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## Development of Fuzzy Logic-based Search Algorithm for Online Search Services

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**Key words:** Fuzzy logic, fuzzy search, search algorithm, information, investigation

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**Abstract:** This study aims to develop a fuzzy logic-based search algorithm for online search services. The use of fuzzy searching is much more powerful than exact searching when used for research and investigation. The algorithm was implemented for searching a travel information for trip planning. The system was evaluated by IT expert using the ISO 9126 criteria. The result of the evaluation is very effective which implies that the system meets the standard criteria in system's development and the algorithm was applicable in generating the best result if implemented for online search services.

### INTRODUCTION

A fuzzy search is a process that locates web pages that are likely to be relevant to a search argument even when the argument does not exactly correspond to the desired information (techtaraget.com). A fuzzy search is done by means of a fuzzy matching program which returns a list of results based on likely relevance even though search argument words and spellings may not exactly match. Exact and highly relevant matches appear near the top of the list. Subjective relevance ratings, usually as percentages, may be given. Fuzzy searching is much more powerful than exact searching when used for research and investigation.

Web is a primary source of information when searching for the appropriate place for planning a trip. Tourists usually search the internet through blogs, travel websites or social media. However, the information available online sometimes is not detailed and it is limited to photos only. Information like amenities, budget

requirements, mode of transportation, route condition and their necessary information that are essential for trip planning are not available. Most of the time tourists who want to visit places have a hard time to choose what kind of place to travel, at the same time, a place that will suit to their preferences in terms of location, budget, etc.

Tour plans are constrained to many factors such as the number of tour members, route of traveling, attractive places to visit, activities during the tour, budget and time. Having a well-organized travel trip needs a time and effort if you don't have an experience of it. The decision support system technology helps assist the tourists for trip planning to reach multiple destinations concerning the trip (Jannach, 2007).

The development of fuzzy logic-based search algorithm was implemented for trip planning application that will aid the tourists in their trip planning, provide detailed information about a place and help them decide on what would be the best place to visit based on their preferences.

**Objectives of the study:** This study aims to develop an FL-Based search algorithm for online search services specifically, it aims to:

- Create a fuzzy logic algorithm
- Test the algorithm for travel information
- Evaluate the effectiveness of the algorithm

**Theoretical framework**

**Fuzzy logic model:** For the development of the algorithm, the Fuzzy Logic System (FLS) (Rouse, 1999) was used as basis in creating the production rule for the knowledge base. An FLS consists of four main parts: fuzzier, rules, inference engine and defuzzier. Figure 1 shows the fuzzy logic system used for the algorithm design.

**The following steps were defined in an FLS algorithm:** Define the linguistic variables and terms (initialization). Linguistic variables are the input or output variables of the system whose values are words or sentences from a natural language, instead of numerical values. A linguistic variable is generally decomposed into a set of linguistic terms.

Construct the membership functions (initialization). Membership functions are used in the fuzzification and defuzzification steps of a FLS, to map the non-fuzzy input values to fuzzy linguistic terms and vice versa. A membership function is used to quantify a linguistic term.

Construct the rule base (initialization). In an FLS, a rule base is constructed to control the output variable. A fuzzy rule is a simple IF-THEN rule with a condition and a conclusion. In this step, a criterion was set which served as the basis for the searching. Convert crisp input data to fuzzy values using the membership functions (fuzzification). The evaluations of the fuzzy rules and the combination of the results of the individual rules are performed using fuzzy set operations. Evaluate the rules in the rule base (inference). After evaluating the result of each rule, these results should be combined to obtain a final result. This process is called inference. Combine the results of each rule (inference). The results of individual rules can be combined in different ways. It contains possible accumulation methods that are used to combine the results of individual rules. The maximum algorithm is generally used for accumulation. Convert the output data to non-fuzzy values (defuzzification). After the inference step, the overall result is a fuzzy value. This result should be defuzzified to obtain a final crisp output. This is the purpose of the defuzzier component of a FLS. Defuzzification is performed according to the membership function of the output variable.

