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# Implementation of Collaborative Filtering Algorithms in Mobile-Based Food Menu Ordering and Recommendation Systems

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**Abstract**−In the business world, the application of technology is becoming common, including in the process of buying or ordering food products which can now be done through a mobile application. Makecents Coffee is a startup in the city of Medan that provides solutions for ordering food and drinks at Android-based restaurants using the QR Code ordering system. To make it easier for buyers to place orders, an automatic recommendation system is needed. One method that can be used to develop an ordering application with a recommendation system is a collaborative filtering algorithm. In this study, a collaborative filtering algorithm was used to work by storing and processing data provided by buyers, such as ratings or comments on the food menu ordered. Using buyer data provides results for users in placing orders because they use an application that has them, as well as making it easier to choose a menu to order because of a recommendation system. The level of accuracy of the prediction of the collaborative filtering algorithm itself has been tested using the MAE and RMSE tests. Where the MAE test obtained a value of 0.67 points, while the RMSE test obtained a value of 0.58 points. The two test results were fairly good when compared to the range of points which only ranged from 1 to 5 points. The results of the recommendations can be implemented in applications designed to increase sales and make it easier to place orders that have been recommended to users.

**Keywords**: Collaborative Filtering; QR Code; Mobile Application; Cossine Similarity

## 1. INTRODUCTION

In the culinary business world, the application of technology is also being developed by many individuals because the culinary industry is not just about buying and selling products[1]. Technology can be incorporated into the buying and selling process through the use of sales applications, marketing tools, or food menu recommendation applications. This breakthrough has been implemented by many businesses. However, not all implementations meet the expectations of business owners, particularly in the case of food menu recommendation applications. Food menu recommendation applications are challenging to implement effectively due to the need for a large sample size to make decisions (recommended food menu) that will be presented to users (customers)[2], [3].

In this research, the author aims to implement the Collaborative Filtering method in a food ordering system. Collaborative filtering is a method or algorithm that provides recommendations based on the preferences or likings of other users, under the assumption that users with similar preferences or likings have similar tastes[4].

In the study conducted by Fadiah and Samsudin in 2022, titled "Implementation of Collaborative Filtering Algorithm in Mobile-Based Food Ordering and Menu Recommendation System," the utilization of technology in the culinary field is discussed, with a focus on Muslim Restaurant Hajjah Zuleka. This journal aims to enhance customer service and facilitate transaction management and reporting through the development of a platform that includes a food ordering system and Collaborative Filtering algorithm for menu recommendations. The research involves evaluating menus based on customer ratings using a scale of 1-5. In this study, the Rendang menu received the highest rating with a Mean Absolute Error (MAE) value of 0.849969096. The developed food ordering system consists of a web-based REST API for transaction administration and an Android application for customers to place food orders. The research findings demonstrate that the Collaborative Filtering algorithm is a simple yet effective method for generating menu recommendations. The display time of menu recommendations based on Collaborative Filtering in the Android application after the page opens is approximately 0.284 seconds, while on the web display, it is around 0.221 seconds. Overall, this study provides insights into the implementation of the Collaborative Filtering algorithm in the context of mobile-based food ordering and menu recommendations[5]. In the study conducted by Ade Kania in 2020, titled "Food Menu Sales Recommendation System in Culinary SMEs Using Association Rule," the role of SMEs (Small and Medium Enterprises) in the Indonesian economy and the negative impact of the COVID-19 pandemic on the SME sector, especially in the culinary field, are explained. This has caused difficulties in production and marketing, thus necessitating alternatives such as online sales. This research utilizes the Association Rule Mining method by leveraging transactional data from culinary SMEs. Market basket analysis is used to identify products that are frequently purchased together by customers. From the analyzed transaction data, this study generates 12 association rules with a support threshold of 5% and a confidence threshold of 80%. These rules depict the purchasing patterns of culinary SME customers, where Aqua water and sweet iced tea are frequently chosen together with various culinary menu items[6]. In the study conducted by Betlian Fajrin in 2020, titled "Development of Meeting Package Menu Recommendation System Using FP-Growth Method (Case Study: Lotus Garden Hotel Kediri)," the importance of fast and accurate information regarding the facilities provided by hotel management to customers is discussed. However, detailed information about meeting package menus and how to order them is often unavailable. To obtain accurate information about room rentals and


