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Design And Development Of A Diffuse Evaluation System

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***Abstract*— This article aims to design and develop a fuzzy evaluation system which was applied in an SME in Southern Guanajuato so that, through it, customers can evaluate the company. The proposed fuzzy system consists of five input linguistic variables: quality, price accessibility, delivery time, term of payment and expiration of the products. Three linguistic labels were used for each of the variables: excellent, regular and bad. The sigmoidal membership function was used. A knowledge base was developed with 32 fuzzy rules. Fuzzy implication and aggregation operators were used. Finally, the defuzzification stage was performed on a scale of 1 to 10 for the final evaluation of the service. The system was validated with the evaluation of 16 customers of the company obtaining an average of 8.216345.**

Keywords*— Fuzzy system, SMEs, Fuzzy rules, Sigmoidal membership function.

I. INTRODUCTION

Defining SMEs involves defining various criteria and approaches aimed at achieving an ideal conceptualization, such as type of activity, technology used, intensity of production, levels of investment, volume of sales, or employment capacity [1]. Its importance lies in its contribution to employment and economic well-being at the level of income, working capital, infrastructure; as well as its flexibility to consolidate emerging technologies [2], [3].

Nowadays it is important for companies to carry out constant evaluations to know their performance, if they are meeting the objectives set out at the beginning or if it is necessary to change the way of working to achieve them. For a company it is important to carry out organizational evaluations since these become dynamic input and feedback for management decisions [4]. In addition, it allows to measure the level of integration of the company as a system, it serves to clarify the objectives and organizational purposes, whether they are focused on productivity, efficiency, effectiveness, effectiveness, survival, competitiveness or growth of the organization [5], [6].

On the other hand, speaking of fuzzy logic, it is defined as a system that provides a natural way to deal with problems in which the source of imprecision is the absence of clearly defined criteria of membership types [7]. In other words, fuzzy logic is a set of mathematical principles based on degrees of membership, the function of which is to model information. This modeling is done based on linguistic rules that approximate a function through the relationship of inputs and outputs of the system [8]. Its importance is based on the fact that it can solve a variety of problems, mainly those related to the control of complex industrial processes and decision systems in general [7].

This research corresponds to a study focused on improving the performance of an SME through the design and development of a fuzzy evaluation system so that through this, customers can evaluate some qualitative criteria of the company.

The evaluation was carried out taking as reference five qualitative criteria that the company has and later introducing them to the system in the form of input linguistic variables and from there go through a process of five stages: fuzzification, fuzzy rules, implication, aggregation and defuzzification to finally obtain an output linguistic variable that in this case is the rating that customers give to the business.

II. LITERATURE REVIEW

An extensive research was carried out in the state of the art to obtain a frame of reference on the work carried out and published that is related to the subject under study, which allows knowing the applications that have been carried out to date on the subject in different areas.

In [9] they used seven knowledge-based artificial intelligence tools, fuzzy logic, automatic knowledge acquisition, neural networks, genetic algorithms, case-based reasoning, and ambient intelligence for the purpose of using them in assembly automation using sets and rules of fuzzy inference. For their part [10] they proposed a system of diffuse inference for color manipulation in digital images with the purpose of modifying their artistic style. [11] carried out the development of four fuzzy systems to measure the industrial confidence index and the business climate index with the intention of comparing the result obtained using fuzzy systems. In [12] they developed a Lean Six Sigma Readiness (LESIRE) assessment model to assess an organization's readiness for LSS deployment using the fuzzy approach. [13] they presented the development of a control system based on fuzzy logic to optimize the energy of a greenhouse and its water consumption. Similarly, in [14] they presented a conceptual model and the application of fuzzy logic for the assessment of thinness in small and medium-sized enterprises (SMEs). Also, in [15] they

developed a mathematical model of fuzzy logic to find the optimal cut-off factors for surface roughness (Ra) and MRR. In [16] they proposed a robust fuzzy logic proportional bypass (PD) controller to track the path of the autonomous mobile robot with non-autonomous differential drive (WMR) wheels of the Quanser Qbot type.

The mentioned bibliographies show the application of fuzzy logic in different areas. This study brings to the state of the art a new application of the tool aimed at the commercial sector that focuses on the evaluation of an SME. The study can serve as a basis for replicating similar applications in companies in the same industry.

