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M-Guide: Hybrid Recommender System Tourism in East-Timor

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***Abstract*—Mobile devices have an important role in supporting every activity of the wide community. Mobile-based (android) tour guide system becomes a benchmark in supporting the Tourist activities. The purpose of this study is to apply M-guide application that utilizes location-based services with hybrid recommender system in guiding Tourists based on recommendation result. Collaborative filtering and content-based filtering methods have an interest in recommending Tourist attractions based on the past Tourist data by using the algorithm k-nearest neighbor (k-NN) to determine the rating of the Tourist attractions. The trend of Smartphone usage became an alternative in determining the contribution in this research by applying M-Guide which has the ability in recommending Tourist attractions and has a guide system in guiding the Tourists based on Tourist attractions in East Timor.**

Keywords—mobile; hybrid recommender system; content based; collaborative filtering; k-Nearest Neighbor

I. INTRODUCTION

Mobile devices have an important role in supporting every activity of wide community based on the number of Smartphone users which has grown exponentially with over 5,13 billion users by 2017 and is estimated to be around 9.1 billion users by 2020 [1]–[3]. Mobile devices with Android platform are the new generations of smart phones platform launched by Google. Android provides mobile map support and location services, which may be of concern to many developers [4]. New e-Tourism challenges have been dealt with the use of mobile computing (e.g., mobile phones, tablets, etc.) as they can provide services to customers anytime and anywhere with connectivity in wireless networks (e.g., GPRS, 3G and 4G) as well as relatively low cost [5]. So, users can access locations by means of Global Positioning System (GPS) with excellent graphics capabilities due to recent high-end mobile devices including Graphics Processing Unit (GPU) and large screen size, allowing 3D user interface development [6].

The strategic geographical location of East Timor as well as its membership in ASEAN and Comunidade Dos Países De Língua Portuguesa (CPLP) encourages the researchers to develop a mobile application guide system for disseminating the Tourism industry in Timor-Leste that has the potential to become destinations by the Tourists by integrate conventional tour guides towards modernization with a mobile guide system so as to facilitate the planning of destinations by Tourists. Tourism industry is a regional resource that has the potential to drive regional and national economies. Tourism industry also brings impacts in global economy, which employs about 200 million people and serves 700 million Tourists around the world. The number of Tourists arrivals around the world is expected to increase by more than 200% by 2020 [7].

The dynamics of the growth of the tourism industry are of particular concern to certain countries in this modern age so that innovative and effective ideas are needed in conveying information according to Tourist criteria and are seen as the most efficient and effective way of planning. A destination by Tourists [8]. The habit of information consumption using mobile devices (Android) presented over the Internet becomes the benchmark for Tourists to choose their destination. Although all the advantages are competitive and the prospects are wide, it is susceptible to too much information, making the information search to customize the tour takes longer [9].

Hybrid recommender system is a computer-based intelligent program which combines several methods using information techniques to handle the problem of too much information in recommending an object to a user to meet user preferences [10]. The hybrid recommender method in this research was used to develop hybrid recommender approach with the combination of collaborative filtering (CF) and content based filtering techniques are effectively adopted in the framework to provide the recommended items in accordance with the user's wishes [11]. The approach of collaborative filtering method is a recommender system based on the data collected to provide relevant and personal recommendations to Tourists based on past Tourist's behavior, using parameter like rating to provide recommenddations, In contrast to Content-based filtering selects information based on semantic content, or from descriptions of an item to recommend items relevant to the user [12].

Collaborative filtering and content-based filtering methods have an interest in recommending Tourist attractions based on the past Tourist data to determine the rating of the Tourist attractions. A classification algorithm k-nearest neighbor that supports the level of accuracy in recommender

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system applied to the Android mobile platform is required to provide appropriate information or Tourist attractions services which has the closest value according to user searches that are similar to users who need recommendations [13].

