HAPPYTRIP: A MOBILE-BASED RECOMMENDER SYSTEM FOR OPTIMIZING TRAVEL

Ma. Esther B. Chio[*1] Rhoda A. Namoco[2]
University of Science and Technology of Southern Philippines, Cagayan de Oro City, Philippines
*For Correspondence; Tel. +639928565831, Email: maesther.chio@ustp.edu.ph

ABSTRACT: *The study presents "HappyTrip," a mobile-based recommender system designed to optimize travel experiences by providing personalized recommendations to travelers. In today's era of technology and mobility, planning and decision-making for travel can be overwhelming due to the abundance of information and diverse individual preferences. The objective of this research is to develop and evaluate a mobile application that leverages user preferences and travel data to generate tailored travel recommendations. The research methodology involves conducting a comprehensive literature review to gather insights into existing recommender systems, interview with would-be for their travel preferences, mobile technologies, and optimization algorithms in the context of travel planning. Building upon this foundation, the HappyTrip system is developed, integrating factors such as user preferences, available resources, travel destinations, and budget constraints. The system is implemented within a user-friendly mobile application, leveraging real-time updates, location-based suggestions, and interactive features to enhance the user experience. Data is collected through user interactions, surveys, and feedback to evaluate the effectiveness of the HappyTrip system. User satisfaction through standard System Usability Scale (SUS) evaluation and server-side performance metrics are conducted. The outcomes of the study include the development and simulation of the HappyTrip mobile-based travel recommender system, insights into its impact on enhancing travel experiences, increasing customer satisfaction, and improving travel planning efficiency. The results contribute to the field of mobile-based recommender systems for travel optimization, offering valuable insights for the travel industry. The Happy Trip system has the potential to revolutionize travel planning by providing personalized recommendations that align with individual preferences, ultimately leading to happier and more satisfying hassle-free travel experiences.*

Keywords: Optimization, Travel Recommender System, Mobile Application, Multiple Criteria Decision-Making

1. INTRODUCTION

The tourism industry heavily relies on information to cater to customers' needs in acquiring comprehensive details about their desired tourism destinations. This information encompasses various aspects such as locations, accommodations, restaurants, routes, attractions, and more. It is crucial for tourists to gather such information before planning and embarking on their trips in order to avoid dissatisfaction or discomfort [2]. Consequently, decision-making becomes a critical and unavoidable aspect, particularly when selecting a travel destination [5].

A decision support system (DSS) can be defined as an interactive computer-based information system which is designed to support and give solutions to decision problems where there is a geographic or spatial component to the decision, with interactive capabilities to improve the understanding of the problem through the use of models and data processing [1]. DSS have an important role for the support that they are able to give decision-makers to achieve their goals. The growing use of GIS and Internet application increase the development of tourism decision support system (TDSS) that have been used to utilize tourism planning process and gain benefit from their accessibility, accuracy, visualization, data handling and sharing capabilities [3].

The increasing prevalence of mobile and web applications has significantly enhanced the convenience of obtaining information for tourists[6]. The availability of such applications has led to a shift in the perception of travel as a distinct activity, as indicated by a study conducted by Wang, Park, and Fesenmaier [9]. Travel-related activities, including finding inspiration on social media platforms or checking flight rates while on the move, can now be accessed directly by end-consumers without any physical barriers [10]. This blurring of boundaries has made travel-related information more easily accessible and integrated into everyday life.

The decision-making process of customers is the cornerstone of the tourism industry and requires thoughtful consideration when designing tourism decision support systems (TDSS). Prior to embarking on a trip, tourists are
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faced with essential choices such as where to travel, what activities to engage in, how much to allocate for expenses, where to stay, and how long to stay. Mobile technology has become a valuable resource in providing answers to these fundamental questions. Table 1 provides a concise summary of the functionalities offered by existing mobile applications in addressing these inquiries and the target features of HappyTrip.

Table 1. Summary of functionalities.