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meeting package menus, transactional data processing is required. In this research, the FP-Growth algorithm is utilized to find frequent itemsets within the dataset. This algorithm assists in determining consumer buying patterns and generating recommendations for meeting package menus[7]. In the study conducted by Riski Nova in 2018, titled "Implementation of Association Rule Mining to Determine Food Package Menus Using the FIN Algorithm with Nodesets (Case Study: R.M. Lesehan Nova Sragen)," the use of the FIN (Frequent Itemset Mining) algorithm in creating package menus at R.M. Lesehan Nova Sragen restaurant is discussed. The restaurant offers a wide variety of menu items, including 116 food items and 44 beverage items. Due to the high menu variations, customers often take a long time to choose their orders. The journal author suggests creating package menus based on customer history in selecting menu items as a solution to improve customer service. In this research, the author employs the FIN algorithm to mine frequent itemsets from sales transaction data. The algorithm is implemented in an automated package menu generation system. Testing is conducted with various minimum support values, and at a minimum support value of 11, six proportional and representative menu package variations are found that align with customer preferences. R.M. Lesehan Nova Sragen is a garden restaurant with various gazebos and a total area of 2000 m2, accommodating up to 300 visitors. There are two types of menus available: the main menu (156 food items and 44 beverage items) and the package menu (30 food and beverage package items). The restaurant visitors consist of couples, families, and group visitors. Group visitors can choose to order package menus or select items individually[8]. In the research conducted by Henri Pandiangan in 2019 entitled "Implementation of Association Rule Mining for Determining Food Menus Using the Apriori Algorithm," it explains that the FIN algorithm is used to mine frequent itemsets from sales transaction data recorded on receipts printed by the cashier machine within a specific time period. By discovering new information through Association Rule Mining, the owner of Warung Miso Pematang can identify the most frequently ordered food menus by customers and determine the ingredients that need to be prepared in larger quantities to meet the demand. The journal concludes that the implementation of Association Rule Mining using the FIN algorithm can assist the owner of Warung Miso Pematang in determining the arrangement of food and beverage menus based on the customers' ordering patterns. As a result, the operations at the eatery can run more effectively and efficiently[9].

The previous studies mentioned above differ from the research that the writer intends to conduct. In this study, the writer will apply the collaborative filtering method in food ordering by implementing an application that provides food menu recommendations based on customer criteria. This will be achieved by training the data from previous customer reviews and categorizing the results to generate suggestions for new customers when placing their food orders. Additionally, the study aims to assist the café in providing efficient and accurate services and boosting sales by utilizing a barcode-based ordering application technology. This research significantly differs from previous studies as the researcher will employ the latest method in the field, thus introducing a breakthrough in the technological world.

Makecents Coffee is a startup that utilizes an Android-based application. The application serves the purpose of food ordering, payment, and transaction recording for each role using the app. The app's workflow involves recording user input orders, where users scan QR codes placed on each table to access the app and identify their seating location[10]. The user input data is then stored in the database and transmitted to the cashier and kitchen. Meanwhile, the collaborative filtering algorithm functions to process user order data and ratings given by users for the food they ordered. This data is processed using mathematical calculations to generate food menu recommendations for other users. This application is well-suited for implementation at Makecents Café Coffee, not only for modernizing the café but also for reducing physical contact[11], [12]. The application aims to facilitate transactions, food ordering, and assist customers in deciding which menu to choose based on the system's recommendations. It also measures the accuracy of the Collaborative Filtering algorithm. The research includes comprehensive testing of the Makecents Café application and the recommendation feature presented to potential or current users[13], [14]. The benefits gained by the owner will undoubtedly increase, and Make Cents Café has the potential to gain more recognition by implementing modernization in their café.

