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Intelligent System to Support Judgmental Business Forecasting: The Case of Unconstraint Hotel Room Demand in Hotel Advisory System

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Abstract: ***In this paper, we describe the research and development of a fuzzy expert system for hotel selection. A prototype system, called hotel advisory system (HAS), has been designed and developed to assist tourists in conducting hotel selection using fuzzy logic. HAS is implemented on personal computers under a Java platform environment. To evaluate the performance of HAS, selected practitioners in the Tamil Nadu hotel industry and potential users from twelve nations were invited to participate in testing the system. The potential users and hotel experts rated highly on the effectiveness and the usability of the system. The results of the prototype evaluation were satisfactory and support the contention that HAS performs its functions as expected. The viability of HAS as an effective procedure for hotel selection has been ascertained by the positive feedback obtained from the survey questionnaires. Using HAS makes hotel selection simple because it can incorporate the linguistic terms which are normally produced by tourists.***

Keywords: Fuzzy expert system, Forecasting, Hotel Industry, Economic revenue management system, Fuzzy logic, Holt-Winter approach

1. Introduction

Among the fastest growing service industries in Tamil Nadu are international tourism and the hospitality industry which have grown dramatically. In fact, it is projected that international tourism will be one of the service-led economies of the 21st Century [1]. Tamil Nadu is one of the world's major hotel-owning/hotel-operating centres and the hotel industry is a very important sector in Tamil Nadu's economy. According to a Tamil Nadu Tourist Association (TNTA) Research Publication [2], there were 90 TNTA member hotels in Tamil Nadu in 2010, providing a total of 35,999 rooms. On average, accommodation-related services account for 26% of the total expenditure by a visitor to Tamil Nadu.

It is always important for tourists to select hotels which suit their needs. For some visitors to Tamil Nadu, identifying a satisfactory hotel is a time-consuming and difficult task, as the factors affecting hotel selection require rather personal judgments. In this paper, a fuzzy expert system, named hotel advisory system (HAS) has been designed and developed to facilitate hotel selection. By using HAS, which incorporates linguistic terms normally used by tourists, hotel selection is made simple. HAS also improves operations, reduces the cost of enquiries, and provides information very quickly. We believe that HAS cannot only help the Tamil Nadu tourism industry, but also the approach and methodology may be applied to overseas context.

The paper is organized as follows. In Section 2, we present a brief review of the literature on applications of artificial intelligence (AI)/expert system (ES) technology in tourism and hospitality. Section 3 describes the development of HAS based on the 11-stage proposed system development approach for fuzzy expert systems. Section 4 concludes the paper and discusses further enhancements of HAS.

2. Literature Review

Many published studies focus on applications of AI/ES technology which support the hotel and tourism domain in such areas as room rental, hospitality management, concierge service, and guided tour scheduling. McCool [3] discussed some considerations necessary for developing expert systems for the hospitality industry. Nissan [4] introduced three expert systems which were applied to the domains of real estate, room rental and hospitality management. An expert system for forecasting menu items in a foodservice operation was developed by Sanchez et al. [5]. Cho et al. [6] argued that hotels could improve their concierge service, both human and electronic, by developing an electronic system that makes use of expert system technology. Cho's system itself engaged hotel guests in an on-screen dialogue to help them find information about hotel services and other attractions in the area. The experience gained in the development of an expert system called an expert system for tour advisory (ANESTA), which could act as a tourist information station for generating self-guided tour schedules as well as providing detailed transportation information was reported by Low et al. [7]. Sterling et al. [8] described lessons learned through the sequential construction of four expert systems for menu planning. They have shown how to represent common sense knowledge about food and menus in a form amenable to successful menu planning. The design and development of an expert system for a tourist information center was outlined by Tsang et al. [9]. The expert system was built to recommend a suitable travel schedule that satisfies user input constraints such as time period, budget and individual preferences. Yeung et al. [10] discussed the implementation on the Internet of a multi-agent based tourism industry. The system allowed the users to retrieve the most up-to-date information about Tamil Nadu through a web browser. The complete system consists of a set of software agents which handle various information categories, such as hotels, shopping centres, and cinemas.

Law and Au [11] proposed using expert system technology to assist tourists in locating the most suitable hotel to meet their needs.

These writers presented a revision of the knowledge representation technique and expanded the knowledge base of an expert system for hotel selections in Tamil Nadu . Some other potential applications of expert systems in tourism can be found in Moutinho et al. [12].

