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Precise method for evaluating the quality service: Case study

Méthode précise d'évaluation de la qualité de service : Étude de cas

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Abstract

The purpose of this work is to propose a new method based on fuzzy logic theory and two other decision support methods (method for converting verbal judgments into numerical values and method for comparing criteria in pairs) for calculating the overall level of customer satisfaction. Also, it is a question of overcoming all the lacunae in the CSAT (Customer SATisfaction) method. First, we begin by reviewing the state of the art of the fuzzy logic theory. Second, we present the methodology followed and the practice study carried to test the validity of the model. Finally, we discuss the results obtained. The result of this work is the proposal of a new method and formula for calculating the overall satisfaction level. The originality of this work consists in overcoming the lacunae in the CSAT method such as vagueness and the uncertainty of the input variables that lead to ambiguities in the calculation of the overall satisfaction level. Thus, the uniformity and continuity of the distribution of customer satisfaction levels.

Keywords: Customer satisfaction; Fuzzy logic; Decision-making support; overall satisfaction level; Performance.

Résumé

L'objectif de ce travail est de proposer une nouvelle méthode basée sur la théorie de la logique floue et deux autres méthodes d'aide à la décision (méthode de conversion des jugements verbaux en valeurs numériques et méthode de comparaison des critères par paires) pour calculer le niveau global de satisfaction des clients. Il s'agit également de pallier toutes les lacunes de la méthode CSAT (Customer SATisfaction). Tout d'abord, nous commençons par passer en revue l'état de l'art de la théorie de la logique floue. Ensuite, nous présentons la méthodologie suivie et l'étude pratique menée pour tester la validité du modèle. Enfin, nous discutons des résultats obtenus. Le résultat de ce travail est la proposition d'une nouvelle méthode et d'une nouvelle formule pour calculer le niveau global de satisfaction. L'originalité de ce travail consiste à combler les lacunes de la méthode CSAT, telles que le flou et l'incertitude des variables d'entrée qui conduisent à des ambiguïtés dans le calcul du niveau de satisfaction global. Ainsi, l'uniformité et la continuité de la distribution des niveaux de satisfaction des clients.

Mots-clés : Satisfaction client ; Logique floue ; Aide à la décision ; Niveau de satisfaction global ; Performance.

Introduction

For any company that wishes to build a relationship of trust with its customers and also to assess its performance against its competitors, measuring customer satisfaction is the key link. It is a key indicator for implementing appropriate actions to improve service quality (Ingram, B. L. & Chung 1997)(Butt, M. M. & De Run 2008)(Royse, D., Thyer, B. A., Padgett, D. K. & Logan 2010)(Tsitskari, E., Quick, S. &Tsakiraki 2014)(Fraser, M. W. & Wu 2016)(Hsieh 2017). Indeed, customer satisfaction is the value judgment resulting from the confrontation between an individual's expectations (expected service) and the perception of the product or service's performance (service rendered) (Juan José Tarí, Jorge Pereira-Moliner, José F. Molina-Azorín 2021)(Ulugbek Abdumalikovich Kirgizov 2021). It is also a matching between initial expectations and consumer's perception once the item is in his possession. The origin of the concept has appeared since the 30 glorious years when customer opinions had no real impact on companies and the quality of the products and services they proposed. Researchers nevertheless began to take an interest in this notion in the 1970s. They seem to have understood that a few decades later, the success of companies would be based on a commercial strategy and experience management focused on the consumer, his needs and expectations. In the early 1990s, consumer empowerment began to grow. Competition between firms is increasing and selling the cheapest product is no longer enough to retain customers and build up their loyalty. In addition, the rise of new technologies and the development of the Internet offered individuals the choice between several similar products. They are starting to become real actors in the market and companies quickly understand that they will have to differentiate themselves from competitors and satisfy their customers in order to keep them coming back and repeat their purchases. Customer satisfaction has four essential dimensions: cognitive, affective, emotional and behavioral. The cognitive dimension refers to the consumer's judgment of the offer. Insofar as an offer is the sum of attributes, each of them can lead to satisfaction or dissatisfaction. The cognitive dimension can therefore be studied in two ways:

- By focusing on each of the criteria that can influence the opinion of prospects.
- By measuring overall satifaction.

In order to study, for a company, the level of satisfaction with each of the attributes of its products or services, it submits a satisfaction questionnaire to customers to gather data on a specific aspect of its offer. The overall satisfaction is the result of a comparison of three factors: quality, reliability and ability to meet expectations. In order to gather the opinion of customers on the overall experience, the marketing manager and his team send consumers a CSAT

(Customer Satisfaction) questionnaire which, by means of a simple calculation, makes it possible to evaluate the overall satisfaction score of its customers (Hsieh, C. M., & Essex 2006) (Lervik Oslen, L., Witell, L. &Gustafsson 2014)(Birch-Jensen, A., Gremyr, I., Hallencreutz, J. &Rönnbäck 2020). This indicator is essential for measuring satisfaction. For the affective dimension of customer satisfaction corresponds to the attachment that a consumer has for a brand. In concrete terms, it is reflected in the likelihood of recommendation of the products or services of that brand. Indeed, if an individual appreciates an article and is satisfied with his purchasing experience, he will tend to recommend it to those around him, whether verbally to his or on the Internet to his contacts or even to strangers on social media. Thus, the emotional dimension takes into account the feelings and emotions experienced by the consumer before, during and after his purchase. The emotional dimension of satisfaction is influenced by the ability of the product/service to answer the desires expressed by an individual. That means, it is above all the customer relationship that is responsible for the buyer/brand bond. The last dimension concerns the buying behaviour of individuals. Satisfied customers with a good buying experience will tend to repeat their purchases. However, good customer feedback offers no guarantee of behaviour.

