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Fuzzy Expert System for the Selection of Effective Road to Travel

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Abstract

This work presents a model of traffic control system, which is designed by using the concept of fuzzy expert system for the selection of a road to travel. Here a trapezoidal membership function is used for input variables and as well as output variables. This model will provide indicative results for traffic control and the results from this system will also help tourist drivers when they are traveling. Further a case study is also considered to support this methodology. We use "weighted average method" for defuzzification. The defuzzification of the data into crisp output is accomplished by combining the results of the inference process. The weighted average method is formed by weighting each membership function in the output by its respective max membership value and the result is taken as the crisp output. Here the crisp output belongs to *GOOD* level (as evident from its membership function). Hence the decision in this case is *GOOD* level with 50.92 % degree of precision.

Keywords: Fuzzy logic, Fuzzy validation expert system, Linguistic variables, Root sum square (RSS)

1 Introduction-

In order to reduce the time and the efficiency of the road, there are many way for the selection of effective road to travel. Here we will introduce some parameters to calculate the traffic on the road and we will try to achieve our goal, i.e. the selection of effective road for which we reached to our destination in minimum time with useful choice. Here we will introduce four parameters for which we will find the useful result of our problem:

1. Goodness of the road.
2. Business of the road.
3. Time to cover a unit distance.
4. Number of crossings.

There are many problems on the road so taking all the problems in our mind we will choose suitable way for our goal. The knowledge base for this fuzzy reasoning systems developed by using the traffic model development. A survey of adaptive traffic control users published by High Dynamic Range (HDR), Inc. in 2010 entitled "Adaptive Traffic Control Systems in the United States: Updated Summary and Comparison" ranked the in Sync system number one in a variety of measures, including affordability, up-time, maintenance, reduction in stops, reduction in delay and reduction in travel time. The U.S. Federal Highway Administration, through its Every Day Counts initiative, is working to accelerate the adoption of adaptive signal control technologies in the United States. Its website states, "Real-time management of traffic systems is proven to work, yet these systems have been deployed on less than 1 percent of existing traffic signals. Federal Highway Administration (FHWA) is now working to bring these technologies to the rest of the country". Traffic Tech. is a leading provider of engineered solutions in traffic control & Intelligent Transportation Systems (ITS). With a Quarter of a Century's Experience in Traffic Engineering Technologies, we deliver innovative and cost effective solutions that exceed global safety standards and optimize traffic and transport operations in the Middle East. From a simple road junction to multiple and complex intersections, our clients tap on our expertise in developing optimum traffic rule on the road. With our decades of experience and a team of highly skilled and equipped technicians and mathematicians, we are considered the most competent service contractor of traffic control systems in the region. This system provides traffic professionals / contractors a tool to monitor work zones and surrounding traffic. India is a large subcontinent offering different road to travel and modes of travel between two given places. Therefore choice of the most appropriate road to travel needs complex analysis. This paper suggests an expert system which identifies the best road and mode of travel between two places. The roads is greatly changed by the constant economic growth for a long time the traffic situation such as the large number of vehicle due to increasing economic scale. A study about an optimal route selection model is researched over late 1980s by development of computer and Geographic information system (GIS), and consisted including research about optimal route that use digital terrain model in domestic such as the earth volume calculations, mass curve output and automation system construction.

2. Fuzzy Logic

The concept of fuzzy sets was introduced in 1965 by Lotfi Zadeh (Zadeh L.A., 1965) as a means of representing vagueness in applications. Fuzzy logic is the logic corresponding to fuzzy sets. In classical two-valued logic, or Boolean logic or binary logic, a proposition is either true or false. The only permitted membership values are 0 or 1. Every item in the universe of discourse is either a full member of the set or not a member at all. Two valued logic works well for problems which are linear and systems that can be modeled precisely and it has proved to be effective in solving such problems. In multivalued logic, a proposition may be true, false or have an intermediate truth value. The set of truth values is assumed to be evenly divided over the interval [0, 1].

In fuzzy logic, the membership function can have values ranging from 0 to 1.

3 Key process and key features

1. The selection of road depends upon four key processes, while controlling the situations creating on the road.

A. Goodness of the road.

B. Business of the road.

C. Time to cover a unit distance.

D. Number of crossings.

These are four key approaches which may help us for the effective road to travel.