Fuzzy logic has proved useful for developing many practical applications, especially in the field of engineering, as it can handle inexact and vague information. Even though an abundance of research in fuzzy logic has been conducted in the past, relatively little attention has been paid to applications of fuzzy logic technology in hotel/tourism-related industries. Petrovic-Lazarevic and Wong [13] underlined the significance of an application of fuzzy control in the hospitality industry in order to achieve or sustain competitive advantage. They applied general fuzzy control model in the hospitality industry to monitor and control the level of service quality provided. Ghalia and Wang [14] proposed an intelligent system using fuzzy logic to estimate the future hotel room demand. However, the applications of fuzzy logic in hotel selection research are almost non-existent based on the results of a literature review conducted by the authors.

This paper describes the development of a fuzzy expert system named HAS, that can be used effectively to assist in hotel selection. Fuzzy expert systems have found widespread use in engineering, particularly in control systems. The advantages of these systems over conventional production rule-based expert systems may be characterized as follows [15 and 16]: (a) fuzzy sets neatly symbolize natural language terms used by experts; (b) since the expert knowledge captured in "IF... THEN" statements is often not naturally true or false, fuzzy sets afford representation of the knowledge in a smaller number of rules; and (c) smooth mapping can be obtained between input and output data.

3. Development of Hotel Advisory System (HAS)

Fuzzy expert system is an expert system that uses fuzzy logic instead of Boolean logic. It can be seen as special rule-based systems that use fuzzy logic in their knowledge base and derive conclusions from user inputs and fuzzy inference process [17] while fuzzy rules and the membership functions make up the knowledge base of the system. The goal of a fuzzy expert system is to take in subjective, partially true facts that are randomly distributed over a sample space, and build a knowledge-based expert system that will apply to them certain reasoning and aggregation strategies to produce useful decisions [15]. The purpose of this research is to design and develop a fuzzy expert system which can achieve the goals of operational effectiveness and ease-of-use in facilitating the selection of hotels. A prototype system, HAS, has been developed with a view to assisting tourists in selecting hotels to suit their needs. In this section, the development methodology of the system is presented. The overview of the framework is shown in Fig.

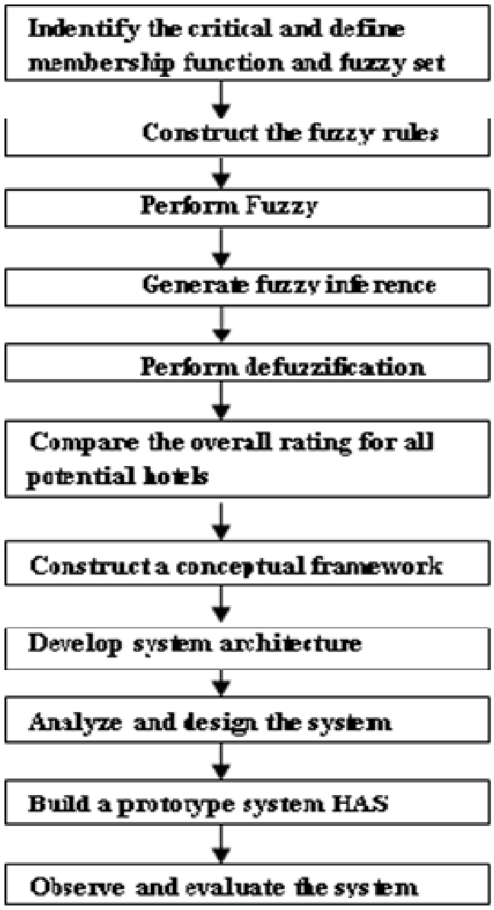

Figure 1: System development methodology for HAS

Essentially, there are 11 fundamental phases in the development of a fuzzy expert system that consist of a combination of the fuzzy inference process and the five-stage development methodology [18]. In this study, the fuzzy inference process proceeds in six steps that is a common procedure for fuzzy inference which can be demonstrated in several past studies [13, 19 and 20]. The choice of this approach to HAS development is based on our prior experience and lessons learnt from the development of several knowledge based systems such as [21 and 22]. It is easy to apply and will provide valuable guidance for developing the proposed system. Eleven phases in the development are outlined in Figure 1.

With reference to Table 1 above, phases 1–6 (fuzzy inference processing) are designed to reach a crisp solution to any problem involving a crisp-to-fuzzy transformation ("fuzzification"), an inference mechanism that applies fuzzy rules, and a fuzzy-to-crisp transformation ("defuzzification"). Phases 7–11 are used to construct HAS following the Nunamaker et al. [18] five-stage methodology for information system development.

