A Framework of Web Based Fuzzy Expert System for Managing Tourism Information

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Abstract

The extensive use of the Internet and the web applications has made it necessary for individuals and organizations to showcase their products and services on the web with the view of gaining global acknowledgement and acceptance. Therefore the beauty of a society in terms of culture, arts and various natural and man-made objects need not be hidden but be exposed to the world for appreciation and visitation. In this paper, web technology is applied to present tourism information with the objective of welcoming tourists into a community. The tourism information focus on arts, culture, recreational and hospitality centers, hotels, natural and artificial objects that are available in a community. The tourism information used in this paper is peculiar to the Nigerian communities and they are managed by the Ministry of Culture, Tourism and National Orientation. The existing manual and mechanical methods used for data and information management in the ministry were studied and adjudged to exhibit some pitfalls. Though the ministry has a website (http://guide.onlinenigeria.com/linkdetail.aspx?id=155) but this site is not equipped with information and also not dynamic. Thus the ministry and the various Tourism Boards under it need a user friendly web based application to store, update, process and present data and information as required by the users. The proposed system carries out an online and real-time stepwise process and presentation of tourism data and information. It also carries out data filtering by applying cognitive and emotional elements. Fuzzy rules are applied to make inferences and useful reports are generated to assist management in decision making. This framework is believed to serve as a tool for the tourists, and other stakeholders in the tourism sector.

Keywords*: Tourism, Fuzzy Expert System, Fuzzy Rules, Knowledge-base, Rulebase, Web Based*

1. Introduction

Tourism business is an information based business that makes use of both structured and unstructured information. It showcases the culture and arts of a community. It informs interested tourists about the resources and potentials of tourist industry, the claim to those resources and the effect of tourist transactions, events and circumstances thereon. Provision of tourism information helps both present and future tourists and other stakeholders in tourism business to determine the impact of tourism and hospitality firms in the society [22].

Tourism industry is identified as one sector that is characterized by the proliferation of small businesses that plays significant role in business development in most developing countries [27], [29]. It is becoming a big industry in the world, which employs people worldwide and is contributing to the world's Gross Domestic Product (GDP).

The increasing development and commercialization of Information and Communications Technology (ICT) for the travel and tourism industries has necessitated tourism and hospitality firms and other various enterprises to adopt this technology. A number of studies have been done to justify this. In [26] a study of hotel information technology with the view of applying Information

Technology (IT) in the hotel industry was carried out. The authors carried out in-dept interview in which hotel managers were interviewed to get their view on the dimension of IT application in their hotel properties. Their findings showed that IT has been used to replace the existing paper based tourism system and also helps to improve customers' services. The authors in [20] investigated the degree to which IT had penetrated the Australian hotel industry as well as to obtain a better understanding of the perception held by management with regard to impact of technology on service and customer loyalty. This was achieved by administering questionnaires comprising of open-ended and close-ended questions. Their results reflected that whilst a lot of the participating hotels recognize that IT contributes to a wide range of services offered by any firm, IT was not properly recognized as a multifunctional tool that can support almost every business activity for example marketing and human resources management.. In [28] a study was carried out on ICT adoption propensity of hotels in Thailand with the aim of exploring ICT-based facilities by hotels in the hospitality sector. The factors considered by the authors were the size of the firm; firm attitude towards innovativeness; ability to evaluate, accept and use the new technologies. They administered some questionnaires directly to the executives of the hotels in Thailand. The results of their analysis showed that the size of the firm had an influence on the adoption propensity of the hotel, also hotel class was found to have a positive impact on propensity to adopt ICT. Moreover the age of the hotel had a high negative impact on a hotel's attitude to adopt ICT. Their finding also showed that hotel occupancy had a high negative impact on a hotel's indication to adopt newer ICT. The study further indicated that hotels that were more inclined to adopt ICT were those that: cater mostly to client who hail from developed countries with a high internet penetration; were located in destination where the occupancy rate is generally low; were of high grade; had a wide scope of activities; and were not very old. Thus the application of IT in the tourism and hospitality sector is making good impacts. It is implied from these studies that tourism expert systems have been attempting to find ways of managing and presenting timely, relevant and sufficient tourism information for proper decision making by the stakeholders in tourism and hospitality industry.

To further increase the access to tourism information, web technologies are applied. For example [5] applied web technology to provide comprehensive information and service packages giving details of all the business activities of Lannentive hotels. Thus the use of Internet offers small and medium-sized hospitality organization a chance to improve their competition position in relation to their larger counterparts by giving them representation in the global market places; promote and distribute their own services; and keep their doors open always at minimal cost to customers all over the world. In [15], a case-based reasoning approach was developed to help the tourist plan his travel by identifying similar cases. The system interacts with the tourists, learns their preferences and responds with targeted personalized recommendations which are based on an underlying knowledge base. Also in [4], semantic web technology was applied to tourism information system with the view of providing mechanism for linking tourism data and ensure rich query operations that also enables applications for commerce and communications. An approach integrating Geographical Information System (GIS) data and tourism data on web is presented in [12]. This approach enables many people to share tourism data by dynamically generating interactive tourism maps that offer user friendly access to tourism data.