In this article, we focus on the cognitive dimension. In fact, despite the positive aspects that CSAT represents, we could not omit its limits. With this method, customer satisfaction ratings are ambiguous because of the vagueness and uncertainty of input variables, the proposed scale quality and also the calculated satisfaction score value. There is also a real problem of subjectivity at various levels. Indeed, in the case of the judgement Customer's, definitions and interpretation words may be different, and so the customer is called upon to make choices that do not match the analyzed situation and will introduce a part of subjectivity. For all these reasons, the satisfaction score has no significance outside of the method. As a result, the satisfaction score assessment remains vague. This can lead the company to take inappropriate actions. Moreover, a detailed analysis of methods revealed two types of problems linked to the distribution of the levels of the customers satisfaction. The first problem is related to uniformity, or equality of distribution of customer satisfaction levels. For example, if a given dimension is fixed to the lowest level, the overall satisfaction score will be still low, regardless of the level of the other dimensions. As a result, this method tends to produce low estimates.The second problem is related to the continuity of the distribution of customer satisfaction levels. Indeed, some methods have discontinuities due to the absence of a uniform gradation. For example, there are differences between the score of customer satisfaction, since moving from a level "dissatisfied" to "satisfied" is done in a brutal way. However, between these two levels we can have several affirmations of satisfaction. Another limitation of this method can be found it is that the calculation of the overall satisfaction score is done by the average of the satisfaction levels of each dimension without taking into consideration the importance of each in comparison with other one in conformity with the company's strategic objectives. Finally, the comparison of the results of estimates of the customers satisfaction with this present method performed several obstacles. These are, on the one hand, the variation in the nature, the number and the notation of the criteria, and the way of calculating the final result. On the other hand, the variation in terminology used to qualify the result. To overcome the limits cited above of this method, we propose a model based on fuzzy logic on the one hand, and of two other decision-makers methods: the method of converting verbal judgments into scores and the comparison method by pair of decision criteria on the other hand.

For this purpose, this paper is organized as follows. First, we begin by reviewing the state of the art of the fuzzy logic theory. Second, we present the methodology followed and the practice study carried to test the validity of the model. Finally, we discuss the results obtained.

1. Fuzzy logic

Fuzzy logic is an approach based on human reasoning and on "values or degrees of truth" in the form of real numbers between 0 and 1. In this respect it differs from classical Boolean logic based on two "truth values" (1 ou 0). In other words, this so-called multivalent logic recognises the possibility of partial truth values and lies between the two extremes 0 and 1. Fuzzy logic was first proposed by the mathematician Lotfi Zadeh in the 1960s, as part of his research into the understanding of natural language by computers (Zadeh, Introduction, and Navy 1965). The advantage of fuzzy logic is that, despite the vagueness and uncertainty of the available knowledge, it still uses the ability of humans to make more accurate decisions and actions. Therefore, fuzzy logic transforms this knowledge into a set of "If... Then", which is useful for decision making and can express uncertainty and imprecision mathematically. From this perspective, this article uses fuzzy logic as a means to transform qualitative evaluation into fuzzy values and then into quantitative evaluation results.

1.1. Fuzzy set and membership function

A classical set owns elements that satisfy all of the specific properties. Elements that do not satisfy these properties do not belong to the set that they describe. More formally, a subset A of a reference set X can be described from its characteristic function $\mu_A : X \rightarrow \{0, 1\}$ in the following way:

$$\mu_A(x) = \begin{cases} 1 & if x \in A \\ 0 & otherwise \end{cases} \quad (1)$$

A fuzzy set A of X is defined by a membership function μ_A that associates any element x of X a real value $\mu_A(x)$ in the interval [0,1]. It represents the degree of membership of the variable x of A.

$$\text{For } x \in X, \quad \mu_A(x) : X \rightarrow [0,1] \quad (2)$$

$\mu_A(x)$: represents the degree of membership of x in the fuzzy set A.

The membership function can theoretically take an infinity of values between 0 and 1. Like, it can take any form. In our case, we use triangular form (figure 1).

The function of membership μ_A (x) is defined by (3):

$$\mu_A(x) = \begin{cases} 0 & if \quad x \leq 1 \\ \frac{x-a}{b-a} & if \quad a < x < b \\ 1 & if \quad x = b \\ \frac{c-x}{c-b} & if \quad b < x < c \\ 0 & if \quad x \leq c \end{cases} \quad (3)$$

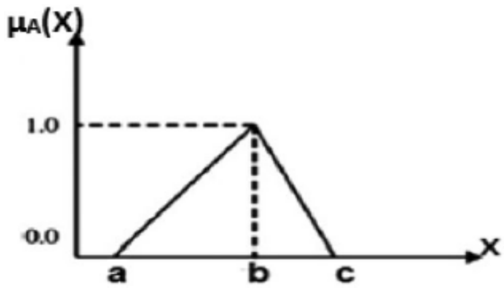

Figure 1 : A triangular fuzzy number

1.2. Fuzzy controller

The fuzzy controller constitutes of four main blocks: Knowledge base, inference system, the interface of fuzzification and defuzzification. The knowledge base constitutes of a database and a rules base. The database contains facts of the form "x is A" linguistic variables of input and the output of fuzzy controller . The base of the rules contains propositions of the form "if x1 is A1 and x2 is A2 then y is B". The inference system is able to reason from information in the knowledge base and make deductions. The figure 2 present an general structure of the fuzzy controller:

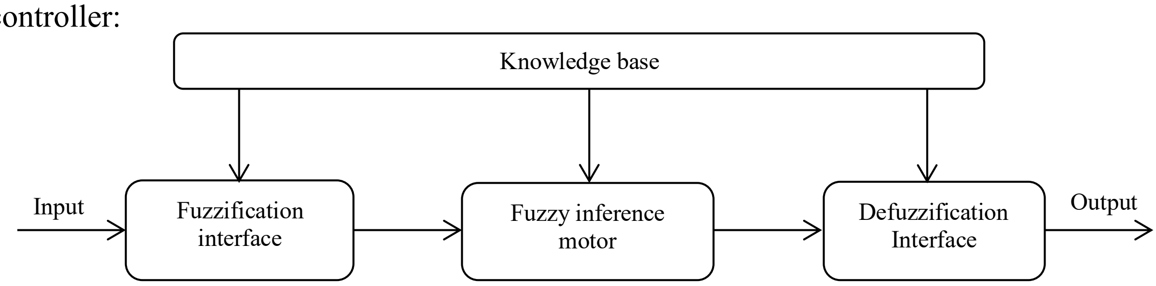

Figure 2 : General scheme of a fuzzy controller

Generally, a fuzzy controller passes by the following steps

- Fuzzification strategy
- Rule base
- Inference method
- Defuzzification strategy

1.2.1. Fuzzification

Il s'agit dans cette étape de transformer les valeurs numériques en variables linguistiques. Pour chaque variable (entrée et sortie) est associée des ensembles qui caractérisent les termes linguistiques pris par ses variables. Les règles d'inférences se basent sur ces termes. La forme triangulaire est la forme la plus utilisée de la fonction d'appartenance. Toutefois, il n'y a pas de règles pour le choix de la forme (Bounit, Irhirane, and Bourquia 2016)(Irhirane, E., Bounit, A., Dakkak, B., Benmoussa, R. &Bourquia 2019).

The fuzzification passes by the steps represented in the figure 3:

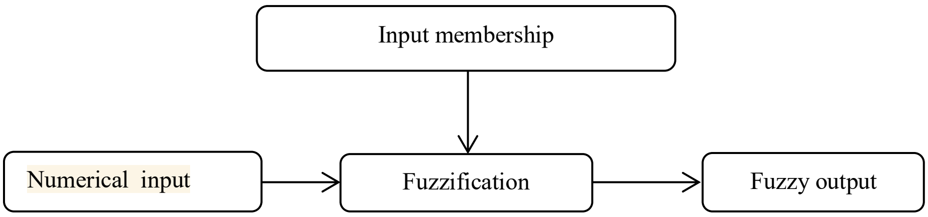

Figure 3: Fuzzification schema

1.2.2. Rule base

Fuzzy logic aims to exploit human reasoning in the sense of modeling concrete situations. To reach this objective fuzzy logic is based on the notion of basic rules. A fuzzy rules base is a collection of rules that allows to link fuzzy input and output variables. The rules take the following form :

if $x_1$is $A_1$and x_2 is A_2 and …. and x_i is A_i then y is B

with x_1,..x_i :Fuzzy input system, y : Fuzzy output system, A_i and B : linguistic terms represented by fuzzy sets.

1.2.3. Fuzzy inference

Fuzzy inference is used to calculate the fuzzy set associated with the command and is done by fuzzy inference operations and rule aggregation. It enters the premise part which constitutes the base of rules. The premise is a set of conditions linked together by form conjunctions « AND », « OR ». The link between the premise and the conclusion in the rules base is established through the conjunction "Then" which can be translated by the product or the minimum. The aggregation of the rules is generally done by the maximum or the sum.

1.2.4. Defuzzification

Treatment of inference rules provides a fuzzy value. The defuzzification step consists to transform the fuzzy set resulting from the aggregation of the rules into a precise numerical quantity of control to be applied to the process. In literature, there are several strategies to accomplish this operation such as the average of maximas, the centre of the aeries and the centre of the maximas. The defuzzification method by the gravity center is the most used method in fuzzy commande. In fact, it intuitively provides the most representative value of the fuzzy set resulting from the rules aggregation (Ponce-Cruz, P. & Ramirez-Figueroa 2010). It is to calculate the gravity center the surface formed by the resulting membership function (4):

$$y = \frac{\int_a^b z.\mu_A(z).dz}{\int_a^b \mu_A(z).dz} \quad (4)$$

1.3. Mamdani fuzzy model

The most commonly used inference methods are Max-Min (Mamdani), Max-Product and Sum-Product (Abul-Haggag, O. Y. & Barakat 2013).

The"Mamdani" fuzzy inference method is based on a collection of rules. Mamdani fuzzy model is one of the most popular algorithms. This method uses the concepts of fuzzy sets and fuzzy logic to translate an entirely unstructured set of linguistic heuristics into an algorithm (Mamdani 1975). So the fuzzy rule takes the following form:

$$\text{I}f X \text{ } is \text{ } A_J and \text{ } Y \text{ } is \text{ } B_J \text{ } then \text{ } Z \text{ } is \text{ } C_J \text{ } J = 1,2,,,,,M \quad (5)$$

Where M is the total number of fuzzy rules, X and Y are input variables, Z is the output variable. A, B and C are fuzzy sets modeled by membership functions $\mu_{A_J}(x_0), \mu_{B_J}(y_0), \mu_{C_J}(z)$ respectively.

The output of the fuzzy system involves several fuzzy rules. The fuzzy inference is the aggregating operation of fuzzy rules by the operator max application. For digital inputs $x_0$and y_0a fuzzy set of outputs denoted F is generated according to the relationship:

$$\mu_F(z) = max_J[min(\mu_{A_J}(x_0), \mu_{B_J}(y_0), \mu_{C_J}(z))] \; J = 1,2, \dots, M \quad (6)$$

1.4. Weights Allocation for each criteria

La méthode de comparaison par paire de critères de décisions sera utilisée pour attribuer l'importance de chaque critère de décision sous forme de poids en tenant compte de la stratégie adoptée par l'entreprise. En effet, cette méthode permet de convertir les jugements verbaux en valeurs numériques afin de calculer les 'scores' de valeur déterministe associés aux termes linguistiques.The different steps of these methods are described as follows:

First, the weights are determined, using the paired decision criteria comparison method described as follows

X_{ij} : The importance of the criterion "i" in relation to the criterion "j".

