Leather Product Recommendation System using Collaborative Filtering Algorithm

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***Abstract*—Currently, e-commerce and marketplaces are constantly evolving to satisfy consumers' needs more efficiently and conveniently. Technological developments make e-commerce smarter to serve users by providing recommendations according to user needs. Various types of products are traded in the marketplace, including leather products. Therefore, this study aims to build a recommendation system for leather products. By using the Collaborative Filtering algorithm, the system will provide recommendations for leather products to users based on patterns formed from the history of rating or user ratings. This research results in a web-based recommendation system to help users find leather products by implementing Collaborative Filtering. The experimental results on 50 leather products and 644 ratings given by 30 respondents showed an average value of Mean Absolute Error (MAE) from the application of Collaborative Filtering of 1,929. This MAE value indicates that Collaborative Filtering can recommend skin products well according to user expectations.**

Keywords—collaborative filtering, e-commerce, leather, recommender system

I. INTRODUCTION

The presence of technology often spoils humans in various daily activities, including shopping. It is undeniable that the current online shopping trend affects the acceleration and improvement of e-commerce, including in Indonesia. According to Technology Empowered Digital Trade in the Asia Pacific, the total size of Indonesia's e-commerce market will reach 43,351 billion dollars in 2021 [1]. This fact is believed to continue to increase and develop rapidly and make e-commerce one of the new backbones for the national economy. Marketplaces have also sprung up in Indonesia, such as Tokopedia, Shopee, Lazada, JD.id, OLX, Bukalapak, and others [2]. A marketplace is a platform that acts as an intermediary between sellers and buyers on the internet. Marketplace acts as a third party in online transactions by providing a place to sell and payment facilities. There is a change in consumer behavior that tends to shop online as one of the triggers for the growth of the marketplace. Not only big corporations and owners of big brands and products that enter the realm of this digital platform, even Macro, Small and Medium Enterprises (*Usaha Mikro Kecil Menengah* - UMKM) also use the marketplace and are supported by the Government.

The Indonesian government supports and encourages UMKM products to compete through the marketplace as a digital platform, including leather products. As a material that looks luxurious and classy, leather is always interesting to explore in various stunning fashions. This is directly proportional to the market demand for this leather product—the more market demand for leather products, the more leather craftsmen there. More than thousands of models of leather products to date have been sold by leather craftsmen, including jackets, bags, wallets, belts, id cards, shoes, and others. The leather industry accounts for 4.93 percent of the large-medium manufacturing industry, with a rate of production rise of 27.73 percent [3].

Furthermore, the value of Indonesian leather exports climbed by around 6.23 percent [4]. Seeing this potential, e-commerce must be able to intelligently provide recommendations for leather products based on trends, ratings, and buyer interests. Of course, this has the potential and opportunity to boost the production and sale value of leather items.

Recommendation system technology has been widely studied before, such as: (1) Development of a recommendation system for fashion retail e-commerce utilising an item-based collaborative filtering algorithm [5]; (2) Exploring a large-scale multi-modal transportation recommendation system using a bipartite graph for the Origin-Destination (OD) pair and the User-OD pair of all query records, then transforming nodes in the bipartite graph to feature vectors using a graph-embedding technique [6]; (3) Personalized real-time movie recommendation system using Collaborative Filtering prototype and assessment [7]; (4) product recommendation system using Apriori algorithm [8], [9]; (5) Content-based filtering and TF-IDF methods for exclusive pen product recommendation system [10]; (6) The case-based reasoning method is used by the thesis topic recommendation system [11]; (7) A new student admission recommendation system based on the Naive Bayes classifier has been developed [12]; and (8) Collaborative Filtering used for product recommendation system such as beauty shop product [13], laptop [14] and agricultural product [15]. Based on previous research, Collaborative Filtering is popularly used for recommendation systems and performs well. Therefore, this study aims to apply the Collaborative Filtering algorithm

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in a leather product recommendation system which is one of the classiest products

II. Research Methods

A. Research activities

This research uses the Waterfall software engineering life cycle to develop a recommendation system for leather products, beginning with requirement analysis, software design, construction/ implementation, and evaluation [16], [17]. The stage of acquiring software requirements is known as software requirements analysis. As a result, developers must understand what their users require. This stage's goal is to summarize what the user wants. After the analysis is completed, the stage of design begins. Developers will be responsible for creating software designs such as data structures, software architecture, interfaces, and coding techniques. The next stage is the implementation phase which results in an information system conforming to what was previously desired. Testing is the final stage of the waterfall process. Of course, this stage is carried out to determine whether the preceding stages' final outcomes are appropriate or not.

