

Implementation of Item-Based Collaborative Filtering Algorithm for Blangkon Product Recommendation on Web-Based E-commerce System

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Abstract—In the development of technology at this time, especially in the trade sector, there is no escape from the development of information technology which has had a significant impact. The most obvious form in the development of information technology in the trade sector is e-commerce, which allows transactions between sellers and buyers to be easier. Not only that, the problem now is that users must be spoiled with features that help to recommend user desires. This requires a recommendation system to help select user desires based on products with high ratings. Therefore, it must continue to develop a system that has features to support the sales system. To achieve the system needs to require a method that supports such as using the collaborative filtering method. This method focuses the analysis on similarities between items, because it is more stable and not always sensitive to changing data with a large number of users. The collaborative filtering method is used in the recommendation system to predict inter-user preferences for blangkon products based on the similarity of other user patterns, so that product recommendations appear that they have never seen or bought before. This technique uses an item-based model in it. The results of the performance test to determine the level of prediction accuracy of the method in this study using the mean absolute error. With MAE for three times trying to get a value of 0.5, 0.3 and 0.2.

Keywords: E-commerce; Collaborative Filtering; Recommendation System; Blangkon; Rating

1. INTRODUCTION

Technological developments continue to lead to positive things that continue to grow very rapidly, providing significant changes along with the increasing progress of industries in various fields, especially trade. Digital trade that uses internet media is able to make changes to the economic activities of society and business, from manual to automatic. The utilization of internet technology in electronic commerce is better known as "electronic commerce" [1]. With the internet, we can easily get information very quickly just in the palm of our hands by typing a few keywords, so all information will come out so quickly directly [2]. In addition to being a means of information, in the point of view among business industry players the website is also useful for marketing or promoting the products they make, for example here is the blangkon [3]. The term blangkon comes from the word "blangko", which means in Javanese society to say something ready to use [4]. This blangkon website is one example of a field engaged in the sale of blangkon using the modernization system that we know as e-commerce. Analyzing for user needs is one of the important things that must be done in an e-commerce platform [5].

The impact of using an online sales system allows us to make easy transaction processes through online media anytime and anywhere and can transact with people out there online without the need to come to the store [6]. This approach to buyers is needed today by relying on the features on the website to get recommendations for various types of products from the blangkon itself. We know that Indonesia is very diverse in terms of ethnicity, race, and traditional culture which is still popular today, for example for the completeness of traditional Javanese clothing such as blangkon. The type of blangkon itself is widely known to have two types, namely Blangkon Solo and Blangkon Yogyakarta [7]. On this blangkon website, it is necessary to have a blangkon product recommendation feature for users who have difficulty finding the type of blangkon, so they experience confusion due to the many types of blangkon offered on this website. Sometimes users want to buy these products that have been recommended by the system so that it can help the process of selecting products that were previously unthinkable but will be interesting to buy and according to their criteria.

Although this problem is to improve user comfort when wanting to buy blangkon products. So it is necessary to have a blangkon product recommendation system for users who find it difficult to find the type of blangkon by using an algorithm or method obtained from the number of other user rating values [8]. A recommendation system is a system that suggests useful information or guesses what a user will do to achieve his goal [9]. It also helps users to get the product they like more quickly in determining the desired product [10]. The recommendation system developed in a website-based so that it can be accessed by customers anywhere and anytime [11]. Thus the application of the recommendation system for the application of product filtering using the item-based collaborative filtering approach.

Collaborative filtering algorithms are one of the most popular methods for recommendation systems [12]. This method is based on the interest of groups of users who like a certain item that will be recommended by the system [13]. Collaborative filtering utilizes rating information from multiple users to predict item ratings for specific users [14]. So that this recommendation is based on items in this method called item-based is one type of method that exists in recommendation systems based on using the similarity or similarity between the rating of a product and the product purchased [15]. By using the calculation formula adjust cosine similarity and weighted sum for testing this algorithm [16]. The system can calculate the value of product similarity as well as predict the value of consumer ratings on a

product [17]. Products that have a high rating with a total rating of 4 to 5 will be recommended on the recommendation page on the blangkong website.