III. METHODOLOGY

The methodology used for the design and development of a fuzzy evaluation system applied to the company Distributor JAFRA Mary is made up of six stages. See fig. 1

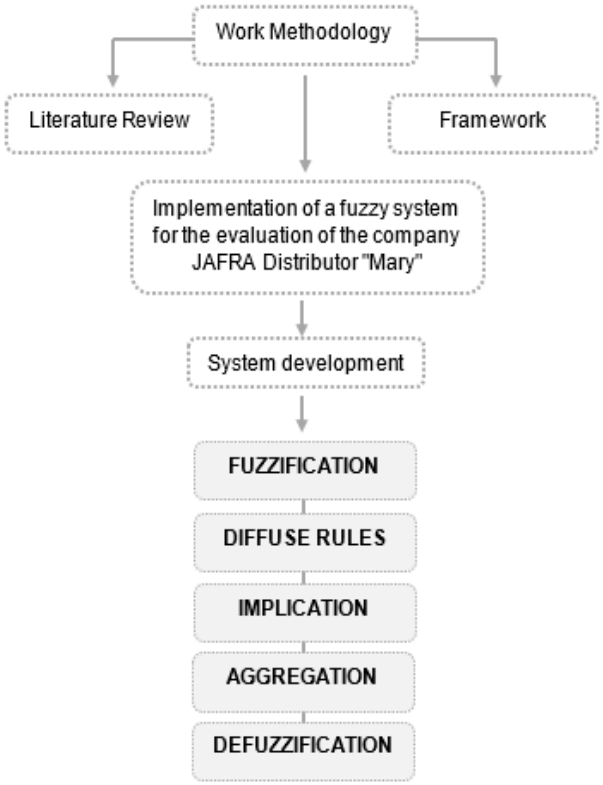

Fig. 1. Research methodology

The fuzzy system is generally made up of fuzzification, which is the input of the system where the linguistic variables are entered so that they can be blurred by means of the sigmoidal membership function. Fuzzy rules are formulated so that IF THEN it will generate the knowledge base. Implication and aggregation are carried out using a fuzzy maximization operator. The defuzzification process allows the output of real data from the system using the centroid method. See fig. 2.

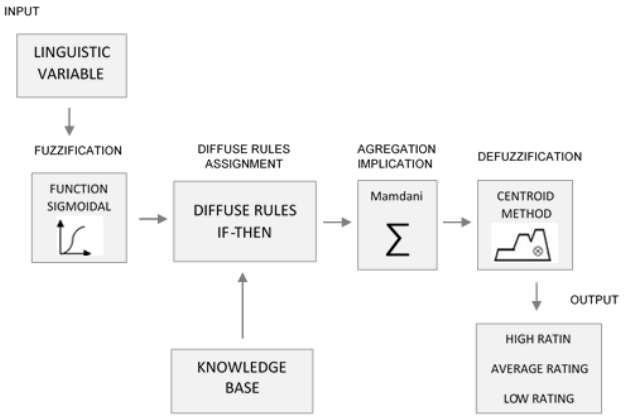

Fig. 2. General scheme of the implemented fuzzy system

IV. RESULTS AND DISCUSSION

The necessary linguistic input variables were defined for the system to be carried out. For this case study, five qualitative variables were considered with which the company has: quality, accessibility in price, delivery time, term of payment and product expiration and an output variable business rating. Subsequently each of the linguistic variables was classified by bad, regular, excellent linguistic labels.

To carry out the fuzzification process, the sigmoidal membership function was used, which consists of three parameters a, m and b. Each parameter was assigned to each of the labels, the ranges were established according to the universe of each linguistic variable to convert the assigned ranges to fuzzy values in an interval between 0 and 1. See tab. 1.