B. Collaborative Filtering algorithm

Collaborative Filtering is a way to evaluate items or filter items using the opinions or opinions of others [18]. Collaborative Filtering evaluates all users to obtain user information in providing a recommendation. In the data filtering process, collaborative filtering works based on the similarity of user characteristics which will later produce new information to users [18]. The Collaborative Filtering technique is the most widely used in the recommendation system [19]. The quality of the recommendation system is highly dependent on the opinions or opinions of other users on a particular item. This recommendation system is operated in a 2 (two) dimensional space of X-item users. The rating given by the user will be represented as Y, where Y is a non-negative integer or an actual number with certain distance conditions. This recommendation system will process the rating prediction that will be given to the user for an item that has never been given a rating before by the user [18].

Giving a rating on a recommendation system using collaborative filtering can take the form of: (1) Giving a scalar model rating, it must consist of a numerical rating, for example, numbers 1 to 5; (2) Rating the binary model, is a model by choosing between agree or disagree; and (3) Giving a unary model rating, namely a rating model by using the way the user is indicated to have purchased an item or observed an item or rated the item positively.

Collaborative filtering is divided into user-based and item-based collaborative filtering [18]. User-based collaborative filtering is assumed to find interesting items by using a method that is good for certain buyers, namely by looking for other buyers who have the same interests or desires. At the initial stage, user-based collaborative filtering will be able to find the closest user (user neighbor) by finding similar users (user similarity), then each rating value obtained from the closest user (user neighbor) will be used as recommendation material for active users [20].

Item-based collaborative filtering has a way of working almost similar to user-based collaborative filtering. The relationship or correlation between buyers will be sought in user-based collaborative filtering. Then in item-based collaborative filtering, the relationship between items favored by system users will be sought, then the system will recommend other system users related items [21]. This research uses Item-based Collaborative Filtering to recommend leather products.

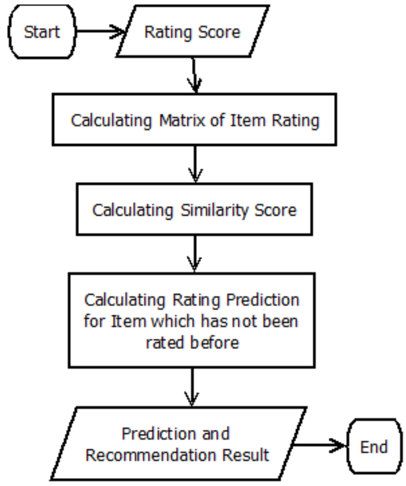

Fig. 1. Flowchart of Item-based Collaborative Filtering

Figure 1 describes the flow of the item-based collaborative filtering algorithm, from the buyer giving a rating until the buyer gets a product recommendation. At the item rating similarity calculation stage, the method used is Centered Cosine Similarity or the Pearson Correlation Coefficient to look for similarities between two items or two different users. The use of centered cosine similarity means that users who do not provide recommendations are not considered to give the worst value in the rating the Centered Cosine Similarity calculation is found in equation (1), in which X_i is the rating of product X by buyer i, X' is the average rating of product X, Y_i is a rating of product Y by buyer i, and Y is the average rating of product Y.

$$Similarity\ (x,y) = \frac{\sum_{i=1}^{n}(X_i - X')(Y_i - Y')}{\sqrt{\sum_{i=1}^{n}(X_i - X')^2}\sqrt{\sum_{i=1}^{n}(Y_i - Y')^2}} \quad (1)$$

After calculating the similarity of items, the weighted sum method is applied to predict the rating value of items that have not been rated by the previous user, the weighted sum equation (2). $P_{u,i}$ is the predictive value for user u on product i, $R_{u,N}$ is the product rating N from user u, while $S_{i,N}$ is the similarity value that has been calculated with Cosine Similarity.

$$P_{u,i} = \frac{\sum all\ similar\ item\ S,N(S_{i,N} \times R_{u,N})}{\sum all\ similar\ item\ S,N(|S_{i,N}|)} \quad (2)$$

C. Mean Absolute Error (MAE)

The evaluation was carried out with Mean Absolute Error (MAE) used to test the performance of item-based collaborative filtering. MAE is used because it can calculate the prediction error value by juxtaposing the rating given by the buyer with the rating prediction by the system. The equation for calculating MAE is found in equation (3), in which $P_{u,i}$ is the rating prediction value, $R_{u,i}$ is the actual user rating value, and N is the number of rating pairs. The smaller the MAE value, the more accurate it is. On the other hand, the higher the MAE value, the more inaccurate it is. MAE results that produce numbers close to 0, indicate that the prediction of a calculation method has better accuracy because the error value is almost 0.

$$MAE = \frac{\sum_{n-1}^{N} |P_{u,i} - R_{u,i}|}{N} \quad (3)$$

III. Result and Discussion

This section presents the result and discussion of study. Beginning with requirement analysis, analysis of Collaborative Filtering implementation, design, implementation, and evaluation of leather recommendation system.