The results and solutions based on the above phenomena and problems, raised the case for this study by discussing the application of a recommendation system on a website that helps and provides information to consumers about the types of best-selling blangkong [18]. The application of this research also uses the calculation of cosine similarity, which is a method used directly in collaborative filtering. Produce numbers from this formula and get an accuracy level performance value of 0.5, 0.3 and 0.2. These results require two vectors by calculating the cosine of the angle between them which produces values ranging from 0 to 1. The value is close to 1, which means that the two are very similar in terms of their rating pattern of the item. This helps collaborative filtering determine the most relevant products to recommend to consumers on the blangkong website based on the highest rated products.

2. RESEARCH METHODOLOGY

2.1 Research Flow

This research flow is carried out to analyze the process of calculating the results of the item-based collaborative filtering method on the blangkong recommendation system. Has a flow to produce a product calculation process that is included in user recommendations, this process is described in Figure 1 below:

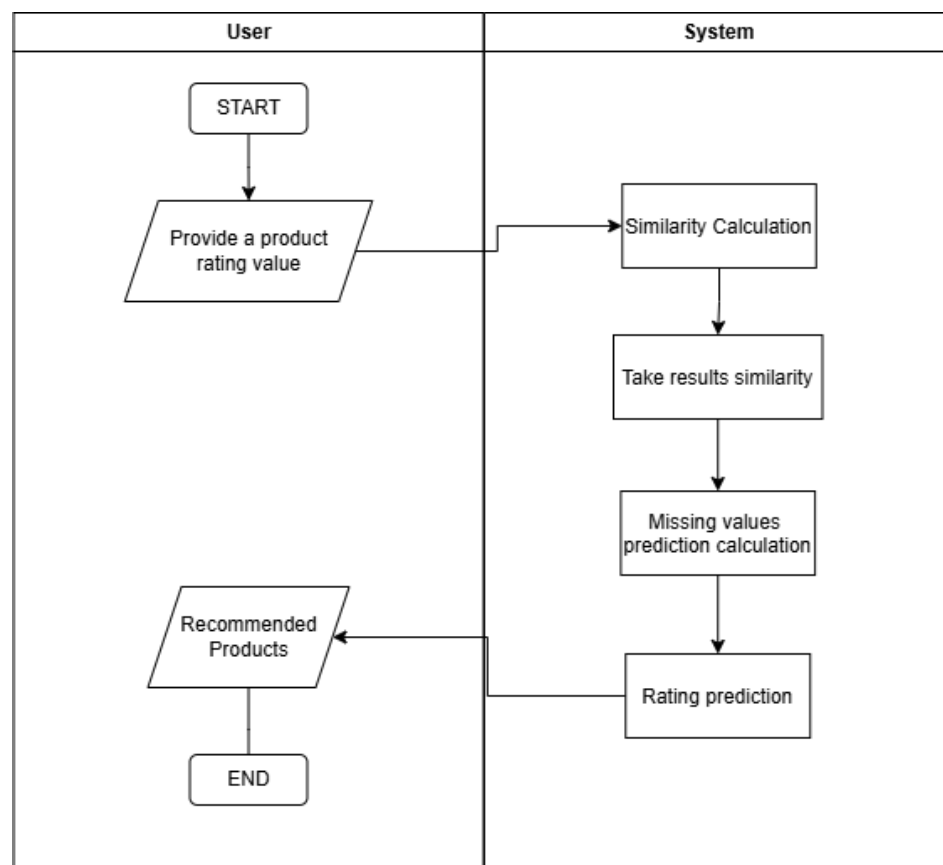


Figure 1. Flow System

The process flow figure 1 gives us how to provide an analysis flow with how the algorithm in the system runs. First, rating, this is the initial user pattern formed when rating each product they have purchased. The system will calculate adjusted cosine similarity to find the similarity between users who have rated with other users who have rated/not rated. After getting the pattern similarity between users, the prediction calculation that has the highest product rating in the pattern will appear and be recommended to the user page.

