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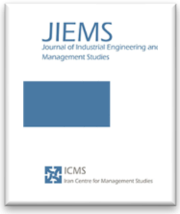

A FIS-based fuzzy Kano's model for consumer needs analysis

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Abstract

Nowadays, not only improving service levels is not sufficient for consumer satisfaction, but also, the consumers themselves determine product or service quality. In other words, we can interpret quality as "the degree of accordance with the consumer's need." Therefore, we should look for solutions to identify consumers' needs and requirements for applying them in the design and development of the product or service. One of these methods is the Kano model. This model shows the decision maker if any of the consumers' requirements are in the product/service or not and how much it will affect their satisfaction. This tool classifies consumers' needs for converting them to design requirements. But, human mentality and behavior always are accompanied by uncertainties. Linguistic variables or fuzzy numbers have been used in the literature to overcome this defect. Researchers developed the fuzzy Kano's model using this method and enhanced the model's efficiency compared to the deterministic one. The efficiency of this model has increased compared with the deterministic one. However, the decision-makers are unsure how to classify customers' needs using this strategy. This research uses a Fuzzy Inference System (FIS) to tackle this challenge. The essential contribution is developing a fuzzy Kano's model based on FIS for consumer requirements analysis. A case study from the restaurant industry in Yazd city of Iran was considered to validate the proposed model. The results show the superior performance of the proposed model compared with fuzzy Kano's model in recognizing consumers' needs.

Keywords: Kano's model; fuzzy theory; fuzzy Kano's model; fuzzy inference system.

Paper Type: Original Research

1. Introduction

In the late 1950s, Frederick Herzberg, an American behaviouralist researching job satisfaction, achieved two category factors: incentive and health (Herzberg, 1959). He believed each method that improves the job satisfaction of individuals must be a combination of these factors. In a more straightforward expression, the positive role of incentives and strategies to improve health conditions should be developed simultaneously. The incentive theory of Herzberg is famous as the two-factor theory. Professor Noriaki Kano borrowed from this theory and developed a model for recognition and classification of qualitative characteristics of a product or service which affects consumer satisfaction. He proposed a linear relationship between consideration of quality characteristics and consumer satisfaction (Meng & Dong, 2018). However, until then, different methods and tools like market surveys, focus groups, individual interviews, creative group interviews, complaint analysis, natural field contacts, warranty data, and affinity diagrams have been developed to understand consumer needs better. A direct survey can lead to biased responses and misinterpreting the results (Meng et al., 2015). Kano's consumer satisfaction model is a methodology for recognizing product or service features that affect consumer satisfaction. This model also demonstrates how to interpret obtained results of the consumers' survey and how the results can be used to represent and manage consumers' satisfaction. (Noriaki Kano, 1984) classified consumer needs or qualitative characteristics into five categories and drew all of them in a two-dimensional diagram. The model defines different categories of needs and assigns each qualitative characteristic to one of them (Avikal et al., 2014).
The traditional Kano's model classified characteristics based on the dominant preference, meaning that each qualitative characteristic belonged to exactly one category. Scientists developed fuzzy Kano's model to overcome this defect. This model permits the characteristics to fit into different classes (Ilbahar & Cebi, 2017). In other words, responders must assign a membership degree from the interval [0,1] to each option, and for each question, the summation of the values should be equal to 1. Therefore, the membership degree vectors of positive and negative performances are achieved for each characteristic. Also, utilizing a simple arithmetic multiplication operator of

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these vectors will determine the fuzzy Kano's evaluation table. Despite being common, this method has severe weaknesses as follows:

1. In fuzzy logic, a fuzzy number with a unique membership function determines each linguistic variable (here is an option).

2. Computations in fuzzy logic differ from classic mathematics and have their own rules. It means the multiplication of two fuzzy numbers by only multiplying their membership functions with an arithmetic multiplication operator is incorrect.

A FIS uses a rule-based structure that has more ability to get the input parameter through the membership function. Also, utilizing the experts' knowledge in constructing the fuzzy rules set brings about more accurate results for a FIS (Jain & Singh, 2020b).

This paper is the first study that combines FIS with Kano's model, which covers the gaps between Kano and fuzzy Kano's models. Also, the proposed approach has solid scientific principles. Generally, the contributions of this paper are as follows:

1. Combining FIS with fuzzy Kano's model.

2. Applying fuzzy logic in all the required computations.

3. Considering each subclass of category as a unique class with its attributes.

4. Conducting all calculations in an uncertain (fuzzy) environment.

The remainder of this paper is organized as follows: Section 2 reviews all related studies by other researchers. Section 3 describes the basic concepts of a fuzzy inference system. The proposed methodology is presented in section 4. Section 5 provides a real numerical example for validating the developed model. Section 6 presents managerial insights of the research. The conclusion and future direction are described in section 7.