**Conceptual framework:** As shown in Fig. 2, the system has two main functions, the web administration for the

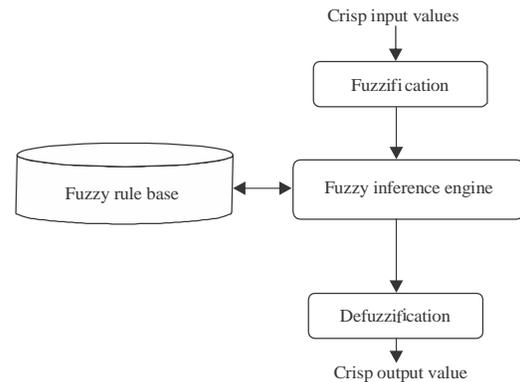


Fig. 1: Fuzzy logic mode

admin side and the fuzzy application that will work in the user side. In the administration, the authorized web administrator is the one who manages the website. The website is secured to prevent unauthorized access of data. To manage the website, the administrator will log in using the username and password. There are three main functions that needs to be managed, the web pages where in it contains the web content, the mapping function to provide the location of the tourist destination and the Search Engine Optimization (SEO) to index the website on search engines. The database serves as the repository of data that will be supplied by the administrator.

For the user side, the user interface lets the user to interact with the system, since, it is web based, the user interacts through the web browser and process the request. A dialogue is conducted by the user interface between the user and the system through the fuzzy logic controller. Once the user will search for a specific travel information, the input data will pass in the fuzzification process where in it will allow the user to input a specific search criteria. The search criteria will be processed in the knowledge base where in it contains the different rules and the system then attempts to provide insights derived (or inferred) from the knowledge base. These insights are provided by the inference engine after examining the knowledge base. Knowledge base consists some encoding of the domain of expertise for the system in a form of production rule. This will generate a rule based driven decision support system which contains the set of rules, procedures, algorithms, and the generated decision.

The fuzzy controller will then look for the requested data in the database. After processing the request the data will be sent to the defuzzification process to generate the output back to the user. Semi structured decision will be generated which means that whatever decisions the system will generate, human judgement will still be followed. The application was hosted online through the web application server.

