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Collaborative and Content-Based Filtering Hybrid Method on Tourism Recommender System to Promote Less Explored Areas

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Abstract **- The COVID-19 pandemic has significantly impacted various areas of life, including tourism. Currently, the tourism sector is starting to recover and start its activities. However, several tourist attractions have not been explored, thus making visitors less aware of information about these tours. This affects the number of tourist visits. Therefore, there is a need of an information technology approach to promote tourism objects, including a tourist recommendation system. This study proposed a hybrid recommendation system incorporating collaborative and content based filtering. This model is proven to be able to produce good rating predictions on a recommendation system. This hybrid method uses a linear combination by calculating the rating matrix and user profile as the first step in providing rating predictions. Collaborative filtering is calculated using the cosine similarity algorithm and weighted sum algorithm, while the content-based filtering method is performed by calculating the weight of each available feature. We apply this model to the Palembang tourism dataset to the the website. This system recommends existing historical tourist attractions based on visitor criteria. The results show the existing data's effective, efficient, and accurate results. The calculation result that the rating prediction using the hybrid method is 3.203. In addition, this method can also help overcome existing cold start problems.**

Index Terms **- Collaborative Filtering, Content-Based Filtering, Hybrid, Recommendation System, Tourism.**

INTRODUCTION

Information technology has now been adopted in every line of life, from primary to secondary to tertiary. The fulfillment of the need for food, education, finance, and even tourism has been greatly supported by information technology. The World Tourism Organization defines tourism more generally. Tourism is not limited to leisure activities but also people's activities to travel and live outside their environment within 24 hours to one year for business and other purposes [1]. Tourism, such as recreation or sightseeing, is carried out together or alone.

Global statistical data show that in 2021 the direct contribution of travel and tourism to GDP will be around 5.8 billion dollars [2].

Information technology provides convenience in the dissemination of information. The tourism industry has led to rapid progress in the domain. The community is offered various alternative tourist destinations with their uniqueness. This results in user confusion in the search for the desired object for the various choices of existing tourism objects. Therefore, we need an approach that can help in overcoming these problems. The strategy that can be used for this condition is the recommendation system [3][4].

Recommendation systems are software applications and techniques based on observations to provide product suggestions according to the interests and desires of certain customers [5]. Developing a recommendation system requires a suitable model to produce item recommendations according to customer wishes. A large amount of available information requires a filter system to select and display important information. The recommendation system selects certain pieces of information according to the user's preferences regarding particular items. This system is able to predict the user's choice of items based on the user's profile [6]. There are several model for developing recommendation methods, such as content-based, collaborative, hybrid, knowledge-based, demographic, and others [7][8][9].

Content-based is a method that recommends to customers based on the similarity of items previously liked by the customer by comparing the available features [8] . The advantage of this method is that it can provide item recommendations without knowing the rating of other items [3]. In comparison, the drawback of this method is that it cannot give accurate recommended items for new users with

insufficient of information. This model also offers a limited degree of novelty as it has to match the availability of profile features and items [8].

The collaborative method provides recommendations based on considerations of other users' preferences [10][6]. For example, most users who like product A also like product B, so if other users like product A, the recommendation system will recommend product B. The advantages of this method are that it is easy to implement and can filter various types of information or goods. In contrast, the drawback of this method is that it requires a rating parameter [11]. Recommendations are based solely on explicit feedback from users in the form of ratings, so the system will not recommend the item if there is a new item.

Furthermore, the hybrid method is a method that can combine more than one recommendation system method to overcome the shortcomings of each method to produce a better recommendation [8][12]. In the hybrid method, there are three ways to merge: linear merging, sequential merging, and merging item-based clustering hybrid methods. This hybrid method has the advantage of overcoming some of the problems in the recommendation system, such as sparsity, scalability, and cold-start [12].

Based on some of the methods and problems described above, the researcher found opportunities to overcome the problem of underexplored tourism. Under-explored tourism has the opportunity to be able to introduce its tourism object to the broader community by utilizing a recommendation system.