The results show that the system can recommend based on the results of the consultation on the planning objective user, Tourist attractions in East Timor with an easy graphical user interface (GUI) to guide travelers by integrating location-based services (LBS) integrated with a mobile device that has the capability of GPS-based location guide on mobile devices.

II. LITERATURE REVIEW

A. Earlier researchers

Zhang et al., in the title of his paper "Hybrid Recommender System Based on User-Recommender Interaction" [14], proposed a hybrid recommender system based on user-recommender interaction and evaluated its performance with recall and diversity metrics with system for the interactive scenario. Through adjusting the recommended parameters and comparing the random and hybrid algorithms. While there is a Jia et al.'s paper with the title "An Agent Framework of Tourism Recommender System", which proposed the development of a framework for travel agents, as the online application that able to provide Tourist information recommendations for user preference system by adopting collaborative filtering and content-based filtering [11]. Recommended agents can generate recommended information by integrating the recommendations of content-based collaborative filtering agent, agent-based and constraint-based agents, In order to make the performance more effective, the linear combination method of data fusion is applied. There is also research from Ismail et al., with the topic "iTourism Travel Buddy Mobile Application," which aimed to promote the Tourism potential as well as an effective way to disperse information [8]. This mobile application is important for the Tourism industry end Tourism Malaysia in order to enhance its performance in promoting Malaysia locally and internationally can also capitalize on the advantage of this application in order to gain visitor feedback on their products or services. While in his research, Gavalas et al., with the title "Mobile recommender systems in Tourism", aimedto utilize Recommender Systems (RSs) to reduce information overload and offer services or information to travelers [15].

B. Mobile Guide

Mobile guide is a smart phone that can be used to direct the user in accordance with the commands or instructions focused to exploit the context of information in helping on the move Tourists to find interesting places or related services [8][6]. The increasing popularity of smart phones also opens opportunities for mobile services to develop mobile Tourism applications to recommend Tourist attractions based on context factors such as location, weather condition, and available time [16]. This mobile Tourism application is seen as the most efficient means to help Tourists on their trip [8].

C. Recommendations System

Recommender system is a software tool and technique for recommending products, information, or services for users in automatic mode tailored to their preferences [13][14]. Recommender system is basically an information filtering system that aims to predict 'rating' to obtain the needs of the user's wishes, either explicitly or implicitly, and recommend the destinations to visit interesting places, events, or activities or a complete package of tours [15].

D. Location Based Service (LBS)

Location-Based Services (LBS) are the location-based services accessed via mobile device (smart phones, etc.), displaying a map along with the location where the mobile device is located [17]. Location-based services (LBS) provide the information tailored to user characteristics so that they can be easily extended to use in many other scenarios, such as guiding routes for transportation systems or Tourist attractions [18].

E. Hybrid Recommender System

In general, hybrid recommender system approach combines different types of recommenders with the aim of backing up the deficiencies of each approach, in order to provide a good recommendation of suitable Tourist attractions [14].

Collaborative and content-based recommender system approaches are often used in recommender system for Tourism domain [19]. Collaborative filtering model is based on calculating and collecting some large amounts of information about user's behaviors, activities or historical preferences and predicting user preferences based on their similarity to other users [20]. By contrast, content-based filtering method does not use parameters of rating system but is based on user recommendations. It is the description based on a user profile, or from description of an item to provide a recommendation [11][16].

F. K-Nearest Neighbor Algorithm

K-Nearest Neighbor is an approach in finding a case by considering the closeness between a new problem and the previous problem based on matching the value weight of some previous features to be used as a classification or prediction depending on the type of label data [21]. K-Nearest neighbor algorithm is also called the lazy learner, which easily stores the data in memory and can classify new items by comparing them with the items already stored using similarity function. The purpose of k-nearest neighbor algorithm is to classify new objects based on attributes and *training samples*. Which the results of the new test samples are classified by most of the categories on k-nearest neighbor algorithm uses location features and a decision-making fusion approach that uses visual and textual tagging features [22].