A. Requirement Analysis of Leather Recommendation System

The product sales recommendation system built on an application aims to advance and increase sales. In this case, the system provides convenience by displaying product recommendations to customers. The recommendations are in the form of products with similar tastes to previous customers. A large number of leather products confuses customers in choosing products. This recommendation system is deemed necessary and will provide convenience for customers when choosing leather products. In this system, the customer can give a rating on the product he has seen. The rating given by each customer is used as the basis for determining product recommendations for the relevant customer. The input given by the customer will display the output in the form of product recommendations. The output appears after the customer gives a rating on the selected product, then the system calculates and looks for the similarity value. Customers can also see the predictive value of the rating given by the system to each product contained in the system. System functionality requirements are available in Figure 2.

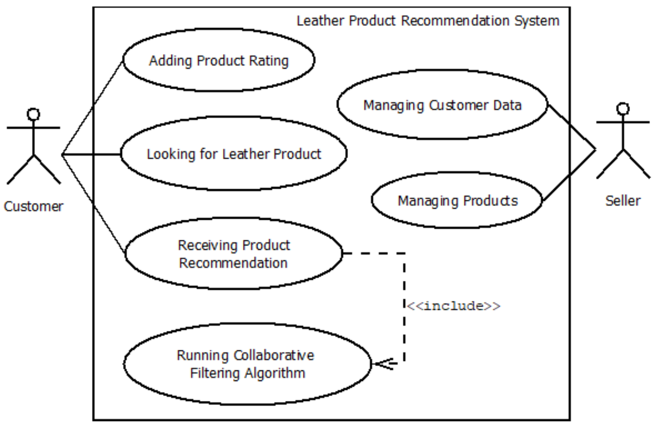

Fig. 2. Use case diagram of leather product recommendation system

B. Analysis of Collaborative Filtering for Leather Recommendation System

The process of running the system will be described sequentially. By using the item-based collaborative filtering method, centered cosine similarity, and weighted sum data calculations will be described clearly to produce leather product recommendations. Furthermore, some sample data will be used to assist the calculation process. The first step is to create a matrix between buyers and leather products. A matrix is used because the item-based collaborative filtering method is based on the similarity of ratings between buyers and the product of choice. In Table I, the rating scenario is described. The value in the table is the rating value presented using numbers, while in the system, it is described in the form of stars. Furthermore, it will be analyzed how buyers with Buyer II are given recommendations for leather products according to their preferences.

TABLE I. RATING SCENARIO

Leather products	Buyer							Mean
	I	*II*	*III*	*IV*	*V*	*VI*	*VII*	
Jacket	3	4	0	0	0	0	4	3.66
Bag	0	4	4	0	0	0	3	3.66
Handbag	3	0	0	0	0	3	4	3.33
Wallet	5	0	0	4	3	0	0	4
Id Card	0	0	0	4	0	4	5	4.33

Leather products include jackets, bags, handbags, wallets, and id cards. The rating awarded by Buyer I-VII. The rating starts from 1 to 5. A value of 0 indicates the buyer does not give a rating for the leather product. The second step is to calculate the similarity value, the calculation is carried out using the centered cosine similarity method. The use of centered cosine similarity was chosen because of the normalization of products that have not been rated by buyers so that they are not rated as the worst. Calculation of centered cosine similarity using equation (1). To normalize the rating, each rating given is reduced by the average rating for the leather product [13]. In Table II, the normalized rating values are presented.

TABLE II. RATING NORMALIZATION

Leather products	Buyer						
	I	*II*	*III*	*IV*	*V*	*VI*	*VII*
Jacket	-0.66	0.34	0	0	0	0	0.34
Bag	0	0.34	0.34	0	0	0	-0.66
Handbag	-0.33	0	0	0	0	-0.33	-0.67
Wallet	1	0	0	0.33	-1	0	0
Id Card	0	0	0	0.33	0	-0.33	0.67

Rating normalization is done by reducing the buyer's rating minus the product's average rating. Buyer I's normalized rating value for jacket products is -0.66 which is the result of reducing the rating value given by the buyer -1 for jacket products by the average rating of jacket products, which is 3 minus 3.66. Buyers with Buyer II have not added ratings for handbags, wallets, and id cards. The resulting value in the centered cosine similarity equation ranges from +1 to -1. Items are considered mutually correlated if the similarity value between the two items is close to +1, and vice versa items are considered uncorrelated if the similarity value is close to -1 [14]. And if the value of similarity 0 means the two items are not correlated (independent) [13]. The example of similarity values between leather products that have been calculated are shown in Table III.