2. Literature review

The related literature will be reviewed in three subsections Kano's model review, fuzzy sets theory review, and fuzzy Kano's model.

2.1 Kano's model review

Noriaki Kano presented Kano's model in the Japanese language in 1984 (Noriaki Kano, 1984). In this paper, qualitative characteristics are classified into three categories: "Must-be," "Attractive," and "Reverse." However, these categories increased to five in the translated article in the English language (Horton & Goers, 2019). (N Kano et al., 1996) presented the model, known as Kano's model type I, and has gained much attention from both the scientific and non-scientific worlds. Since then, this model has been taken into consideration by researchers worldwide, and more than 10000 hits for Kano's model and more than 150000 hits for similar phrases have been achieved by searching in Google scholar (Horton & Goers, 2019). (Yang, 2005) added importance concept to qualitative characteristics, and broke the first four categories of Kano's model down to eight: High attractive, less attractive, High value-added, Low value-added, Critical, Necessary, Potential, and Carefree. This model was named Kano's model type II. Moreover, the authors developed Kano type III by considering the consumers' product evaluation. (Clegg et al., 2010) presented a new approach to measure and quantify the relationship between customer satisfaction and fulfillment of customer requirements (S-CR), as shown in Kano's model. (L.-S. Chen et al., 2010) developed a novel Creativity-based Kano model (C-Kano model), which combined creativity, TRIZ, and SCAMPER techniques with the traditional Kano model. (Kuo et al., 2012) presented an IPA-Kano model. The authors declared that despite Kano's model's efficiency in consumers' requirements analysis, the model neglects the effect of the importance and performance of qualitative characteristics on classification results. In other words, they used importance-performance analysis to identify the critical improvement attributes. (Shahin et al., 2013) reviewed the literature from 1979 to 2010 and claimed that only 10% of research improved Kano's model weaknesses. (Shahin et al., 2014) presented the revised Kano model considering the life cycle. Their model partitioned the category "Must-be" into three subclasses "High must-be," "Must-be," and "Less must-be." Also, the class "Attractive" is partitioned into three subclasses "Less attractive," "Attractive," and "Highly attractive," in turn. The authors embedded the Kansei engineering model in the revised Kano's model, developed a new one and implemented the resulting model in the automotive industry. (Meng & Dong, 2018) reviewed Kano's model literature and presented a comprehensive and novel classification of related research. Also, they determined the future direction of the model based on a network of citations and topics of the research. (Horton & Goers, 2019) concentrated on mistranslating Japanese keywords to English in Kano's model. They proposed a new revised Kano's model based on this fact. (Shi & Peng, 2021) proposed a classification of customer requirements method for product design using big data and improved Kano's model. The authors used traditional Kano's model in their method. (Zhao et al., 2021) studied consumer satisfaction based on online reviews and developed a method using the improved Kano's model from the perspective of risk attitude and aspiration for this aim. (M.-C. Chen et al., 2021) applied Kano's model for investigating the quality of the transportation industry.

2.2 Fuzzy sets theory review

(Zadeh, 1996) presented the fuzzy sets theory to represent uncertainty and vagueness in human thinking. A fuzzy set involves a class of members, each of which has its membership degree. Identification of a fuzzy set is a membership function that assigns one membership degree to each member.

2.3 Fuzzy Kano's model review

(Lee & Huang, 2009) developed a fuzzy Kano questionnaire to cope with the uncertainty of consumer requirements. The model defined each characteristic by values representing the degree of membership in each category. (Wang & Wang, 2014) exploited from the Fuzzy Analytical Hierarchy Process (Fuzzy AHP) and fuzzy Kano's model for optimization of product varieties in smart cameras. (He et al., 2017) presented a 2-tuple linguistic fuzzy Kano questionnaire for uncertainty modeling and diversity of customers' assessments. (Ilbahar & Cebi, 2017) determined the class of each characteristic by using deterministic Kano's model and fuzzy sets. (Jain & Singh, 2020a) used a modified fuzzy Kano's model to categorize the supplier selection criteria. The method was the same as the developed model (Lee and Huang 2009). Also, the authors utilized Kano's type IV model to break up the categories "Must-be" and "Attractive" into three subcategories. (Ucal Sari & Sevinc, 2021) studied customer needs analysis for equipment combinations of automobiles using fuzzy Kano's model. The authors applied the model proposed by (Ilbahar & Cebi, 2017) in their research. Table 1 presents a survey of related research.