Table 1. Fuzzification of linguistic variables

FUZZIFICATION									
INPUT LINGUISTIC VARIABLE	LINGUISTIC LABELS								
QUALITY	BAD			REGULAR			EXCELLENT		
	a	m	b	a	m	b	a	m	b
	0	3	8	2	5	9	5	7	10
ACCESIBILITY IN THE PRICE	BAD			REGULAR			EXCELLENT		
	a	m	b	a	m	b	a	m	b
	0	2	8	1	5	9	2	7	10
DELIVERY TIME (DAYS)	EXCELLENT			REGULAR			BAD		
	a	m	b	a	m	b	a	m	b
	0	15	28	1	15	29	2	19	30
TERM OF PAYMENT (DAYS)	EXCELLENT			REGULAR			BAD		
	a	m	b	a	m	b	a	m	b
	0	15	28	5	17	29	8	16	30
PRODUCT EXPIRATION (WEEKS)	BAD			REGULAR			EXCELLENT		
	a	m	b	a	m	b	a	m	b
	0	17	38	3	18	39	5	21	40
OUTPUT LINGUISTIC VARIABLE									
BUSINESS RATING	BAD			REGULAR			EXCELLENT		
	a	m	b	a	m	b	a	m	b
	0	4	8	2	5	9	3	6	10

Figure (3) shows the results obtained after applying the sigmoidal membership function to the three assigned linguistic labels: bad, regular, and excellent for each of the five linguistic variables.