Existing Technology	Features in Existing Mobile Apps and Proposed TDSS App					
	Recommendation	Accommodation	Budget optimization	Map	Rates/ Fees	Activity/ Amenities
Citymapper				✔		
TripAdvisor	✔			✔	✔	✔
Kayak		✔			✔	
Airbnb		✔			✔	✔
Uber				✔	✔	
Google Maps				✔		
HappyTrip	✔	✔	✔	✔	✔	✔

Nevertheless, it is widely acknowledged that the majority of travelers desire to have clarity on all essential aspects before embarking on their journeys. However, obtaining answers to these fundamental questions can become intricate, particularly when both budget and comfort are significant factors to consider in travel planning. One might find themselves in a situation where opting for a comfortable trip exceeds their budget, while adhering strictly to the budget could result in a more economical but rather inconvenient travel experience.

The analytic hierarchy process (AHP) is a decision-making technique developed by Thomas L. Saaty in the 1970s [4]. It is widely recognized and utilized in various fields and industries due to its effectiveness in dealing with complex decision-making situations. AHP addresses decision problems that involve evaluating and selecting the best alternative among a set of options [6] . It begins by identifying a set of evaluation criteria that are relevant to the decision at hand. These criteria represent different factors or dimensions that need to be considered when making the decision. For example, in the context of tourism, criteria could include cost, comfort, location, amenities, and customer reviews.

Once the criteria are established, AHP facilitates a systematic evaluation process. It involves pairwise comparisons between the criteria and the alternatives based on their relative importance or performance. Using a scale of preference, decision-makers assess the significance or effectiveness of one criterion or alternative compared to another. These pairwise comparisons are then used to derive numerical values known as weights or priority values, which quantify the relative importance of each criterion and alternative.

AHP employs a mathematical model to synthesize these priority values and determine the overall rankings of the alternatives. The model considers both the criteria weights and the performance ratings of the alternatives to calculate a composite score or utility value for each alternative. This score represents the overall desirability or suitability of an alternative based on the decision-maker's preferences and priorities.

The strength of AHP lies in its ability to structure and decompose complex decision problems into a series of manageable pairwise comparisons [7]. It provides a systematic approach that helps decision-makers clarify their thinking, explicitly consider the relative importance of different criteria, and derive informed decisions based on a rational and consistent evaluation process.

The objective of this research is to develop and evaluate a mobile application that leverages user preferences and travel data to generate optimized travel recommendations. To achieve this, the study employs the analytic hierarchy process (AHP) an optimization algorithm invoked into the recommender system that takes into consideration the tourists' preferred activities, desired amenities, and budget limitations. The model aims to provide the most optimal travel itinerary that aligns with the tourists' preferences while accommodating their financial constraints. By incorporating these factors, HappyTrip aims to offer user friendly interactive features to enhance the user experience of a mobile-based travel recommender system.

2. METHODOLOGY

A. Data Gathering

To gather significant information, this study concentrated on accredited tourist attraction sites within and around Northern Mindanao. The researchers conducted interviews and made site visits to collect the necessary data. Additionally, randomly selected tourists were interviewed to determine their typical travel budget and the activities and amenities they usually seek in places of interest (POI) destinations. Key officials from the Department of Tourism (DOT) Region X were also consulted to provide valuable inputs, aiming to establish a more realistic approach for evaluating and ranking criteria and alternatives of tourist attractions, facilitating better decision-making for travelers.

B. Integrating Optimization Algorithm

Utilizing the obtained information, the Analytic Hierarchy Process (AHP) was employed to derive the vector of weights for each evaluation criterion based on the tourists' pairwise comparisons of the criteria [4]. The options were then ranked based on the computed scores derived from the pairwise comparisons. The AHP process encompasses the following steps:

1. Identify the problem at hand and establish its objective.
2. Organize the hierarchical structure starting from the top level, representing the decision maker's objectives, and moving down through intermediate levels, which consist of criteria that depend on the levels above, until reaching the lowest level that includes a list of alternatives.
3. Create multiple pairwise comparison matrices (sized n x n) for each lower level. Each matrix corresponds to the elements in the immediate level above and is constructed using the relative scale measurement. The pairwise comparisons involve determining the dominance of one element over another.
4. The development of the matrix set in step 3 requires n (n-1)/2 judgments. Reciprocals are automatically assigned during the pairwise comparisons.
5. Employ hierarchical synthesis to assign weights to the eigenvectors based on the criteria weights. The sum is then calculated over all weighted eigenvector entries that correspond to the next lower level in the hierarchy.
6. After completing the pairwise comparisons, evaluate the consistency by utilizing the eigenvalue (λmax) to compute the consistency index (CI) using the formula: CI = (λmax - n)/(n-1), where n represents the size of the matrix.