Table 1.The survey of the related research

Reference	#M	#A	#I	#Q	#R	#O	Deter	Fuzzy	Classic ari	Fuzzy ari	Rule-base
(Noriaki Kano, 1984)	1	1	0	0	1	0	✓		✓		
(N Kano et al., 1996)	1	1	1	1	1	1	✓		✓		
(Yang, 2005)	2	2	2	1	1	0	✓		✓		
(Lee & Huang, 2009)	1	1	1	1	1	1		✓	✓		
(L.-S. Chen et al., 2010)	1	1	1	1	1	1	✓		✓		
(Clegg et al., 2010)	1	1	1	1	1	1	✓		✓		
(Kuo et al., 2012)	1	1	0	0	1	1	✓		✓		
(Shahin et al., 2014)	3	3	1	1	1	1	✓		✓		
(Wang & Wang, 2014)	1	1	1	1	1	1		✓	✓		
(He et al., 2017)	1	1	1	1	1	1		✓	✓		
(Ilbahar & Cebi, 2017)	1	1	1	1	1	1		✓	✓		
(Horton & Goers, 2019)	1	1	1	1	3	1		✓	✓		
(Jain & Singh, 2020a)	1	1	1	1	1	1		✓	✓		
(Shi & Peng, 2021)	1	1	1	1	1	1	✓		✓		
(M.-C. Chen et al., 2021)	1	1	1	1	1	1	✓		✓		
(Ucal Sari & Sevinc, 2021)	1	1	1	1	1	1		✓	✓		
This paper	3	3	9	2	7	1		✓		✓	✓

#M: Number of M sub-classes	#A: Number of A subclasses	#I: Number of I subclasses	#Q: Number of Q subclasses
#O: Number of O sub-classes	#R: Number of R subclasses	Deter: Deterministic model	Classic ari: Classic arithmetic

3. Fuzzy Inference System

A FIS is a nonlinear system that uses fuzzy IF-THEN rules to model different aspects of the qualitative knowledge of the human without employing explicit quantitative analysis methods (Pourjavad & Mayorga, 2019). Each fuzzy rule has two parts: antecedent and consequent. The most common fuzzy logic techniques can be divided into three categories: linguistic models (Mamdani-type) (Mamdani & Assilian, 1975), relational equation models, and Takagi-Sugeno-Kang models. In the linguistic models, both the antecedent and consequent are fuzzy sets. In contrast, in the Takagi-Sugeno-Kang models, the antecedent consists of fuzzy sets, and the consequent is a combination of linear equations (Pourjavad & Mayorga, 2019). Four basic steps and functional operations are followed in a FIS: fuzzification, fuzzy inference, aggregation of outputs, and defuzzification (Alonso et al., 2014). In other words, the basis of a FIS is the inference of fuzzy output variables from fuzzy input variables based on a set of logic inference rules (in the form of linguistic terms). These rules are extracted from the knowledge base of the fuzzy system (Olugu & Wong, 2012). Figure 1 illustrates a graphical view of a Mamdani-type FIS. In this system, the fuzzification operator is used to determine the correctness of each antecedent, and membership functions are applied to the actual values of the input variables. This way solves the problem of fuzzy representation of the antecedent.

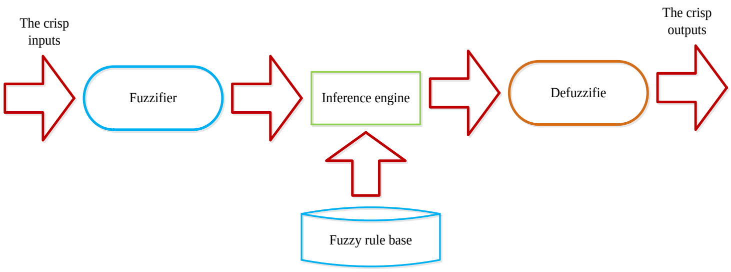

Figure 1. Structure of a Mamdani-type FIS (Amindoust et al., 2012)

One example of fuzzy IF-THEN rules is presented in Equation 1 (Guimaraes & Lapa, 2004). In this Equation, F_i^l s and G^l are fuzzy sets, $x=(x_1,x_2,\dots,x_n)$ are linguistic variables of the antecedent, and y is an output linguistic variable in the consequent part.