The management of tourism information is often complex and time consuming for tourists and tourism experts [15]. It involves a state space search of tourism and hospitality knowledge, which become cumbersome when the variables involved are numerous. The knowledge can be structured and unstructured. The various expert systems proposed so far are able to acquire, represent and utilize the knowledge available. However the problem of representing and managing unstructured or imprecise tourism information still exists. In [2], a knowledge based system was proposed to manage information relating to national tourism. This excludes the information on national arts and culture, moreover the system is not web based. Thus we are proposing in this paper a web based system that will be capable of managing data and information relating to national culture, arts and tourism and also enable tourists all over the world to have access to this

information using the Internet technology. Also the concept of fuzzy logic is applied with the view of enabling the proposed expert system to posses the following strengths:

a. Mimics human decision to handle vague concepts
b. Manage and process imprecise or imperfect information
c. Resolves conflicts by collaboration, propagation and aggregation
d. Improves knowledge representation and uncertainty reasoning

This framework is developed using the following tools: Macromedia Dreamweaver, Active Server page (ASP), Internet Information System (IIS), and Microsoft Access.

Section 2 presents an overview of fuzzy expert system. In section 3, the conceptual model of the proposed system is presented and Section 4 concludes the paper.

2. Fuzzy Expert Systems

The concept of Fuzzy Logic (FL) was conceived by [33] as a way of processing data by allowing partial set membership rather than crisp set membership or non-membership. FL provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. FL does not require precise inputs, is inherently robust, and can process any reasonable number of inputs and numerous outputs can be generated, though system complexity increases rapidly with more inputs and outputs. Simple, plain-language IF X AND Y THEN Z rules are used to describe the desired system response in terms of linguistic variables rather than mathematical formulas, which makes FL work closely to the way human reasoning does. Just as the classical logic forms the basis of conventional expert systems, fuzzy logic forms the basis of fuzzy expert systems [16]. Besides dealing with uncertainty, fuzzy expert systems model commonsense reasoning, which is difficult in conventional systems that model mainly exact reasoning. Fuzzy logic is related to approximate reasoning in the same way that two-valued logic is related to precise reasoning.

Fuzzy expert system (FES) can be thought of as a special kind of expert system that is incorporated with fuzzy sets [33]. FES exhibits transparency to users due to its utilization of "if-then" format used in natural languages. In a FES, a knowledge base is used for a reasoning purpose as well as in decision making process: a combination phase and a projection phase [1]. There are four different methods of fuzzy rules inference. These are *max-min* operation [34],[11],[16], *max-product* inference [16], *sum-dot* method [23], and *drastic product* operation [23]. The *max-min* operation is based on choosing a *min* operator for the conjunction in the premise of the rule as well as for the implication function and the *max* operator for the aggregation. The *max-product* (*max-dot*) method is characterized by scaling (product). It scales each member function to fit under its respective peak value and takes the horizontal coordinate of the "fuzzy" centroid of the composite area under the function(s) as the output. The *max-min* is described as an adopted method in this study.

If A is a fuzzy subset of a numerical set X with membership function $\mu_A(x)$, and K is a fuzzy relation on the Cartesian product of X with a numerical set Y, then

$B=R \circ A$

is a fuzzy subset of Y with membership function:

$$\mu_B(y) = \overbrace{\max_x}^{aggregation} [\underbrace{\min_x}_{implication} (\mu_A(x), \mu_R(x,y))]$$

This is the *max-min* composition of R with A. In a simple case of two items of evidence per rule,

IF E_{11} AND E_{12} THEN H_1
IF E_{21} AND E_{22} THEN H_2
:
.
IF E_{N1} AND E_{N2} THEN H_N

Therefore, the *max-min* compositional inference rule is:

$$\mu_H = \max [\min (\mu_{E_{11}}, \mu_{E_{12}}), \min (\mu_{E_{21}}, \mu_{E_{22}}), \ldots \min (\mu_{E_{N1}}, \mu_{E_{N2}})]$$

with similar extensions for additional evidence E_{i3}, E_{i4}, etc.

The defuzzification interface is a mapping from a space of fuzzy actions defined over an output universe of disclosure into a space of non-fuzzy actions. This is due to the fact that the output from the inference engine is usually a fuzzy set, while for most real life applications, crisp values are often required. The three common defuzzification techniques are: *max-criterion*, *center-of-gravity* and the *mean of maxima*. The max criterion is the simplest to implement. It produces the point at which the possibility distribution of the action reaches a maximum value [1]. The center of gravity (COG) is an averaging technique. The difference is that the (point) masses are replaced by the membership values. This method is called the center of area defuzzification method in the case of 1-dimensional fuzzy sets. In a continuous form, COG is defined by:

$$\mathrm{COG}(\mathrm{B}^o) = \frac{\int_Y \mu_{\mathrm{B}^O}(y) y dy}{\int_Y \mu_{B^O}(y) dy}$$

and the discrete form is defined by:

$$COG(B^O) = \frac{\sum_{q=1}^{N_q} \mu_{B^O}(y_q) y_q}{\sum_{q=1}^{N_q} \mu_{B^O}(y_q)}$$

where N_q is the number of quantization used to discretize membership function $\mu_B{}^o(y)$ of the fuzzy output B^o. Figure 2.1 shows the final output of the aggregation using the max-min while Figure 2.2 shows the center of gravity defuzzification method for continuous and discrete cases respectively.