   The consistency of judgments can be assessed by calculating the consistency ratio (CR) of the consistency index (CI) using the corresponding value in Appendix A. A CR value **below 0.10 is considered acceptable**, indicating a consistent judgment matrix. If the CR **exceeds 0.10, it indicates inconsistency in the judgment matrix**. In such cases, the judgments should be reviewed and improved to achieve a consistent matrix. These steps (3-6) are applied to all levels within the hierarchy. The synthesis of the pairwise comparison matrix involves dividing each element of the matrix by its column total.

The numerical values used in the AHP process range from **1 to 9**. In AHP, each pairwise comparison represents an estimation of the priority or weight ratio between the compared elements. These pairwise comparisons can be represented in a matrix format as follows:

Once the quantified judgments for each pair are recorded in matrix A,

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix}.$$

The recorded value weights on the objectives are represented by a set of numerical weights, denoted as w_1, w_2, ..., w_n. Let's assume that the quantified vector W is as follows:

$$W = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix},$$

where *wi* means the quantified weight of item i. Assume that the judged weights are merely the result of precise physical measurement

$$W' = A \times W = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \times \begin{bmatrix} W_1 \\ W_2 \\ \vdots \\ W_n \end{bmatrix} = \begin{bmatrix} W_1 \\ W_2 \\ \vdots \\ W_n \end{bmatrix},$$

where n is the number of judgments. By simplifying the above equation, one can obtain AW = λW, where λ is an eigenvalue of A and W is an eigenvector of A, respectively [6].

Then compute the average of these values to obtain λmax:

$$\lambda \max = \frac{1}{n}\left(\frac{W_1}{W_1} + \frac{W_2}{W_2} + \frac{W_3}{W_3} + \cdots \frac{W_n}{W_n}\right),$$

where λmax and n are not equal, the deviation represents the degree of inconsistency, which is evaluated with consistency index (CI): (λmax 2 n)/(n21). Thus a higher ratio of CI shows a higher degree of inconsistency. Furthermore, Saaty (1990) developed another consistency index for AHP, called random consistency index (RI). The ratio of CI to the average RI for a matrix of the same order is called the consistency ratio (CR): CI/ RI. A consistency ratio of 0.1 or less is considered **acceptable**.

In assessing tourist's preferences, this study used the criteria based on Taluay, Seminar, Monintja [5] for ranking tourist destination in decision making. Some criteria that are not applicable in the localization of this study are omitted. Figure 2 shows the AHP pairwise questions where respondents indicate the **importance rating from 1 to 9**, each pairwise comparison represents an estimate of the ratio of priorities or weights of compared elements. Figure 2 shows the hierarchy that is each criteria has its corresponding sub-criteria for another round of pairwise comparison.

AHP Questionnaire: Pairwise Question										
Criteria	Importance Rating									Criteria
	9	7	5	3	1	3	5	7	9	
Attraction					■					Attraction
Attraction										Tourist Activities
Attraction										Facility
Attraction										Acessibility
Tourist Activities										Attraction
Tourist Activities					■					Tourist Activities
Tourist Activities										Facility
Tourist Activities										Acessibility
Facility										Attraction
Facility										Tourist Activities
Facility					■					Facility
Facility										Acessibility
Acessibility										Attraction
Acessibility										Tourist Activities
Acessibility										Facility
Acessibility					■					Acessibility

Legend:	
9	indicates the objective has the highest possible order of affirmation
7	means strongly favored and its dominance demonstrated in practice
5	indicates experience and judgment strongly favor one objective over the other
3	means experience and judgment slightly favored one objective over the other
1	means two objectives contribute equally to the consumer.

Figure 2. AHP Pairwise Question and Importance

Figure 3 shows the hierarchy on which the goal is to determine the tourist destination. To achieve the goal, the pairwise comparison matrix of the criteria and sub criteria is used to obtain each hierarchical factor weight. The greater the weight the more relevant it is to the goal.