(2) The main key futures of this proposed work are:

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

(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 there has been formulated in order to recognize genuineness while setting such case".

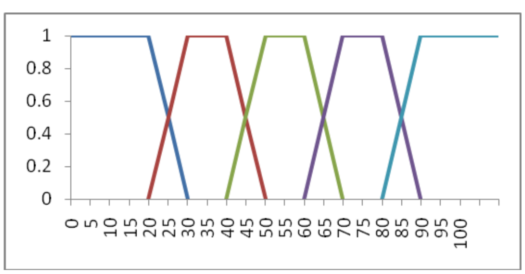
(d) Fuzzy logic is very useful tool for dealing which psychological reasoning, decision making process which involves ambiguity approximation inaccuracy in exactness, uncertainty, vagueness.

(e) The vagueness index for the information selection i^{th}, is given by (say):-

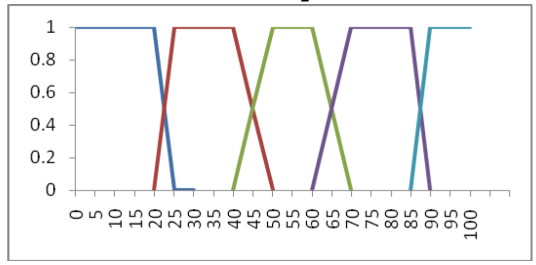
$$X_1 = \frac{\sum_{i=1}^{I}\sum_{j=1}^{J} w_{ij}\Delta_{ij}}{I} \qquad (1.1)$$

where w_{ij} is the weighted or impact factor given to the j^{th} information of the i^{th} section and Δ_{ij} is 0-1 variable (if there is any deviation on the road). All the weights for a set of i^{th} information $\sum w_{ij}$ added to unity. Similarly, the values of the other inputs can be determined.

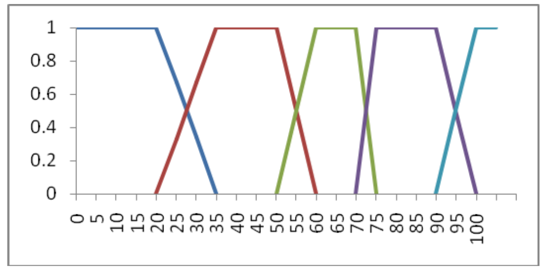
1. Goodness of the road X_1



2. Business of the road X_2



3. Time to cover a unit distance X_3



4. Number of crossings X_4

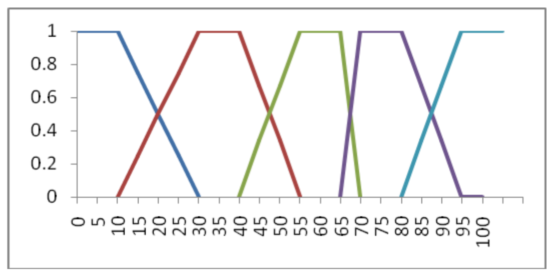


Figure 1.1: Membership functions of inputs

4 Algorithm- using fuzzy approaches

Inputs:-

1. The crisp value of the inputs settlements and other information obtained.

2. Evaluated the inputs:- Determined the goodness of the road X_1, Business of the road X_2, Time to cover a unit distanceX_3, Number of crossingsX_4.

3. Fuzzify the crisp value inputs: Through the use of membership fictions defined for each linguistic variable, determined the degree of membership of a crisp value in each fuzzy set. The equations of computing membership are:

$$f(x,a,b,c,d) = \begin{cases} \frac{x-a}{b-a} & a \le x \le b \\ 1 & b \le x \le c \\ \frac{d-x}{d-c} & c \le x \le d \end{cases} \qquad (1.2)$$

$$\mu_{VL}(x_1)=\begin{cases}1 & x_1 \le 20\\ \dfrac{30-x_1}{10} & 20 \le x_1 \le 30\end{cases} \quad (1.3)$$