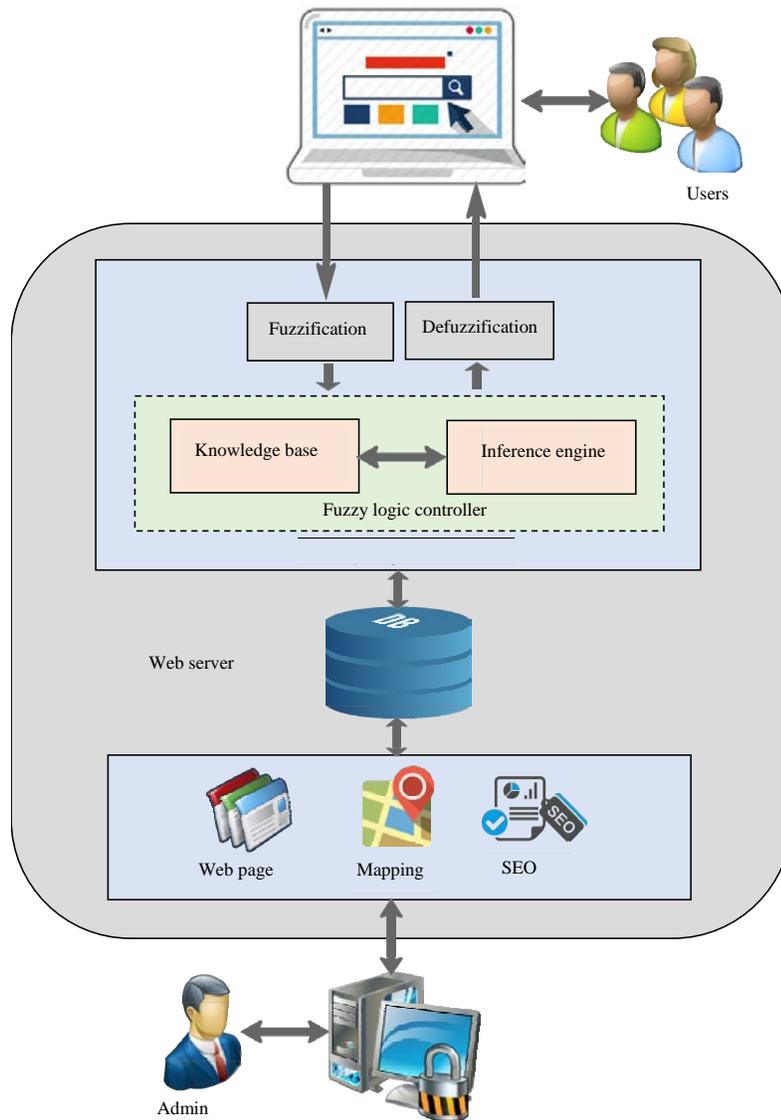


Fig. 2: Conceptual framework

## MATERIALS AND METHODS

**System development:** A system development process can follow a number of standard or company specific frameworks, methodologies, modeling tools and languages. Software development life cycle normally comes with some standards which can fulfill the needs of any development team. Like software, websites can also be developed with certain methods with some changes and additions with the existing software development process (Mendel, 2001).

In the development of the application the web development lifecycle was used, it contains several steps which is effective in web development. The cycle is illustrated in Fig. 3.

**Analysis:** During the analysis phase, the initial requirements were identified, a careful planning was conducted. In this phase the researcher prepared a detailed plan by identifying the target user and conducted a prior art search. Data gathering was also conducted during this phase.

**Specification building:** In this phase, preliminary specifications were drawn up by covering up each and every element of the requirement. The modules of the site including general layout, site navigation and dynamic parts of the site were included in the specifications. The researcher also outlined the scope of the project including, time lines and costs (Table 1).

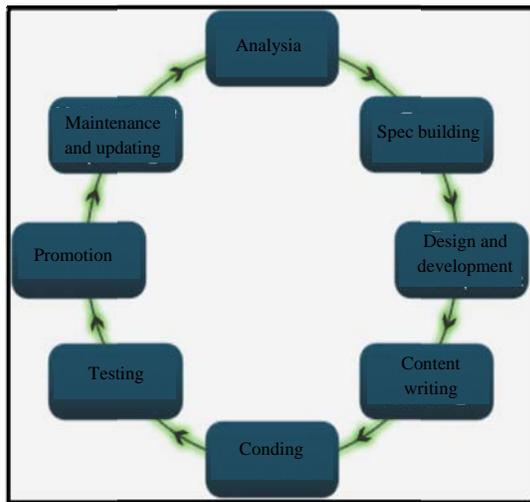


Fig. 3: Web development lifecycle

Table 1: To interpret the scores, the five point likert scale was used

Range	Descriptive rating
4.21-5.00	Very effective
3.41-4.20	Effective
2.61-3.40	Moderately effective
1.81-2.60	Ineffective
1.0-1.80	Very ineffective

**Design and development:** After building the specification, work on the website was scheduled, the layouts and navigation was designed as a prototype. Throughout the design phase the researcher developed a test plans and procedures for quality assurance. The database, data structures and sample data was also prepared.

**Content writing:** In this phase, the input data were supplied into the system. The data were categorized according to the group of information that the tourist can select. All the data for tourist attractions, resorts and restaurant were added.

**Coding:** In this phase, the algorithm was developed. The fuzzy logic was utilized and the implementation of decision support function was integrated in this phase. The search engine optimization method was also employed and the mapping function. Other coding methodologies were developed to run the logical function of the system.

**Testing:** In this phase, the researcher prepared testing plans to check the functionality of the system. The test cases with test data were set to check the output generated by the system. The testing of browser compatibility was done in this phase to check whether the system’s function

will adopt in multiple browsers, since, it is a web-based application. The fuzzy logic application was tested to ensure the accuracy of search result.

**Promotion:** In this phase, the web pages were uploaded and hosted online. A domain was purchased to map the pages and make the website live. Webmaster applications were also utilized to track the performance of the website in the search engine’s ranking and indexing.

**Maintenance and updating:** This phase involves proper monitoring of the website to ensure that it is functional and the management of content should be done for update.