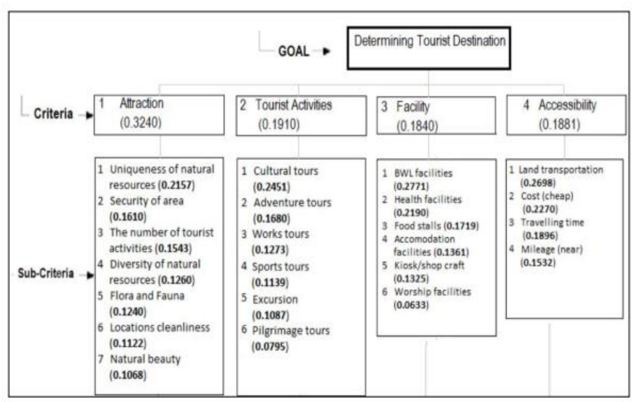


Figure 3. Hierarchical structure relations objectives, criteria, sub-criteria, and determine alternative tourist destinations

C. Design and Development of Web app and Mobile app

This TDSS with AHP optimized travel recommender was implemented in development of web app for content management and mobile app for user's interactive interface. Figure 4 shows the system architecture. In the development of the mobile application for the user a hybrid mobile application with the use of Ionic Framework and Ionic Geolocation were used for the mapping. The Analytical Hierarchy Process (AHP) algorithm is used for optimizing travel recommender. In the development of the web application for content management, web technologies such as HTML, CSS, Javascript, PHP, JQuery, CodeIgniter, GoogleMap API and MySQL were used.

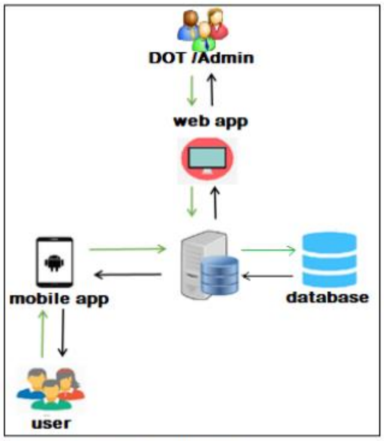


Figure 4. System architecture

Figure 5 shows the context diagram as a design for the functionalities of the tourist decision support system. The data input and output from and to the actors are as follows:

The **user** who is the tourist traveler will input the data for user login details and user account profile. For the user to be able to generate recommended of tourist destination the user must input filters such destination preferences and travel budget. The system will show the menu of recommended attractions based on the budget constraint. Once the user finalized its desired attraction, an optimized itinerary will be generated to be saved for offline reference should there be areas with no data signal during the actual travel.

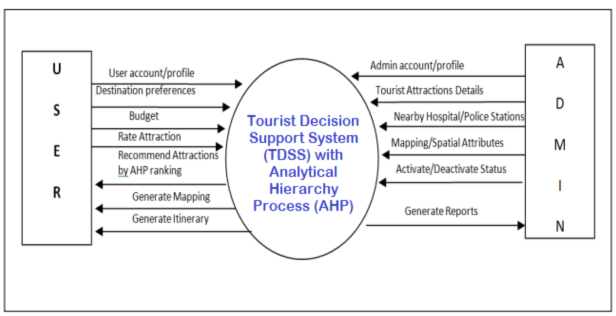


Figure 5

The **admin** who is an official from Department of Tourism (DOT) is tasked to input the complete information details of the registered and updated tourist attraction including but not limited to its complete address, amenities, activities, fees and the likes. Essential information for the safety of tourist like nearby hospitals and police stations will also be an input to the database. Spatial attributes for mapping for each and every tourist attraction spots' longitude and latitude will be plotted on Google Map's API. The admin also has the authority to activate and deactivate those tourist attraction establishments who did not renew and complied requirements for their registration with the DOT office. A report can be generated for references to policy making can generated for use of DOT office.

3. RESULTS AND DISCUSSIONS

A. Design and Development Mobile-base recommender system

The successful development of the system has achieved the graphical user interface of the mobile app for tourist to interact and then the system can generate their optimized travel itinerary through the web app based on the budget constraint and map for the selected location of each POI destinations. Figure 6 shows a sample screenshot from the mobile app.