B_{n*n}: The matrix of the n considered criteria

$$B_{n\times n} = \begin{bmatrix} X_{11} & \cdots & X_{1n} \\ \vdots & \ddots & \vdots \\ X_{n1} & \cdots & X_{nn} \end{bmatrix} (7)$$

In this matrix, the relating scores X_{ij} of the element i and the element j (i, j) →(1,...,n) are successively compared.

Two calculations are necessary to arrive at the values of the weights.

The calculation of the geometric average of lines GM_i (average of the line « i »)is made by equation (8):

$$GM_i = \left[\prod_{j=1}^{n} X_{ij}\right]^{1/n} \quad (8)$$

This method will be adopted because it's the most practical and applies to the coefficients by which their values are multiplied and gives a good approximation of data central tendency.

The normalization of the averages matrix: every GM_i is divided by sum of GM_i

$$w_i = \frac{GM_i}{\sum_{i=1}^{n} GM_i} (9)$$

w_i : the weight of the criterion « i »

(Chen, S. J., Hwang, C. L. & Hwang 1992) suggested an approach to define X_{ij}(scores). He proposes a method of converting linguistic terms into scores. This method is carried out in two steps:

Step 1: This step consists of graphically representing linguistic variables with their fuzzy sets and subdividing the universe of discourse [0 i] in a number that varies between two and eleven fuzzy sets. Figure 4below shows an example of a variable with five fuzzy sets.

Step 2: This step consists of converting verbal judgments (fuzzy sets) to scores (deterministic values). It is a way to normalize and to simplify the interpretation of evaluations made by different persons.

Here is an example describing this method in detail:

Let the fuzzy sets M_{fi} describe by function of appearance of triangular type (10) and represented in the figure 4.

$$\mu_{Mfi}(x) = \begin{cases} 4x & \text{If } 0 \leq x \leq 0.25 \\ 2 - 4x & \text{If } 0.25 \leq x \leq 0.5 \\ 0 & Otherwise \end{cases} \qquad (10)$$

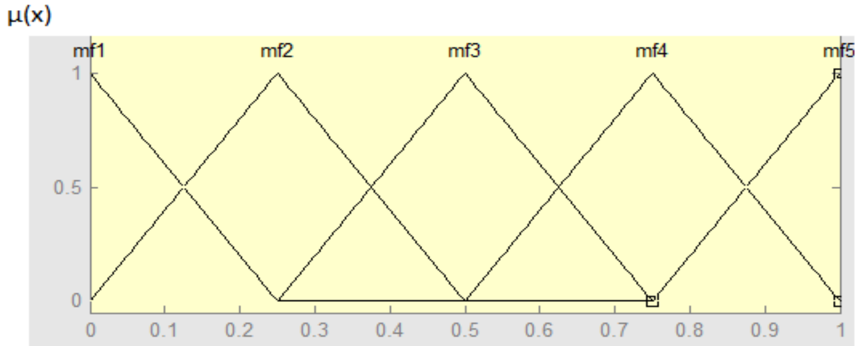

Figure 4 : The Membership Functions Corresponding to the 5 Fuzzy Sets

The representations of the max and min functions make it possible to define the maximum and minimum values of the score illustrated in figure 5. They are defined by taking into account the position of the membership functions on the interval.

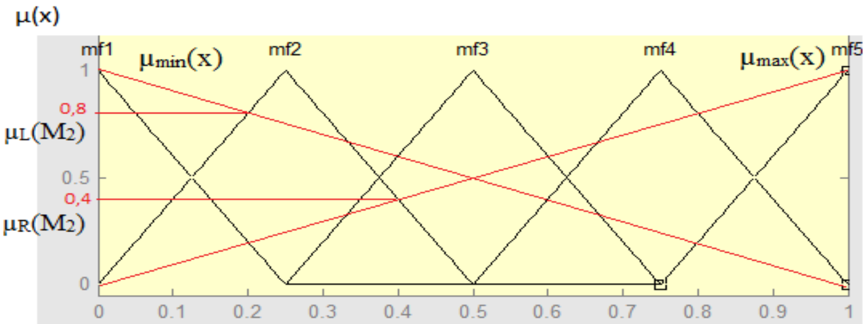

Figure 5: The Minimum and Maximum Scores of the Fuzzy Sets 'M2'

The intersection of each membership function with the two maximum and minimum functions allows us to determine the maximum $\mu_L(M_i)$ and minimal$\mu_R(M_i)$ values of the score and then calculate the total score of each fuzzy set $\mu_T(M_i)$.

$$\mu_{max}(x) = \begin{cases} x if & 0 \leq x \leq i \\ 0 & otherwise \end{cases} \qquad (11)$$

$$\mu_{min}(x) = \begin{cases} i - x if & 0 \leq x \leq i \\ 0 & Otherwise \end{cases} \qquad (12)$$

$$\mu_T(M_i) = \frac{\mu_R(M_i) + 1 - \mu_L(M_i)}{2} \qquad (13)$$

Finally, the table (1) summarizes the scores to the fuzzy sets :

Table1 : Fuzzy Sets and their Corresponding Scores.

Linguistic terms	$\mu_R(M_i)$	$\mu_L(M_i)$	**Score** : $\mu_T(M_i)$
M_i	…	…	….