2.2 Recommendation System

A recommendation system is a system feature in software that works to provide the best advice on the application in the form of products that are liked or interesting from other users. The recommendation system is made to help users choose popular items based on other users' assessment of the item's rating. This feature has been in the best research field since the formation of papers on collaborative filtering in 1998 [19]. They have proven to be useful IO processing tools for online clients and have become one of the most common and powerful e-commerce tools. The Collaborative Filtering Algorithm (CF) is the basis of many existing recommendation systems and has been commonly used in e-commerce [20].

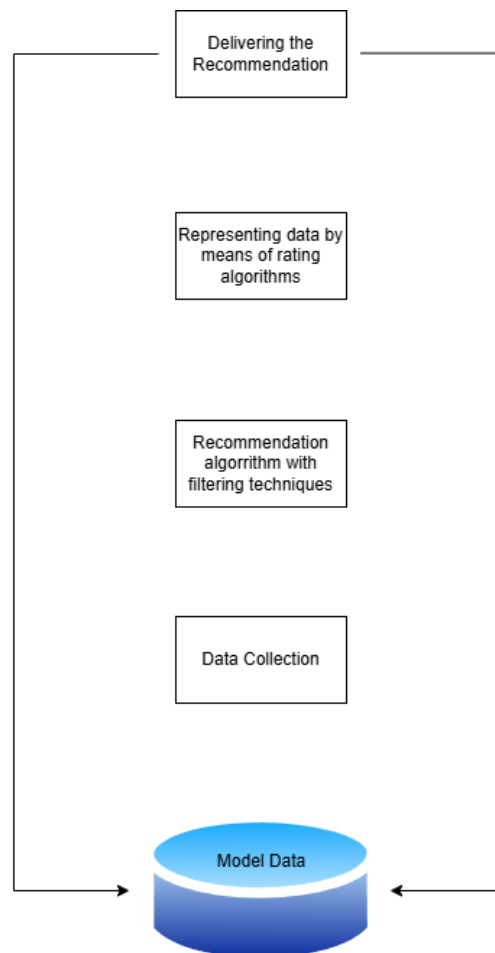


Figure 2. Recommendation system function

The purpose of the recommendation system is to form useful recommendations for users on items or items that have the highest rating among users or items to be able to produce recommendations with good value, there are two main approaches in collaborative filtering:

a. User-Based Collaborative Filtering (UBCF)

One of the methods in recommendation systems that aims to provide suggestions to users based on similar preferences or behavior with other users. This approach assumes that if two users have similar patterns of behavior or preferences in a number of items, it will be able to be recommended to other users.

b. Item-Based Collaborative Filtering (IBCF)

This method has similar preferences using a similar-item approach based on the interaction patterns of many users. Recommendations are then made by offering similar items to those already rated by the user.

2.3 Collaborative Filtering Algorithm Method

Collaborative Filtering is a method in a recommendation system that runs or works based on the behavior or preferences of previous users who relevel through similarity patterns. Combining rating data prediction techniques from other users is used to find users with similar rating patterns between users. Collaborative filtering requires data from the database that is interrelated with the rating, user and transaction tables so that it can create prediction patterns for features in the recommendation system, namely user and product data. So that each user gives a value to the product rating in the form of the number of stars to each product they buy on a numerical scale of 1 to 5. Ratings are denoted by numbers in this table. Still not all users rate the products or items they have purchased, this is one of the challenges that arise is the sparsity problem. The factors are illustrated in table 1 below.

Table 1. Example of product rating matrix

	p1	p2	p3	p4	pm
User1	5	3		1	
User2	4		2	4	
User3		3	5		
Userm					

Table 1 shows that there are several items that are blank indicating that users have not rated the items they purchased previously. This is always missing information in the recommendation system algorithm to predict which products/items users might like in the future in this application. This is a challenge because the sparser it is, the harder it is to find relationships or patterns between users or products. An example of a pattern in the table above is that product1 and product4 are often rated in a similar way by many users, so if a user likes product1, the system will recommend product4.

2.4 Item-Based Collaborative Filtering

A system that searches for similar relationships between products based on rating patterns from users to provide recommendations for items (products) that are similar between each item that has been rated by the user based on other users' ratings of the product [21]. In order for this to work well, it must require a model called item or product correlation to find out the relationship between products from the acquisition of the rating value obtained [22]. This approach will recommend a new item to the user based on the rating pattern of the highest similarity or rating on the item.