$$IF\left(x_1\ is\ F_1^l\right) and \dots \left(x_n\ is\ F_n^l\right)\ THEN\ \left(y\ is\ G^l\right) \tag{1}$$

Usually, t-norm $\wedge$ (minimization) is used for logical interface "and" as Equation 2.

$$\mu_A(x)\ and\ \mu_B(x)=MIN\left\{\mu_A(x),\mu_B(x)\right\} \tag{2}$$

Similarly, s-norm $\vee$ (maximization) is applied for logical interface "or" as Equation 3.

$$\mu_A(x)\ or\ \mu_B(x)=MAX\left\{\mu_A(x),\mu_B(x)\right\} \tag{3}$$

The inference engine applies an implication relation R between the obtained fuzzy number of fuzzy operators and the consequent C for each activated rule. The typical implication operator is minimization, which is depicted in Equation 4.

$$\mu_R(x,y)=MIN\left\{\mu_A(x),\mu_C(y)\right\} \tag{4}$$

The last step of a FIS is the aggregation of the different rules output. Different operators like arithmetic, geometric or harmonic means, minimum or maximum can do this action (Pedrycz & Gomide, 2007). When compensation among input variables is desirable, the maximum operator is used. Look at Equation 5.

$$AG(.)=MAX\left(\mu_{R_1}(x),\mu_{R_2}(x),\mu_{R_3}(x),\dots,\mu_{R_n}(x)\right) \tag{5}$$

In the defuzzification interface (defuzzifier), the fuzzy output numbers are converted to deterministic ones. A usual defuzzification technique is a centroid looking for an area's midpoint. The technique is presented in Equation 6.

$$Z_{centroid} = \frac{\int_z \mu_A(Z)Z\,dZ}{\int_z \mu_A(Z)\,dZ} \tag{6}$$

4. The proposed method

First, we provide complementary information about deterministic and fuzzy Kano's models. Then, the steps of the proposed model will be explained. The five categories of characteristics based on traditional Kano's model are as follows (Tseng, 2020):

Attractive (A): fulfillment of these qualitative characteristics leads to an increase in the level of consumer satisfaction more than the ratio. If these characteristics are not satisfied, the consumer will not be dissatisfied. Identifying these characteristics is hard because they are hidden, and the consumer does not expect their existence in the product/service.

One-dimensional (O): the amount of consumer satisfaction will be proportional to the fulfillment level of this characteristic and vice versa. The consumer usually requests these characteristics.

Must-be (M): if these characteristics are not fulfilled, the consumer will be very unsatisfied. They are the primary criterion of the product/service and determine the minimum specified quality level of the product/service, which has to be fulfilled by the company.

Indifferent (I): Whether these characteristics will be met or not, they are indifferent from the consumer's point of view. As a result, Indifferent characteristics are those that, whether present or absent, have no impact on customer satisfaction or dissatisfaction. Reverse (R): the consumer does not want these characteristics, and if the product or service meets them, he will be dissatisfied.

Figure 2 presents the relationship diagram of the five characteristics categories and a company's performance (Zhang & von Dran, 2001).

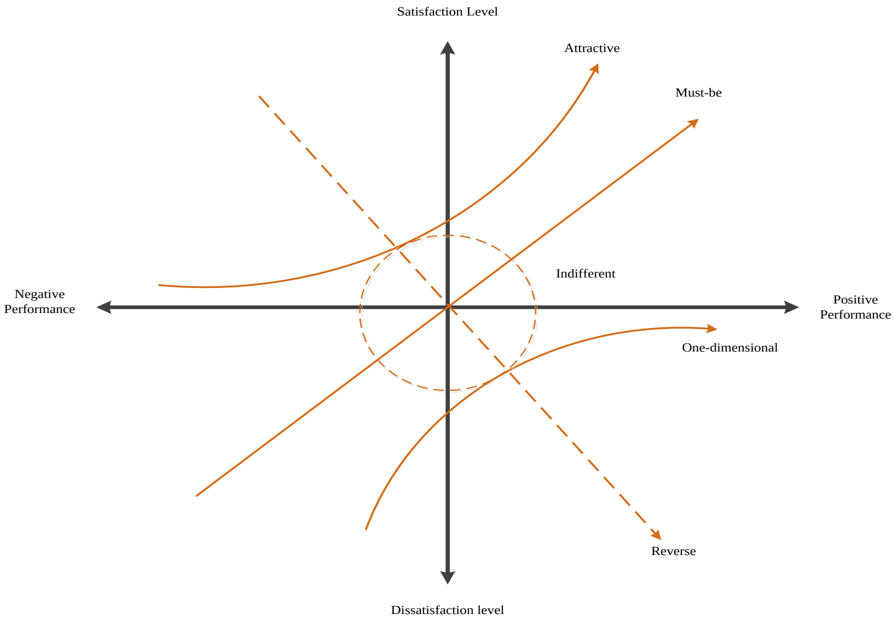

Figure 2. The relationship diagram of the categories and the performance

In the following, the steps of Kano's model are explained.