III. RESEARCH METHOD

A. Scheme Design of Research Method

The scheme design of research method was a step used by the researchers to sort the process occurred in this research, and the expected contribution as in Fig. 1. Which sorted the process taken by separating some blue dashed line is the early stage in formulating the topic of research as well as collecting the data and conducting literature study. While the yellow dashed line indicates that the method is used in previous studies. The red dashed line indicates some categories of Tourism and some facilities offered by the researchers in this research by utilizing the research methods once used by previous studies that could be used for modern Tourism to improve the quality of the Tourism industry in East Timor better.

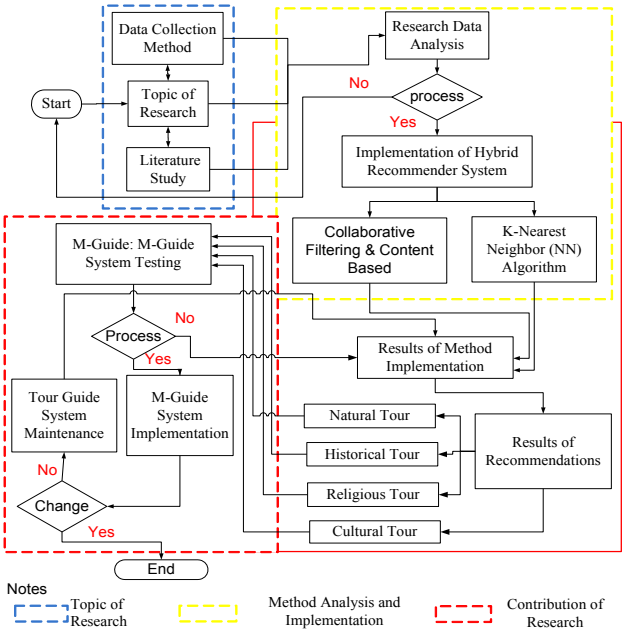

Figure 1. The Scheme Design of Research

B. System Process Flow

Based on the recommendation system, M-Guide has several process sequences in providing recommendations by combining several methods as in Fig. 2.

C. Blok Diagram Hybrid Recommender System

This system block diagram explains how the system will receive user input data to the Tourist location and user data. The calculation process used collaborative filtering and content based filtering methods. In this case, the researchers performed the system testing by using questionnaires to the parties concerned, aiming to measure the system functionality in assisting the planning of Tourist destinations.

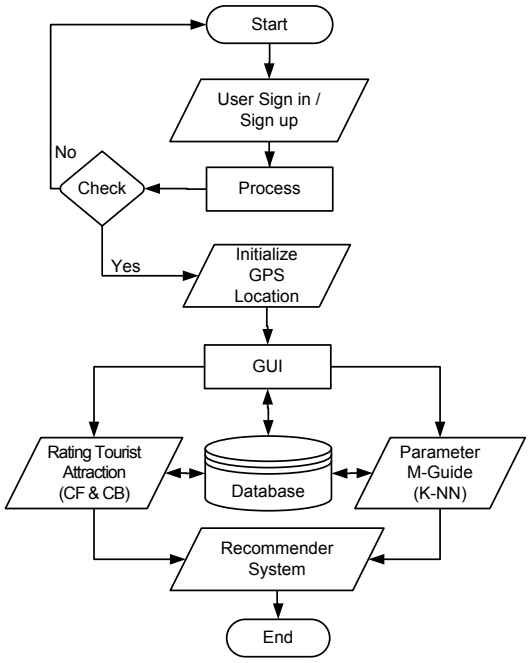

Figure 2. The System Process Flow

The data of 50 new users became the benchmark in determining the level of similarity of the recommendation attribute. The user rated the Tourist destinations of the total of all Tourist attractions that had been determined and user data to make recommendations. The similarity of each new user was added to the similarity results of the other users. The results were then divided with the number of correspondence value of the Tourist attractions and the available user data to be recommended. The results of questionnaires of system on hybrid method (content based-collaborative) were then calculated by the following: Hybrid = (Total Similarity/Total Correspondent) *100%.

