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Using Fuzzy Decision-Making in E-tourism Industry: A Case Study of Shiraz city E-tourism

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Abstract

In recent years, e-commerce has had great impacts on various industries by developing new approaches. Its benefits include faster and easier access to information and the possibility to coordinate for any task before attempting it. In the tourism sector, e-commerce is playing a great role to develop the industry and improve services. On the other hand, combining e-commerce technology with mathematics and the other basic sciences has provided special facilities for flexibility in complying human needs. These include the use of fuzzy knowledge in this technology. Tourism combined with fuzzy knowledge and e-commerce technology will create further expansion of this industry especially in better addressing customers' needs and tastes. The aim of this project is to introduce an electronic tourism system (e-tourism) based on fuzzy knowledge for the city of Shiraz, as a case study. This electronic system is in the form of a website, which tourists can use to find an appropriate accommodation by inputting data related to their interests and needs.

Keywords: *E-Tourism, Fuzzy, Decision-Making, Internet, Shiraz*

1. Introduction

The introduction of the internet in the early 1990s has changed the way of doing business in the tourism industry dramatically [1]. The Internet is already the primary source of tourist destination information for travelers [2]. Nowadays, most people who plan a trip or a day-out will first initiate a search through the internet. More and more people realize the advantages of the new technologies for planning leisure activities as an increasing number of companies and institutions offer tourist information which is easily accessible through web services [3]. The Internet has improved hotel reservation process and facilitated extensive services for online distribution and bookings, which are reliable, diverse and rapid. Hotels can develop their presence and partnership with distributors. Reservation through the Internet provides effective and efficient communication mechanism, particularly for their frequent customers [4].

Using efficient and helpful techniques to suggest better options to tourists will result in customer satisfaction, which in turn attracts tourists and promote tourism industry. There are many factors affecting tourists' decision making, but the main factor is to suggest options that better address customers' interests, needs and preferences. Various techniques have been developed to facilitate this task. Fuzzy logic improves classification and decision support systems by allowing the use of overlapping class definitions and improves the interpretability of the results by providing more insight into the classifier structure and decision making process [5]. In tourism, selecting suitable accommodation considering costs, facilities and distance to the tourists' destination are very important. Therefore, this project was a new attempt to use fuzzy knowledge and its inference method for e-tourism in Shiraz, providing an electronic system to suggest a list of accommodation to the tourists based on their interests and priorities.

2. Fuzzy decision-making structure

The overall structure of decision-making in a fuzzy environment is presented in figure 1.

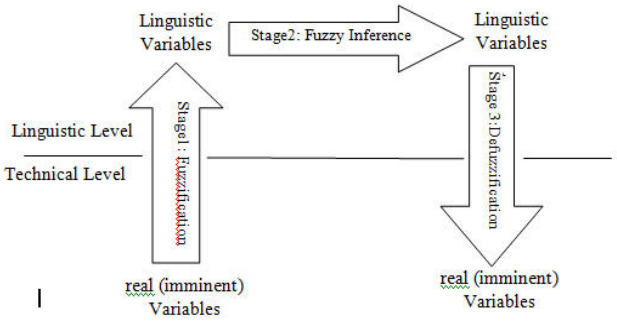

Fig. 1. Fuzzy Decision-making structure[6]

2-1. Step 1: Fuzzification

The first step in fuzzy decision-making process is making fuzzy real (imminent) variables, in which absolute variables are converted to linguistic variables. This step is called Fuzzification, since fuzzy sets are used to convert real (imminent) variables to fuzzy variables [6]. Fuzzy membership functions are needed for this purpose.

2-1-1. Chart and fuzzy membership functions

A fuzzy set is described by its membership functions. A more precise way to define a membership function is expressing it as a mathematical formula. Several different classes of membership parametric function are introduced, and in real world of fuzzy sets applications, membership function shapes usually are restricted to a definite class of functions that can clarify with few parameters [7]. Most famous shapes are Triangular, Trapezoidal and Gaussian shaped as shown in figure 2.

