Fuzzy Expert System for the Selection of Tourist Hotel

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Abstract: *A model is represented for the selection of tourist hotel using the concept of fuzzy expert system. There are several ways for the selection of tourist hotel but till date no mathematical model is available, therefore we try to design a model the selection of tourist hotel. We use trapezoidal and triangular membership function for input factors as well as output factors. Further, we use some authenticated factors to solve the problem of selection of tourist hotels. In the process, case study is also considered to support this methodology.*

Keywords: *Fuzzy Logic, membership function, tourist hotel, fuzzy inference system.*

I Introduction:

In order to present a model of selection of hotels, we have to fulfill the expectations of arriving tourists. There is a huge problem in hotel industry and the tourists face the problems in selection of tourist hotels. In this study, we attempt to find a suitable response to this research needed by a mathematical model, using fuzzy expert system. Therefore, hotel accommodations are formulated by appropriate fuzzy logic system. In this order, we have to select a prime location for the hotels. The location is the main issue in the hotel industry. Here, we have to try to solve the problems of selection of tourist hotels by using some important parameters. Many methods are developed for the selection of tourist hotels; almost evaluation method has its strong points and issues for different situations. In this order, we will use fuzzy logic to solve the problems of selection of tourist hotels because hotels are main important part for positive thinking in the field of hotels industry.

Fuzzy logic is a new tool to find out the solution of various problems especially for the control system. Prof. Lofti Zadeh (1965) at University of California, Barkley, start to work in this direction and develop a new way to solve the problem known as Fuzzy Logic System. In order to develop the fuzzy decision making model for selection of tourist hotels, we will focus on some parameters, which will help us in selection of tourist hotels. In this session, we use location of hotels, building structure of hotels, quality of hotels, feedback of hotels and advertisement of hotels. Approximately 80 % of all cases of the tourist are related to hotel. Every tourist wants that, how they choose the hotels of their level. Here we have three level hotels for the tourists and try to control this problem in a better way.

II Key process and key features:

1. The selection of tourist hotels depends upon five key processes.

1. Location of hotels.
2. Building structure of hotels.
3. Quality of hotels.
4. Feedback of hotels.
5. Advertisement of hotels.

2. The main key features of this proposed work are:

(a) The proposed system can evaluate the efficiency of the hotels.

(b) The fuzzy logic expert system for detecting the efficiency of the designed model by the index of vagueness system.

(c) An index known as “vagueness index” has been formulated in order to recognize genuineness while setting such case.

(d) Fuzzy logic is very useful tool for dealing with psychological reasoning and decision making process, which involves ambiguity, approximation, accuracy, exactness, uncertainty, vagueness or sources of imprecision that are non statistical in nature.

(e) By applying fuzzy logic, we can quantify the contribution of a set of information to various parameters in terms of fuzzy membership.

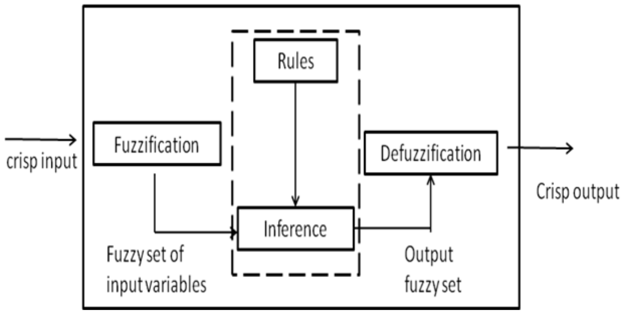


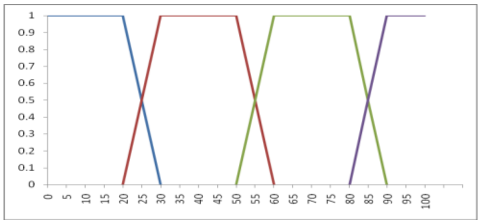
Figure 4.1 Fuzzy Validation Expert System