The detailed description of these phases is as follows:

Phase 1: Identify the critical factors and define membership functions and fuzzy sets.
The first phase involved the compilation of a list of critical factors based on a literature review and in depth interviews with tourists and hotel practitioners. According to Chu and Choi [23] and a survey conducting by Tamil Nadu Tourism

Board [24], room rate, recreational facilities, and hotel food and beverage facilities are the importance factors for hotel selection. The "Location" of the hotel is not included as a critical factor because Tamil Nadu is a compact city. With the implementation of major mass transit and highway links (West Rail, MTR lines, Route 3, East Rail Ma On Shan Extension, etc.) and the new Tamil Nadu International Airport at Chek Lap Kok nodal areas are created within new networks, so that all hotels are easily accessible. However, HAS still reserve a location selection for tourist to select their accommodation place. Finally, we have identified three factors which are critical in the selection of Tamil Nadu hotels: (1) price; (2) facilities; and (3) food type for fuzzy selection.

The data displayed in databases was based on information obtained from the literature [2 and 25] and from in depth interviews with twenty potential users (tourists) and 10 hotel practitioners. These data serve as guidelines for selecting hotels. We assume that the decision-makers (the tourists) can assign ratings to different hotels under different selection criteria using common linguistic terms, for example, "cheap", "moderate" and "expensive" as these are the linguistic terms used as criteria for "Hotel Price" and "few", "some" and "many" are the criteria used to denote "Hotel Facilities". Each linguistic term is defined by a membership function which helps to take the crisp input values and transform them into degrees of membership. The most commonly used membership function has three types: bell-shaped, triangle-shaped and trapezoid-shaped. In the present study, we assume the input and output fuzzy numbers are triangular forms and these forms approximate human thought processes. Triangular membership functions have been used to define the fuzzy sets for the linguistic values of "Hotel Price", "Hotel Facilities" and "Hotel Food Type". The same triangular membership functions have been defined for "Wanted Price", "Wanted Facilities" and "Wanted Food Type". The membership functions of "Price Matching". "Price Matching" indicates the degree of matching in price between "Hotel Price" and the customer's "Wanted Price". It takes "low", "medium" and "expensive" as its linguistic terms. The same approach is used to define "Facilities Matching" and "Food Matching". The definition of fuzzy sets is based on the information provided by the "Official Hotel Guide" published by the Tamil Nadu Tourist Association [25].

Phase* 2: *Construct the fuzzy rules

Fuzzy expert systems make decisions and generate output values based on knowledge provided by the designer in the form of IF ⟨condition⟩ THEN ⟨action⟩ rules. The rule base specifies qualitatively how the output parameter "Overall Rating" of the hotel is determined for various instances of the input parameters of "Price", "Facilities" and "Food Type".

Phase* 3: *Perform fuzzification

Fuzzification refers to the process of taking a crisp input value and transforming it into the degree required by the terms. The "fuzzified" values are determined by intersecting the input value to the fuzzy set associated with each linguistic label. For instance, an input value of "Hotel Price" HK$2050 results in a degree of membership in the set labeled "moderate" of 0.8726 and a degree of membership in the set labeled "expensive" of 0.1274 (see in Database “price” table).

Phase* 4: *Generate fuzzy inference

Fuzzy inference is guided by the fuzzy rules. The standard max–min inference algorithm was used in the fuzzy inference process, as it is a commonly used fuzzy inference strategy. In the max–min composition fuzzy inference method, the min operation is used for the AND conjunction (set intersection) and the max operation is used for the OR disjunction (set union) in order to evaluate the grade of membership of the antecedent clause in each rule. For example, assume a hotel's room rate (hotel price) is equal to HK$2050. Suppose fuzzification for the variable "Hotel Price" produces a 0.8726 degree of membership in the set "moderate" and 0.1274 degree of membership in the set "expensive". Assume a tourist wants a price of $1400 and fuzzification for the variable "Wanted Price" produces a 0.2867 of membership in the set "cheap" and a 0.7133 degree of membership in the set "moderate", then:

Rule 1: IF "Wanted Price" is *cheap* AND "Hotel Price" is *moderate*
THEN "Price Matching" is *medium*
EVALUATION: min (0.2867, 0.8726)= 0.2867 "Price Matching" is *medium*