$$\mu_{L}(x_1)=\begin{cases}\dfrac{x_1-20}{10} & 20 \le x_1 \le 30\\ 1 & 30 \le x_1 \le 40\\ \dfrac{50-x_1}{10} & 40 \le x_1 \le 50\end{cases} \quad (1.4)$$

$$\mu_{M}(x_1)=\begin{cases}\dfrac{x_1-40}{10} & 40 \le x_1 \le 50\\ 1 & 50 \le x_1 \le 60\\ \dfrac{70-x_1}{10} & 60 \le x_1 \le 70\end{cases} \quad (1.5)$$

$$\mu_{H}(x_1)=\begin{cases}\dfrac{x_1-60}{10} & 60 \le x_1 \le 70\\ 1 & 70 \le x_1 \le 80\\ \dfrac{90-x_1}{10} & 80 \le x_1 \le 90\end{cases} \quad (1.6)$$

$$\mu_{VH}(x_1)=\begin{cases}\dfrac{x_1-80}{10} & 80 \le x_1 \le 90\\ 1 & x_1 \ge 90\end{cases} \quad (1.7)$$

$$\mu_{VL}(x_2)=\begin{cases}1 & x_2 \le 20\\ \dfrac{25-x_2}{5} & 20 \le x_2 \le 25\end{cases} \quad (1.8)$$

$$\mu_{L}(x_2)=\begin{cases}\dfrac{x_2-20}{5} & 20 \le x_2 \le 25\\ 1 & 25 \le x_2 \le 40\\ \dfrac{50-x_2}{10} & 40 \le x_2 \le 50\end{cases} \quad (1.9)$$

$$\mu_{M}(x_2)=\begin{cases}\dfrac{x_2-40}{10} & 40 \le x_2 \le 50\\ 1 & 50 \le x_2 \le 60\\ \dfrac{70-x_2}{10} & 60 \le x_2 \le 70\end{cases} \quad (1.10)$$

$$\mu_{H}(x_2)=\begin{cases}\dfrac{x_2-60}{10} & 60 \le x_2 \le 70\\ 1 & 70 \le x_2 \le 85\\ \dfrac{90-x_2}{5} & 85 \le x_2 \le 90\end{cases} \quad (1.11)$$

$$\mu_{VH}(x_2)=\begin{cases}\dfrac{x_2-85}{10} & 85 \le x_2 \le 90\\ 1 & x_2 \ge 90\end{cases} \quad (1.12)$$

$$\mu_{VH}(x_3)=\begin{cases}1 & x_3 \le 20\\ \dfrac{35-x_3}{15} & 20 \le x_3 \le 35\end{cases} \quad (1.13)$$

$$\mu_{H}(x_3)=\begin{cases}\dfrac{x_3-20}{15} & 20 \le x_3 \le 35\\ 1 & 35 \le x_3 \le 50\\ \dfrac{60-x_3}{10} & 50 \le x_3 \le 60\end{cases} \quad (1.14)$$

$$\mu_M(x_3)=\begin{cases}\frac{x_3-50}{10} & 50\le x_3\le 60\\ 1 & 60\le x_3\le 70\\ \frac{75-x_3}{5} & 70\le x_3\le 75\end{cases} \quad (1.15)$$

$$\mu_L(x_3)=\begin{cases}\frac{x_3-70}{5} & 70\le x_3\le 75\\ 1 & 75\le x_3\le 90\\ \frac{100-x_3}{10} & 90\le x_3\le 100\end{cases} \quad (1.16)$$

$$\mu_{VL}(x_3)=\begin{cases}\frac{x_3-90}{10} & 90\le x_3\le 100\\ 1 & x_3\ge 100\end{cases} \quad (1.17)$$

$$\mu_{VL}(x_4)=\begin{cases}1 & x_4\le 10\\ \frac{30-x_4}{20} & 10\le x_4\le 30\end{cases} \quad (1.18)$$

$$\mu_L(x_4)=\begin{cases}\frac{x_4-10}{20} & 10\le x_4\le 30\\ 1 & 30\le x_4\le 40\\ \frac{55-x_4}{15} & 40\le x_4\le 55\end{cases} \quad (1.19)$$