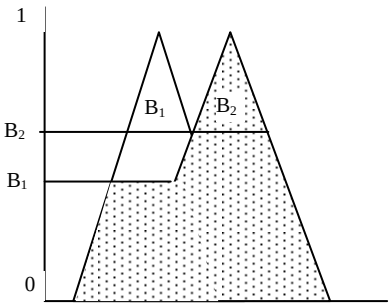

Figure 2.1: Aggregation output using the max-min method

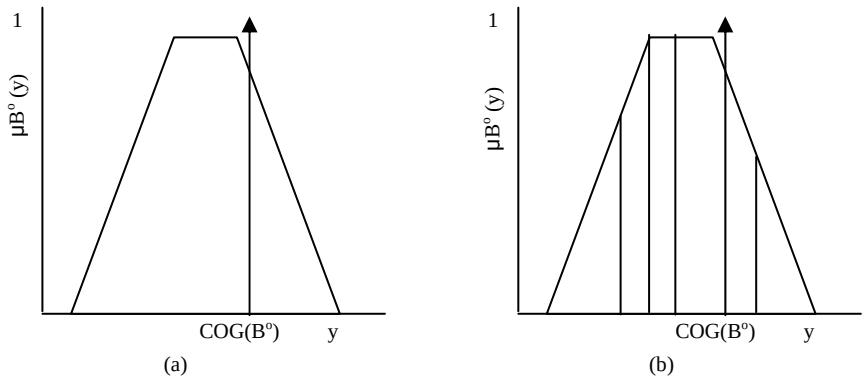

Figure 2.2: COG defuzzification method (a) Continuous (b) Discrete

3.0. The Tourism Fuzzy Expert System (TOFES)

The Fuzzy Expert System presented in this paper is aimed at assisting the stakeholders in tourism sector to carrying out the following functions: manage tourism data and information and present them to people in an understandable form; serve as a search engine that will assist people in obtaining geographic information about a place; know where things are located, know what amenities are available and what tourist objects are present and where they are located. It also assists in obtaining information about the climate of a place before visitation. The system also uses cognitive and emotional filtering parameters to assist the management in making decisions on strategic issues; and also assist tourists in decision making. The functionality of TOFES is

demonstrated using a case study of the Tourism Boards and Ministries of Culture and Tourism in Nigeria. The conceptual framework of the system is presented in Figure 3.1.