(f) If Δij is *0-1* variable (if there is any deviation in the hotels), while w_{ij} is the weighted or impact factor given to the j^{th} information of the i^{th} section. The vagueness index for the information selection i^{th}, is given by (say):-

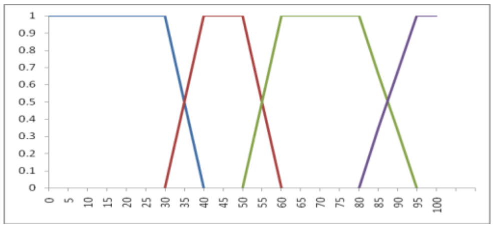
$$X_1 = \frac{\sum_{i=1}^{I}\sum_{j=1}^{J} w_{ij}\Delta_{ij}}{I}, \qquad (1)$$

and all the weights for a set of i^{th} information $\sum w_{ij}$ are added to unity. Similarly, the values of the other inputs can be determined.

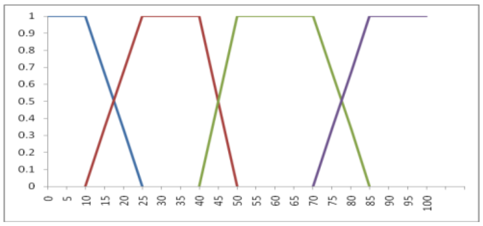
1. Location of hotels X_1



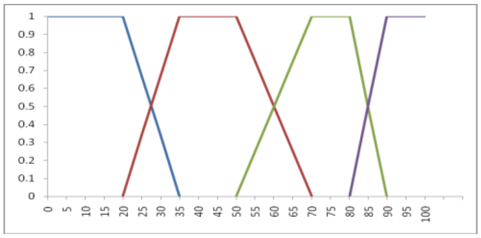
2. Building structure of hotels X_2



3. Quality of hotels X_3



4. Feedback of hotels X_4



5. Advertisement of hotels X_5

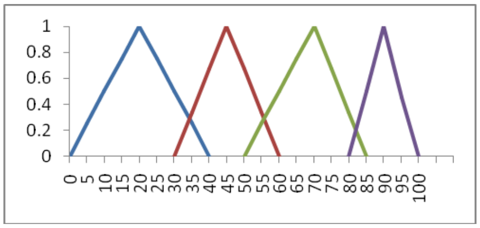


Figure 4.2: Membership functions for inputs factors

III Algorithm- using fuzzy approach:

Inputs:-

1. The crisp value of the inputs settlements and other information are obtained.
2. Evaluation of inputs: Determine the location of hotels X_1, building structure of hotels X_2, quality of hotels X_3, feedback of hotels X_4 and advertisement of hotels X_5.
3. Fuzzify the crisp value inputs: Through the use of membership functions defined for each linguistic variable, we determined the degree of membership of a crisp value in each fuzzy set. The equations of computing membership are:

$$f(x,a,b,c,d)=\begin{cases}\dfrac{x-a}{b-a} & a\le x\le b\\ 1 & b\le x\le c\\ \dfrac{d-x}{d-c} & c\le x\le d\end{cases} \quad (2)$$

$$\mu_L(x_1)=\begin{cases}1 & x_1\le 20\\ \dfrac{30-x_1}{10} & 20\le x_1\le 30\end{cases} \quad (3)$$

$$\mu_A(x_1)=\begin{cases}\dfrac{x_1-20}{10} & 20\le x_1\le 30\\ 1 & 30\le x_1\le 50\\ \dfrac{60-x_1}{10} & 50\le x_1\le 60\end{cases} \quad (4)$$

$$\mu_G(x_1)=\begin{cases}\dfrac{x_1-50}{10} & 50\le x_1\le 60\\ 1 & 60\le x_1\le 80\\ \dfrac{90-x_1}{10} & 80\le x_1\le 90\end{cases} \tag{5}$$

$$\mu_E(x_1)=\begin{cases}\dfrac{x_1-80}{10} & 80\le x_1\le 90\\ 1 & x_1\ge 90\end{cases} \tag{6}$$