Rule 2: IF "Wanted Price" is *cheap* AND "Hotel Price" is *expensive*
THEN "Price Matching" is *low*
EVALUATION: min (0.2867, 0.1274)=0.1274 "Price Matching" is *low*

Rule 3: IF "Wanted Price" is *moderate* AND "Hotel Price" is *moderate*
THEN "Price Matching" is *high*
EVALUATION: min (0.7133, 0.8726)=0.7133 "Price Matching" is *high*

Rule 4: IF "Wanted Price" is *moderate* AND "Hotel Price" is *expensive*
THEN "Price Matching" is *medium*
EVALUATION: min (0.7133,0.1274)=0.1274 "Price Matching" is *medium*

Since Rules 1 and 4 have the same consequent label *medium*, the max operation is used to resolve conflicts. As a result, the value 0.2867 is used to "clip" the *medium* "Price Matching" output membership function shape. Similarly, the value 0.1274 is used to "clip" the "Price Matching" output membership function shape for *low* and the value 0.7133 is used to "clip" the "Price Matching" output membership function shape for *high*. This is databases demonstrated in “price” table. The clipped membership functions resulting from the application of nine rules are then merged to produce one final fuzzy set. The max operation is used to merge overlapping regions.

Phase* 5: *Perform defuzzification

When the inference process is complete, the resulting data for each output of the fuzzy classification system are a collection of fuzzy sets or a single, aggregate fuzzy set. The process of computing a single number that best represents the outcome of the fuzzy set evaluation is called defuzzification. There are several existing methods that can be used for defuzzification. These include the methods of maximum or the average heights methods, and others. These methods tend to jump erratically on widely non-contiguous and non-monotonic input values [26]. We chose the centroid method, also referred to as the "center-of-gravity (COG)" method, as it is frequently used and appears to provide a consistent and well-balanced approach.

Phase* 6: *Compare the overall rating for all potential hotels

The overall ratings for all potential hotels are obtained by passing measures of their initial factors and weightings through the proposed fuzzy logic model. The final score is calculated in defuzzification. The system finally ranks all hotels (88 hotels) according to their final scores (COG) and displays them in descending order.

Phase* 7: *Construct a conceptual framework

HAS was structured to consist of three levels of modules, comprising a fuzzy hotel search module, a hotel detail information module and a hotel virtual visit module.

(1) The fuzzy hotel search module uses the concept of fuzzy logic to select a suitable hotel for a tourist according to their specified searching criteria and the relative importance of the criteria expressed in linguistic terms. The result of the search provides the tourist with a list of recommended hotels.

(2) *The hotel detail information module* provides detailed hotel information such as the address, telephone/fax number, available facilities, food type, map of the hotel, and URL address of the hotel.

(3) ***The hotel virtual visit module*** provides a virtual visit to each selected hotel based on the results of the fuzzy search described above, before the tourist makes a reservation.

Phase* 8: *Develop system architecture

(1) Good system architecture provides a road map for the system building process, by putting the system components into perspective, defining the functionalities of the system components, and demonstrating how they interact with one another [18]. Based on the conceptual framework discussed in ***Phase* 7** and our interview with hotel experts and potential users, we have developed the following architecture of HAS, which includes five main components: **(1) a user interface, (2) a database, (3) a fuzzy rule base, (4) a fuzzy inference engine, and (5) a membership function base.**

(i) ***User interface***: The interface which enables communication between users and HAS is carried out mainly in menus and graphics supplemented by natural language. The interface of the system allows the user to specify the searching criteria for the hotel and to weight the importance of the criteria.

(ii) When a parameter item is selected, the crisp input value is translated into the fuzzy term. The user can define the relative importance of each criterion directly from the menu by choosing the buttons. Through the window interface, therefore a combination of the following modifications can be performed: (a) supply of a new parameter value and (b) modification of the importance (weight) associated with a certain parameter. The hotels recommended are communicated as outputs to the user through the user interface.

(iii) ***Database***: Mysql database is used to support the database subsystem which maintains the necessary information on each hotel. The data are extracted from internal and external data sources [2, 25 and 27].

(iv) ***Fuzzy rule base***: The fuzzy rule base which is a mechanism for storing fuzzy rules as expert knowledge is based on membership functions.

(v) ***Fuzzy inference engine***: This is a core part of the HAS engine that executes the inference cycle of fuzzy matching, fuzzy conflict co-coordinating and fuzzy rule-firing according to given facts.