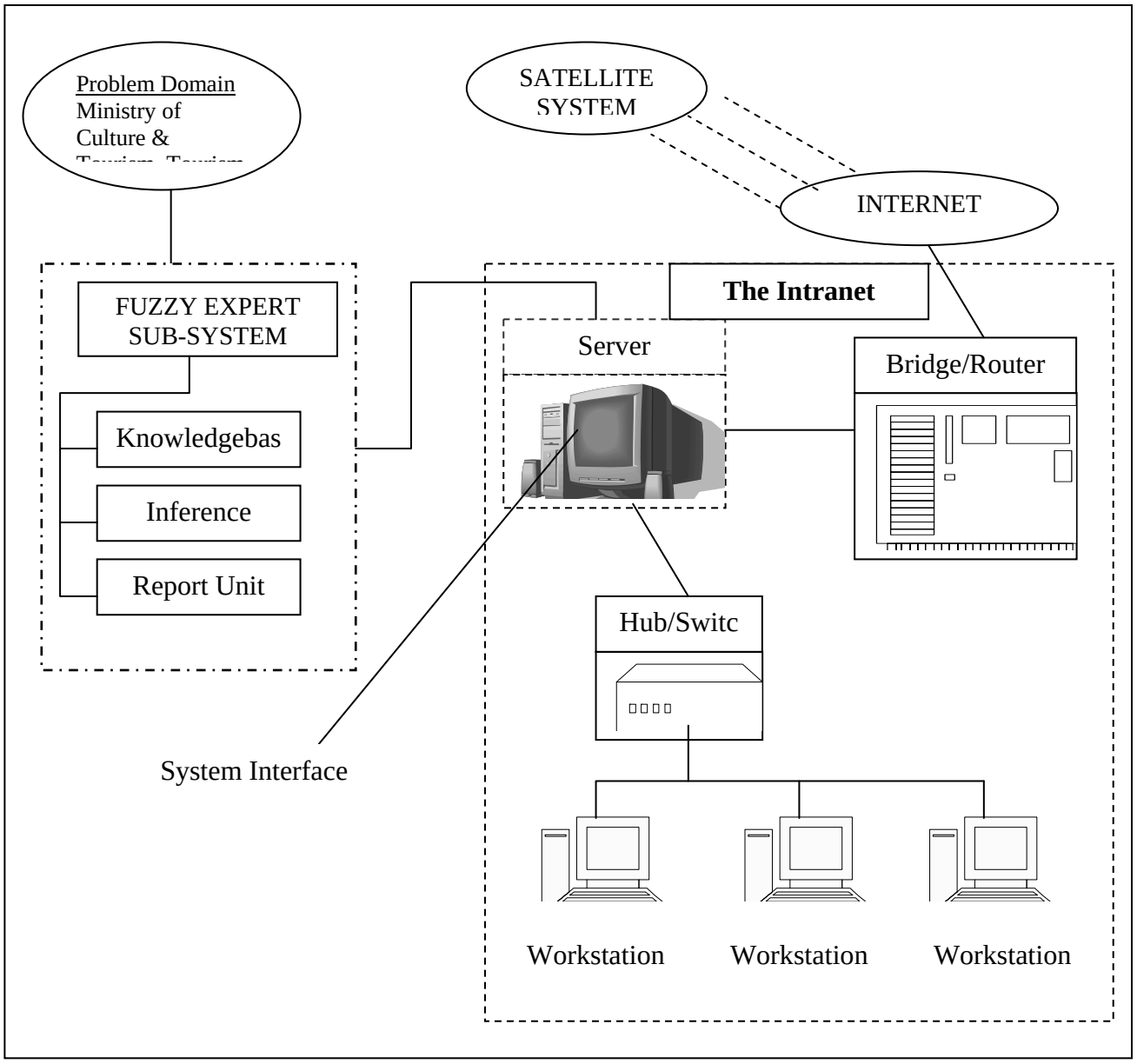

Figure 3.1. Conceptual Frameworks of TOFES

3.1. Knowledge Base

Knowledge is a key component of an expert system. Knowledge base is made up of structured and unstructured knowledge [19]. The knowledge base of the proposed system is composed of both database and rulebase. The database is conceptualized as a network of relations. A relation is a two-dimensional table containing tuples and attributes. The rulebase is the set of rules that are applied on some data in the database to generate some information, which can also be added to the facts in the knowledgebase. The following relations are considered in the database of TOFES:

a. REGISTRATION[reg-no,name-of-institution,class-of-institution,amount-paid, date-of-registration,date-due-for-reregistration]

b. TOURIST CENTER[tourist-center–id-number, reg-no,tourist-center-name,town, local-government-area,center-description,level-of-development,name-of–supervising-officer, number-of-staff, revenue-generated].
c. RES-HOT-EAT[ResHotEat–id-number, reg-no, ResHotEat-name, tourist-center–id-number town, local-government-area, street-name, grade, rate-of-booking, number-of-suites, type-of-facility].
d. CONTRACTOR[contractor-id-no,contractor-name,contractor-addr,phone-no,tourist-centre-id-no,res-hot-eat-id-no]
e. MAINTENANCE[tourist-center-id-number,contractor-id-no, type-of-contract-awarded,date-awarded, cost-involved]
f. FACILITY[facility-id-number, facility-name, reshoteat-id-number, tourist-center-id-number, suite-id-number,type-of-facility,facility-quantity]
g. DEMAND_FORM[staff-id-number, staff-name, sex, religion, date-of-birth, marital-status, state-of-origin, contact-address, loc-govt-area, department, date-of-employment, post-held, grade-level, date-of-last-promotion, date-of-retirement]
h. PERSONNEL-BIODATA[staff-id-number,t-board-id-no,name,title,sex,home-twon,state-of-origin,nationality,address,place-of-deployment,dept,rank]
i. QUALIFICATION[staff-id-number, qualification, date-obtained]
j. RENOVATION[reg-no,date-last-renovated,date-of-present-renovation]
k. ESTABLISHMENT[reg-no,date-established]
l. TOURISM-BOARD[t-board-id-no,t-board-name,board-chairman,board-address]
m. VISITATION[reg-no,name-of-visitor,visitor-nationalitydate-of-visitaion,fee-paid,no-of-people,time-in,time-out]
n. REVENUE[reg-no,revenue-generated,date-considered]
o. CULTURAL-PROPAGATION[culture-name,custom,dialet,music-type,musical-instrument]
p. PROPAGATION-MEDIUM[programme-code,programme-title,tv-channels,programme-duration,presentation-time]
q. SPONSORSHIP[name,address,cere-date,sponsorship-scope,duration-sponsor,email]
r. SALES[item-code,item-description,no-item,amount,date-sold]
s. CULTURAL-HALL[hall-code,hall-name,purpose,date-constructed,location]
t. CULTURAL-TROOP[c-troop-code,c-troop-name,contact-address,email]
u. BOOKING[code-of-booked-entity,date-booked,date-needed,duration,amount-
v. WEATHER[city-code,daily-weather-rec,date-of-rec]

Figures 3.2, 3.3, and 3.4 below present the record update transaction pages and sample data entry forms of some of the above relations. The update operation can be performed on the web provided a user has the access right thus make the web system to be dynamic.