2.5 Cosine Similarity

Cosine similarity is a calculation that is often connected when a recommendation system is built to measure the similarity between two vectors where each user has a different rating scheme [23]. In the context of item-based collaborative filtering, this calculation helps recommend items to users based on similarity with other items that have been rated. The similarity calculation in this study uses the item correlation coefficient [24]. The form of formula (1) cosine similarity below:

$$\text{Similarity} = \text{sim}(A, B) = \frac{A \cdot B}{\|A\| \times \|B\|} = \frac{\sum_{i=1}^n A_i \times B_i}{\sqrt{\sum_{i=1}^n A_i^2} \times \sqrt{\sum_{i=1}^n B_i^2}} \quad (1)$$

To calculate the similarity of items between (a,b) with the item rating given by each user, then add up A as the rating of item a and then multiply the results of item B rating. Then multiply between items a and b to find the numerator. Next, find the denominator of item (a,b) using the same method as the numerator multiplied between all ratings on the product item (a,b) but after that it is squared and then rooted. The last step divides between the numerator and denominator.

2.6 Rating Prediction

After calculating the similarity value, the next step is to find the value for predicting product ratings that are not rated by users or in the table worth 0 using the prediction formula. The calculation will use formula 2:

$$p(u, j) = \frac{\sum_{i \in I} (R_{i,u} \times S_{u,i})}{\sum_{i \in I} (|S_{i,u}|)} \quad (2)$$

To calculate the rating prediction between user u and product item a, for $R_{a,i}$ and $S_{a,i}$ is the similarity between items a and b. This equation uses the cosine similarity metric obtained from the result of multiplying items a and b with user u against a. Where $P(u,a)$ is the prediction of item a against the result $S_{i,a}$ is the similarity value of item a and item b and n is the total value of active users.

2.7 Mean Absolute Error

To assess the performance of a recommendation system, a method and calculation is needed to be able to measure the quality level of predictions generated by the system. So the last step after the prediction is complete is to calculate the mean absolute error (MAE) is an approach that is often used when testing to evaluate how accurate the prediction results of the recommendation system are. The lower the MAE value, the more accurate the prediction that has been produced [25]. The following is the MAE formula:

$$\text{MAE} = \frac{1}{N} \sum_{i=1}^N |r_i - p_i| \quad (3)$$

MAE calculates the storage of the predicted value from the true value, for each pair of predicted and true values (r_i and p_i) written in the equation. So that the results range between -1, 0 and 1. If it is less than -1 then the similarity value is very inversely proportional. Then, if the similarity value is 0 then there may be a similarity value between the items, and if the value is 1 then, the similarity value of the items is very high.

3. RESULTS AND DISCUSSION

3.1 Item-Based Approach

The results of the blangkon website recommendation system research for testing calculations on collaborative filtering algorithms using an item-based approach that involves several important steps to recommend items based on similarity

with other items that have been favored by users. The first step is to build an item similarity matrix by using several comparison values on other product item rating data using similarity metrics such as cosine similarity. This metric calculates how similar two items are based on research patterns or user interactions with both items. After similarity is established, testing of the results is carried out using the calculation of the MAE (Mean Absolute Error) value as an evaluation phase for the performance of how accurate the predictions generated by a recommendation system model used now. Then converted to a percentage from the original MAE results to MAPE so that the results can be read in percent form no longer in the original nominal form. In this experiment, the samples used were 5 user data and 5 data on the number of ratings on each product. The example in table 2 is calculated as follows:

Table 2. Original Rating Calculation Table

	Product 1	Product 2	Product 3	Product 4	Product 5
User A	5	5	3	4	0
User B	4	0	3	2	2
User C	0	4	5	4	3
User D	2	2	0	3	5
User E	3	1	4	0	5

From the data in Table 2 that has been collected, it needs to be converted into transposed data by moving the rating format to the product because this research uses a collaborative filtering approach with item-based type. Aiming to compare one product with another product based on the rating pattern given by the user. The following data transpose table 3:

Table 3. Data Transpose Table

	User A	User B	User C	User D	User E
Product 1	5	4	0	2	3
Product 2	5	0	4	2	1
Product 3	3	3	5	0	4
Product 4	4	2	4	3	0
Product 5	0	2	3	5	5