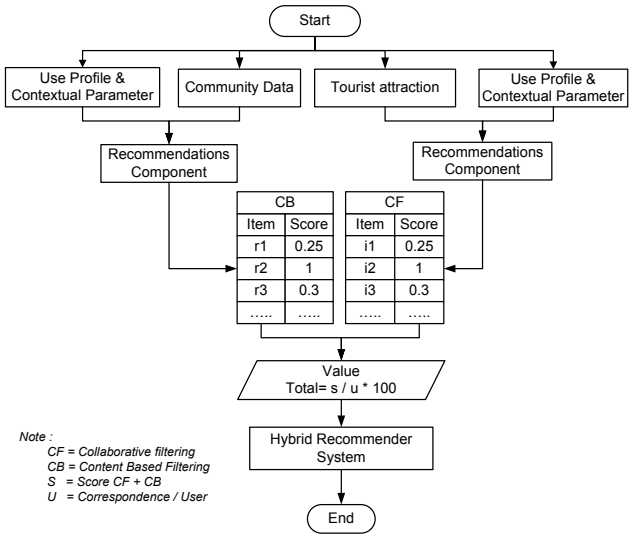

Figure 3. Block Diagram of Hybrid Recommender System

D. The Selection of Tourist Attractions

The M-guide Hybrid recommender system recommended has a consultation menu to facilitate the user in determining the destination in accordance with the desired criteria. There are several attributes that serve as a system benchmark to be able to provide recommendations in accordance with the choice of attributes or criteria of the user. Table I shows tourism attributes that are used in the system.

TABLE I. TOURISM ATTRIBUTE

Attribute	Value
Type of Tour	Natural, Historical, Cultural, and Religious
Price	Free, Cheap, Fair, and Expensive
Facility	Toilet, Souvenir, Restaurant, Bistro etc.
Activity	Refreshing, Adventure, Playing
Transportation	Motorcycle, Car, and Bus
Location	GPS Coordinate

IV. RESULTS AND DISCUSSION

A. Collaborative Filtering

Collaborative filtering will filter information based on the rating of the attractions based on the users of the past tour. If content based filtering methods do not find recommendations that match user preferences, then the filtering action of collaborative filtering method is done by looking at the rating of a tourist object that has been done by the user. The following is the application of the 1-weighted sum equation in performing the rating process of an object or item.

$$P_{(u,j)} = \frac{\sum_{i \in I} (R_{u,i} * S_{i,j})}{\sum_{i \in I} |S_{i,j}|} \quad (1)$$

Notes:
$P_{(u,j)}$ = Prediction for user u on item j.
$i \epsilon I$ = The set of items similar to item j.
$R_{(u,i)}$ = User rating u on item i.
$S_{(i,j)}$ = The value of similarity between item i and item j.

Table II shows an example of data from the rating process of each user on each object, as well as the average rating of users and tourist objects.

TABLE II. AVERAGE VALUE OF OBJECTS

User	Tourist Attraction						Avg Rating User
	A	B	C	D	E	F	
1	-	3	5	4	-	-	**4.00**
2	-	2	1	4	2	3	**2.40**
3	-	3	-	-	-	3	**3.00**
4	1	-	1	-	2	-	**1.33**
Avg Value Tourist Attraction	**1.00**	**2.66**	**2.33**	**4.00**	**2.00**	**3.00**	

Data will be looking for value similarity between an object A with object B with equation 2 adjusted cosines as follows.

$$sim(i,j) = \frac{\sum_{u \in U} (R_{u,i} - \overline{R}_u)(R_{u,j} - \overline{R}_u)}{\sqrt{\sum_{u \in U} (R_{u,i} - \overline{R}_u)^2} \sqrt{\sum_{u \in U} (R_{u,j} - \overline{R}_u)^2}} \quad (2)$$

The application of (2) aims to get a similarity value between Tours A with Tours B as shown in Table III.