2. Case study

Pour mettre en application l'approche de calcul de l'indicateur de mesure de satisfaction des clients, nous présentons dans ce qui suit une étude de cas réalisée dans une institution hôtelière. En effet, de telles institutions se basent souvent sur des questionnaires CSAT pour mesurer la satisfaction de ses clients (Chin-Lung Hsu 2021). Aussi, ces institutions sont les plus dominants dans la ville d'appartenance de notre structure de recherche. Pour ce faire, nous allons suivre la méthodologie décrite dans la figure 7:

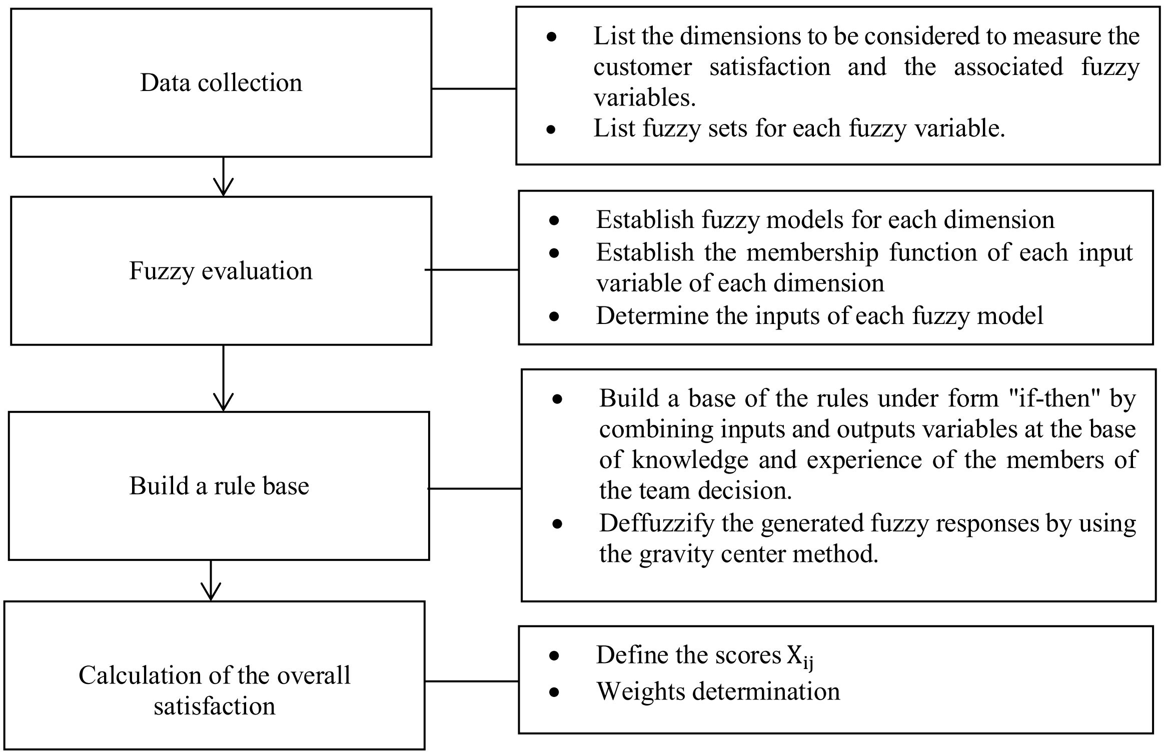

Figure 6: Methodology steps

2.1. Data collection

The data collection is composed in two steps:

- List the dimensions to be considered to measure the customer satisfaction and the associated fuzzy variables. Four dimensions deemed relevant by the manager of a hotel establishment were retained to conduct a case study. For each dimension, we have associated the most representative criteria as shown in Table 2:

Table 2: Dimensions list and corresponding criteria

Dimension	Reception	Room	Restaurant	Staff
Criteria (Fuzzy Input Variables)	- Welcoming - Welcoming staff - Availability - Access to information	- Comfort - Cleanliness - Service - Sanitary and Bathroom	- Quality of the dishes and products - Diversity and quantity - Waiting time - Price	- Effectiveness - Welcoming - Total appearance - Availability

- List fuzzy sets for each fuzzy variable. In our case, we chose four fuzzy sets for each dimension by using the triangular membership function. Fuzzy inputs and outputs variables are represented in tables 3 and 4 respectively.

Table 3: Table of fuzzy values associated with the input variables

Linguistic term	Insatisfied (I)	Little satisfied (LS)	Satisfied (S)	Very satisfied (VS)
Membership function	(0,1,2)	(1,2,3)	(2,3,4)	(3,4,5)

Table 4 : Table of fuzzy values associated with the output variables

Linguistic variable	**Linguistic terms**	**Description of linguistic values**	**Membership function**
Dimension level	Satisfied (S)	Tolerable level for the establishment	(-100, 1, 1.5)
	Insatisfied (I)	Not tolerable level for the establishment	(1,5,2,100)

2.2. Fuzzy evaluation

To evaluate the satisfaction level of each dimension, four Fuzzy models were established. In this section, we develop a fuzzy model of the 'reception' dimension based on the Mamdani algorithm by using the software Matlab (figure 8). The methodology remains the same for the other three fuzzy models.