**Project evaluation:** To evaluate the effectiveness of the system, the ISO 9126 criteria (Pressman, 2005) was used which determines its functionality, reliability, usability, efficiency, maintainability and portability. It was evaluated by five IT experts.

## RESULTS AND DISCUSSION

**Development of the system:** The development of FI-based search algorithm was implemented using the travel information, it provides support in decision making process of the tourists for trip planning and travelling. The system generates semi-structured decision where the tourists are provided detailed information about the place as basis for their trip and this will help in their decision-making process. The system is also knowledge-based and uses database as a repository of all the data being processed in the system. As the tourist selects the choices the database will provide filtered results according to the tourist query. A mapping structure is integrated into the application to familiarize the user of the location and other important information about the place.

The system is a web-based application hosted online, it can be accessed using a personal computer or through a mobile device. The system will be optimized using the search engine optimization technique wherein it can be searchable on search engines.

**Search function:** The travel search function contains the search criteria to look for a specific place. The search criteria include the type of place, package, destination, travel budget and amenities (Fig. 4).

In order to search, from the search criteria, select a type of destination. Tourist attraction, resorts and hotels or food and dine. Enter additional details in the textbox. e.g., destination, amenities, travel budget (Fig. 5 and 6).

**Click the search button:** The list of search result will be generated Fig. 7. Click view and explore button to view the individual result (Fig. 8 and 9).