After transposing the data so that each row represents the product and the column represents the user for further calculations, it is first necessary to calculate using the similarity formula. The formula calculates for the process of finding similarity between two vectors in a high-dimensional space by measuring the cosine angle between them. The following is an example of the calculation of each product similarity based on the data that has been collected and the results of transposing the data.

$$\begin{aligned} \text{sim}_{(\text{product 1, product 2})} &= \frac{(5 \times 5) + (4 \times 0) + (0 \times 4) + (2 \times 2) + (3 \times 1)}{\sqrt{(5)^2 + (4)^2 + (0)^2 + (2)^2 + (3)^2} \sqrt{(5)^2 + (0)^2 + (4)^2 + (2)^2 + (1)^2}} = 0,6421 \\ \text{sim}_{(\text{product 1, product 3})} &= \frac{(5 \times 3) + (4 \times 3) + (0 \times 5) + (2 \times 0) + (3 \times 4)}{\sqrt{(5)^2 + (4)^2 + (0)^2 + (2)^2 + (3)^2} \sqrt{(3)^2 + (3)^2 + (5)^2 + (0)^2 + (4)^2}} = 0,6909 \\ \text{sim}_{(\text{product 1, product 4})} &= \frac{(5 \times 4) + (4 \times 2) + (0 \times 4) + (2 \times 3) + (3 \times 0)}{\sqrt{(5)^2 + (4)^2 + (0)^2 + (2)^2 + (3)^2} \sqrt{(4)^2 + (2)^2 + (4)^2 + (3)^2 + (0)^2}} = 0,6897 \\ \text{sim}_{(\text{product 1, product 5})} &= \frac{(5 \times 0) + (4 \times 2) + (0 \times 3) + (2 \times 5) + (3 \times 5)}{\sqrt{(5)^2 + (4)^2 + (0)^2 + (2)^2 + (3)^2} \sqrt{(0)^2 + (2)^2 + (3)^2 + (5)^2 + (5)^2}} = 0,5658 \\ \text{sim}_{(\text{product 2, product 3})} &= \frac{(5 \times 3) + (0 \times 3) + (4 \times 5) + (2 \times 0) + (1 \times 4)}{\sqrt{(5)^2 + (0)^2 + (4)^2 + (2)^2 + (1)^2} \sqrt{(3)^2 + (3)^2 + (5)^2 + (0)^2 + (4)^2}} = 0,7486 \\ \text{sim}_{(\text{product 2, product 4})} &= \frac{(5 \times 4) + (0 \times 2) + (4 \times 4) + (2 \times 3) + (1 \times 0)}{\sqrt{(5)^2 + (0)^2 + (4)^2 + (2)^2 + (1)^2} \sqrt{(4)^2 + (2)^2 + (4)^2 + (3)^2 + (0)^2}} = 0,9231 \\ \text{sim}_{(\text{product 2, product 5})} &= \frac{(5 \times 0) + (0 \times 2) + (4 \times 3) + (2 \times 5) + (1 \times 5)}{\sqrt{(5)^2 + (0)^2 + (4)^2 + (2)^2 + (1)^2} \sqrt{(0)^2 + (2)^2 + (3)^2 + (5)^2 + (5)^2}} = 0,5016 \\ \text{sim}_{(\text{product 3, product 4})} &= \frac{(3 \times 4) + (3 \times 2) + (5 \times 4) + (0 \times 3) + (4 \times 0)}{\sqrt{(3)^2 + (3)^2 + (5)^2 + (0)^2 + (4)^2} \sqrt{(4)^2 + (2)^2 + (4)^2 + (3)^2 + (0)^2}} = 0,7375 \\ \text{sim}_{(\text{product 3, product 5})} &= \frac{(3 \times 0) + (3 \times 2) + (5 \times 3) + (0 \times 5) + (4 \times 5)}{\sqrt{(3)^2 + (3)^2 + (5)^2 + (0)^2 + (4)^2} \sqrt{(0)^2 + (2)^2 + (3)^2 + (5)^2 + (5)^2}} = 0,6725 \\ \text{sim}_{(\text{product 4, product 5})} &= \frac{(4 \times 0) + (2 \times 2) + (4 \times 3) + (3 \times 5) + (0 \times 5)}{\sqrt{(4)^2 + (2)^2 + (4)^2 + (3)^2 + (0)^2} \sqrt{(0)^2 + (2)^2 + (3)^2 + (5)^2 + (5)^2}} = 0,5822 \end{aligned}$$

After calculating the similarity value, the next step is to find the value for predicting product ratings that are not rated by users or in the table worth 0 using a prediction formula called weighted sum.