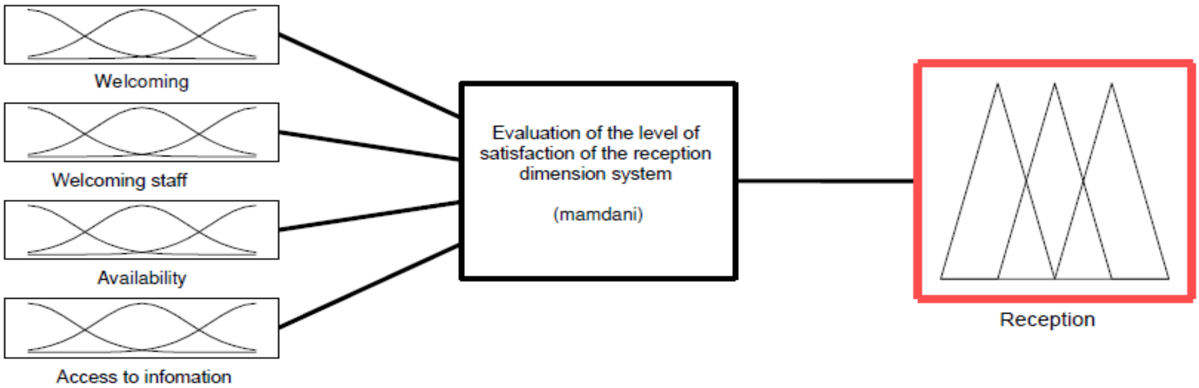

Figure 7: Fuzzy model for evaluating the satisfaction level of the "reception" dimension

The membership functions of the input criteria of the "reception" dimension take the triangular form. Figure 9 represents, by way of example, the membership function of the welcoming criterion. Figure 10 represent the output membership function of the "reception" dimension.

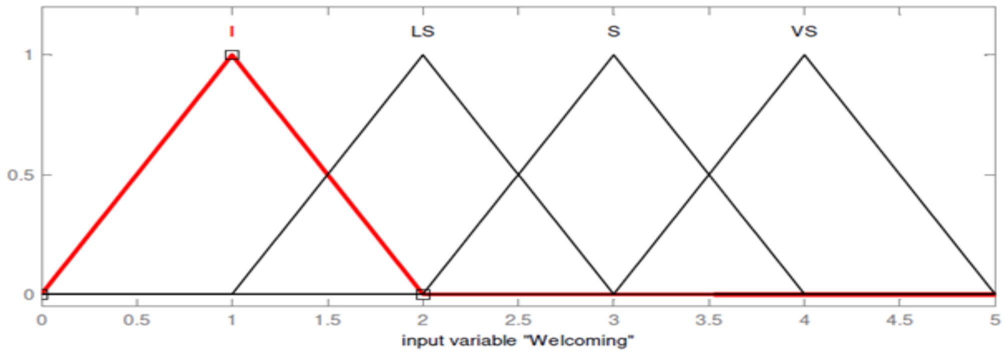

Figure 8 : membership function of welcoming criterion of ''Reception'' dimension

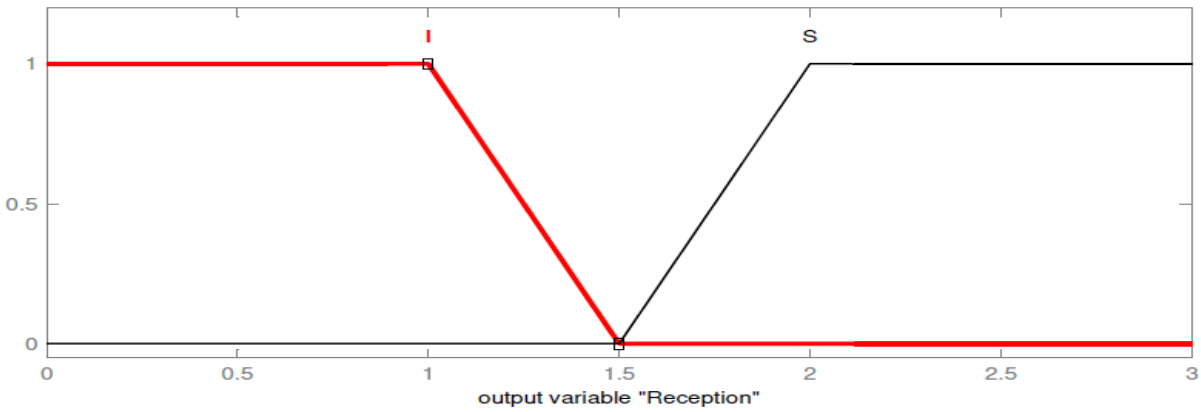

Figure 9 : The two levels of output variables "reception"

To determine the inputs of each fuzzy model, we choose a sample of 50 customers over a period of two months. These inputs are obtained by the average arithmetic of the scores given by 50 customers. Four tables were established to measure the satisfaction level of each criterion of the dimension. Indeed, each customer assigns a score to each criterion according to the following notation (1: Insatisfied, 2: Little satisfied, 3: Satisfied, 4: Very Satisfied). Fault of place, we give Table 5, which illustrates the satisfaction level of the criteria for the dimension ''reception''.

Table 5: The average satisfaction level of each criterion of the dimension ''reception''

Customer	Welcaming	Welcaming staff	Availability	Access to information
1	3	2	3	4
2	4	1	3	3
3	2	2	4	2
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
50	4	2	2	3
Average	3.1	2.8	3.2	3.12

2.3. Build a rule base

Build a base of the rules under form "if-then" by combining inputs and outputs variables at the base of knowledge and experience of the members of the team decision. Table 6 illustrates, by way of example, the combination of the 256 fuzzy rules of the dimension "reception". The principle of establishing the other bases of fuzzy rules remains the same for the other dimensions. In Table 6, the inputs represent the fuzzy sets of input variables in the "Reception" dimension. The intersection of a column and a line gives the fuzzy set of the output variable defined by the rule.