(vi) ***Membership function base***: The membership function base is a mechanism that presents the membership functions of different linguistic terms.

When the user inputs parameters through the user interface, the fuzzy inference engine performs according to the fuzzy rules and membership functions, using data from the database, and sends fuzzy or crisp results through the user interface to the user as outputs.

Phase* 9: *Analyze and design the system

Analysis and design are important parts of a system development process. Design involves an understanding of the domain being studied, the application of various alternatives, and the synthesis and evaluation of proposed alternative solutions. Design specifications are used as a blueprint for the implementation of the system [18]. Almost no work has been done researching the design of a fuzzy expert system for hotel selection. In order to begin the process and to determine user needs, we interviewed 20 tourists and 10 hotel practitioners in our study. The first step in the system design process was to decide how the functions of the HAS will be performed. This initial phase considered the design of data structures, database, user interface, and final output.

Phase* 10: *Build a prototype system

The procedure of building a prototype system has been widely used in software engineering research [18] because basic inherent problems emerge at an early stage and can be addressed promptly. In addition new concepts of user interface design can be evaluated and the developers gain insights into the application area and into the users' work tasks and the problems they face. The prototype system, HAS, was developed according to the above conceptual framework. It was written using JDK1.**5** and ran on a personal computer under a Microsoft Windows environment. Microsoft Windows was selected for use as the operating system because of its current popularity. A thorough review of the available software was conducted prior to the final selection of JDK1.5 as a programming tool for the prototype. JDK1.5 for Windows was chosen because it is an easy-to-learn and easy-to-use graphical user interface (GUI) programming language which allows rapid prototype development. The software and hardware requirements for HAS are as follows:

(i) *Hardware*

• A Pentium PC, 16 Mbytes RAM and 500 Mbytes for hard disk
• A LED monitor with 1024×600 resolution

(ii) *Software*

• Microsoft Windows
• JDK1.5 or above
• Microsoft Internet Explorer ™ 5.0 or above
• Mysql5.1.4.2 or above

Phase* 11: *Observe and evaluate the system

Once the prototype system is built, testing and evaluation of the prototype system can be performed. Researchers can capture information on what users like and dislike and what the system does and does not do to meet their needs. The following subsections focus on the process adopted in the evaluation of the proposed fuzzy expert system.

System validation: This concerns system evaluation by implementers and domain experts. All the modules of the HAS were tested for accuracy and completeness by the development team during system development and debugged by hotel practitioners, who had not been involved in system development, as they were written. We believe that HAS should be able to meet the real needs of the users by helping them in finding a suitable hotel. The algorithms were tested, and these tests produced answers that were operationally realistic or meaningful [28].

Outcome evaluation: The evaluation objective is to assess the overall value of a fuzzy expert system [29]. Outcome evaluation consists of two phases; the first phase is potential user evaluation. The second evaluation is domain expert evaluation. The outcome evaluation of the prototype is described below:

(1) *Potential users*' (*Tourists*') *evaluation*

Evaluations by users help to determine the utility of the system according to the following criteria: (a) its ease of interaction, (b) the extent of its capabilities, (c) its efficiency and speed, (d) its reliability and whether it produces useful results [30]. We randomly selected a total of 85 potential users, coming from 12 nations, who had just arrived at the Tamil Nadu (Raju Gandhi) International Airport during the period of 15–20 May 2013, and they agreed to participate in the evaluation. At the evaluation session, the system prototype was demonstrated and feedback was solicited through discussion and a formal questionnaire.

(2) *Hotel experts' evaluation*

Evaluations by domain experts help to determine the accuracy of the embedded knowledge [30], and the consistency and completeness of responses. The system was evaluated by two academics and 5 part-time bachelor degree students, in Hotel and Catering Management at SRM University. These students are hotel practitioners with an average of 4 years of experience in the hotel industry.

Consolidate and compare the outcome evaluation. Consolidation and comparison of outcome evaluation can be achieved through a questionnaire survey. An open-ended questionnaire is analogous to an interview in that it gives respondents an opportunity to say what they want. It is designed to obtain verbal comments from the subject with a request for examples to support each item discussed. We particularly wanted the potential users to tell us what they considered to be the strengths and weaknesses of the prototype system, and how it should be improved. A formal questionnaire containing both closed and open-ended questions was designed and consisted of three sections: (a) demographic data, (b) the effectiveness of the prototype system, and (c) the usability of the prototype system. The potential users were asked to use five-point scales (1=stronglydisagree, 3=undecided, 5=stronglyagree) to rate the following two main aspects of the prototype system: (i) its effectiveness and (ii) its usability.