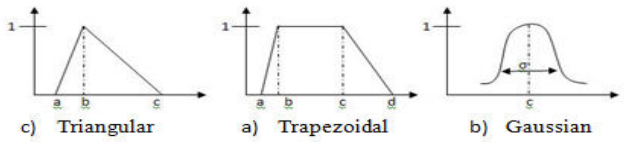

Fig. 2. Fuzzy Decision-making structure[6]

2-2. Step 2: Fuzzy inference

In this step, the behavior of a system is defined using a set of "if → then" rules. Result of this inference will be a linguistic value for a linguistic variable[6]. In the case study section, you can find more explanation about Fuzzy inference way.

2-3. Step 3: De-Fuzzification

In the third step (making definite), linguistic values will be changed to definite numbers in order to do decision-making [6].

3. Case Study

This is a case study on Shiraz e-tourism. The goal is to suggest the best accommodation to tourists, based on their preferences. The tourists enter their preferences for accommodation, including their budget, residence facilities and desired distance from sights of visit. System does the Fuzzification of tourists' desired values, including budget, facilities and distance to the spots, and then prioritizes the accommodations, using Fuzzy inference methods.

3-1.Tourist decision-making criteria (system input)

In decision models, criteria selection process is accomplished according to decision objectives [9, 10]. In this case study, the following factors are considered:

- Accommodation cost for one night in Shiraz, using fuzzy charts, are converted to linguistic values of "cheap", "moderate" and "expensive".
- Importance of each accommodation facilities. In this case study, we considered eight facilities. This criteria is converted to linguistic values of "low", "medium" and " high".
- Distance from historical sight in downtown Shiraz (origin: Arg-e Karimkhan)
- Distance from business center (origin: Setareh-Fars shopping center)
- Distance from cultural attractions (origin: Hafeziyeh)
- Distance from pilgrimage center (origin: Shah-Cheragh)
- Distance from academic center (origin: Shiraz University - Faculty of Engineering, building No. 1)

All of distances are converted to linguistic parameters of "far", "average" and "near," using the relations of fuzzy charts.

3-2.Data Collection

One of the required data for calculation in fuzzy decision-making is accommodations' price list, facilities and distance from the desired origin. Membership matrix is derived from these data and is kept for the next calculation. In this case study, all distances are calculated based on the newest map of Shiraz and in kilometers. Figure 3 shows the price of accommodations and distance from different spots in the website admin panel, where this information can be easily modified using related forms.

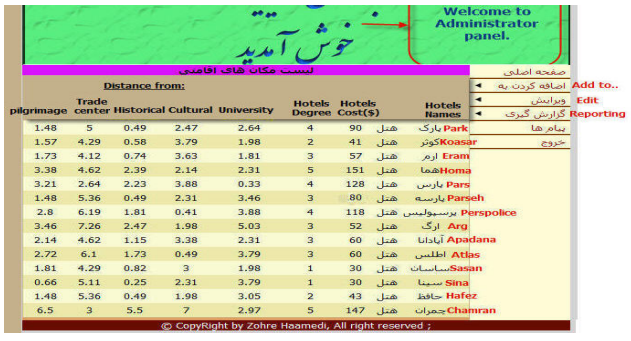

Fig. 3. Reporting of real hotels cost and their distances from different centers in admin panel of website

3-3. Fuzzy decision-making steps

3-3-1. Step 1: Data Fuzzification

As previously mentioned, in order to fuzzify data, membership functions and fuzzy charts are used. Boundary values of function can be managed by website administrator, and given values are just samples used for the purpose of this project and based on the current prices, distances and the researcher's interests.

3-3-1-1. Membership functions for Shiraz Case Study

In Shiraz case study, membership functions are considered as triangular. Triangular membership function formula for three different scales of linguistic variables are "low", "Average" and "high".