$$\mu_L(x_2)=\begin{cases}1 & x_2\le 30\\ \dfrac{40-x_2}{10} & 30\le x_2\le 40\end{cases} \tag{7}$$

$$\mu_A(x_2)=\begin{cases}\dfrac{x_2-30}{10} & 30\le x_2\le 40\\ 1 & 40\le x_2\le 50\\ \dfrac{60-x_2}{10} & 50\le x_2\le 60\end{cases} \tag{8}$$

$$\mu_G(x_2)=\begin{cases}\dfrac{x_2-50}{10} & 50\le x_2\le 60\\ 1 & 60\le x_2\le 80\\ \dfrac{95-x_2}{15} & 80\le x_2\le 95\end{cases} \tag{9}$$

$$\mu_E(x_2)=\begin{cases}\dfrac{x_2-80}{15} & 80\le x_2\le 95\\ 1 & x_2\ge 95\end{cases} \tag{10}$$

$$\mu_L(x_3)=\begin{cases}1 & x_3\le 20\\ \dfrac{35-x_3}{15} & 20\le x_3\le 35\end{cases} \tag{11}$$

$$\mu_A(x_3)=\begin{cases}\dfrac{x_3-20}{15} & 20\le x_3\le 35\\ 1 & 35\le x_3\le 50\\ \dfrac{70-x_3}{20} & 50\le x_3\le 70\end{cases} \tag{12}$$

$$\mu_G(x_3)=\begin{cases}\dfrac{x_3-50}{20} & 50\le x_3\le 70\\ 1 & 70\le x_3\le 80\\ \dfrac{90-x_3}{10} & 80\le x_3\le 90\end{cases} \quad (13)$$

$$\mu_E(x_3)=\begin{cases}\dfrac{x_3-80}{10} & 80\le x_3\le 90\\ 1 & x_3\ge 90\end{cases} \quad (14)$$

$$\mu_L(x_4)=\begin{cases}1 & x_4\le 10\\ \dfrac{25-x_4}{15} & 10\le x_4\le 25\end{cases} \quad (15)$$

$$\mu_A(x_4)=\begin{cases}\dfrac{x_4-10}{15} & 10\le x_4\le 25\\ 1 & 25\le x_4\le 40\\ \dfrac{50-x_4}{10} & 40\le x_4\le 50\end{cases} \quad (16)$$

$$\mu_G(x_4)=\begin{cases}\dfrac{x_4-40}{10} & 40\le x_4\le 50\\ 1 & 50\le x_4\le 70\\ \dfrac{85-x_4}{15} & 70\le x_4\le 85\end{cases} \quad (17)$$

$$\mu_E(x_4)=\begin{cases}\dfrac{x_4-70}{10} & 70\le x_4\le 85\\ 1 & x_4\ge 85\end{cases} \quad (18)$$

$$\mu_L(x_5)=\begin{cases}\max\{0,\ \dfrac{x_5-0}{20} & x_5<20\\ \max\{0,\dfrac{40-x_5}{20} & 20\ge x_5\end{cases} \quad (19)$$

$$\mu_A(x_5)=\begin{cases}\max\{0,\ \dfrac{x_5-30}{15} & x_5<40\\ \max\{0,\dfrac{60-x_5}{15} & 45\ge x_5\end{cases} \quad (20)$$

$$\mu_G(x_5) = \begin{cases} \max\{0, \dfrac{x_5 - 50}{20} & x_5 < 70 \\ \max\{0, \dfrac{85 - x_5}{15} & 70 \geq x_5 \end{cases} \quad (21)$$

$$\mu_E(x_5) = \begin{cases} \max\{0, \dfrac{x_5 - 80}{10} & x_5 < 90 \\ \max\{0, \dfrac{100 - x_5}{10} & 90 \geq x_5 \end{cases} \quad (22)$$

where (*a*, *b*, *c*, *d*) are the vertices of the trapezoidal membership functions and (*a*, *b*, *c*) are the vertices of the triangular membership function, while *L*, *A*, *G* and *E* represents the fuzzy set for low, average, good and excellent respectively.