For this research, we utilized the tourism dataset of Palembang, Indonesia. This city is famous for its culinary tourism, while nature tourism, such as mountains and beaches, is unavailable. However, the city of Palembang provides a place worth exploring, namely its historical place. The tourism recommendation system will utilize a hybrid method between collaborative and content-based filtering through a linear combination. Combining methods can produce effective and can overcome existing cold-start problems. The resulting rating will be better, which can help spread information about less explored tourism to the wider community. Cold start is an issue in the recommendation system where the system cannot recommend a relevant item to customers because there is no adequate information about the item [13][12].

Our previous publication proposed the initial design of a web based tourism recommendation system [14]. This paper focuses on developing hybrid collaboration filtering that integrates collaborative and content-based filtering using a linear combination.

The next parts of this paper are outlined as follows: Section 2 brings up the literature review related to the research. Section 3 reveals the methodology used. Section 4 discusses the results and discussion. Finally, Section 5 is the conclusion.

RELATED WORK

Several studies have researched, observed, and discussed recommendation systems as part of e-tourism.

Many studies on smart recommendation systems in the tourism sector have been developed, including content-based, collaborative filtering, demographic, knowledge-based, community-based, and hybrid recommender systems [15]. A study of e-tourism recommendation research trends was conducted. The research identified content-based, collaborative, preference-based product ranking, and language modeling [16].

A personalized travel destination recommendation system for individuals and groups has been designed [17]. Recommendations are formulated based on user rating profiles, personal interests, and requests for future destinations. The system algorithm uses a hybrid approach combining content-based, collaborative filtering and knowledge-based solutions. The results of the individual approach and the hybrid approach are compared. The results prove that users prefer hybrid algorithms over each individual technique.

The concept of smart tourism is a logical development of e-tourism based on the widespread adoption of information and communication technologies and their relationship to the physical and digital worlds. Hamid, et al surveyed the opportunity of tourism recommender systems (TRS). The survey presented that 38% of the system recommendations in the paper use the hybrid method [18].

Research by Esmaeili, et al provides a social hybrid recommendation system on e-commerce to offer recommendations for tourist attractions. The result of this study is to demonstrated a personalized list of tourist attractions for each tourist based on the common desires and interests of users, trust, reputation, relationships, and social community [19].

Another study developed a hybrid recommendation system using the K-Nearest Neighbor (K-NN) algorithm. The was applied to calculate the similarity between Collaborative Filtering and Content-Based Filtering. This model is also involved Pearson Correlation to rank user items [20].

An interactive hybrid context-based tourism recommendation system was built to obtain user account feedback and additional contextual information. It presents a personalized tour to the user based on his preferences based on a combination of a case-based reasoning framework and an artificial neural network [21].

Another model that is often implemented is to combine Collaborative Filtering and Content-based Filtering is Demographic Filtering. This is obtained by classifying user information related to visitor recommendations to certain places to match the preferences of places that have been visited before [22][23].

Tourism recommendation systems have been widely implemented to support tourism in various countries, as the example Morocco [24], Oman [25], Australia [26], Tunisia

[27], Ecuador [28], Nepal [29], Portuguese [30], and Thailand [31]. Our research aims to propose a form of tourism recommendation system in Palembang.

Some tourist attractions are less explored areas. This city's lack of tourist information is one of the main challenges in creating a recommendation system. Furthermore, we propose a hybrid recommendation system to represent the tourism insight of Palembang city.

PROPOSED METHOD

I. Collaborative Filtering

Collaborative filtering determines correlation by assigning past users' item rankings to new users. The preferred correlation rank is determined using a matrix decomposition method for users and items. This product value matrix is built up from two component value matrices [5]. Figure 1 illustrates the collaborative filtering method.