- Membership Function for linguistic variable: "Low" :

$$\mu_{cheap}(x) = \begin{cases} 1 & if \quad x = 0 \\ \frac{c-x}{c} & if \quad 0 \le x < c \\ 0 & if \quad x \ge c \end{cases} \qquad (1)$$

- Membership Function for linguistic variable: "Average" :

$$\mu_{Medium}(x) = \begin{cases} 0 & if \quad x \le a_m \\ \frac{x-a_m}{b_m-a_m} & if \quad a_m \le x \le b_m \\ \frac{c_m-x}{c_m-b_m} & if \quad b_m \le x \le c_m \\ 0 & if \quad x \ge c_m \end{cases} \qquad (2)$$

- Membership Function for linguistic variable: "High":

$$\mu_{Expensive}(x) = \begin{cases} 0 & if \quad x \le a_E \\ \frac{x-a_E}{b_E-a_E} & if \quad a_E \le x < b_E \\ 1 & if \quad x \ge b_E \end{cases} \qquad (3)$$

These membership functions are configured for different parameters of accommodation budget, distances, and facilities, with different bordering values. Figure 4, 5 and 6 show these functions, drawn in MatLab.

3-3-1-2.Shiraz tourism fuzzy charts

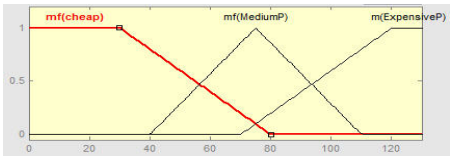

Fig 4: Membership function charts for 1 night stay in hotels.

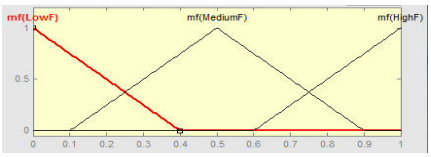

Fig 6: Membership function charts for hotels facilities

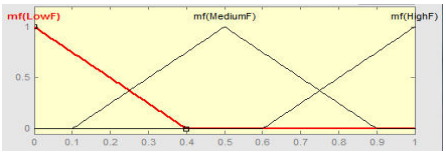

Fig 6: Membership function charts for hotels facilities

3-3-1-3. Tourist entry in the system

Tourist input form is shown blow. As you see in the form, criteria stated in Section 3-1 are entered as input by the tourists.

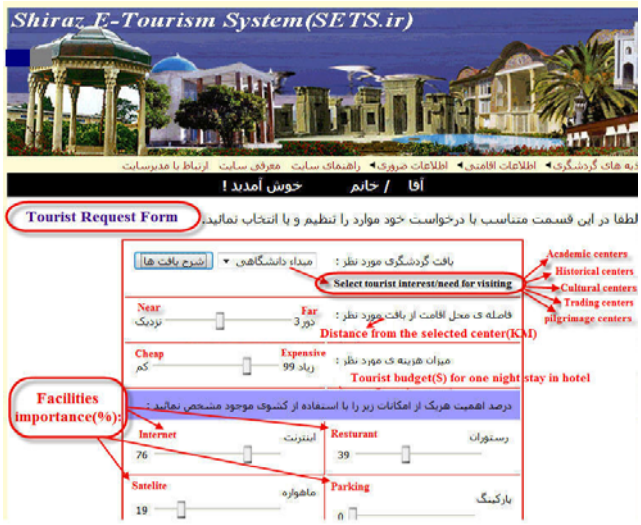

Fig. 7. Request form of tourist

To increase options for distance, at first users can choose from the categories of visiting spots including cultural, historical, pilgrimage, commercial or academic spots. Then, the users select distance from these spots. Minimum and maximum distance values and prices are adjusted by the website administrator. Users have to register to the website to be able to access to this information and follow their requests.

3-3-2. step 2: Fuzzy inference

In this step, the system should be able to suggest suitable accommodations to the users based on input values and tourist interests and priorities. In the usual fuzzy method,

at first it is needed to define a set of "if → then" rules, which are defined as follow in this research.

3-3-2-1. Fuzzy Rules

Fuzzy rules are defined and adjusted by the administrator or a skilled expert. Website software has the ability to create, modify or delete the conditions. Figure 8 shows a part of adjusted fuzzy conditions report in admin panel of the website.