IV Fire the rule bases that correspond to these inputs

All expert system which are based on fuzzy logic, uses *if-then* rules. The *"if"* part is known as conditions, where as the *"then"* part is termed as a consequence or conclusion. Since four inputs have five fuzzy sets (*L*- low, *A*-average, *G*-good, *E*-excellent) therefore *1024(4X4X4X4X4)* fuzzy decisions are to be fired. Here we will use the outputs in level system followed by : *LEVEL 1, LEVEL 2, LEVEL 3.*

V Execute the inference engine

Once all crisp input values have been fuzzified into their respective linguistic values, the inference engine will access the fuzzy rule base of the fuzzy expert system to derive linguistic values for the intermediate as well as the output linguistic variables. The two main steps in the inference process are **aggregation** and **composition**. Aggregation is the process of computing the values of *if* (antecedent) part of the rules while composition is the process of computing the value of the *then* (conclusion) part of the rules. During aggregation, each condition in the *if* part of a rule is assigned a degree of truth based on the degree of membership of the corresponding linguistic term. From here, product (*PROD*) of the degree of truth of the conditions are computed to clip the degree of truth from the *if* part. This is assigned as the degree of truth of the *then* part. The next step in the inference process is to be determining the degree of truth for each linguistic term of the output linguistic variable. Usually, either the maximum (*MAX*) or sum (*SUM*) of the degrees of truth of the rules with the same linguistic terms in the then parts is computed to determine the degrees of truth of each linguistic term of the output linguistic variable.

Table 1: Sample rule base for the fuzzy logic based expert system:

Rule No.	Inputs					Output
	X_1	X_2	X_3	X_4	X_5	Y
1	AVERAGE	LOW	AVERAGE	LOW	GOOD	LEVEL 1
2	AVERAGE	LOW	AVERAGE	LOW	EXCELLENT	LEVEL 1
3	AVERAGE	LOW	AVERAGE	AVERAGE	GOOD	LEVEL 1
4	AVERAGE	LOW	AVERAGE	AVERAGE	EXCELLENT	LEVEL 2
5	AVERAGE	LOW	GOOD	LOW	GOOD	LEVEL 1
6	AVERAGE	LOW	GOOD	LOW	EXCELLENT	LEVEL 1
7	AVERAGE	LOW	GOOD	AVERAGE	GOOD	LEVEL 2
8	AVERAGE	LOW	GOOD	AVERAGE	EXCELLENT	LEVEL 2
9	AVERAGE	AVERAGE	AVERAGE	LOW	GOOD	LEVEL 2

10	AVERAGE	AVERAGE	AVERAGE	LOW	EXCELLENT	LEVEL 2
11	AVERAGE	AVERAGE	AVERAGE	AVERAGE	GOOD	LEVEL 2
12	AVERAGE	AVERAGE	AVERAGE	AVERAGE	EXCELLENT	LEVEL 2
13	AVERAGE	AVERAGE	GOOD	LOW	GOOD	LEVEL 2
14	AVERAGE	AVERAGE	GOOD	LOW	EXCELLENT	LEVEL 3
15	AVERAGE	AVERAGE	GOOD	AVERAGE	GOOD	LEVEL 3
16	AVERAGE	AVERAGE	GOOD	AVERAGE	EXCELLENT	LEVEL 2
17	GOOD	LOW	AVERAGE	LOW	GOOD	LEVEL 1
18	GOOD	LOW	AVERAGE	LOW	EXCELLENT	LEVEL 1
19	GOOD	LOW	AVERAGE	AVERAGE	GOOD	LEVEL 2
20	GOOD	LOW	AVERAGE	AVERAGE	EXCELLENT	LEVEL 2
21	GOOD	LOW	GOOD	LOW	GOOD	LEVEL 1
22	GOOD	LOW	GOOD	LOW	EXCELLENT	LEVEL 1
23	GOOD	LOW	GOOD	AVERAGE	GOOD	LEVEL 2
24	GOOD	LOW	GOOD	AVERAGE	EXCELLENT	LEVEL 2
25	GOOD	AVERAGE	AVERAGE	LOW	GOOD	LEVEL 3
26	GOOD	AVERAGE	AVERAGE	LOW	EXCELLENT	LEVEL 3
27	GOOD	AVERAGE	AVERAGE	AVERAGE	GOOD	LEVEL 3
28	GOOD	AVERAGE	AVERAGE	AVERAGE	EXCELLENT	LEVEL 3
29	GOOD	AVERAGE	GOOD	LOW	GOOD	LEVEL 2
30	GOOD	AVERAGE	GOOD	LOW	EXCELLENT	LEVEL 3
31	GOOD	AVERAGE	GOOD	AVERAGE	GOOD	LEVEL 3
32	GOOD	AVERAGE	GOOD	AVERAGE	EXCELLENT	LEVEL 3