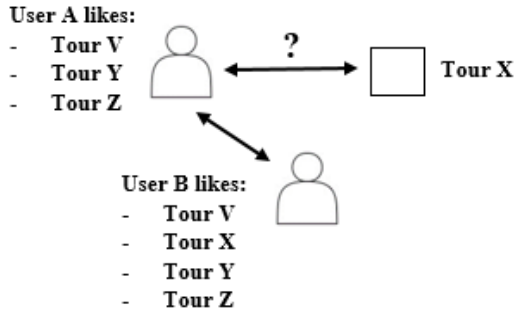

FIGURE 1 COLLABORATIVE FILTERING METHOD

TABLE I
MATRIX USER X ITEMS IN COLLABORATIVE FILTERING

users/items	$item_1$	$item_2$	$item_3$	$item_4$	$item_5$
U_1	5	7	5	7	?
U_2	5	7	5	7	9
U_3	5	7	5	7	9
U_4	6	6	6	6	5
U_5	6	6	6	6	5

The collaborative filtering recommendation system operates in a two-dimensional *user x item space*. The rating given by the user to an item can be represented as *R* which contains a non-negative integer or a real number with a certain distance. If the user has not yet rated an item, the recommendation system will attempt to guess the rating. For example, there are five users namely U_1, U_2, U_3, .. U_5, and five items $item_1$, $item_2$, $item_3$ ... $item_5$. The recommendation system wants to predict the rating value that will be given by U_1-*item5*, as shown in Table 1.

Equation (1), known as the weighted sum formula [32], can be used to estimate or forecast a user *U* rating of an item *i* based on the average rating of other users (neighbors).

$$R'(u,i) = \frac{1}{\sum u' \in N(u)|sim(u,u')|} \sum_{u' \in N(u)} sim\,(u,u') * R(u',i) \quad (1)$$

description :

- $R'(u,i)$ = user *U* expected score for item *i*
- $R(u'i)$ = user rating *U* for item *i*
- $Sim\,(u,u')$ = comparable user bases
- $N(u)$ = another collection of users like user *U*

The cosine similarity algorithm is the best algorithm to calculate the similarity between the two users [32]. The cosine similarity algorithm can be calculated, following Equation (2).

$$Sim(U1,U2) = \frac{U1\ .\ U2}{||U1||\ ||U2||} \frac{\sum_{i=1}^{n} AiBi}{\sqrt{\sum_{i=1}^{n} A_i^2}\ \sqrt{\sum_{i=1}^{n} B_i^2}} \quad (2)$$

Description:

- $Sim\,(U1,U2)$ = the similarity between data-1 and data-2
- $AiBi$ = U_1 and U_2 rated products

II. Content-Based Filtering

The content-based filtering employs existing user preferences to forecast the rating of unrated items by selecting the most relevant phrases. is generated based on information retrieval techniques, which can be in the form of text and vector representation [8]. For example, through his activity history on other items such as likes, dislikes, ratings, etc. Then, when the system will recommend an item, the system will examine the profile of an item whether to be liked or not based on the user's profile. Figure 2 illustrates the content-based filtering method.

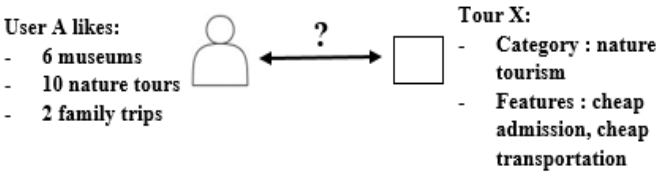

FIGURE 2 CONTENT-BASED FILTERING METHOD

The content-based filtering recommends items based on user profile. For example, a user has given a rating value to five *items* $item_1$, $item_2$, $item_3$, $item_4$, $item_5$ which have four features J_1, J_2, J_3, J_4, as shown in Table 2. The value=1 indicates that the item has a similarity attribute, while the value=0 indicates that the item does not have a similarity attribute.

TABLE II
FEATURED ITEMS

item	J_1	J_2	J_3	J_4	rating
$item_1$	1	1	1	1	4
$item_2$	1	0	1	1	3
$item_3$	1	0	0	0	2
$item_4$	1	0	1	1	3
$item_5$	1	1	0	1	?