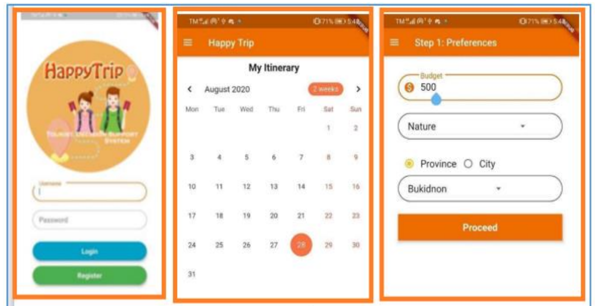


Figure 6. Sample Screenshots from HappyTrip Mobile-based Travel Recommender

C. Integrating Optimization for Travel Recommender

The HappyTrip travel recommender is dynamic. Figure 7 shows that for each and every user's preference, budget and personal judgment scores a new weight is computed to achieve the goal which is to recommend a tourist destination.

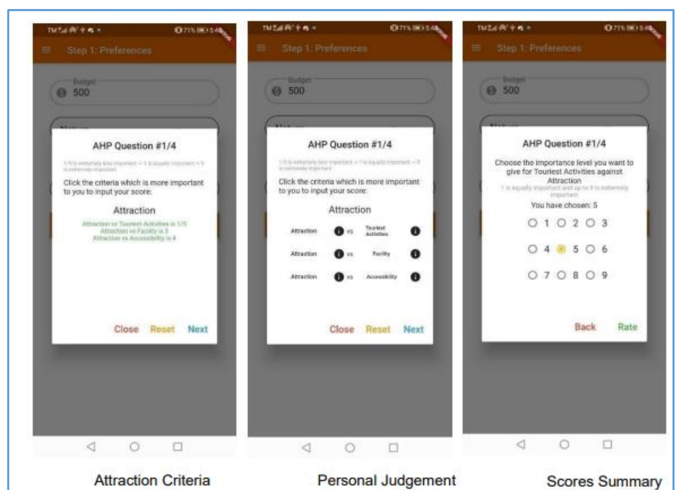


Figure 7. Invoking Criteria and Personal Judgement as elements for implementing AHP

A display in Figure 8 A shows the *recommended ranked list of attractions* after AHP computation to aid the user in the decision making process. The user may view details of the attraction to be included it to the final itinerary while keeping track of their budget with the *budget tracker*.

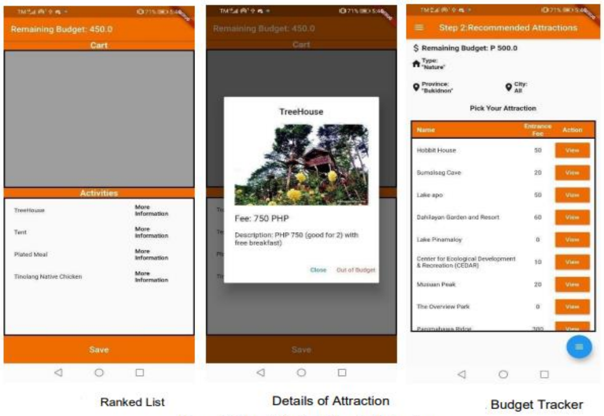


Figure 8. List of Ranked Tourist Attractions

Figure 9 displays the direction and distance information (from one attraction to the other attraction) as selected POI of the user and plotted to the map as a result of invoking the Google Maps API.

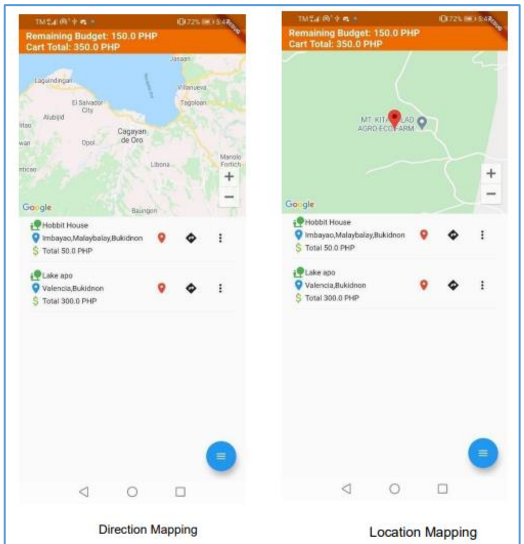


Figure 9. Integrating Google Maps API

Figure 10 shows the final transaction of the user to HappyTrip is the optimized travel itinerary. The itinerary file is saved. It shows the target date of the planned travel and final list of travel destinations.