$$\mu_M(x_4)=\begin{cases}\frac{x_4-40}{15} & 40\le x_4\le 55\\ 1 & 55\le x_4\le 65\\ \frac{70-x_4}{5} & 65\le x_4\le 70\end{cases} \quad (1.20)$$

$$\mu_H(x_4)=\begin{cases}\frac{x_4-65}{5} & 65\le x_4\le 70\\ 1 & 70\le x_4\le 80\\ \frac{95-x_4}{15} & 80\le x_4\le 95\end{cases} \quad (1.21)$$

$$\mu_{VH}(x_4)=\begin{cases}\frac{x_4-80}{15} & 80\le x_4\le 95\\ 1 & x_4\ge 95\end{cases} \quad (1.22)$$

where *VL*, *L*, *M*, *H*, *VH*, represent the fuzzy set for very low, low, medium, high, and very high respectively.

5. Fire the rule base that corresponds 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 (*VL*-very low, *L*-low, *M*-medium, *H*-high, *VH*-very high) therefore *625(5X5X5X5)* fuzzy decisions are to be fired. Here are two outputs: *GOOD* road –G and *BAD* road -*B*.

6 Execute the inference engine :

Once all crisp input value have fuzzified into their respective linguistic values, the inference engine will accesses 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.

7 Defuzzification :

The last phase is in the fuzzy expert system is the defuzzification of the linguistic values of the output linguistic variables into crisp values. The most common techniques for defuzzification, center of maximum (*COM*) is used here for the defuzzification of output although one may go for (center of area (*COA*). *COM*, first determines the most typical value for each linguistic term for an output linguistic variable, and then computes the crisp value as the best compromise for the typical values and respective degrees of membership.

8. Output of decisions of the expert system :

In this case, the outputs are: good road and bad road. The specific features of each controller depends upon the model and performance measure. However, in principle, in all the fuzzy logic based expert system, we explore the implicit and explicit relationships within the system by

9. Case Study :

For the purpose of illustration, we consider that the nature of the road using four inputs *viz* goodness of the road X_1, business of the road X_2, time to cover a unit distance X_3, number of crossings X_4.

(1) Evaluate the authenticity of the road: The values of the inputs of the road have to evaluated, $X_1=48$, $X_2=64$, $X_3=54$, $X_4=42$(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:

$$\mu_{VL}(x_1)=0,\ \mu_L(x_1)=0.2,\ \mu_M(x_1)=0.8,\ \mu_H(x_1)=0,\ \mu_{VH}(x_1)=0 \quad \textbf{(1.23)}$$

$$\mu_{VL}(x_2)=0,\ \mu_L(x_2)=0,\ \mu_M(x_2)=0.6,\ \mu_H(x_2)=0.4,\ \mu_{VH}(x_2)=0 \quad \textbf{(1.24)}$$

$$\mu_{VH}(x_3)=0,\ \mu_H(x_3)=0.6,\ \mu_M(x_3)=0.4,\ \mu_L(x_3)=0,\ \mu_{VL}(x_3)=0 \quad \textbf{(1.25)}$$

$$\mu_{VL}(x_4)=0,\ \mu_L(x_4)=0.87,\ \mu_M(x_4)=0.13,\ \mu_{VH}(x_4)=0,\ \mu_H(x_4)=0 \quad \textbf{(1.26)}$$

(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:

1. If X_1 is *LOW*, X_2 is *MEDIUM*, X_3 is *HIGH*, X_4 is *LOW* then *Y* is *BAD*.
2. If X_1 is *LOW*, X_2 is *MEDIUM*, X_3 is *HIGH*, X_4 is *MEDIUM*, then *Y* is *BAD*.
3. If X_1 is *LOW*, X_2 is *MEDIUM*, X_3 is *MEDIUM*, X_4 is LOW then *Y* is *GOOD*.
4. If X_1 is *LOW*, X_2 is *MEDIUM*, X_3 is *MEDIUM*, X_4 is *MEDIUM* then *Y* is *GOOD*.
5. If X_1 is *LOW*, X_2 is *HIGH*, X_3 is *HIGH*, X_4 is *LOW* then *Y* is *BAD*.

mimicking human thinking and subsequently develop the optimal fuzzy control rules as well as knowledge base.