TABLE III. SIMILARITY VALUE

Tourist Attraction 1	Tourist Attraction 2	Similarity
Tours A	Tours B	0
Tours A	Tours C	1
Tours A	Tours D	0
Tours A	Tours E	−1
Tours A	Tours F	0
Tours B	Tours C	−0.24
Tours B	Tours D	−0.37
Tours B	Tours E	1
Tours B	Tours F	−1
Tours C	Tours D	−0.81
Tours C	Tours E	0.30
Tours C	Tours F	−1
Tours D	Tours E	−1
Tours D	Tours F	1
Tours E	Tours F	−1

From the results of similarity values, that can be used to make the predictions or recommendations. The results obtained using the equation 2-weighted sum are presented in Table IV.

TABLE IV. PREDICTED RESULTS

User	Tourist Attraction	Predictions
1	A	2.5
1	E	0.11
1	F	−1
2	A	−0.33
3	A	0
3	C	−1.11
3	D	0.59
3	E	0
4	B	0.67
4	D	−0.88

B. Content Based

Content-based filtering will filter information based on the attributes of each user's recommendations derived from the activities of travelers as a preference. The system will search and filter other users who share the same attribute recommendations based on data stored in the database. Similarly, for users who have done the destination will automatically update the process of recommendation attributes for users who have made the destination in accordance with the last visit he did. Then from the result attribute recommendation of each user who has logged will

be calculated proximity between users based on the values of its recommendation attributes

Utilization of weights in attributes is an important step in each user attribute to be recommended has a weight and closeness between the values in the recommendation attribute. Based on logged-in users will then calculate the value of proximity among other users by using a nearest neighbor algorithm based on the greatest distance results from each weight calculation on each user as in The Simulation of Consultation Calculation process.

Implementation of the nearest neighbor algorithm is to find the largest distance by performing calculations between the proximity of attribute values and attribute weights. Here are the stages of determining the greatest distance using the nearest neighbor:

C. The Simulation of Consultation Calculation

The process of this calculation simulation involved all the attributes and categories of each Tourist attraction where, when the user specifies some desired parameters, the system will find the highest value of the similarity level of each category of Tourist attraction that has the same type as other predefined categories, then the weight of its value will be calculated by k-nearest neighbor (k-NN) to get the recommendation results from the old case to the new case based on some user priorities such as, Main Priority with value of 7, Medium Priority with value of 5, and Not a Priority with value of 3, as in the example below With the following Euclidean distance equation.

$$Similarity(T,S) = \frac{\sum_{i=1}^{n} f(T_i, S_i) * w_i}{w_i} \quad (3)$$

Notes:
T = New case
S = Existing cases in memory (storage)
n = The number of attributes in each case
i = Until the individual attribute is between 1 and n
f = Function similarity attribute between case T and case S
w = Function similarity attribute between case T and case S

The weight of the parameter used (B) is as in Table V.

TABLE V. WEIGHTS OF PARAMETERS

Top Main Priority (7)	Medium Priority (5)	Not a Priority (3)
a. Cultural Tour	a. Bistro	a. Souvenir
b. Religious Tour	b. Seller of Snacks / Stalls	b. Expensive (price)
c. Historical Tour	c. Fair (price)	c. Car
d. Natural Tour	d. Vacation	
e. Lodging	e. Bus	
f. Toilet		
g. Cheap (price)		
h. Refreshing		
i. Adventure Tour		
j. Motorcycle		

In this calculation, the researchers used the formula of:

$$Similarity(\text{problem, case}) = \frac{s_1 * b_1 + s_2 * b_2 + \ldots + s_n * b_n}{b_1 + b_2 + \ldots + b_n} \quad (4)$$

Notes:
s = *Similarity,* i.e., 1 (same) and 0 (different)
b = *Weight*

In the process of calculating the value of similarity to the case raised, the researcher determines a new situation or case by using some attributes as in Table VI.