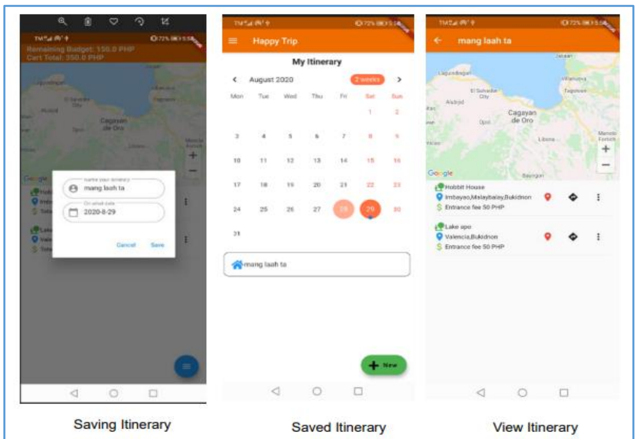


Figure 10. Generating Optimized Travel Itinerary

D. Content Management on the Web App

Figure 11 displays the page for AHP criteria management. The admin can add or modify more criteria to be used for the pairwise comparison of the AHP matrix. The web app also holds the content management of the user accounts, attractions database, customer review ratings, user's personal judgment scores processing and the likes to be able to synchronize and pass computed results to the mobile app of the tourist or user.

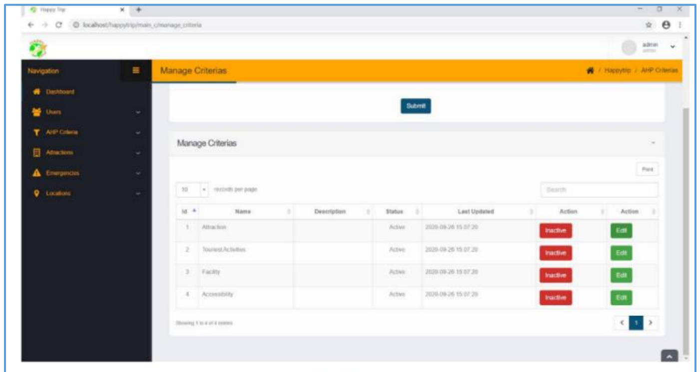


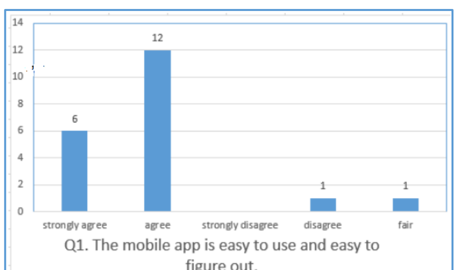
Figure 11. Web App GUI for Criteria Management

After a series of the system test and refinements, a system survey was conducted to evaluate its usability and functionality using the standard 10 item-questionnaire SUS survey questionnaire and then answers were consolidated. The system was tested through administration of web application and mobile application. In the process, there were twenty (20) respondents of prospect travelers and IT experts who evaluated the system's usefulness and user experience satisfaction. Furthermore, the system was also tested in relation to the server-side processes specifically on the cost time of the AHP algorithm. The details of the evaluation are shown below in two (2) parts:

1. System Evaluation utilizing **System Usability Scale** (SUS)
2. Evaluation of the system on the **server-side processes cost time**

D.1 System Usability Scale (SUS) Evaluation Result

The standard 10-item questionnaire SUS evaluation results are shown in Figures 12 to Figure 21. User's satisfaction result show that HappyTrip mobile-based travel recommender is user-friendly, unnecessarily complex and does not require technical assistance when used.