Step 1- Identifying consumers' needs and expectations: Kano's model start point makes a Kano questionnaire in which the requirements of the product or service can be specified in them. (Griffin & Hauser, 1993) found out polls of only 25 to 30 individuals are sufficient in homogeneous sections for determining approximately 90 to 95 percent of the consumers' requirements.

Step 2- Questionnaire design and distribution: There are two parts in the questionnaire design related to each characteristic. The first part focuses on the positive side of the characteristic, meaning that the product or service has the selected characteristic when the consumer uses it. For example, "how do you feel if characteristic X would have existed in the product or service?". The second part is a question that considers the opposing side, and the consumer of the product or service is not faced with the character when using it. For example, "how do you feel if characteristic X would not have existed in the product/service?". The consumer selects only one option to answer each part. These options are determined based on a five-point Likert scale (Pai et al., 2018). The overview of one question is illustrated in Table 2.

Step 3- Determining Kano's evaluation table: the received answers to the questions are gathered in this table. The main task of this table is converting two received answers of one qualitative characteristic into one answer (Wang & Wang, 2014). Table 3 shows the structure of this table.

Table 2.Overview of one question in Kano's questionnaire

Type	Question	Options
Positive Performance	How do you feel if characteristic X would have existed in the product/service?	1. It is attractive. 2. I expect it. 3. It is not important. 4. I tolerate it. 5. I do not like it at all.
Negative Performance	How do you feel if characteristic X would not have existed in the product/service?	1. It is attractive. 2. I expect it. 3. It is not important. 4. I tolerate it. 5. I do not like it at all.

Table 3. Kano's evaluation table

Negative Performance						
I do not like it at all	I tolerate it	It is not important	I expect it	It's attractive		
O	A	A	A	Q	It's attractive	**Positive Performance**
M	I	I	I	R	I expect it	
M	I	I	I	R	It is not important	
M	I	I	I	R	I tolerate it	
Q	R	R	R	R	I do not like it at all	

Step 4- Analysis of the results: one of the standard methods is the questionnaire analysis based on maximum frequency. This method selects the most frequent option as a final category for each characteristic (Avikal et al., 2014). This method is described in Table 4.

Table 4. Analysis of the results based on the maximum frequency

Characteristic	M	O	A	I	Q	R	Sum	Category
1	1	1	21				23	A
2		22				1	23	O
3	11			10	2		23	M
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
n	1	9	5	1	1	6	23	O

As inferred from the steps of deterministic Kano's model, the class of a characteristic can be changed by the answer of only one responder (look at characteristic 3 in Table 4). Fuzzy Kano's model solves this problem.

In fuzzy Kano's model, customers are asked to select a number from interval [0,1] for each option. This number is the membership degree of the option. Thus, the membership degree vectors of positive and negative performance are calculated. As an example, assume these vectors for a given characteristic are $\mathrm{P} = [0.75, 0.21, 0.04, 0, 0]$ and $N = [0, 0, 0, 0.91, 0.09]$. Now fuzzy Kano's evaluation table is determined according to Equation 7.

$$S = P^t * N = \begin{bmatrix} 0 & 0 & 0 & 0.68 & 0.06 \\ 0 & 0 & 0 & 0.19 & 0.01 \\ 0 & 0 & 0 & 0.03 & 0.003 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad (7)$$

Thus, for the characteristic $Q=0, R=0, I=0.22, M=0.013, O=0.06, A=0.68$ and as a result, this characteristic belongs to the category A means that this characteristic is attractive. As shown in equation 1, a simple arithmetic multiplication operator is used to achieve Kano's evaluation table in fuzzy Kano's model. In other words, uncertainty has no role in this step. In addition, with a simple summation of all elements belonging to each category, the final category of the characteristic is determined like the deterministic model. In this paper, with the assistance of a fuzzy inference system, we cope with these defects.