## 2. RESEARCH METHODOLOGY

### 2.1 Research Stages

In this study, the researchers apply the Collaborative Filtering method to create a food menu recommendation system for customers who visit and want to order food at Makecents Coffee[15]. The following is an overview of the research process that will be conducted from start to finish.

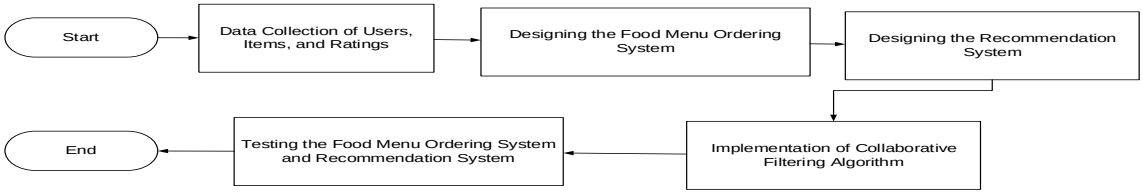


**Figure 1.** Research Process Stages


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In Figure 1 above, data collection of users, items (food menu), and ratings provided by users is conducted. Then, the food ordering application is developed first for users. Next, the recommendation system is implemented using collaborative filtering. Lastly, testing is performed on the food ordering system and the recommendation system to evaluate their performance and determine if the systems are functioning properly. The following is a description of the research stages[5].

### 2.2 Data Collection

During the data collection process, the author collected data from the Makecents Coffee database regarding customer information and order details. To obtain rating data, the author conducted interviews with several customers and asked them to manually rate some food menu items that were being tested[16]. To create the recommendation system, the author required the user_id, menu_id, and rating data. The user_id and menu_id values are unique identifiers representing the relationship between users and menu items in the system. The rating, on the other hand, represents the evaluation given by users to each menu item. This information is crucial as it forms the basis of the dataset used in the Collaborative Filtering method to discover patterns in the relationships between users and menu items[17].

The total data used in this research is 7737, consisting of 7000 auxiliary data and 737 actual user data from the Makecents Coffee application. Auxiliary data is used because, as a startup, there is a limitation in the number of orders, so additional data is needed to achieve better results. The auxiliary data was obtained from the API responses of the application used[18].

### 2.3 Implementation of the Method

In this research, the collaborative filtering algorithm has two types: item-based collaborative filtering and user-based collaborative filtering. However, this research will only use user-based collaborative filtering because it focuses on comparing user preferences to find similarities among them, resulting in more accurate recommendations[19]. The following are the steps involved in the user-based collaborative filtering equation.

1. Calculating the average rating value using the formula for finding the general average.
2. Calculating the new rating value. To calculate the new rating value, the following equation can be used:

$$r_{ui} = avgr_u - \bar{r}_i \quad (1)$$

Where :
$r_{ui}$ = the predicted new rating for the user.
$avgr_u$ = the average of previous ratings.
$\bar{r}_i$ = the rating value given by the user[20].

3. Calculating the similarity value between the target user, for whom the recommendations are being sought, and other users. To calculate the similarity value, the following equation can be used:

$$similarity(A,B) = \frac{A.B}{\|A\| \times \|B\|} = \frac{\sum_{i=1}^{n} A_i \times B_i}{\sqrt{\sum_{i=1}^{n} A_i^2} \times \sqrt{\sum_{i=1}^{n} B_i^2}} \quad (2)$$

Where :
sim(x,y) = Similarity value between user x and user y
$A_i$ dan $B_i$ = Rating value on the same item