To calculate the weight of each attribute, you can use the following content-based filtering formula [33].

$$w(u,jk) = \frac{1}{|Iu|}\sum_{i \epsilon Iu} x(i,j)r(u,i) \quad (3)$$

description :

- *w(u,jk)* = The user *U's* weight on feature *jk*
- *Iu* = user-rated products
- *x(i,j)* = a feature's existence value (*1 or 0*)
- *r(u,i)* = The user *U's* rating evaluation of item *i*

III. Hybrid Methods

Figure 3 shows how hybrid solutions overcome separate approaches' weaknesses. The hybrid strategy is employed in this inquiry to relieve the challenges produced by the two methodologies outlined above, which cannot offer new items. This hybrid technique may perform linear, sequential, and item-based clustering mergers (ICHM). Figure 4 illustrates the hybrid linear combination used for this study.

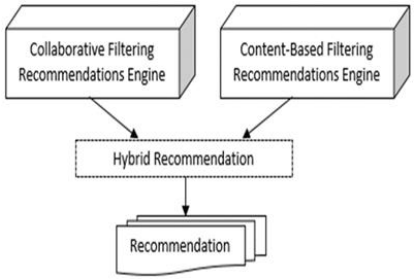

FIGURE 3 COLLABORATIVE FILTERING AND CONTENT-BASED FILTERING HYBRID METHOD [22]

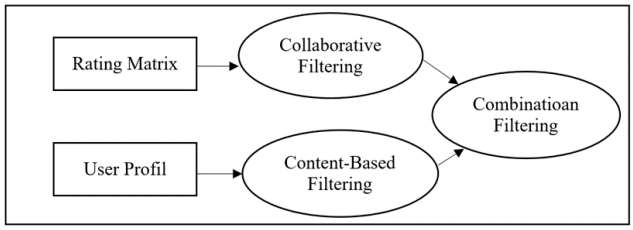

FIGURE 4 HYBRID LINEAR COMBINATION

Hybrid linear combination utilizes the rating matrix and user profile where the value of the rating matrix can be determined using collaborative filtering calculations, while the value of the user profile can be determined using content-based filtering calculations. Therefore, the hybrid method will produce a combination filter. The computation of this linear combination uses the weighted average formula, following Equation 4 [33]:

$$R\text{-}hybrid = (W_1R_1+W_2R_2+\ldots W_nR_n) / (W1+W2+\ldots W_n) \quad (4)$$

description :

- *R-hybrid* = hybrid rating prediction
- W_n = weight of rating prediction with nth method
- R_n = rating prediction with the nth method

IV. Calculation Rating Model

In developing the calculation rating model, we build a scenario by employing a recommendation system based on the name and characteristics of the tourist attraction in the beginning. Here are some examples of places that visitors may go to when they are in Palembang, Indonesia. In such locations, we also supply a variety of intriguing stuff. Therefore, we have provided an initial rating for the location, which can be found in Table 3.

TABLE III
SOME TOURIST ATTRACTIONS

Id	Tourism	Features	Rat
6	Bukit Siguntang	Nature, culture & history, indoor, toilet, tourist distance, restaurant, tour price	4
11	Balaputra Dewa Museum	Culture & history, indoor, toilet, tourist distance, price tourism	3
13	Sriwijaya Kingdom Tourism Park	Culture & history, indoor, toilet, tour distance, tour price	4
15	Kemaro Island	Nature, culture & history, outdoor, toilet, tour distance, restaurant, tour price	5
14	Ampera	Culture & history, outdoor, toilet, culinary, travel distance, restaurant, tour price	5

Calculating the prediction rating with the content-based filtering approach is the initial stage in getting the suggestion, and the results of this calculation are presented in Table 4. Subsequently, compute the user's weight for each following characteristic Equation (3):

TABLE IV
THE FEATURE ITEMS

	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	rat
itm_6	1	1	1	0	0	1	0	1	1	1	4
itm_{11}	0	1	1	0	0	1	0	1	0	1	3
itm_{13}	0	1	1	0	0	1	0	1	0	1	4
itm_{15}	1	1	0	1	0	1	0	1	1	1	5
itm_{14}	0	1	0	1	0	1	1	1	1	1	5

The computation of the user weight result for each feature is presented in Table 5. After this sort of weighing has been completed, it will be necessary to determine the anticipated tourist attractions using the following Equation (5):

TABLE V
THE RESULTS OF THE WEIGHT CALCULATION

	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}
users	2	5	3	2	0	5	1	5	3	5

$$R'(u,i) = \frac{1}{|Di|}\sum j\epsilon\ Di\ W(u,j) \quad (5)$$

description :

- *R' (u,i)* = The item *i* prediction by user *U*
- D_i = The item *i's* features.