The mobile app is easy to use and figure out (Q1).
Figure 12. System Usability Test Evaluation Result

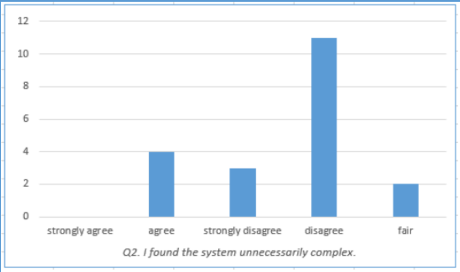


Fig.13 SUS Question#2 Results

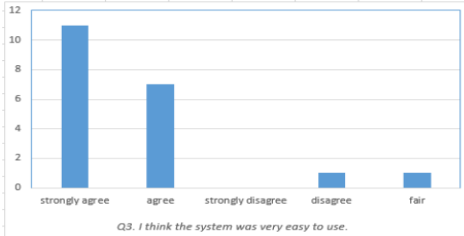


Fig.14 SUS Question #3 Result

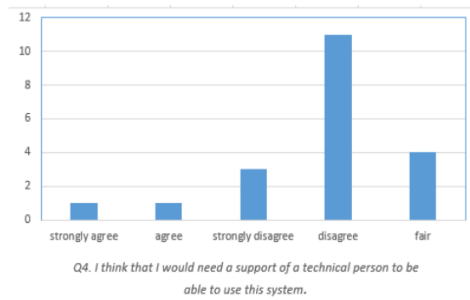


Fig.15 SUS Question #4 Results

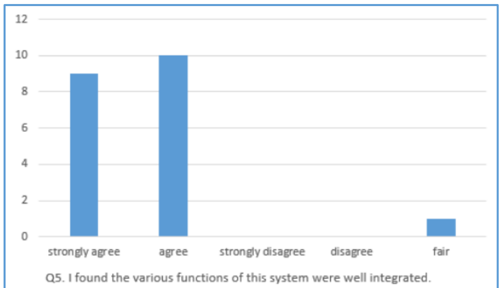


Fig. 16 SUS Question #6 Results

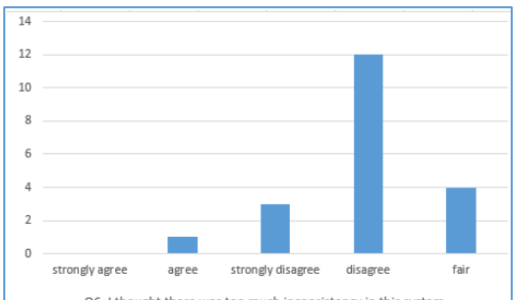


Fig.17 SUS Question #6 Results

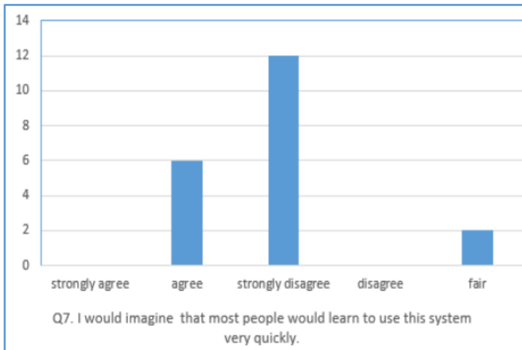


Fig.18 SUS Question #7 Results

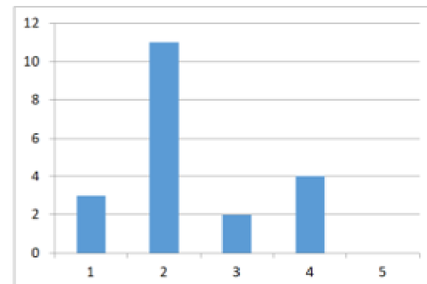


Figure 8. Survey result on the complexity of the system.
Fig. 19 SUS Question#8 Results

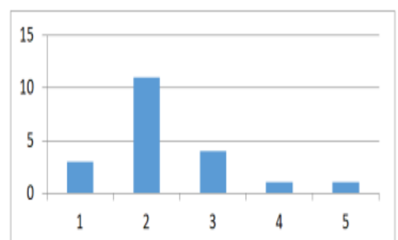


Figure 9. Survey result on the need for technical support in using the system.
Fig.20 SUS Question #9 Results