4. Calculates the rating prediction value from the target user whose recommendation you want to find. To calculate the predictive value, you can use the equation:

$$P_{a,i} = \bar{r_a} + \frac{\sum u \in K(r_{u,i} - \bar{r_u}) \times W_{a,u}}{\sum_{u \in K} W_{a,u}} \quad (3)$$

Where :
$P_{a,i}$ = Predicted value of the item to be rated
$\bar{r_a}$ = average target user value
$\sum(r_{u,i} - \bar{r_u})$ = the rating value of other users minus the acerage rating of other users
$W_{a,u}$ = target user similarity value, with other users meeting the threshold criteria
$\sum_{u \in K} W_{a,u}$ = total similarity value from other users who meet the theshold criteria[21].

System testing aims to ensure that the application and the underlying system function properly and prevent the occurrence of errors or bugs. In order to test the accuracy of predictions made by the Collaborative Filtering algorithm, MAE (Mean Absolute Error) and RMSE (Root Mean Square Error) are evaluation metrics used to measure how closely the predictions generated by the algorithm or model align with the actual values[22]. MAE calculates the absolute difference between the predicted rating and the actual rating, while RMSE calculates the square root of the average of the squared differences between the predicted rating and the actual rating. Here is the equation for MAE that will be used in the testing of this research[23]:

$$MAE = \sum \frac{|Y^1 - Y|}{n} \quad (4)$$


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Information:
$Y^1$ = Predicted value
$Y$ = Actual value
n = Number of data points
The equation for RMSE that will be used in the testing of this research is as follows:

$$RMSE = \sqrt{\sum \frac{(Y^{1-}iY)^2}{n}} \quad (5)$$

From some of the equations used in this study, then the researcher will carry out the calculation process using the current formula above[6], [24].

# 3. RESULT AND DISCUSSION

## 3.1 User Rating Data

In the discussion phase, the researcher examined the user data and the ratings given for each item available. After collecting data for two weeks on four items at Makecents Coffee.

**Table 1.** User Rating Data

| | Item (1) | Item (2) | Item (3) | Item (4) |
|---|---|---|---|---|
| User (1) | 5 | 3 | 4 | |
| User (2) | 3 | 1 | 2 | 3 |
| User (3) | 4 | | 4 | 5 |
| User (4) | | 3 | 5 | 2 |
| User (5) | 3 | 5 | 3 | 2 |
| User (6) | 5 | 4 | 4 | 3 |

In Table 1, there are six users who have made purchases of various different items and have provided ratings for each item they purchased. The table also shows four items: Item 1 (*fried rice*), Item 2 (*grilled chicken*), Item 3 (spaghetti bolognese), and Item 4 (beef black pepper). It can be observed that three users have not yet provided ratings for certain items. The data in Table 2 will be used in the implementation of the collaborative filtering algorithm to create an item recommendation system based on ratings given by other users.

To determine the new rating value, the first step is to determine the target user for whom item recommendations will be generated. In this research, the target user is user (1). To calculate the average rating for each user, two conditions need to be met: first, only ratings from item (1), item (2), and item (3) are considered; second, the number of data points is based on the total number of rating data provided by user (1). This is because user (1) has only provided ratings for these three items, while user (1) has not provided a rating for item (4), which is the focus of this research[25].

**Table 2.** Average Rating

| | Item (1) | Item (2) | Item (3) | Rata-rata |
|---|---|---|---|---|
| User (1) | 5 | 3 | 4 | 5+3+4/3 = 4 |
| User (2) | 3 | 1 | 2 | 3+1+2/3 = 2 |
| User (3) | 4 | | 4 | 4+0+4 = 2.7 |
| User (4) | | 3 | 5 | 0+3+5 = 4 |
| User (5) | 3 | 5 | 3 | 3+5+3 = 3.67 |
| User (6) | 5 | 4 | 4 | 5+4+4 = 4.33 |

The next step is to find a new rating value by subtracting the average value in table 3 above, using equation (1). By using this equation, a new rating value will be generated, as follows.

