using equation 1), Fuzzy Indifference Degree (FID) for each university and a candidate student can be calculated as presented in Tables 6, 7, and 8.

Table 6: Fuzzy Indifference Degree per University for Candidate Student 1.

University	Fuzzy Indifference Degree (FID)
A	0.4032
B	0.4426
C	**0.2876**
D	0.4143

Table 7: Fuzzy Indifference Degree per University for Candidate Student 2.

University	Fuzzy Indifference Degree (FID)
A	0.4532
B	**0.2134**
C	0.4876
D	0.4253

Table 8: Fuzzy Indifference Degree per University for Candidate Student 3.

University	Fuzzy Indifference Degree (FID)
A	**0.2182**
B	0.4486
C	0.4367
D	0.4643

Based on the results in Table 6-8, then the best selection for each candidate student as shown in Table 9.

Table 9: Best Selection for Each Candidate Student.

Candidate Student	Best University Alternative
C1	C
C2	B
C3	A

5 CONCLUSION

Selecting best product by a customer involves many attributes to be considered. Preferences for each attribute that decides by a customer in some cases are stated in linguistic terms. This paper covers the fuzzy set to be applied to solve such problems, and it is applied on university selection by a candidate student. The Fuzzy Indifference Degree (FID) was proposed to find the best choice for a customer based on his/her preferences. The best choice provides the good values for each attribute of the product.

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