TABLE III. THE SIMILARITY BETWEEN LEATHER PRODUCTS

Leather products	Leather products		
	Handbag	*Wallet*	*Id Card*
Jacket	0.68	-0.57	0.34
Bag	-0.68	0	-0.66
Handbag	1	-0.28	0.84
Wallet	-0.29	1	0
Id Card	0.84	0	1

The next step is to calculate rating predictions using the weighted sum method. Calculation of the weighted sum using equation (2). To calculate the prediction value of the rating, the researcher uses the two highest similarity values obtained from the calculation of the similarity value. Based on the weighted sum calculation, “Handbag” has rating value 1.78, “Id Card” has 1.15, and “Wallet” is 0. Furthermore, calculations which are carried out using the weighted sum method will be sorted starting from the highest value to the lowest value to be used as a recommendation for leather products to the buyer. Next, a number of N sequences of recommendations are selected to be recommended to buyers. Based on the limitations of this research, only five products will be displayed as recommendations to buyers based on the highest rating prediction value. To find out the value of the prediction error is calculated using the MAE method using equation (3). The results obtained from the MAE method are 1.69%. Due to these results, the MAE range is around <10%, so it can be said that the MAE results have good forecasting model capabilities.

C. *Design of Leather Recommendation System*

Leather recommendation system is designed using Unified Modeling Language (UML) [22] with object-oriented software development approach. Class diagram of system is available in Figure 3 which has class of Leather Product, Rating, Recommendation, and User. Software design of leather recommendation system is also modeled by sequence, activity, and state diagram. System is built as web-based application, in which, the user interface design is presented in the Figure 4 (available in Indonesian language).

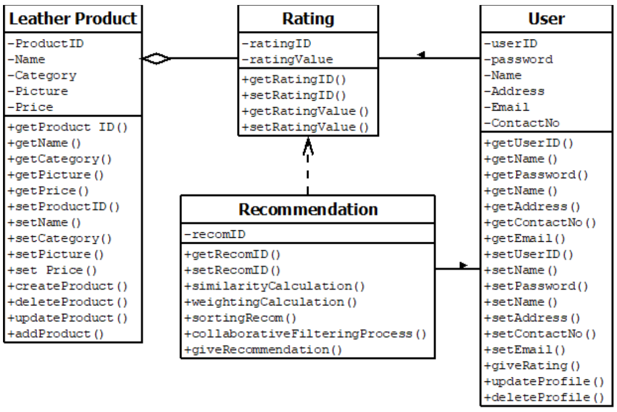

Fig. 3. Class diagram of leather product recommendation system

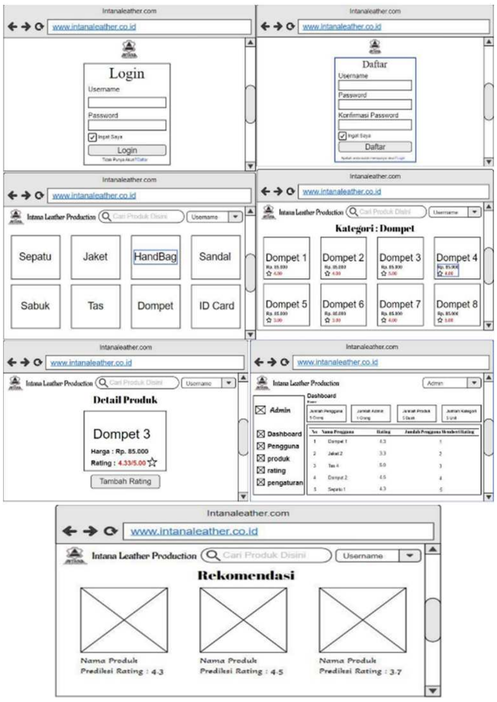

Fig. 4. User interface design of leather product recommendation system

D. *Implementation of Leather Recommendation System*

Figure 5 presents the example of leather recommendation system implementation. The design of the item-based collaborative filtering method is implemented into the system using the PHP programming language, where the result of the implementation is in the form of JSON. The following is the process of implementing the item-based collaborative filtering source code on the leather product recommendation system.