Collaborative filtering will be used to make predictions after rating calculation has been obtained. The first step is to look at Table 6 and create a rating matrix that compares the primary users to the users who are most like them. Because of this, we will employ the cosine similarity method calculated following Equation (1). Subsequently, the average value of other users' ratings is calculated following Equation (2) to derive the users' ratings *U's* for item *i*. The final stage involves doing hybrid computations according to Equation (4).

TABLE VI
USER RATING MATRIX AND ITEM

	itm_6	itm_{11}	itm_{13}	itm_{15}	itm_{14}	itm_{16}
U_{10}	4	3	4	5	5	?
U_{11}	3	4	4	5	5	3
U_{15}	4	4	3	4	4	5
U_{19}	5	3	5	5	5	4
U_{20}	4	3	4	4	4	3

RESULTS

I. Rating Content-Based Filtering

The content-based filtering method calculates each feature's weight based on rating items. The following results from the weight calculation follow Equation (1).

$$W(Lenora, Nature) = \frac{(1x4)+(0x3)+(0x4)+(1x5)+(0x5)}{5} = 1.8$$
$$W(Lenora, Culture\ \&\ History) = \frac{(1x4)+(1x3)+(1x4)+(1x5)+(1x5)}{5} = 4.2$$
$$W(Lenora, Indoor) = \frac{(1x4)+(1x3)+(1x4)+(0x5)+(0x5)}{5} = 2{,}2$$
$$W(Lenora, Outdoor) = \frac{(0x4)+(0x3)+(0x4)+(1x5)+(1x5)}{5} = 2$$
$$W(Lenora, Rides) = \frac{(0x4)+(0x3)+(0x4)+(0x5)+(0x5)}{5} = 0$$
$$W(Lenora, Toilet) = \frac{(1x4)+(1x3)+(1x4)+(1x5)+(1x5)}{5} = 4{,}2$$
$$W(Lenora, Culinary) = \frac{(0x4)+(0x3)+(0x4)+(0x5)+(1x5)}{5} = 1$$
$$W(Lenora, Travel\ Distance) = \frac{(1x4)+(1x3)+(1x4)+(1x5)+(1x5)}{5} = 4{,}2$$
$$W(Lenora, Restaurant) = \frac{(1x4)+(0x3)+(0x4)+(1x5)+(1x5)}{5} = 2.8$$
$$W(Lenora, tour\ price) = \frac{(1x4)+(1x3)+(1x4)+(1x5)+(1x5)}{5} = 4.2$$

If all the variables have been included, the greatest scores are discovered for cultural and historical attractions, restrooms, distances traveled by tourists, and the cost of tours. Rating prediction using the content-based technique will be computed using this weight.

$$R'(u,i) = \frac{(1.8+4.2+2.2+2+0+4.2+1+4.2+2.8+4.2)}{10} = 2.66$$

II. Rating Collaborative Filtering

Cosine Similarity Algorithm: Cosine Similarity Algorithm is trying to calculate the similarity between user-1 and user-2, as shown in Table 7. The algorithm uses a set of ratings for the two users on the same item.

The output of this algorithm is the value of similarity which ranges from 0 to 1, where a value=0 means that the two users have no similarity or similarity, while the value=1 means that the two users have similarities. The next step is calculate cosine similarity using Equation (2).

Therefore, the calculation value between Lenora and Desti users has a value of 0.981, Lenora and Hattan users have a value of 0.994, and Lenora and Anita users have a value of 0.993. The order of these values shows that Lenora and Hattan users have a higher similarity value than other users. This value will be used in calculating the rating weighting sum prediction on collaborative filtering.