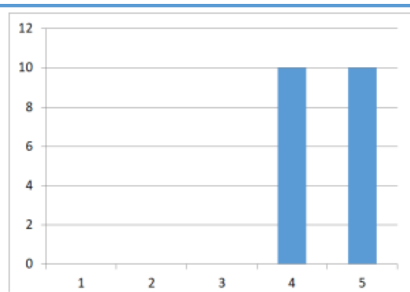


Figure 10. Survey result on user's overall satisfaction.
Fig.21 SUS Question #10 Results

D.2 Evaluation of the system on the ***server-side processes cost time***

In the performance evaluation of server-side process cost time, several factors were considered to check how AHP behaves during its pairwise comparison. Table 2 and Table 2 show the summary of the test conducted involved such an increase in the number of criteria with fixed number of alternatives and its reverse fixed number of criteria with increasing number of alternatives and then the cost time is noted.

Based on the evaluation and analysis results, the researcher offers the following recommendations for improving the system:

1. It is recommended to incorporate artificial intelligence (AI) techniques into the system to enhance personalization and automate the recommendation process further.
2. The Department of Tourism should explore the potential of utilizing the web and mobile app platform to expand the promotion of tourist attractions, thereby increasing global visibility and reaching a larger audience of potential travelers. This strategic approach has the potential to boost tourist influx and attract more visitors to the Philippines.

Table 3 Evaluating Server-side cost time with increasing alternatives

Number of Criteria	Number of Alternatives	Cost Time
4	15	0:00:00.222522
4	30	0:00:00.255106
4	60	0:00:00.249344

Table 2 Evaluating Server-side cost time with increasing AHP pairwise criteria

Number of Criteria	Number of Alternatives	Cost Time
4	15	0:00:00.222522
5	15	0:00:00.240228
6	15	0:00:00.224334
7	15	0:00:00.237025

Figure 22 to Figure 24 shows are the actual screenshots taken on
the actual test there is a difference of cost time in the server-side
processing with varying the number of criteria and alternatives.

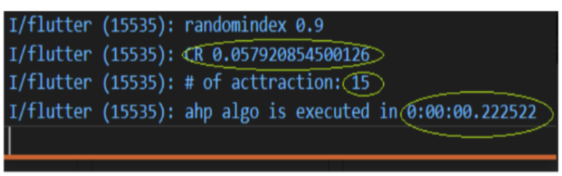


Fig. 22 Cost time for criteria value is 4, alternative is 15

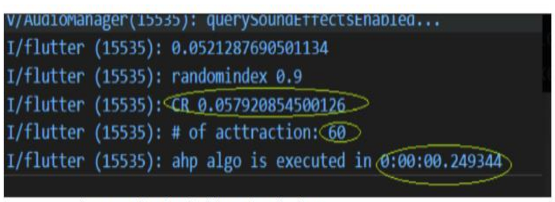


Fig. 23 Cost time for criteria is 4 , alternative is 60

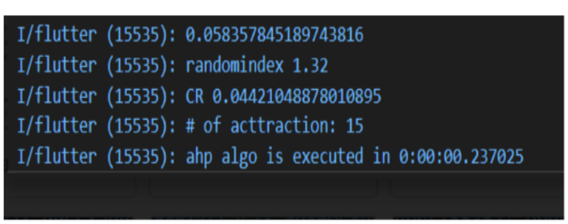


Fig. 24 Cost time for criteria value is 7, alternative is 15

4. CONCLUSION AND RECOMMENDATION

The results indicate that the system has achieved high satisfaction ratings for its user-friendly interactive features, thereby enhancing the overall user experience. Thus, this research study has successfully developed HappyTrip, a mobile-based travel recommender system that aims to optimize travel planning. The study contributes valuable insights to the field of recommender systems in the context of travel planning and emphasizes the potential of HappyTrip to revolutionize the tourism industry. By providing personalized recommendations aligned with individual preferences, HappyTrip strives to deliver happier and more satisfying hassle-free travel experiences.

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