The following is an example of calculating the prediction of blangkon product recommendations given to user C to product 1 based on the results of the similarity value above. The value calculation for product 1 is:

$$p(\text{user C, product 1}) = \frac{(4 \times 0,6421) + (5 \times 0,6909) + (4 \times 0,6897) + (3 \times 0,5658)}{0,6421 + 0,7486 + 0,9231 + 0,5016} = 4,05$$

The following is an example of calculating the prediction of blangkon product recommendations given to user D to product 3 based on the results of the similarity value above. The value calculation for product 3 is:

$$p(\text{user D, product 3}) = \frac{(2 \times 0,6909) + (2 \times 0,7486) + (3 \times 0,7375) + (5 \times 0,6725)}{0,6909 + 0,7486 + 0,7375 + 0,6725} = 2,97$$

The following is an example of calculating the prediction of blangkon product recommendations given to user E to product 4 based on the results of the similarity value above. The value calculation for product 4 is:

$$p(\text{user E, product 4}) = \frac{(3 \times 0,6897) + (1 \times 0,9231) + (4 \times 0,7375) + (5 \times 0,5822)}{0,6897 + 0,9231 + 0,7375 + 0,5822} = 3,02$$

An example of a weighted sum calculation to find predictions on products 1, 3, 4 that have not been given a value and then calculate the weighted sum that the predicted rating value that has been tested for performance gets a prediction result of 4.05, 2.97 and 3.02 for the product value rounded to 4, 3, and 3 based on the calculation example above, then a rating prediction is obtained that was empty or has not been given a value by the user. Now it can be seen in table 4 below:

Table 4. Rating Prediction Results

	Product 1	Product 2	Product 3	Product 4	Product 5
User A	5	5	3	4	4
User B	4	3	3	2	2
User C	4	4	5	4	3
User D	2	2	3	3	5
User E	3	1	4	3	5

From the two calculation methods above, it produces table 4 to find the rating value that is still empty, so predicting the value can use cosine similarity to find the similarity pattern of each product rating. The second weighted sum is used so that it can help calculate the accuracy or the amount of error in predicting the rating value. The last step after the prediction is complete is to calculate the mean absolute error (MAE) is an approach that is often used when testing to evaluate how accurate the prediction results of the recommendation system are.

The following is the calculation of the (MAE) based on the example of the predicted values obtained above for products 1, 3, and 4:

$$MAE = \frac{|4 - 4,05|}{1} = 0,05$$

$$MAE = \frac{|3 - 2,97|}{1} = 0,03$$

$$MAE = \frac{|3 - 3,02|}{1} = 0,02$$

So from the calculation of the mean absolute error based on two examples of products that are calculated to produce accuracy or the level of error in predicting the rating of blangkon products of 0.05, 0.03 and 0.02 which shows from the results of three very small experiments means that the prediction model is very accurate. The results of this absolute error are converted into a percentage form, to make it easier to read and easy to understand the level becomes the mean absolute percentage error value taken from the value closest to 1%, namely 2% owned from the calculation of product rating prediction 4 from the comparison of numbers states the results are considered very good and shows that this prediction model has a very small error.