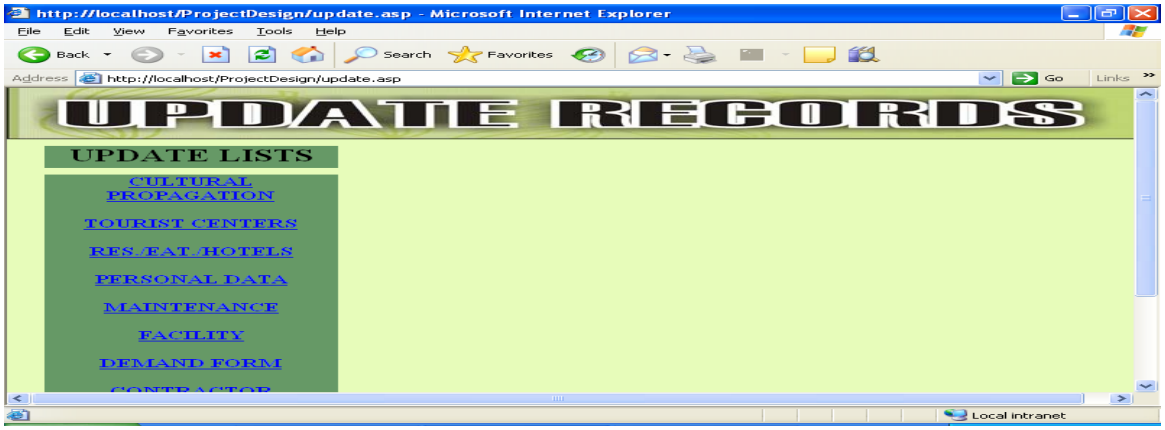

Figure 3.2 Record Update Transaction Page

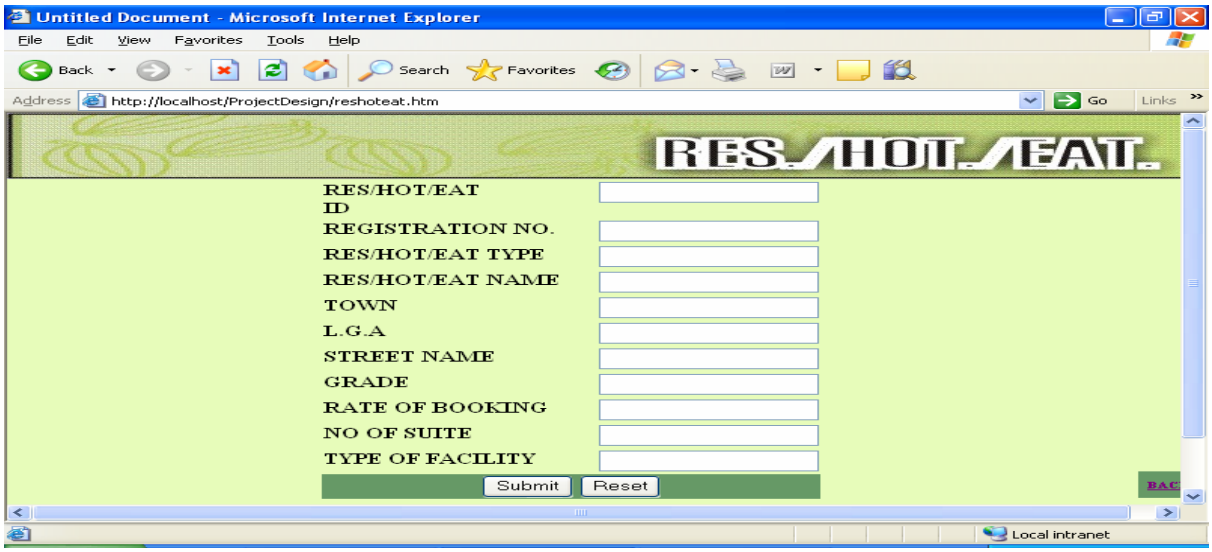

Figure 3.3 Data Entry Form to Capture Details of a Hotel/Eateries/Restaurant

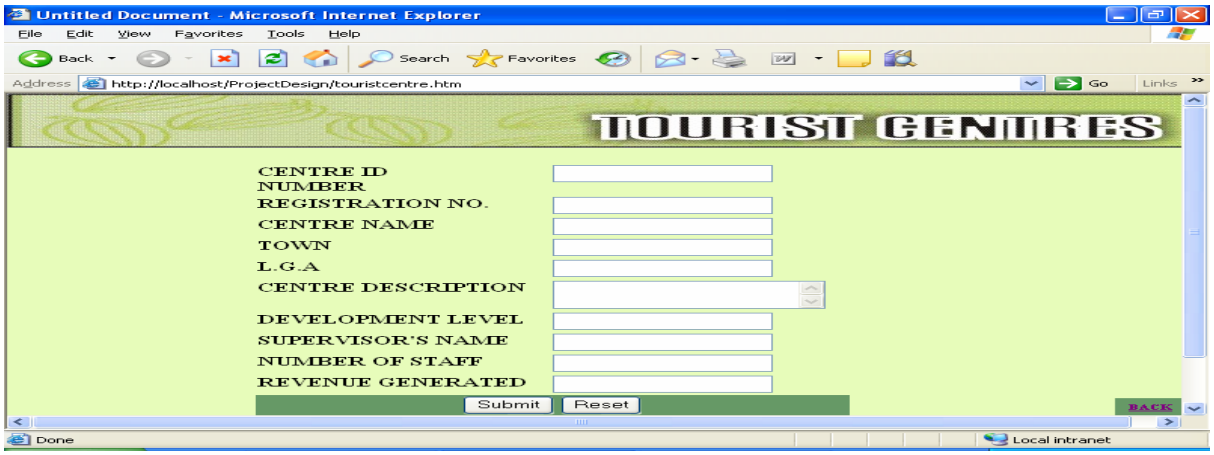

Figure 3.4 Data Entry Form to Capture Details of a Tourist Centre

3.2. Inference Engine

The inference engine provides the reasoning ability that enables the proposed TOFES to search through the knowledge base by using the production rule mechanism and hence proffers solutions to various query transactions envisaged for the system. The inference engine is composed of an Evaluation Unit and Filtering Unit.

3.2.1 Evaluation Unit

This unit helps to carry out appropriate tests on the various components of tourism, such as tourist centres, hotels, eateries, and many more. These tests are carried out based on available facts

obtained through the combination of some decision variables on tourism issues and some conclusions are drawn. Some of the evaluation modules envisaged for the TOFES are stated below:

a. Evaluate the performance of tourist centres
b. Evaluate the standard of hotel, restaurants and eateries
c. Evaluate the operations carried out at Tourism Management Board
d. Evaluate the security facilities in the tourist and hotel areas
e. Evaluate the types of public transportation available in the tourist and hotel areas.
f. Evaluate the medical facilities available in the hotels and tourist centre
g. Evaluate the plans, programmes and projects that would help to stimulate the tourist and hotel activities.
h. Evaluate the accommodation facilities available in the hotels
i. Evaluate the climatic condition of the tourist area.