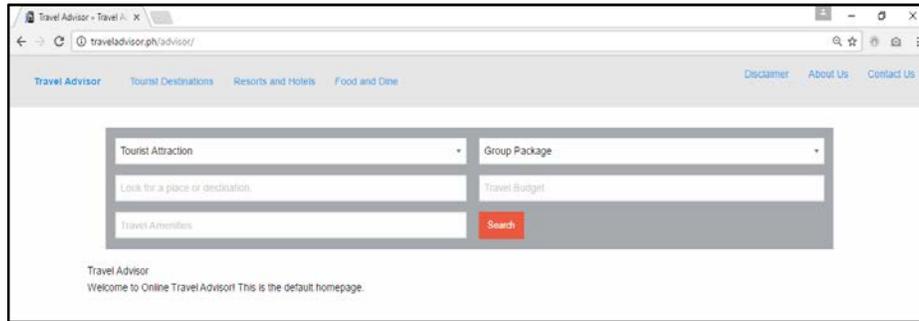


Fig. 4: Search function

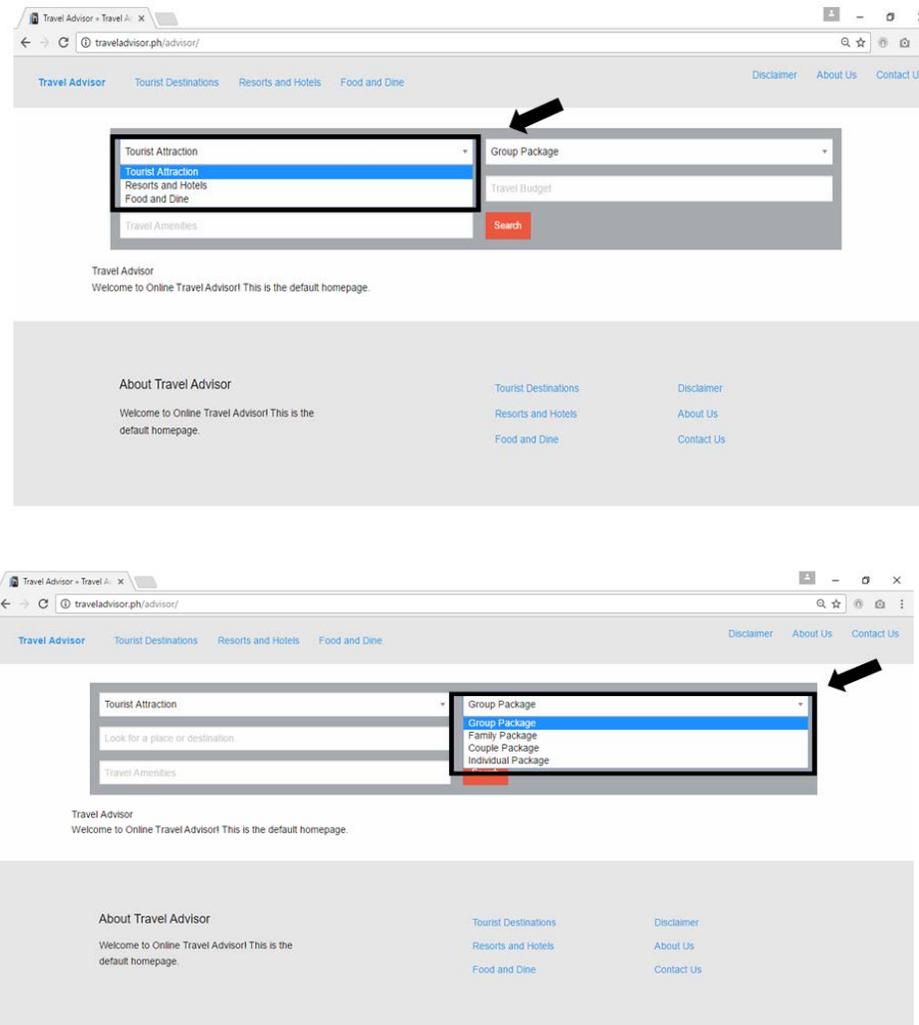


Fig. 5: Type of destination

**System's evaluation:** Evaluation of the software quality standards based on ISO 9126 by IT experts (Table 2). Five Information Technology (IT) experts who were in

line with web application and algorithm development were surveyed to gather feedbacks whether the system has complied with the quality standards set by ISO 9126. The