VI Defuzzificaton

The center of gravity (*COG*) method is used for defuzzification process, which is the most popular technique and is widely utilized in actual applications. In this method, the weighted strengths of each output membership function is multiplied by their respective output membership function center points and summed. Finally, this area is divided by the sum of the weighted membership function strength and the result is taken as the crisp output. The *COG* method can be expressed as :

$$\text{OutputData} = \frac{\sum_{i \in x_{\min}}^{x_{\max}} x_i . \mu(x_i)}{\sum_{i \in x_{\min}}^{x_{\max}} \mu(x_i)} \tag{23}$$

VII Output of decisions of the expert system

In this case, the outputs will provide us the level of hotels. Here, we will divide the levels in three parts followed as; *LEVEL* 1, *LEVEL* 2, *LEVEL* 3. Each level has the specific quality and the specific features and depends upon the model and performance measure. However, in all the fuzzy logic based expert system, we explore the implicit and explicit relationships within the system by mimicking human thinking and subsequently develop the optimal fuzzy control rules as well as knowledge base.

VIII Case Study

For the purpose of illustration, we consider that the nature of the road using four inputs *viz.*, location of hotels X_1, building structure of hotels X_2, quality of hotels X_3, feedback of hotels X_4 and advertisement of hotels X_5.

(1) Evaluate the authenticity of the tourist hotels: The values of the inputs of the tourist hotels have been evaluated,

$X_1=52, X_2=34, X_3=54, X_4=18, X_5=83$ (say).

(2) Fuzzification of the crisp values of inputs: Through the use of membership functions defined for each fuzzy set for each linguistic variable, the degree of membership of a crisp value in each fuzzy set is determined as follows:

$$\mu_L(x_1)=0,\ \mu_A(x_1)=0.8,\ \mu_G(x_1)=0.2,\ \mu_E(x_1)=0 \qquad (24)$$

$$\mu_L(x_2)=0.6,\ \mu_A(x_2)=0.4,\ \mu_G(x_2)=0,\ \mu_E(x_2)=0 \qquad (25)$$

$$\mu_L(x_3)=0,\ \mu_A(x_3)=0.8,\ \mu_G(x_3)=0.2,\ \mu_E(x_3)=0 \qquad (26)$$

$$\mu_L(x_4)=0.47,\ \mu_A(x_4)=0.53,\ \mu_G(x_4)=0,\ \mu_E(x_4)=0 \qquad (27)$$

$$\mu_L(x_5)=0,\ \mu_A(x_5)=0,\ \mu_G(x_5)=0.13,\ \mu_E(x_5)=0.3 \qquad (28)$$

(3) Fire the rule bases that correspond to the inputs: Based on the value of fuzzy membership function values for the example under consideration, the following rules apply:

Rule No.	If					then
	X_1	X_2	X_3	X_4	X_5	
1	*AVERAGE*	*LOW*	*AVERAGE*	*LOW*	*GOOD*	*LEVEL 1*
4	*AVERAGE*	*LOW*	*AVERAGE*	*AVERAGE*	*EXCELLENT*	*LEVEL 2*
9	*AVERAGE*	*AVERAGE*	*AVERAGE*	*LOW*	*GOOD*	*LEVEL 2*
14	*AVERAGE*	*AVERAGE*	*GOOD*	*LOW*	*EXCELLENT*	*LEVEL 3*
17	*GOOD*	*LOW*	*AVERAGE*	*LOW*	*GOOD*	*LEVEL 1*
20	*GOOD*	*LOW*	*AVERAGE*	*AVERAGE*	*EXCELLENT*	*LEVEL 2*
25	*GOOD*	*AVERAGE*	*AVERAGE*	*LOW*	*GOOD*	*LEVEL 3*
30	*GOOD*	*AVERAGE*	*GOOD*	*LOW*	*EXCELLENT*	*LEVEL 3*

(4) Execute the inference engine: We use "Root Sum Square" (*RSS*) method to combine the effects of all applicable rules. Root Sum Square method scales the function at their respective magnitudes and computes the "fuzzy centroid" of the composite area. This method is more complicated mathematically than other methods..The respective output membership function strengths (range: [*0, 1*]) from possible rules (*R 1-1024*) are:

$$Level\ 1 = \sqrt{\sum_{i \in L_1} (\mu_{R_i})^2} = \sqrt{(0.13)^2 + (0.13)^2} = 0.1838$$

$$Level\ 2 = \sqrt{\sum_{i \in L_2} (\mu_{R_i})^2} = \sqrt{(0.3)^2 + (0.13)^2 + (0.2)^2} = 0.3832$$

$$Level\ 3 = \sqrt{\sum_{i \in L_3} (\mu_{R_i})^2} = \sqrt{(0.13)^2 + (0.2)^2 + (0.2)^2} = 0.3112$$

(5) Output function:

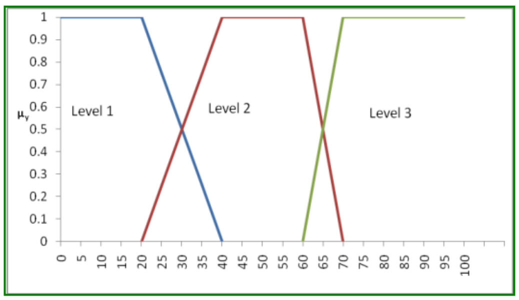


Figure 3: Output of the decision of the fuzzy expert system

$$Output = \frac{(0.1838 \times 0.20) + (0.3832 \times 0.45) + (0.3112 \times 0.80)}{0.1838 + 0.3832 + 0.3112}$$

$$= 0.5215$$

This output shows that the hotel is *LEVEL 2* with *52.15 %* degree of precision.

(6) Defuzzification:

We use "Center of gravity (*COG*)" for defuzzification. The defuzzification of the data into crisp output is accomplished by combining the results of the inference process. In the COG method, the weighted strengths of each output membership function is multiplied by their respective output membership function center points and summed. Finally, this area is divided by the sum of the weighted membership function strength and the result is taken as the crisp output. Figure 4.3 shows the crisp output belongs to *LEVEL 2* with *52.15 %* degree of precision.

(7) Output of the fuzzy expert system:

Here, we obtained fuzzy model to provide good and exact information about the tourist hotels and the performance of this fuzzy model is also shown here by taking a real data base of the tourist hotels. This model concludes that the hotel is *LEVEL 2* with degree of precision *52.15 %*.

IX Conclusion

This work provides a fuzzy rule based method to calculate the indicative result of our system. Here we used four input parameters. We have limited our work to these four parameters that play an important role in this area. In this whole process, we think about the effective output and try to find that, what parameters are useful for the effective result and at the last we got the effective result to make selection. We propose that the use of GA, neural network and *MATLAB* can produce an optimum for the tired combination.

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