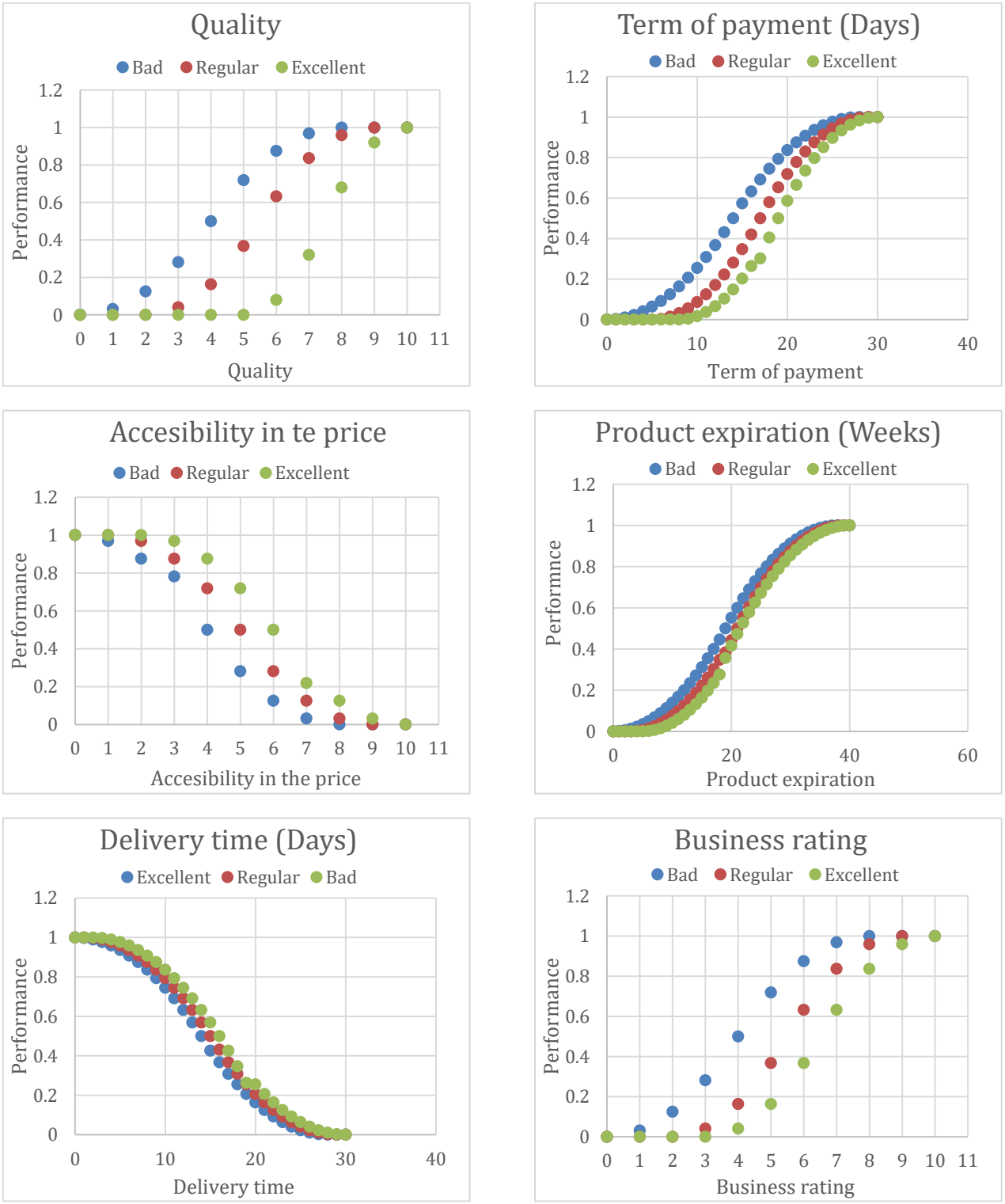

Figure 3. Grouping of language labels

This stage is the knowledge base where the essence of the system is located, so it is necessary to establish the optimal fuzzy rules for the diffuse system to operate properly. In this sense, 32 fuzzy rules were defined. The fuzzy rules were established in the IF-THEN form. Where: B = Bad, R = Regular, E = Excellent. See tab. 2.

Table 2. Knowledge Base

RATING			QUALITY		4	DELIVERY TIME		22	PRODUCT EXPIRATION		35
			ACCESIBILITY IN THE PRICE		1	TERM OF PAYMENT		10			
EVALUACIÓN											
Quality	Lenguaje label	Fuzzification	Accesibility in the price	Lenguaje label	Fuzzification	Delivery time	Lenguaje label	Fuzzification	Term of payment	Lenguaje label	Fuzzification	Product expiration	Lenguaje label	Fuzzification	Business rating
4	R	0.16326	1	B	0.96875	22	B	0.16326	10	E	0.01652	35	B	0.98753	LOW
4	R	0.16326	1	B	0.96875	22	B	0.16326	10	B	0.25510	35	E	0.96347	LOW
4	E	0	1	B	0.96875	22	B	0.16326	10	B	0.25510	35	E	0.96347	LOW
4	B	0.16326	1	R	0.96875	22	E	0.09183	10	B	0.25510	35	B	0.98753	LOW
4	E	0	1	B	0.96875	22	E	0.09183	10	B	0.25510	35	B	0.98753	LOW
4	E	0	1	B	0.96875	22	B	0.16326	10	R	0.08680	35	B	0.98753	LOW
4	E	0	1	B	0.96875	22	B	0.16326	10	B	0.25510	35	E	0.96347	LOW
4	B	0.5	1	B	0.96875	22	E	0.09183	10	B	0.25510	35	B	0.98753	LOW
4	E	0	1	B	0.96875	22	R	0.125	10	B	0.25510	35	B	0.98753	LOW
4	R	0.16326	1	B	0.96875	22	B	0.16326	10	E	0.01652	35	B	0.98753	LOW
4	B	0	1	E	0.96875	22	R	0.125	10	B	0.25510	35	B	0.98753	LOW
4	R	0.16326	1	B	0.96875	22	E	0.09183	10	R	0.08680	35	R	0.97530	MEDIUM
4	E	0	1	R	1	22	E	0.09183	10	R	0.08680	35	R	0.97530	MEDIUM
4	R	0.16326	1	R	1	22	E	0.09183	10	E	0.01652	35	R	0.97530	MEDIUM
4	R	0.16326	1	R	1	22	R	0.125	10	E	0.01652	35	E	0.96347	MEDIUM
4	R	0.16326	1	R	1	22	E	0.09183	10	R	0.08680	35	E	0.96347	MEDIUM
4	E	0	1	R	1	22	R	0.125	10	R	0.08680	35	E	0.96347	MEDIUM
4	R	0.16326	1	R	1	22	E	0.09183	10	B	0.25510	35	R	0.97530	MEDIUM
4	E	0	1	B	0.96875	22	R	0.125	10	R	0.08680	35	R	0.97530	MEDIUM
4	R	0.16326	1	R	1	22	E	0.09183	10	B	0.25510	35	R	0.97530	MEDIUM
4	E	0	1	B	0.96875	22	E	0.09183	10	E	0.01652	35	R	0.97530	HIGH
4	E	0	1	B	0.96875	22	E	0.091836	10	R	0.08680	35	E	0.96347	HIGH
4	E	0	1	B	0.96875	22	R	0.125	10	E	0.01652	35	E	0.96347	HIGH
4	R	0.16326	1	B	0.96875	22	E	0.09183	10	E	0.01652	35	E	0.96347	HIGH
4	E	0	1	R	1	22	E	0.09183	10	E	0.01652	35	E	0.96347	HIGH
4	B	0.5	1	B	0.96875	22	E	0.09183	10	E	0.01652	35	E	0.96347	HIGH
4	E	0	1	B	0.96875	22	E	0.09183	10	E	0.01652	35	E	0.96347	HIGH
4	E	0	1	B	0.96875	22	B	0.16326	10	E	0.01652	35	E	0.96347	HIGH
4	E	0	1	B	0.96875	22	E	0.09183	10	B	0.25510	35	E	0.96347	HIGH
4	E	0	1	B	0.96875	22	E	0.09183	10	E	0.01652	35	B	0.98753	HIGH
4	E	0	1	E	1	22	E	0.09183	10	E	0.01652	35	E	0.96347	HIGH