6. If X_1 is *LOW*, X_2 is *HIGH*, X_3 is *HIGH*, X_4 is *MEDIUM* then *Y* is *BAD*.
7. If X_1 is *LOW*, X_2 is *HIGH*, X_3 is *MEDIUM*, X_4 is *LOW* then *Y* is *BAD*.
8. If X_1 is *LOW*, X_2 is *HIGH*, X_3 is *MEDIUM*, X_4 is *MEDIUM* then *Y* is *GOOD*.
9. If X_1 is *LOW*, X_2 is *MEDIUM*, X_3 is *HIGH*, X_4 is *LOW* then *Y* is *BAD*.
10. If X_1 is *LOW*, X_2 is *MEDIUM*, X_3 is *HIGH*, X_4 is *MEDIUM* then *Y* is *BAD*.
11. If X_1 is *LOW*, X_2 is *MEDIUM*, X_3 is *MEDIUM*, X_4 is *LOW* then *Y* is *GOOD*.
12. If X_1 is *LOW*, X_2 is *MEDIUM*, X_3 is *MEDIUM*, X_4 is *MEDIUM* then *Y* is *BAD*.
13. If X_1 is *LOW*, X_2 is *HIGH*, X_3 is *HIGH*, X_4 is *LOW* then *Y* is *BAD*.
14. If X_1 is *LOW*, X_2 is *HIGH*, X_3 is *HIGH*, X_4 is *MEDIUM* then *Y* is *BAD*.
15. If X_1 is LOW, X_2 is *HIGH*, X_3 is *MEDIUM*, X_4 is *LOW* then *Y* is *BAD*.
16. If X_1 is *LOW*, X_2 is *HIGH*, X_3 is *MEDIUM*, X_4 is *MEDIUM* then *Y* is *BAD*.

(4) Execute the inference engine: We use the "Root Sum Squares" *(RSS)* method to combine the effects of all applicable rules, scale the functions at their respective magnitude. The respective output membership function strengths (range: *[0, 1])* from possible rules (*R1-625)* are:

$$\textbf{\textit{BAD}} = \sqrt{\begin{aligned}&(0.2)^2+(0.13)^2+(0.2)^2+(0.13)^2+(0.2)^2+(0.6)^2+\\&(0.13)^2+(0.13)^2+(0.4)^2+(0.13)^2+(0.4)^2+(0.13)^2\end{aligned}}$$