In this section, a FIS is proposed and is tried to cope with the above-mentioned defects by using it. In the beginning, a new Kano evaluation table is created, similar to Table 3. For example, cell A_1 in the table is as shown in the below Equation. In other words, each option is determined by a linguistic variable, a fuzzy number with a specific membership function.

$$IF\left(PositivePerformance = Attractive\right) and \left(NegativePerformance = Expected\right) THEN \left(ClassA = A_1\right) \quad (8)$$

Table 5.A new Kano's evaluation table

	Negative Performance					
Disgusting	**Tolerable**	**Unimportant**	**Expected**	**Attractive**		
O	A_3	A_2	A_1	Q_1	Attractive	Positive Performance
M_1	I_3	I_2	I_1	R_1	Expected	
M_2	I_6	I_5	I_4	R_2	Unimportant	
M_3	I_9	I_8	I_7	R_3	Tolerable	
Q_2	R_7	R_6	R_5	R_4	Disgusting	

Now, by aggregating obtained results of rules belonging to the same category, the membership degree of the category is determined. For better understanding, see Equation 9.

$$\begin{aligned} &IF\left(PositivePerformance = Attractive\right) and \left(NegativePerformance = Expected\right) THEN \left(ClassA = A_1\right) \\ &IF\left(PositivePerformance = Attractive\right) and \left(NegativePerformance = Unimpor\tan t\right) THEN \left(ClassA = A_2\right) \\ &IF\left(PositivePerformance = Attractive\right) and \left(NegativePerformance = Tolerable\right) THEN \left(ClassA = A_3\right) \end{aligned} \quad (9)$$

After the design of the questionnaire, its distribution starts. In this stage, each responder is asked to select one number from interval $[0,100]$ for answering each question related to the positive and negative performance. Regarding the responses and according to Equation 5, the final membership degree of each category is determined. A created FIS based on Equation 9 is depicted in Figure 3.

A unique FIS must be designed for each of the classes, M, A, Q, I, O, and R.

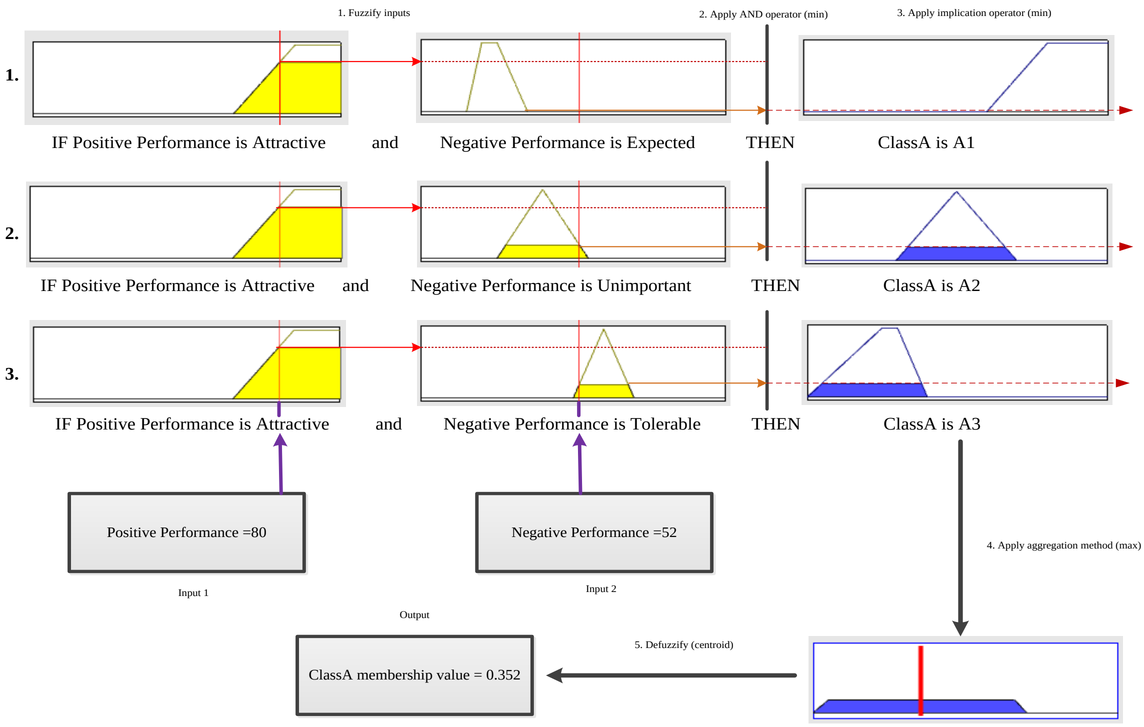

Figure 3. A FIS created based on equation 9

5. A numerical example

The Talar-e-Yazd restaurant (located in Yazd city, Yazd province, Iran) was studied to evaluate the proposed method. We considered the taste of one particular type of meal called Kebab. The fuzzy number of each option was determined by acquiring the experts' opinions; the results are summarized in Table 6.