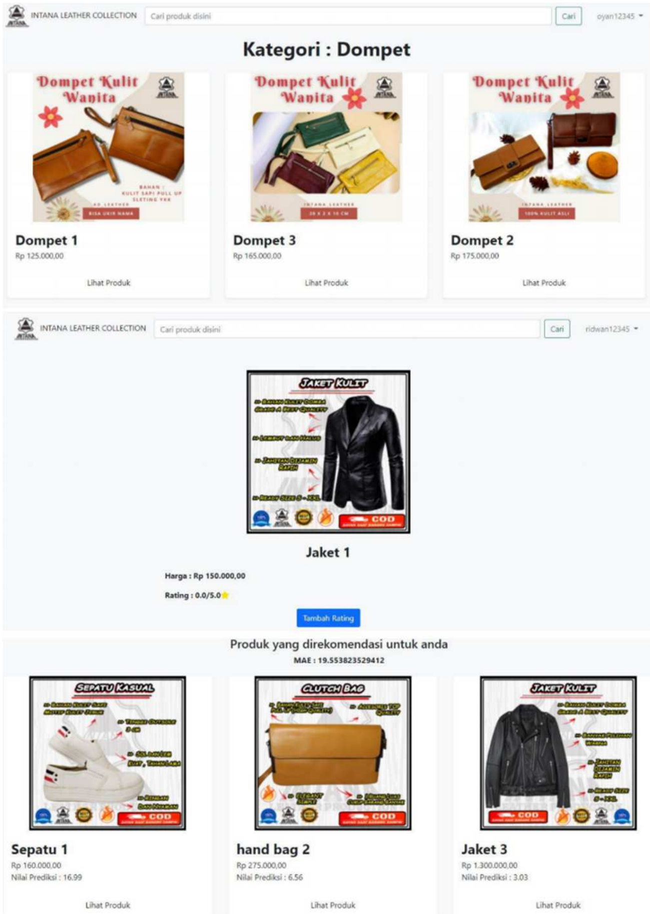

Fig. 5. Implementation example of leather product recommendation system

E. *Evaluation and Discussion*

Evaluation of this research includes two scenarios. First, functionality evaluation of leather recommendation system using black-box testing. Second is the performance evaluation of Collaborative Filtering in recommending a leather product. Black box evaluation shows that all system functionalities run well following requirements. Furthermore, Mean Absolute Error (MAE) is used to test the performance of item-based collaborative filtering. MAE is used because it can calculate the prediction error value by juxtaposing the rating given by the buyer with the rating prediction by the system. The smaller the MAE value, the more accurate it is. On the other hand, the higher the MAE value, the more inaccurate it is.

TABLE IV. MEAN ABSOLUTE ERROR (MAE) RESULT

Buyer ID	MAE Value	Total Rated Product
1	1.904	12
2	1.704	20
3	2.793	4

Buyer ID	MAE Value	Total Rated Product
4	1.680	22
5	3.217	14
6	2.759	6
7	2.162	13
8	1.877	21
9	1.486	22
10	0.741	35
11	3.420	7
12	0.943	43
13	2.233	39
14	2.439	11
15	0.998	34
16	1.821	23
17	1.540	31
18	1.959	19
19	2.264	27
20	1.995	26
21	2.176	35
22	2.051	21
23	2.813	7
24	1.689	22
25	1.690	47
26	1.713	13
27	2.930	9
28	1.905	14
29	1.818	22
30	1.819	25

The MAE calculation is applied to each buyer, then the average value of all assessments is taken. The number of buyers involved in this testing process is 30 people, the number of ratings is 644 ratings, and the number of products is 50 products. MAE calculation scenarios are presented in Table IV. From the results of the MAE calculation, the largest error value obtained was 3,420 by buyers with Buyer ID 11 for 7 products. At the same time, the smallest error value is 0.741 by buyers with username Buyer ID 10 for 35 products. And the average MAE value is 1.929 out of 644 ratings added by 30 buyers. The closer to zero the MAE value, the better the prediction accuracy will be. The factor that influences the prediction is the number of ratings available.

CONCLUSION

This research has designed and built a leather product recommendation system using the item-based collaborative filtering method. The item-based collaborative filtering algorithm has been successfully applied to the leather product recommendation system to make it easier for buyers. The recommendations from 30 respondents, 50 products, and 644 ratings obtained an average MAE value of 1,929. The closer the MAE value is, the better the prediction accuracy. The factor that affects the prediction is the number of available ratings. Further research can use other algorithms such as user-based collaborative filtering or combining the item-based and user-based to get better recommendation results.

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