Fig 8. Reporting of adjusted fuzzy conditions in admin panel of website

3-3-2-2. Inference Method 1: Min-Max or Max-Prod method

One way to compare two fuzzy sets is using the criteria of necessity and possibility. The possibility criteria of fuzzy set A in relation to fuzzy set B is defined as Pos (A, B), which is as follows:

$$Pos(A,B) = Max[\min(A(x), B(x))] \quad ,x \in X \qquad (4)$$

Criterion and measurement possibility shows the overlap amount of A and B [7]. So, using the fuzzy max-min or max-prod relation, fuzzy rules and tourist entry, we can obtain the priorities.

3-3-2-3. Inference Method2: Distance computing method

In addition to standard fuzzy method, we can use another method called "Euclidean distance" to compare the user's requests with existing accommodations and determine their priority. In this method, a three-dimensional space of cost-distance-facilities based on fuzzy values are considered and marked on each accommodation using distance, cost and facilities membership functions. The location of tourist entry is determined in this space, and then the distance of this point to each accommodation will be computed. The accommodations with less distance to user's request have more priority. The advantage of this method is independency to fuzzy rules as well as simplicity, and priority of all hotels will be computed. It should be noted that all three different parameters (cost, distance and facilities) must be changed to fuzzy-value and also normalized. In other words, fuzzification is required and since the number of decision criteria is more than one, we cannot apply it on non-fuzzy values.

In general, if A and B are from a world debate X, we can define the distance between A and B using Minkovsky rule as follows:

$$D(A,B) = \left\{\sum |A(x) - B(x)|^P\right\}^{1/P} \quad ,x \in X \qquad (5)$$

Considering $P \geq 1$ [7].

There are different states for P in applications. The best state that matches our problem is when P = 2, which is called "Euclidean distance".

3-3-3. Step 3: De-Fuzzification

It is clear that in system output, suggested accommodations are shown to the users. In addition, system can reply as an e-commercial system with fee.

Since the membership functions are not included in the output of fuzzy inference system in our case study, and the output is only a list of suggested accommodation, the output values are constant and no-fuzzy and then, our problem is from Fuzzy-Crisp type and hence there isn't the third step or de-fuzzification.

3-4. Comparing method 1 and 2

With a brief comparison between the methods of inference 1 and 2, they can be expressed as bellow:

1. Euclidean distance method determines priorities of all accommodations, while in Max-Prod or Max-Min method just the nearest accommodations are shown and the users have no idea about them unless select their features. But, in distance computing method, using a simple mathematical formula, the priority of all accommodations will be determined. On the other hand, providing priorities of all accommodations does not seem to be very interesting, especially when there are enormous accommodations, which makes users confused.

2. In standard fuzzy, when the numbers of decision-making factors increase, the number of fuzzy rule must be increased. For example, for three 3-state factors, a maximum of 81 rules are needed, and if the number of

factors increases, the number of fuzzy rules will be much more. However, according to skilled experts' opinion, many of these rules may not be used, but the rules will increase and need to be analyzed.

3. Computational complexity of the method of calculating the distance is much less than the standard method.

4. In terms of development capability and generalization, if the number of factors increases, calculating the distance method will be quite responsive and easy and just by putting in a formula, priorities will be determined. But, if we want to generalize the users' input values on an interval, then Max-Min or Max-Prod method has more capability and flexibility.

Conclusion

In this research, as a new work, we tried to apply fuzzy decision-making in e-tourism industry and in order to increase research integrity, we focused on Shiraz city. Our goal was to find a simple and applicable way. So, we used two methods; one of them is the usual method for fuzzy decision-making, and the other is Euclidean distance method, which is very simple in calculation. After inspecting both methods, we selected the usual method as the main method of fuzzy inference in our website. Distance method also can present a complete list of all accommodations and their priorities to the users. The most important result in this research is providing a system of e-tourism in which tourists can enter their interests and needs without conflicting binary systems and receive an appropriate suggestion to plan their traveling to Shiraz. The results of this research show that in an e-tourism system using fuzzy decision-making is more efficient.

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