The evaluation unit employs the use of production rules in its inferences. The production rules are made using fuzzy values, which are converted to fuzzy membership sets using fuzzy triangles. Examples include the following:

R1: If hotel is *near* a game center and vehicle traffic on the road *close* to the hotel is *fair*, then consider lodging at the hotel

R2: If tourist center is *famous* and cost of visit is *expensive*, then if tourist center is *busy* during festive periods, then defer visit to festive period.

The italicized words are fuzzy and are converted to fuzzy membership functions. For instance, in R1, the fuzzy based rule could be:

If (x; 0.8) and (v; 0.4) then y (0.6)

where x is the hotel facility with nearness of 0.8 to the game facility; v is the vehicle traffic with intensity 0.4, and y(0.6) implies a probability of 0.6 consideration for the hotel

3.2.2. Filtering Unit

The filtering unit is responsible for further processing of data by applying cognitive and emotional parameters. The cognitive and emotional filters help to clarify both the objective and subjective value judgments made when evaluating the possible consequence of alternative decisions. They carry out the inductive and deductive reasoning on the information content of the output report of the evaluation unit. The filtering component assists the potential tourists in making their final decision on tourism visits. It also assists tourism management units to make decisions.

Given below are some typical situations that would necessitate cognitive filter and emotional filters

a. The decision to renovate a tourist center in preference of others that are equally qualified for renovation based on the fact that the demand for it is very high.
b. The decision by a tourist not to visit a location based on the fact that the location has recent incidents of terrorism or other acts of violence
c. The decision to integrate culture and ancient sculpture of a community as part of the attraction in a tourist center based on the popularity of such cultures.
d. The decision to include natives of a community as tourist guides based on their knowledge of the terrain of the environment.
e. The decision to lodge in a given hotel based on previous reports regarding services in the hotel.

Shown in Figure 3.5 is a typical decision support filter screen.

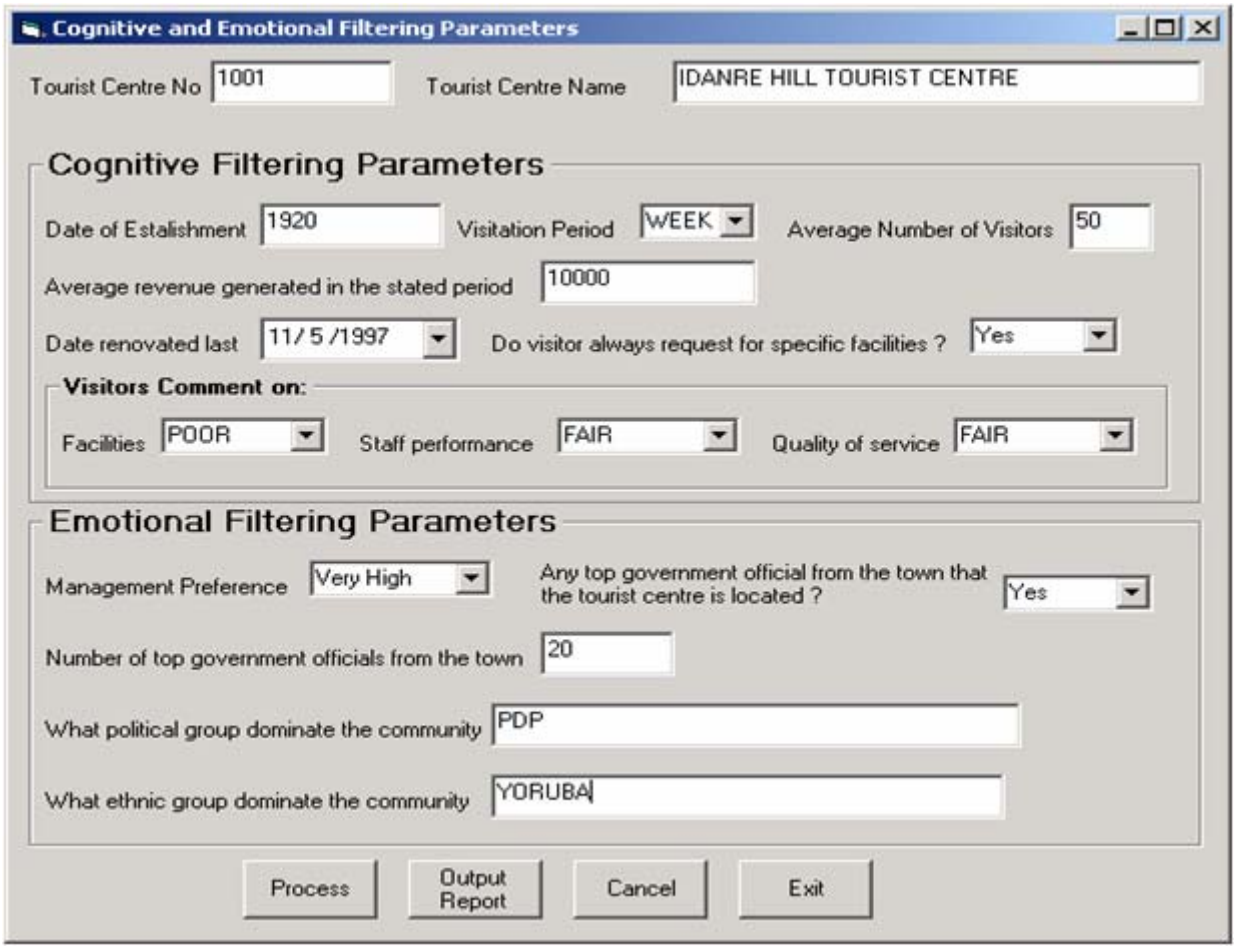

Figure 3.5- Decision Support Filter Screen

3.2.3 Report Generation Unit

This is responsible for producing the various reports envisaged for the proposed system. Stated below are the report modules envisaged in this framework:

a. List of all tourist center in a given community.
b. List of hotels/restaurants/eateries established in a community.
c. Details of tourist center renovated within a given period.
d. Details of revenue generated from tourist centers/recreational centers/hotels/restaurant/eateries.
e. Details of Tourism Boards across Nigeria.
f. List of personnel in a given Tourism Board.
g. Details of maintenance operations carried out in the tourist centers.
i. List of banks in the tourist and hotel areas.
j. List of attractive places near the tourist and hotel areas.
k. List of cultural / natural amenities located; their operational schedule and cost to attend.
l. List of shopping centres available.
m. List of hospitals available.
n. List of stops / stations of public transportation.
o. List of Cultures
p. List of cultural troops
q. List of bookings for the use of cultural centers

r. List of bookings for cultural troop

The Figures 3.6a, 3.6b, 3.7, and 3.8 below present some of the sample introductory pages and reports which can be viewed on web pages.

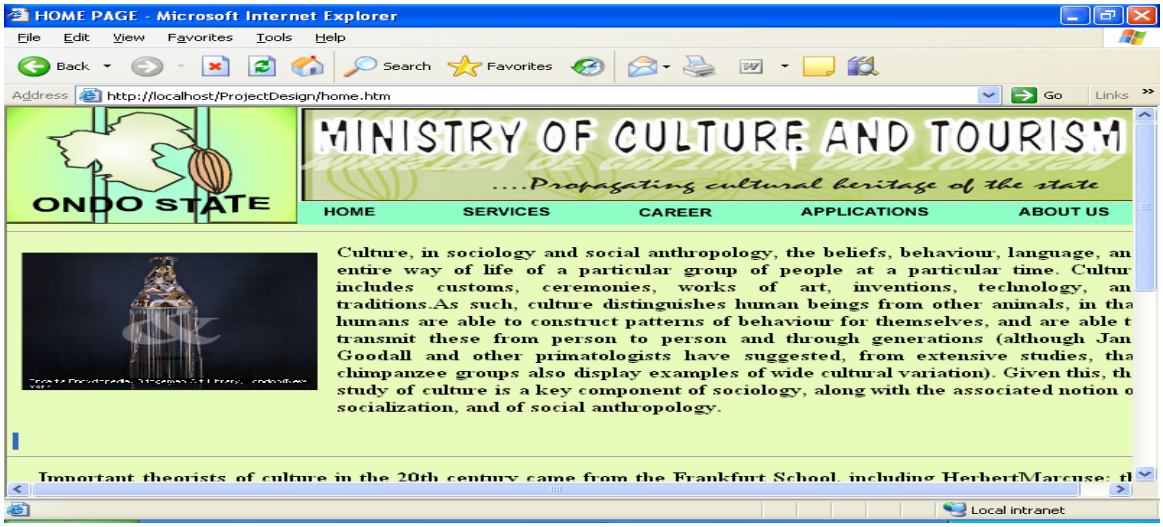

Figure 3.6a Sample Home Page

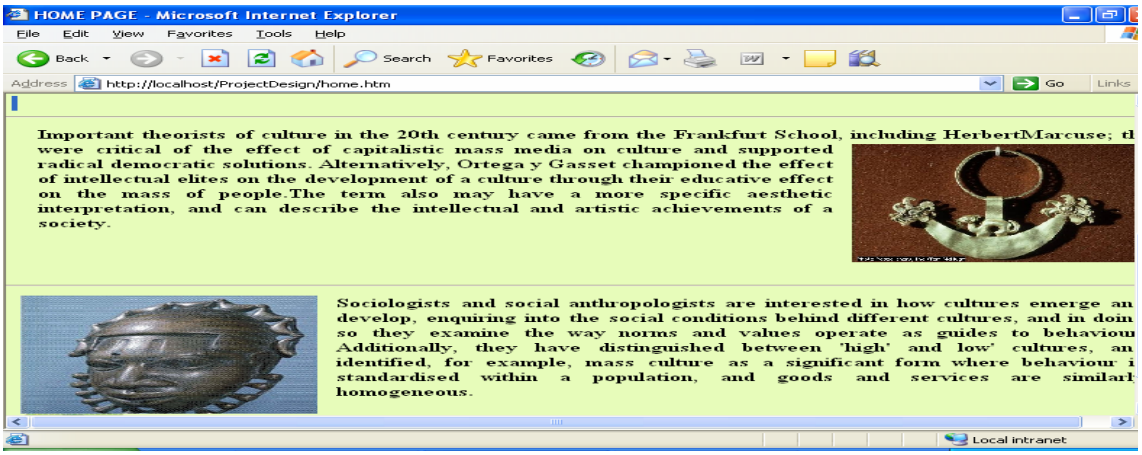

Figure 3.6b Sample Home Page

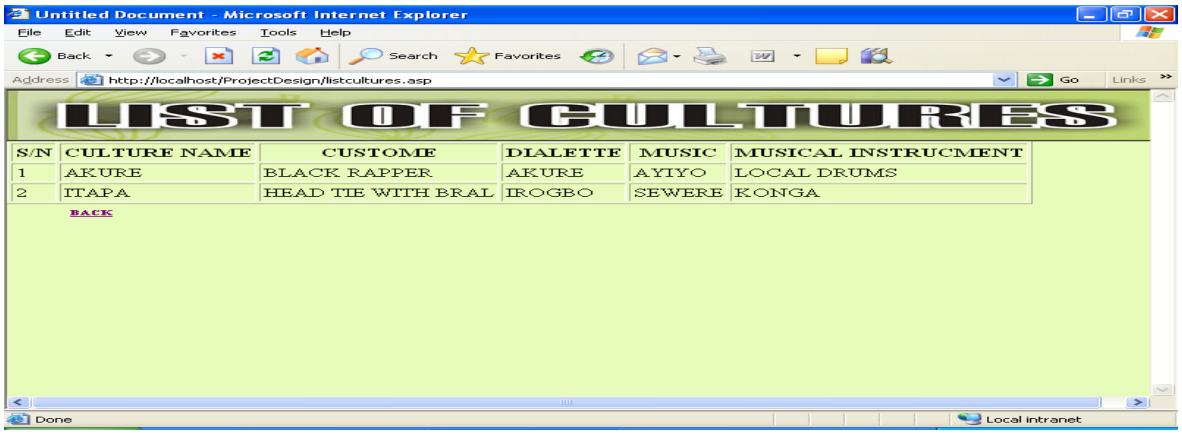

Figure 3.7 List of Cultures

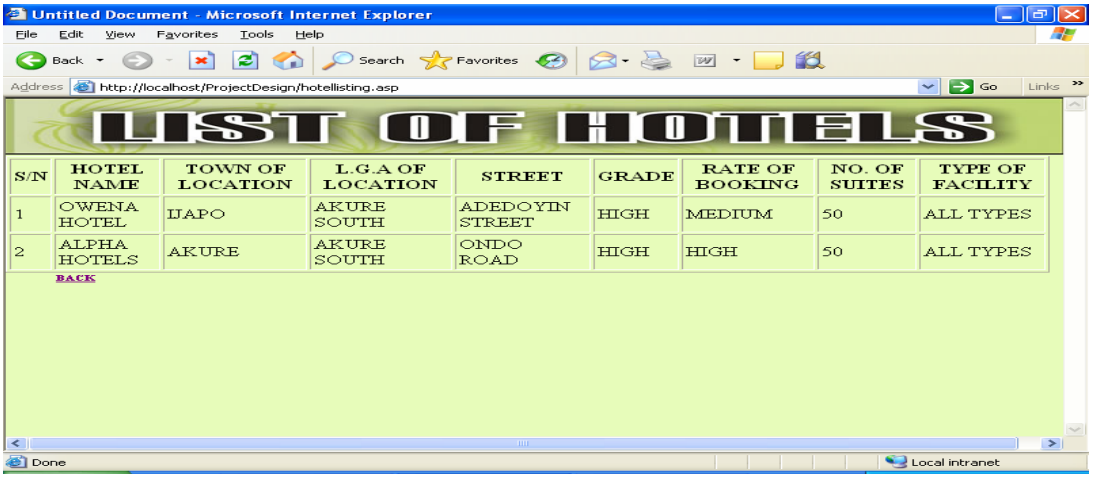

Figure 3.8 List of Hotels

3.2.4 The Intranet

The intranet is a local area network which can be established in the Tourism Boards and the various Ministry of Culture and Tourism across the country. It is composed of the following components: Server, Workstations, Hub/Switch and Bridge/Router.

Server

The server runs the administrative software that controls access to all or part of the network and its resources. Also the server runs the Fuzzy Expert System and enables client stations to have access to it via the Internet. Access right is given to users depending on the type of information needed from the system.

Workstation

The workstations are client terminals that are connected to the server from remote locations. Users have access to the information on the server via these workstations.

Hub/Switch