The results of the analysis of the questionnaire are shown in Table 2. The potential users and hotel experts rated the system highly on the above two aspects with a mean score of at least 3.7 on a five-point scale with ratings of 5 being ‘strongly agree’, 3 being ‘undecided’ and 1 being ‘strongly disagree’. The prototype is seen to be a promising system for supporting the selection of hotels based on the positive results of its evaluation. In addition, the viability of HAS as an effective procedure for hotel selection has been ascertained by the positive feedback obtained from the questionnaires.

Table 1: Mean responses to the system evaluation by hotel practitioners/experts and potential users

Question		Hotel practioners/experts n = 25		Potential users n = 85	
		Mean rating 1–5 scale[a]	S.D.	Mean rating 1–5 scale[a]	S.D.
	Effectiveness of the system				
1.	Helps in selecting suitable hotels	4.1	0.7	3.9	0.9
2.	Provides clear information for selected hotels	3.9	0.8	3.8	1.0
3.	Provides new insight in selecting suitable hotels	4.0	0.8	3.9	1.0
	Usability of the system				
4.	System is easy to use	4.3	0.9	4.2	0.9
5.	System is user friendly	4.2	0.8	4.0	0.9
6.	Screen display is well designed	3.5	0.9	3.8	0.7
7.	Achieves the stated objective	3.7	0.8	3.9	0.8
8.	Response time in the system is acceptable	3.8	0.7	3.7	0.9
9.	System contains functions which user requires	3.7	0.7	3.8	0.8
10.	System's commands are self-explanatory and easy to understand	3.8	0.6	3.7	0.7
11.	Likely to recommend to other users	4.1	0.7	4.0	0.8

Further analysis was conducted to investigate whether there is a difference between hotel practitioners and potential users in the mean ratings of effectiveness and usability of the prototype in the prototype evaluation. The non-parametric Wilcoxon signed-rank tests were used to examine the difference between hotel practitioners and potential users in the mean rating of effectiveness and usability of the prototype; as the survey data are in an ordinal scale, non-parametric tests are more appropriate for testing the hypotheses. The difference between hotel practitioners and potential users in the mean ratings of effectiveness and usability of the prototype was found to be not significant (for effectiveness, Z-score=−1.6036, P-value=0.1088; for usability, Z-score=−1.8593, P-value=0.0630). We concluded that there were no significant differences between hotel practitioners and potential users in the mean ratings of effectiveness and usability of the prototype at a 0.05 level of significance.

4. Illustrative Example of Using the HAS

In the following section, some examples of a dialogue between a user (a tourist) and the prototype, HAS are shown.

Annotations are added to give a deeper insight into the operation of HAS.

To start the session of "fuzzy hotel search", the user can specify the searching criteria, for example "Price", "Facilities" and "Food Type" of the hotel by adjusting the slider accordingly. The user can proceed to define the importance of the selected criteria by stating the weighting either as "most important", "important" or "less important". One example of a selection is for "Price" "expensive", for Facilities "some" and for "Food Type" "less". The importance of criteria as "most important" for "Price", "important" for "Facilities" and "less important" for "Food Type".

5. Conclusion

This paper has described the development of a fuzzy expert system, HAS, which is used to assist tourists by facilitating hotel selection. By developing and deploying HAS, we have shown that it is a feasible procedure to use fuzzy logic to assist with hotel selection. HAS provides the best match between the customer's requirements and available hotel services and facilities. A system evaluation was performed using expert validation, prototype testing and outcome evaluation to see whether HAS achieved its designed purpose and functioned properly. The results of the prototype evaluation are satisfactory and support the view that HAS has performed its functions as expected. The feedback and comments collected from respondents have been used to make necessary adjustments to HAS to satisfy potential users' needs. The results of the questionnaires evaluation feedback strongly support the position that HAS has achieved the primary objectives of being easy to use and able to enhance efficiency and effectiveness in supporting hotel selection using fuzzy logic. We believe that experience and design expertise gained from building HAS can be generalized so that this expertise can be used in other situations. Based on the feedback from the potential users and experts, the following improvements to the prototype system are intended and will be added to a later version of HAS:

HAS is implemented in a stand-alone manner. An Internet version of the client program using the Java networking language is in progress. A multi-language (Chinese, Japanese, French) function will be incorporated in the user-interface.

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