$$= \sqrt{0.9014} = 0.9494(approx.)$$

$$\textbf{\textit{GOOD}} = \sqrt{(.2)^2+(.13)^2+(.13)^2+(.4)^2}$$

$$= \sqrt{0.2338} = 0.4835\ (approx.)$$

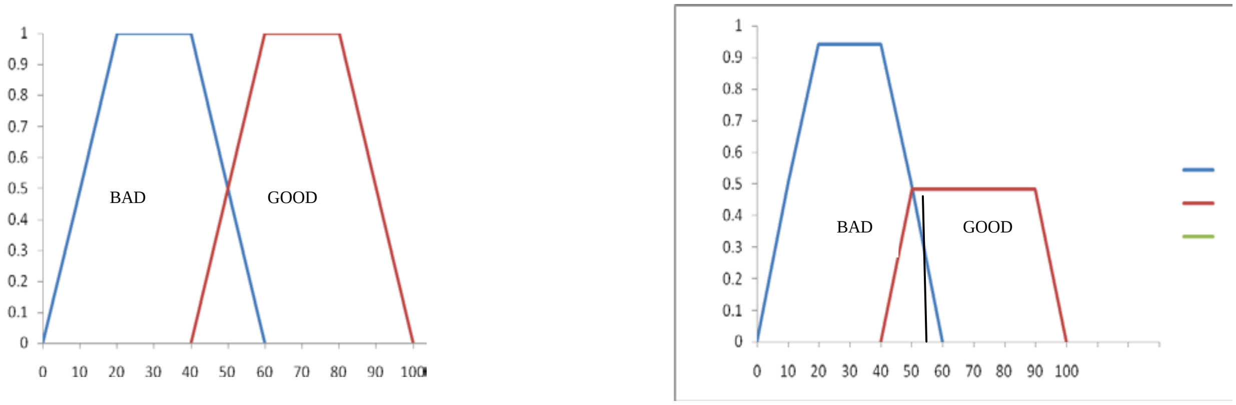


Figure 1.3: Output of the decision of the expert system

10. Conclusion:

In this whole process we think about the effective output and try to find that, what parameter are useful for the effective result and at the last we got the effective result for the selection of road to travel. We propose that the use of genetic algorithm, neural network and MATLAB can produce an optimum for the tired combination. Here we obtained fuzzy model provide good and exact information about the road. Here the performance of this fuzzy model is also shown here by taking a real data base of the road. This model concludes that the road is Good level with degree of precision 50.92 %.

References

[1] Abramowitz and Stegun (1964), Handbook of Mathematical Functions with Formulas, Graphs and Mathematical Tables, 1046.

[2] Zadeh, L. A. (1968), Fuzzy algorithms, Info. & Ctl, 12, 94-102.

[3] Zadeh, L. A. (1973), "Outline of a new approach to the analysis of complex system and decision process". SMC-3, 1, 28-44.

[4] Zadeh, L. A. (1975), "The concept of a linguistic variable and its application to approximate reasoning", Information Sciences, 8, 199-249.

[5] Arbel, A. and Pizam, A., (1977), "Some determinants of urban hotel location: the tourist inclinations" , Journal of Travel Research, 15, 3, 18-22.

[6] Zimmermann, H. J. (1978), Fuzzy programming and linear programming with several objective functions, Fuzzy sets and Systems, 281-298.6.

[7] Roth, F.H. (1994), "The knowledge based expert system: A tutorial", IEEE Computer 17, 9, 11-28

[8] Tsaur, S. H. and Tzeng, G. H. (1996), Multiattribute decision making analysis for customer preference of tourist hotels, Journal of Travel & Tourism Marketing, 4, 4, 55-69.

[9] Begin, S. (2000), "The geography of a tourist business: Hotel distribution and urban development in Xiamen, China," Tourism Geographies, 2, 4, 448-471.

[10] Nicolau, J. L. (2002), "Assessing new hotel openings through an event study," Tourism Management, 23, 1, 47-54.

[11] Chang, C. (2003), A fuzzy set theoretical approach to asset and liability management and decision making, intelligent and other computational techniques in insurance: Theory and applications, World Scientific Publishing Company, 301-333.

[12]Urtasun, A. and Gutierrez, I. (2006), "Hotel location in tourism cities: Madrid 1936–1998," Annals of Tourism Research, 33, 2, 382-402.

[13] Chou, T. Y. , Hsu, C. L. and Chen, M. C. (2008), A fuzzy multi- criteria decision model for international tourist hotels location selection, International Journal of Hospitality Management, 27, 293-301.

[14] Sharma, F. B. , Sharma, A. and Sharma, N. (2010), Fuzzy logic applications for traffic control: "An optimum and adaptive controlling application". International Journal of Emerging Technologies 1(1), 41-45, 0975-8364.

[15]Kumar, S. and Pathak, P. (2010), Indicative results of cancellation of policies- Fuzzy approach. Proc. National Conf. on Appl. Of math. to Sc. & Tech., 17-23.

[16] Kumar, S. and Pathak, P. (2010), Fuzzy Based Bonus –Malus System for Premium Decision In Car Insurance. Int. Review Of Pure And Applied Maths., 6(1), 77-88.

[17] Hamedi, Z. and Jafari, S. (2011), using fuzzy decision-making in E-tourism Industry: A case study of Shiraz city E-tourism, International Journal of Computer Science Issues, 8, 3, 1, 1694-0814.

[18] Jowkar, Z. and Samizadeh, R. (2011), Fuzzy risk analysis model for E-tourism investment. Int. J.Manag. Bus. Res, 1, 2, 69-76.

[19] Shoval, N. , McKercher, B . , Ng, E. and Birenboim (2011), "Hotel location and tourist activity in cities," Annals of Tourism Research, 38, 4, 1594-1612.

[20] Barak, S. and Fallahnezhad, M. (2012), "Cost Analysis of Fuzzy Queuing Systems," International Journal of Applied Operational Research, 2, 2, 25-36.

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