TABLE VI. NEW CASES (X)

Option
1. Natural Tour
2. Fair
3. Toilet
4. Souvenir
5. Restaurant
6. Refreshing
7. Motorcycle

Based on the attributes of the new case, it can calculate the similarity value of the old case with the new case similarity value based on some of the attributes that the user chooses against the old case to find the similarity level with the new case, as shown in Table VII.

TABLE VII. PREVIOUS USER OPTIONS

Attribute		
Option 1	**Option 2**	**Option 3**
1. Natural Tour	1. Natural Tour	1. Natural Tour
2. Fair	2. Expensive	2. Fair
3. Toilet	3. Toilet	3. Toilet
4. Souvenir	4. Souvenir	4. Restaurant
5. Bistro	5. Bistro	5. Bistro
6. Refreshing	6. Lodging	6. Refreshing
7. Bus	7. Refreshing	7. Motorcycle
	8. Car	
Results of Recommendations		
Area Branca Manu Leu	Area Branca Cristo Rei	We'e Tuda Tiris

The weight values for Option 1 are shown in Table VIII.

TABLE VIII. WEIGHT SOLUTION OF OPTION 1

Similarity (problem, case)	
Option 1	**Value/Weight**
1. Natural Tour	7
2. Fair	5
3. Toilet	7
4. Souvenir	3
5. Bistro	5
6. Refreshing	7
7. Bus	5

Based on Option 1 or the criteria entered then Similarity (X, 1) is calculated as the following.

$$\frac{(1*7)+(1*5)+(1*7)+(1*3)+(1*5)+(1*7)+(0*5)}{7+5+7+3+5+7+5}=0.87$$

The weight values based on Option 2 are shown in Table IX.

TABLE IX. WEIGHT SOLUTION OF OPTION 2

Similarity (problem, case)	
Option 2	**Value/Weight**
1. Natural Tour	7
2. Expensive	3
3. Toilet	7
4. Souvenir	3
5. Bistro	5
6. Lodging	7
7. Refreshing	7
8. Car	3

For Option 2, Similarity (X, 2) can be calculated as the following.

$$\frac{(1*7)+(0*3)+(1*7)+(1*3)+(1*5)+(0*7)+(1*7)+(0*3)}{7+3+7+3+5+7+7+3}=0.69$$

The weight values in Option 3 are calculated against the old case based on the attributes used to find the similarity value, as shown in Table X.

TABLE X. WEIGHT SOLUTION OF OPTION 3

Similarity (problem, case)	
Option 3	**Value/Weight**
1. Natural Tour	7
2. Fair	5
3. Toilet	7
4. Restaurant	5
5. Bistro	5
6. Refreshing	7
7. Motorcycle	7

For Option 3, Similarity (X, 3) can be calculated as the following.

$$\frac{(1*7)+(1*5)+(1*7)+(1*5)+(0*5)+(1*7)+(1*7)}{7+5+7+5+5+7+7}=0.88$$

Based on the results of the simulation of calculation of the old case to the new case, there were different similarity values, so that the similarity level could be assumed based on the highest weight used as a reference for the recommendation.

Based on the discussion on the consultation process, the following is the interface page of the consultation process and the recommendation view accompanied by the back button to return to the previous page, while the History button to view the history of the tourist location and Guide button has a function in guiding travelers with navigation on Google maps. The page is also accompanied by a distance to the location of the temporary tourist spot so as to facilitate the tourists in traveling. The page display as described above is in Fig. 4.

Figure 4. The Displays of the Results of Consultation

In Fig. 4, it can be seen several consultation pages and recommendations that are integrated with Google map in guiding the Tourists with the guide button that has been provided

V. CONCLUSION

The implementation of hybrid recommender system and K-Nearest Neighbor Algorithm methods provided android-based (M-Guide) recommender system of Tourist attractions and tour guide based on several categories of tours such as, Natural, Cultural, Historical, and Religious Tours. This system was very effective and efficient in helping Tourists to determine their destination planning in East Timor. The M-Guide is expected to develop in multiplatform with flexible parameters and multi criteria in the future, thus, providing better results of the recommendations than this research.

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