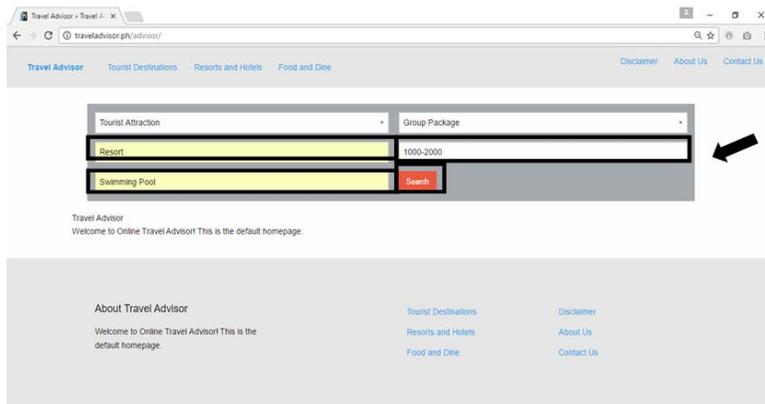


Fig. 6: Travel budget

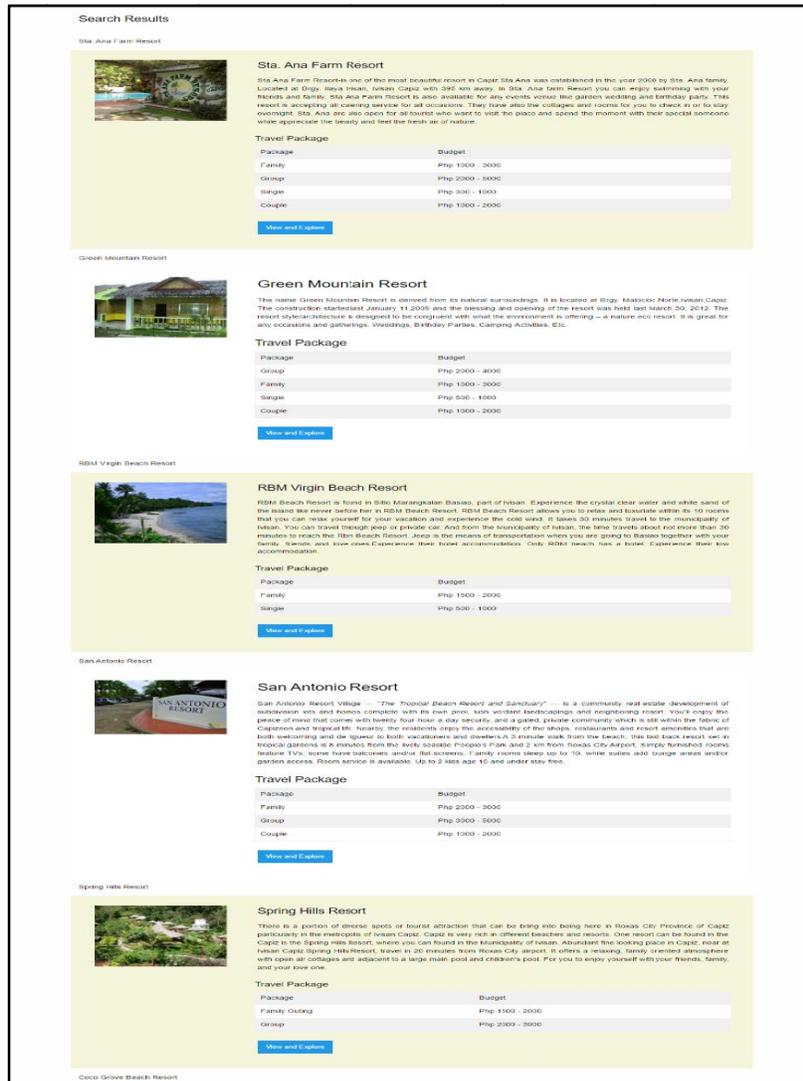


Fig. 7: Search result

### Sta. Ana Farm Resort

Sta Ana Farm Resort is one of the most beautiful resort in Capiz Sta Ana was established in the year 2000 by Sta Ana family. Located at Brgy. Ilaya Ivisan, Ivisan Capiz with 395 km away. In Sta Ana farm Resort you can enjoy swimming with your friends and family. Sta Ana Farm Resort is also available for any events venue like garden wedding and birthday party. This resort is accepting all catering service for all occasions. They have also the cottages and rooms for you to check in or to stay overnight. Sta Ana are also open for all tourist who want to visit the place and spend the moment with their special someone while appreciate the beauty and feel the fresh air of nature.

**What you can see and experience with Sta. Ana Farm Resort?**



**Welcome to Sta Ana Farm Resort**

In Sta Ana farm Resort you can enjoy swimming with your friends and family. Sta Ana Farm Resort is also available for any events venue like garden wedding and birthday party. This resort is accepting all catering service for all occasions.

**What are amenities with your visit at Sta. Ana Farm Resort?**



**Pool**

Sta Ana Farm Resort has three (3) pools, namely kiddie pool, medium and the biggest one for adults. They have also the cottages for rent. Before you go to swimming you must read and follow their instruction for your safety. That's why they post those instructions beside the pools. You can call them pool maintenance or their staff to help you like any other resort with pools. The first priority of their resort is your safety while you enjoy swimming. Regardless to their cottages they have seven (7) cottages to choose from.

Sta Ana Room Information

**Accommodation**

Sta Ana Farm Resort has its rooms that will sure fit according to your budget. Every room has its unique settings, everything inside their rooms are well arranged. A bed with soft bed sheets, pillows and blanket. Some of their rooms have also comfort rooms, this room is the bigger one. It is for a whole family or for group vacation. Some of it is for small number of occupancy only. Every room has its own price in case of your needs, you can call their people for assistance, they very well available to help you regardless to your needs. Your payment will be surely paid with their very good service and accommodations.





**Cottages**

This resort is accepting all catering service for all occasions. They have also the cottages and rooms for you to check in or to stay overnight.

**Function Hall**

They offer a catering services for any occasions such as Wedding, Birthdays, Anniversaries, Meeting, Seminar and other functions.