Table 6. The fuzzy number of each option

Option	Fuzzy number
Attractive	$trap = [65, 85, \text{inf}, \text{inf}]$
Expected	$trap = [50, 55, 60, 70]$
Unimportant	$trap = [35, 40, 45, 55]$
Tolerable	$trap = [25, 30, 35, 40]$
Disgusting	$trap =$ [-inf,-inf,15,30]

In table 6, symbol $trap = [a, b, c, d]$ means an option is a trapezoidal number with values a, b, c, and d. For example, the membership function of option "Expected" is shown in Figure 4.

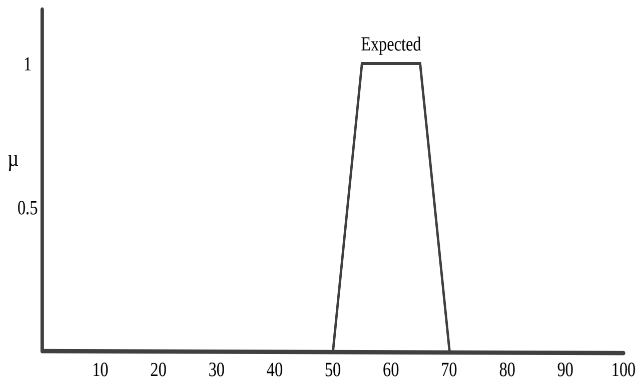

Figure 4. Membership function of option "Expected"

The society understudy is all consumers of the restaurant who order the food per day. The minimum size of the study sample from this society is calculated by using Equation 10. In this Equation, $N = 25$, $S = 0.5$, and $V = 0.05$ are the size of the society, the standard deviation of the number of consumers, and the standard error, respectively. These parameters are calculated based on the daily historical data of related consumers. The minimum size of the study sample is calculated using the Equation 10. It means $n = 20$.

$$n = \frac{n'}{1+\left(\frac{n'}{N}\right)} \qquad n' = \frac{S^2}{V^2} \tag{10}$$

Twenty consumers in one day were selected randomly and asked to complete the designed questionnaire. In the questionnaire, each consumer determines the membership degree of each option, like fuzzy Kano's model, which also assigns a number from interval $[0,100]$ to each question. The structure of the designed questionnaire is as Figure 5. After the answers are received, the membership degree of each option is calculated with two methods fuzzy Kano's model and the proposed FIS. The obtained results of these two methods are shown in Table 7. It is noteworthy that all of the FIS was developed and executed using MATLAB R2015b software on a Core i5 CPU, 3GB RAM PC.

A new criterion is presented for evaluating the proposed model's ability to classify qualitative characteristics compared to the traditional fuzzy Kano's model. The criterion is DI and is calculated according to Equation 11.

$$DI = \sum_{i=1}^{n}\left(M1_i - M2_i\right) \tag{11}$$

In Equation 11, $M1_i$ and $M2_i$ are the first and the second biggest membership degree of the characteristic, respectively, and the symbol i is the responder number. Also n is the total number of responders. For better understanding, consider $i = 6$; from Table 7, we can obtain $M1_i = 0.77$ and $M2_i = 0.55$ for the proposed method. Obviously, the bigger the criterion, the more the method's ability in the classification.

The criterion value for the fuzzy Kano's model and the proposed FIS is 7.7 and 8.02, respectively. The values demonstrate the superior performance of the proposed method compared with that of the fuzzy Kano's model.