Table 6: Rules Matrix

				Welcaming															
				I				**LS**				**S**				**VS**			
				Welcoming staff				**Welcoming staff**				**Welcoming staff**				**Welcoming staff**			
				I	**LS**	**S**	**VS**	**I**	**LS**	**S**	**VS**	**I**	**LS**	**S**	**VS**	**I**	**LS**	**S**	**VS**
Access to information	**I**	**Availability**	**I**	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			LS	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			S	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			VS	I	I	I	I	I	I	I	I	I	I	I	S	I	I	S	S
	LS	**Availability**	**I**	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			LS	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	S
			S	I	I	I	I	I	I	I	I	I	I	I	S	I	I	S	S
			VS	I	I	I	I	I	I	I	I	I	I	S	S	I	S	S	S
	S	**Availability**	**I**	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			LS	I	I	I	I	I	I	I	I	I	I	I	S	I	I	S	S
			S	I	I	I	I	I	I	I	I	I	I	S	S	I	S	S	S
			VS	I	I	I	S	I	I	S	S	I	S	S	S	S	S	S	S
	VS	**Availability**	**I**	I	I	I	I	I	I	I	I	I	I	I	S	I	I	S	S
			LS	I	I	I	I	I	I	I	S	I	I	S	S	I	S	S	S
			S	I	I	I	S	I	I	S	S	I	S	S	S	S	S	S	S
			VS	I	I	S	S	I	S	S	S	S	S	S	S	S	S	S	S

After the building of the rule base from expert opinion, the fuzzy responses generated by these rules are deffuzified by using the gravity center method. Figure 9 represents an extract of 10 rules among the 256 rules defined by the combination of the input variables in the fuzzy model for evaluating the satisfaction level N1 of the "reception" dimension. The values for each criterion shown in Figure 11 represent the average of 50 customer score.

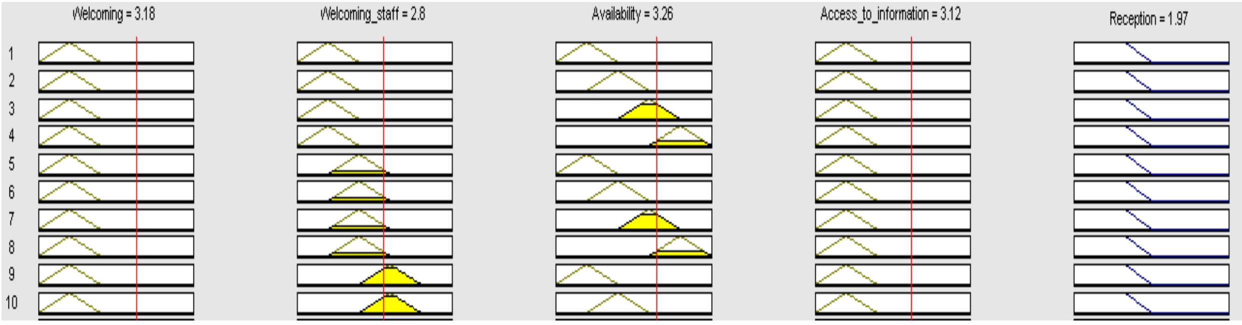

Figure 10: Extract from 10 rules of the "reception" dimension

2.4. Calculation of the overall satisfaction level (OSL)

Based on the method indicate in section 2.4, we calculate the weight of each dimension by following two phases

- **1st phase: define the scores X_{ij}**

From exploitation of the approach described previously which simplifies the definition of fuzzy sets related to decision criteria, we can convert the linguistic terms in score.

Given the choice of the type 2 scale (Important, less important), we calculate the deterministic "score" values associated with the linguistic terms.

Either the fuzzy sets Mf1 and Mf2 described by triangular membership functions and represented in Figure 12. Equation (14) gives the membership function $\mu_{Mf_1}(x)$:

$$\mu_{Mf_1}(x) = \begin{cases} 3.3\,x \ \text{ if } 0 \le x \le 0.3 \\ 1.75 - 2.5\,x \ \text{ if } 0.3 \le x \le 0.7 \\ 0 \quad \text{otherwise} \end{cases} \quad (14)$$

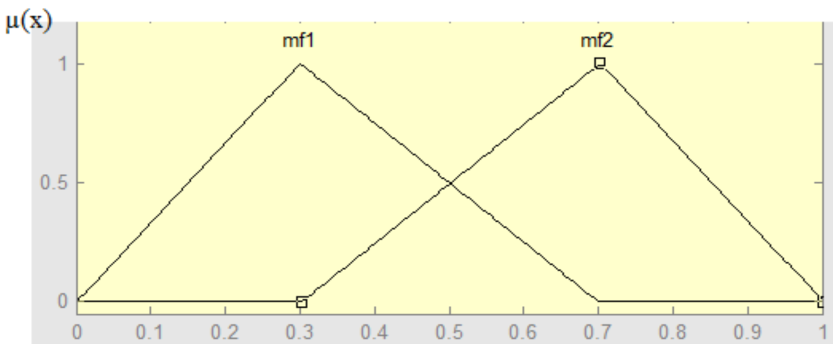

Figure 11: The membership functions corresponding to the 2 fuzzy sets

The representation of the functions max and min to allow define the maximum and minimum score shown in figure 13. They are defined taking into account the position of the membership function on the discourses universe.

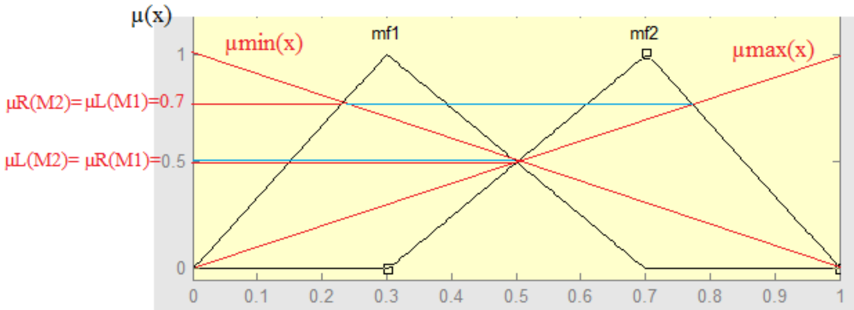

Figure 12: The minimum and maximum scores of the fuzzy sets "Mf1" and "Mf2".