**How to get at Sta. Ana Farm Resort?**

Transportation Type	Route Direction	Estimated Fare
Jeepney	Roxas City to Ivisan	P15.00

**How much will you spend to visit Sta. Ana Farm Resort?**

Package	Budget
Family	Pnp 1000 - 3000
Group	Pnp 2000 - 5000
Single	Pnp 300 - 1000
Couple	Pnp 1000 - 2000

**Whom shall be contacted to when you visit Sta. Ana Farm Resort?**

Name	Phone	E-Mail
MRS. SOCCORO G. STA ANA	+63 905 277 1016	staanafarmresort@yahoo.com



Fig. 8: View and explore button

Table 2: ISO 9126 survey result

ISO 9126 software quality criteria	Mean	SD	Descriptions
<b>Functionality</b>			
The software functions appropriately according to its specified attributes	4.40		Very effective
The software produces accurate result and functions without errors or problems	4.50		Very effective
The software adheres to related standards or conventions or regulations	4.60		Very effective
The software shows ability to prevent unauthorized access and fraudulent user	4.30		Very effective
Total	4.45	0.2582	Very effective
<b>Reliability</b>			
The software can function for a long time without crashes or service interruptions	4.40		Very effective
The software can manage and/or recover from environmental failure	4.60		Very effective
The software revives and becomes fully operational even in the event of failure	4.50		Very effective
Total	4.50	0.1757	Very effective
<b>Usability</b>			
The software can be operated easily by different users	4.40		Very effective
The software is user-friendly. It does not require learning effort for different types of users	4.40		Very effective
The software requires less effort to operate	4.80		Very effective
Total	4.53	0.1721	Very effective
<b>Efficiency</b>			
The software responses immediately during processing time and yields accurate data	4.80		Very effective
The software requires minimal amount of computing resources	4.60		Very effective
Total	4.70	0.3496	Very effective
<b>Maintainability</b>			
The software has the ability to keep confidential records of the application	4.50		Very effective
The software can manage to record changes in every transaction	4.50		Very effective
The software requires less effort for modification, fault removal or environmental change	4.80		Very effective
The software utilizes verify or update records	4.40		Very effective
Total	4.55	0.3496	Very effective
<b>Portability</b>			
The software conforms with the industry standard	4.60		Very effective
The software allows easy exchange of given software/hardware component within specified environment	4.80		Very effective
Total	4.70	0.2582	

value of mean and Standard Deviation (SD) were computed to determine the general perception of IT experts.

Table 1 shows the expert’s evaluation on the functionality of the system. As to the system’s functionality, the result was “very effective” with the rating mean score of 4.45. This meant that the system’s function was effective.

As to the system’s reliability, the result was “very effective” with the mean score of 4.50. This meant that the system has the ability to fully operate its service amidst failures and interruptions.

As to the system’s usability, the result showed a “very effective” rating with the mean score of 4.53. This meant that the system is easy to use and is user-friendly. As to the system’s efficiency, the result showed a “very effective” rating with the mean score of 4.70. This meant that the system’s response was not affected by the minimal amount of resources required and could continue to deliver its function well.

As to the system’s maintainability, the result showed a “very effective” evaluation rating with a mean score of 4.55. This meant that the system requires less effort for the modification of its service and would not be affected by any change during the maintenance period. As to the system’s portability, the result revealed a “very effective” evaluation rating with the mean score of 4.70. This meant that the system conforms to the standard and could easily adapt to changes within a specified environment without

affecting its operation. The overall result of the expert’s evaluation on the system based on ISO 9126 criteria was “very effective” with the mean score of 4.57 and a standard deviation of 0.0568. The SD further implies that the system could meet the software quality characteristics set by ISO 9126 standards. This implied that the software is of good quality and could provide quality service to its clientele.

## CONCLUSION

In the development of the application, the following conclusions were drawn: the fuzzy algorithm used was applicable in generating the best result if implemented for online search services. The overall result of the expert’s evaluation on the system based on ISO 9126 criteria was very effective. This means that the system meets the software quality characteristics set by ISO 9126 standards as to functionality, reliability, efficiency, maintainability and portability.

## RECOMMENDATIONS

The application may be presented to the tourism office for implementation, accreditation and promotion. Since, the application is web-based, anative mobile application may be developed for a better access using mobile phones. The algorithm may be tested on other

search services and more specific criteria may be added to produce a more detailed result. Similar studies may be conducted to expand the scope of the application.

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