After the input variables were converted to linguistic values and entered the knowledge base, the implication and aggregation process was carried out. It consists of the fuzzy inference of the system that helped to identify the rules that were applied to each situation. These values were calculated using the fuzzy maximization operator. See tab. 3.

The defuzzification stage was used to determine the value that best represents the fuzzy set. In this stage, the transformation of the fuzzy values into real results was carried out.

To approximate these values, the approximate centroid method was used, which helped generate the defuzzification of the data to obtain an average with a value between 0 and 10. This value indicates the rating that each of the clients gave to the business. See tab. 3.

Table 3. Implication, aggregation and defuzzification

IMPLICATION	AGGREGATION	DEFUZZIFICATION (Euf)
0.987534626	0.98753463	8.216345883
0.96875		
0.96875		
0.987534626		
0.987534626		
0.987534626		
0.96875		
0.987534626		
0.987534626		
0.987534626		
0.987534626		
0.975308642	1	
1		
1		
1		
1		
1		
1		
0.975308642		
1		
0.975308642	1	
0.96875		
0.96875		
0.96875		
1		
0.96875		
0.96875		
0.96875		
0.96875		
0.987534626		
1		

Table (4) shows the evaluation that 16 company clients gave to each of the linguistic variables that were assigned for the case study, also shows the general rating that each one gave to the company.

Table 4. Customer evaluation

	LINGUISTIC VARIABLE					
COSTUMER	QUALITY	ACCESIBILITY IN THE PRICE	DELIVERY TIME	TERM OF PAYMENT	PRODUCT EXPIRATION	BUSINESS RATING
Rosalba	8	9	15	25	36	8.987181
Lilia	10	9	21	23	30	9
Lourdes	7	8	27	24	35	8.917159
Adriana	10	10	29	28	38	9
Soledad	6	9	30	30	21	9
Julia	8	7	24	21	33	8.823504
Guadalupe	9	8	21	19	35	9
Josefina	10	10	26	23	31	9
Elena	6	8	18	23	31	8.813609
Alicia	9	9	19	17	29	9
Alejandra	7	8	26	24	38	8.993113
Elvira	7	6	16	24	40	8.216345
Margarita	6	10	27	20	35	8.859900
Luisa	9	10	28	25	39	9
Fatima	6	9	15	21	32	8.547510
Teresa	8	7	18	25	37	8.987181

CONCLUSIONS

The design and development of a fuzzy evaluation system helps the company under study to obtain in a short time an accurate evaluation of the perception that customers have of it.

By applying fuzzy logic to the evaluation process, a result more closely related to reality is achieved, which is not only based on labels, but also generates a more significant result, a result that provides quantitative evidence of how the customers perceive the company. For based on that, start making decisions for your benefit.

In general, fuzzy logic helps provide meaningful information that aids decision-making, service improvement, creating a better user experience, maintaining customer loyalty, measuring customer satisfaction, demonstrating that your opinion is valued and It serves primarily as a basis for measuring company performance and establishing a correct way to run it.

It is important to mention that this tool gives the possibility of replicating in any discipline such as economics, finance, psychology, physics, to name a few.

Finally, it is worth emphasizing the excellent willingness provided by the owner of the company, who efficiently provides the necessary information for the development of this study.

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