TABLE VII
USER AND ITEM MATRIX FOR RATING CRITERIA

user	tourist attraction					
	item6	*item11*	*item13*	*item15*	*item14*	*item16*
U_{10}	4	3	4	5	5	?
U_{11}	3	4	4	5	5	3
U_{15}	4	4	3	4	4	5
U_{19}	5	3	5	5	5	4
U_{20}	4	3	4	4	4	3

- *Weighted Sum Algorithm:* Weighted Sum Algorithm is an array containing similarities between the target user and neighbor users. The result of this algorithm is the prediction of the user's rating on the target. The following is the prediction example calculation by user: Lenora to target: PuntiKayu tourism using Equation (4).

$$R' = \frac{(0.9890x3) + (0.9815x5) + (0.9940x4) + (0.9938x3)}{0.9890 + 0.9815 + 0.9940 + 0.9938} = 3.747$$

III. Hybrid Methods

After calculating the predictions using the collaborative and content-based filtering methods, the following two predictions combine the predictions using a linear approach hybrid method. The content-based filtering computations suggest a rating of 3.74. In comparison, the rating prediction using collaborative filtering is 2.66. Then the next step is to calculate the rating prediction using (4).

$$R_{hybrid} = \frac{(3.7470488456x2) + (2.66x2)}{2+2} = 3.2033$$

Based on the calculations, it can be concluded that the rating prediction uses the method hybrid given by *user10* for *item16*. is 3.203.

III. Web Implementation

The purpose of the web application in this research is to improve the Punti Kayu (i_6) tourist ranking. Figure 5 and Figure 6 below will demonstrate the changes that occurred as a result of employing the proposed hybrid methods. Figure 5 depicts the results of implementing a website only using the collaborative filtering technique, whereas Figure 6 depicts the results of implementing a website using proposed hybrid methods.

It demonstrates that combining two different types of filtering approaches can provide more accurate ratings than using either approach alone.

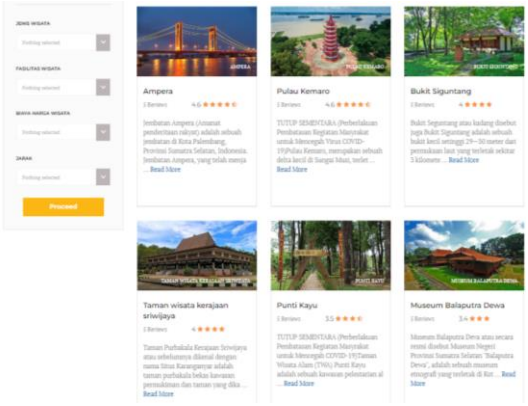

FIGURE 5 WEB IMPLEMENTATION USING COLLABORATIVE FILTERING

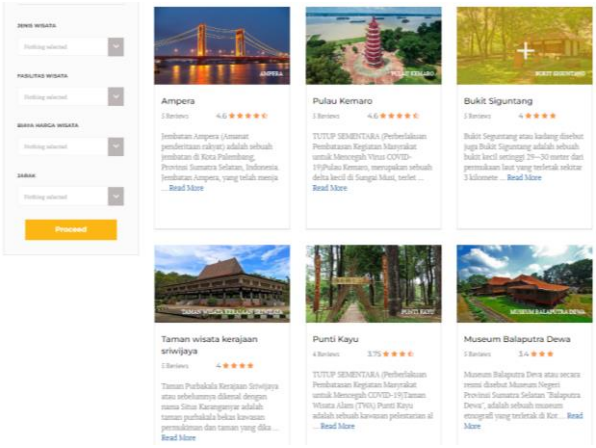

FIGURE 6 WEB IMPLEMENTATION USING HYBRID METHODS

CONCLUSIONS

The collaborative filtering approach generates the rating from the preceding user's history, yielding 3.747. While the content-based filtering estimates 2.66 based on item characteristics. Subsequently, the proposed hybrid methods get a rating of 3.203. Based on the hybrid method's calculation, the final value does not surpass the collaborative filtering calculation results. The hybrid calculation method will grow with future visitor ratings. This will benefit less-known tourism sites. This work has numerous limitations that might be exploited for future research, particularly cold-start challenges are computed using a hybrid linear combination.

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