The intersection of each membership function with the two max and min functions allows to determine the maximum $\mu_L(M_i)$ and minimum $\mu_R(M_i)$ of the score and then calculate the total score of each fuzzy set $\mu_T(M_i)$ using equation (13).

Finally, Table (7) summarizes the scores for fuzzy sets:

Table7: Fuzzy sets and their corresponding scores

Linguistic term	Interpretation	$\mu_R(M_i)$	$\mu_L(M_i)$	Score : $\mu_T(M_i)$
Mf 1 :Less important	Criterion is less important than other	0.5	0.7	0.4
Mf 2 : Important	Criterion is more important than other	0.7	0.5	0.6

- **2nd phase : weights determination**

The classification of dimensions is based on the strategic objectives of each. In fact, following a discussion with the manager of the hotel, we classified the four dimensions in the following order of priority: Room (R), Restaurant (Re), Reception (Rec) and Staff (S).

The weights of the dimensions are determined by using the comparison pair of criteria method. Either X_{ij} : the importance of dimension "i" in relation to dimension "j" and it corresponds to $\mu_T(M_i)$ score

And either $B_{4*4}$the matrix of the four dimensions considered (15):

$$B_{4*4} = \begin{array}{c} \\ R \\ Re \\ Rec \\ S \end{array} \begin{array}{c} \begin{array}{cccc} R & Re & Rec & S \end{array} \\ \begin{pmatrix} 1 & 0.4 & 0.4 & 0.6 \\ 0.6 & 1 & 0.6 & 0.6 \\ 0.6 & 0.4 & 1 & 0.6 \\ 0.4 & 0.4 & 0.4 & 1 \end{pmatrix} \end{array} \quad (15)$$

Using equations (8) and (9), we calculate the weights of the four dimensions (Table 8):

Table 8: Table of dimensions weights

Dimension	GM_i	W_i
Room	0.681	0.291
Restaurant	0.61	0.259
Reception	0.556	0.237
Staff	0.5	0.213

The overall satisfaction level (OSL) is calculated by taking into account the weights and satisfaction level of each dimension by equation (16):

$$OSL = \sum_{i=1}^{4} W_i \times N_i \qquad (16)$$

With : W_i and N_i are the weight and satisfaction level of each dimension respectively.

Table 9. summarizes the results of the calculation of the overall satisfaction level (OSL).

Table 9: Summary table for calculating the overall satisfaction level

Dimension	Criteria	Fuzzy model input	satisfaction level of dimension (N_i)	Weight W_i	Overall Satisfaction Level (OSL)
Reception	- Welcoming - Welcoming staff - Availability - Acess to information	3.18 2.80 3.26 3.12	1.97	0.237	1.654
Room	- Comfort - Cleanliness - Service - Sanitary and Bathroom	3.60 3.74 3.92 2.90	2.13	0.291	
Restaurant	- Quality of the dishes and products - Diversity and quantity - Waiting time - Price	3.50 3.14 2.94 2.54	1.53	0.259	
Staff	- Effectiveness - Welcoming - Total appearance - Availability	2.08 3.16 2.84 2.12	0.803	0.213	

3. Discussion of results

The contribution of our work has been the proposal of anew indicator to calculate the overall satisfaction level. This indicator integrates the company's strategy. In fact, this approach was based on the use of fuzzy logic and the two multicriteria methods of decision-making support: the method of converting verbal judgments into numerical values and pair comparison of decision criteria method. The results of this approach show that it is able to overcome the lacunas of the classical CSAT method. The contribution of this work summarizes in the following two points:

- The use of fuzzy logic allows to model in a flexible manner the quantitative and qualitative knowledge stemming from the prenantes parties opinions. And consequently to build a coherent modeling of the knowledge imperfections including the uncertainty and the inaccuracy tainting the input parameters by the use of the fuzzy sets associated with fuzzy intervals. The fuzzy intervals used to describe the gradual transition from a level of satisfaction to the other. This eliminates the discontinuity problem of the customer satisfaction levels distribution. Also, the use of the method of gravity centre seen its performance to represent results containing subjective information allows to palliate the problem linked to uniformity or to equality of the customer's levels satisfaction.
- The use of two multicriteria decision-making support methods facilitate the establishment of a compromise between the decision-makers having sometimes contradictory opinions on the satisfaction level. These opinions are always subjective because of the confrontation of the opinions of the decision makers. These last can define the importance of the dimensions in terms of weight taking into account the strategy adopted by the company. The allocation of weights to dimensions is done by two multi-criteria decision-making support methods makes to integrate the effect of the company's strategy into the calculation of the overall satisfaction level.

From the results in table 9, the overall satisfaction level calculated by our approach is of the order 1.654 which is greater than the limit value 1.5 (Figure 8). This allows the company to judge that its customers are globally satisfied.

Conclusions

In this article, we have proposed an indicator to evaluate the customer overall satisfaction level. To do this, we used fuzzy logic to establish four fuzzy models corresponding to the chosen dimensions on the one hand. On the other hand, the weights relative to each dimension are determined using the pair comparison of decision criteria method.

To illustrate the application of this approach, a case study is made in a hotel institution. In this study, we chose the toolbox Matlab for the implementation of our model. The results obtained show that the proposed approach is suitable for measuring the overall satisfaction level by overcoming all the limitations of other methods. In addition, they allow decision makers to prioritize and establish a policy of maitrise the level of satisfaction of each dimension.

The main perspective of this work is to improve the proposed approach by integrating a comparison model between the investments related to the company's strategy and the variation in the overall satisfaction level.

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