3.2 System Implementation

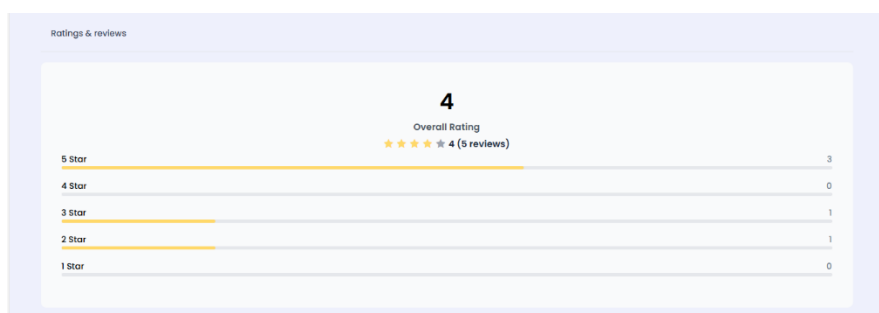


Figure 3. Overall rating

In the implementation of the results of Figure 3 is the number of users who have given a rating or review to a product item. There are 5 users who rate with the number of rating values there are those who give 3 stars, 2 stars and 5 stars varying for each user with an average total rating on the product item which is 4. This item will enter the depth of the recommendation product because it has a high item rating to be recommended to other users. In Figure 4 an example of a user product recommendation display.

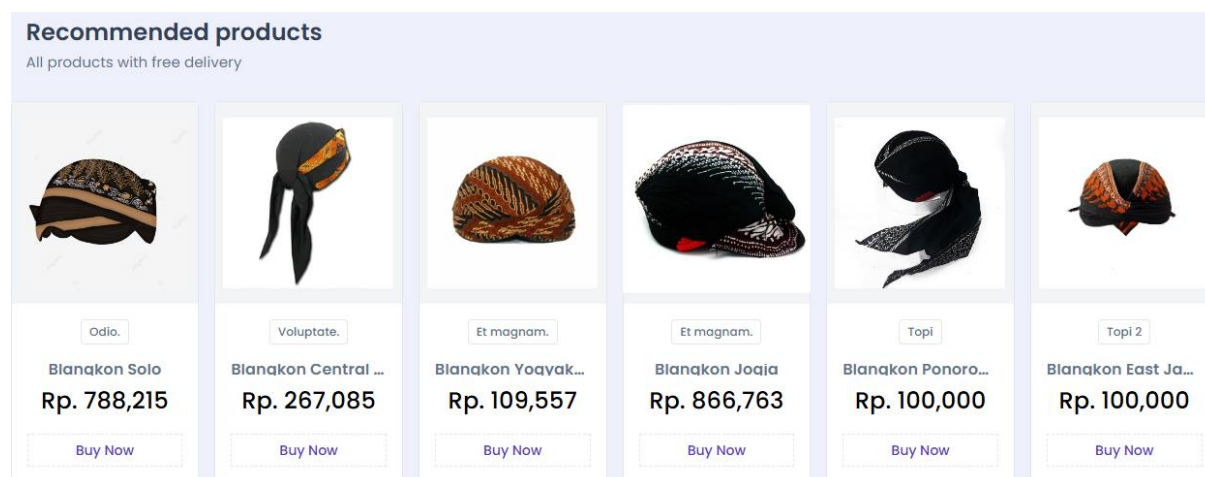


Figure 4. Application implementation results

The results in Figure 4 are the results of the display of the recommendation system will provide products that are predicted to have the highest rating, based on similarities with other users. The example query above ensures that only products that have enough ratings and have a decent average rating will appear in the recommendation list.

4. CONCLUSION

Development of a recommendation system based on a blangkon e-commerce website that uses the item-based collaborative filtering method. After the design of the application tool, the recommendation shows in predicting the product well. The goal is to improve the user experience when using this application in choosing blangkon products. This research recommends using blangkon data attributes for more specific recommendations. The test results based on the results of the discussion and in the chapters that have been discussed, it can be concluded that the results of prediction calculations using the item-based collaborative filtering method, the authors conducted research in the analysis of improving predictions with collaborative filtering methods in functional and non-functional matrix factorization in the form of building a system, making experimental data to perform manual calculations in stages. First, implementing the item-based method using cosine similarity calculation to find similarity patterns and build the system, then testing the confusion matrix in the form of prediction results, and the last test MAE to assess the accuracy of predictions calculated at the previous stage. From the results of all calculations successfully identified the prediction results on product 2 as a high similarity of 2%, which means that this result shows that the system is included in the very good accurate group in the product prediction level.

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