This is the network device that allows the server, workstations and other devices like the network printer to be connected together to allow network information to pass from one workstation to another or from one network to another provided they are of the same network standard.

Bridge/Router

This network device helps to connect the intranet with other networks and hence makes the information on the server to be available to all users of the internet depending on the access right given.

3.2.5 Internet

The internet is composed of other networks in the globe having a bidirectional access to the server via the bridge / router.

3.2.6 Satellite System

The satellite system receives a microwave signal, then amplifies and retransmits the signal back to a receiving station or stations at a different frequency. The communication that exists between the server and the internet is as a result of the satellite communication system.

4. Conclusion

A web based fuzzy expert system is proposed in this paper to facilitate fast and accurate online information storage, retrieval, processing and presentation. It helps to reduce the problem of manual walkthrough of voluminous tourism data and reduce the volume of traditional paper works. The proposed framework enhances the management of structured and unstructured tourism data. The major features of the system are: a tourism knowledgebase, an inference subsystem, a report generation subsystem, Intranet, Internet and the satellite system. The application of fuzzy logic concepts enables the system to achieve the following: mimics human decision to handle vague concepts; manage and process imprecise or imperfect information; resolves conflicts by collaboration, propagation and aggregation; improves knowledge representation and uncertainty reasoning.

The system is tested using some data collected in the Tourism Board of Ondo State of Nigeria. The framework presented is able to meet the needs of the Tourism Boards and the Ministry of Culture Tourism and National Orientation in Nigeria, therefore it can be adapted to the needs of any commission and various organizations or industries in the tourism sector.

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