Table 7. The obtained results

Consumer	Method	*M*	*A*	*Q*	*I*	*O*	*R*
1	Fuzzy Kano	0	0	0	0.4	0	0.51
	FIS	0	0	0	0.63	0	0.75
2	Fuzzy Kano	0	0	0.3	0	0	0.64
	FIS	0	0	0	0	0	0.92
3	Fuzzy Kano	0.51	0.44	0	0	0	0
	FIS	0.69	0	0	0	0	0
4	Fuzzy Kano	0	0	0.28	0.72	0	0
	FIS	0	0	0	0.48	0	0
5	Fuzzy Kano	0	0	0	0.3	0	0.67
	FIS	0	0	0	0	0	0.22
6	Fuzzy Kano	0.51	0	0	0.47	0	0
	FIS	0.77	0	0	0.55	0	0
7	Fuzzy Kano	0	0	0.01	0	0	0.98
	FIS	0	0	0	0	0	0.54
8	Fuzzy Kano	0	0	0.99	0.01	0	0
	FIS	0	0	0.27	0	0	0
9	Fuzzy Kano	0.19	0.8	0	0	0	0
	FIS	0	0.5	0	0	0	0
10	Fuzzy Kano	0	0	0.17	0.8	0	0
	FIS	0	0	0	0.5	0	0
11	Fuzzy Kano	0.15	0	0.3	0.5	0	0
	FIS	0.2	0	0	0.08	0	0
12	Fuzzy Kano	0	0	0.4	0	0	0.57
	FIS	0	0	0.73	0	0	0.92
13	Fuzzy Kano	0	0	0.41	0.59	0	0
	FIS	0	0	0	0.82	0	0
14	Fuzzy Kano	0.5	0	0.5	0	0	0
	FIS	0.22	0	0.27	0	0	0
15	Fuzzy Kano	0.5	0	0.05	0.45	0	0
	FIS	0.5	0	0	0.38	0	0
16	Fuzzy Kano	0.2	0.1	0	0	0.7	0
	FIS	0	0	0	0	0.65	0
17	Fuzzy Kano	0	0	0.3	0.7	0	0
	FIS	0	0	0	0.5	0	0
18	Fuzzy Kano	0	0	0.1	0.1	0	0.8
	FIS	0	0	0	0	0	0.63
19	Fuzzy Kano	0.4	0.6	0	0	0	0
	FIS	0	0.21	0	0	0	0
20	Fuzzy Kano	0	0	0.6	0.4	0	0
	FIS	0	0	0.27	0	0	0

#Responder	Question	Options	Membership degree	Assigned number
	How do you feel if the food be sourer?	It is attractive		
		I expect it		
		It isn't important		
		I tolerate it		
		I don't like it at al		
	How do you feel if the food be less sour?	It is attractive		
		I expect it		
		It isn't important		
		I tolerate it		
		I don't like it at al		

Figure 5.The structure of the designed questionnaire

6. The managerial insights

This paper is the first one that combines FISs with fuzzy Kano's model. This approach also has a strong scientific background and eliminates all defects of Kano and fuzzy Kano's models. The proposed model helps managers prioritize consumers' needs in a completely uncertain environment. Decision-makers can be sure about obtained results due to the powerful scientific principles behind the approach and considering uncertainties in all stages. In other words, it can be claimed that the results reflect all preferences of customers. When the design of a new product or service is considered, implementing the model is more valuable. In this situation, the lack of historical data brings about the fuzzy theory is recommended. A question arises: "what is a reasonable scheme to embed this theory in Kano's model in such situations?" Maybe the "fuzzy Kano's model" comes to mind as an answer. However, we explained the inherent defects of this method and demonstrated that our proposed model covers them better. Another notable point is the developed model's ability to categorize the customers' needs. We indicate this fact by using a numerical example.

7. Conclusion and future direction

Using Kano's model has been in the spotlight of researchers and practitioners for a long time. This paper developed a FIS-based fuzzy Kano's model for analyzing the consumers' requirements. The qualitative characteristics were classified based on the dominant preference in the deterministic Kano's model. It means that each characteristic is assigned to exactly one category. In other words, the response of only one consumer can change the class of the characteristic. Also, according to equation 1, the simple arithmetic multiplication operator is used in fuzzy Kano's model to achieve Kano's evaluation table. In simple words, uncertainty has no role in this stage. In addition, similar to the deterministic Kano's model, the final category of each characteristic is determined with a simple summation of all elements assigned to the same category.

This paper develops a novel method of coping with the defects mentioned above. The proposed approach combines FISs with fuzzy Kano's model. This scheme does not have the weaknesses of the counterpart models but also follows strong scientific principles. A FIS uses a rule base structure that has more ability to get input parameters through the membership functions and the rule base. Moreover, a FIS leads to more accurate results by applying experts' knowledge to create the fuzzy rules set. Besides, uncertainty is considered throughout the process of the method. The obtained results of the numerical example highlight the superior performance of the proposed method in classifying qualitative characteristics compared to those of the common one.

The efficiency of the proposed method will be enhanced by using concepts like Dempster-Shafer theory for modeling the impacts of unknown agents. Also, metaheuristic algorithms can be applied to tune the parameters of the proposed FISs.

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