**Table 2.** New Rating Calculation Results

| | Item (1) | Item (2) | Item (3) |
|---|---|---|---|
| User (1) | 1 | -1 | 0 |
| User (2) | 1 | -1 | 0 |
| User (3) | 0 | | 0 |
| User (4) | | -1.00 | 1.00 |
| User (5) | -0.67 | 1.33 | -0.67 |
| User (6) | 0.67 | -0.33 | -0.33 |

In table 2 above, After obtaining the average rating values from the second table using the equation mentioned earlier, the next step is to calculate the similarity values using the adjusted cosine similarity method.


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The adjusted cosine similarity method is used to find the similarity in ratings between the target user and other users for the same items[26]. Its objective is to provide the target user with item recommendations based on the best ratings given by other users. To calculate the adjusted cosine similarity, the equation (2) can be used. Here are the results of applying equation (2) to find the similarity between user (1) and all other users.

**Table 3.** Result of Similarity Calculation (Adjusted Cosine Similarity)

| | A.B | $\|\|A\|\|$ | $\|\|B\|\|$ | sim(A,B) |
|---|---|---|---|---|
| $sim(U1,U2)$ | 2 | 1.41 | 1.41 | 1 |
| $sim(U1,U3)$ | 0 | 1.41 | 0 | 0 |
| $sim(U1,U4)$ | 1 | 1.41 | 1.41 | 0.5 |
| $sim(U1,U5)$ | -2 | 1.41 | 1.63 | -0.866 |
| $sim(U1,U6)$ | 1 | 1.41 | 0.82 | 0.866 |

From Table 3, it can be concluded that the highest similarity value is between user (1) and user (2), with a value of 1. It should be noted that when the similarity value approaches or is equal to 1, it can be inferred that the two vectors have high similarity. Therefore, on the homepage of user (1) when placing a food menu order, item recommendations from item (4) will be displayed. These recommendations are based on the rating given by user (2), which is 3 points.

### 3.2 Calculation of rating predictions

The prediction of ratings is performed to predict the ratings that have not been filled by user (1). This is done to ensure that the recommendation process for subsequent users can also be carried out. To calculate the predicted ratings, equation (3) can be used. Here are the results of applying equation (3) to find the predicted ratings between user (1) and all other users.

$$r_{(U1,U2)}=4+\frac{(1\times(2-3))+(0.50\times(2-4))+(0.86\times(3-4.33))}{\|1\|+\|0.50\|+\|0.86\|}=\mathbf{3.5}$$

Based on the calculation results, the prediction is that user (1) will give a rating of 3.5 points to item (4). Therefore, based on this prediction, the system can determine recommendations for other users who have not yet provided ratings for certain items[27].

**Table 4.** Overall calculation of unrated items

| User to - | User Rating Data | Item (1) | Item (2) | Item (3) | Item (4) | New Rating | Item (1) | Item (3) | Item (4) | Sim (A.B) | Pred Rating |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **User (3** | User (1) | 5 | 3 | 4 | 3.5 | User (1) | 0.83 | -0.17 | -0.67 | -0.32 | |
| | User (2) | 3 | 1 | 2 | 3 | User (2) | 0.33 | -0.67 | 0.33 | **0.24** | |
| | User (3) | 4 | | 4 | 5 | User (3) | -0.33 | -0.33 | 0.67 | | **2.7** |
| | User (4) | | 3 | 5 | 2 | User (4) | | 1.50 | -1.50 | -0.25 | |
| | User (5) | 3 | 5 | 3 | 2 | User (5) | 0.33 | 0.33 | -0.67 | -0.46 | |
| | User (6) | 5 | 4 | 4 | 3 | User (6) | 1.00 | 0.00 | -1.00 | -0.31 | |
| **User (4)** | User (1) | 5 | 3 | 4 | 3.5 | User (1) | -0.5 | 0.5 | 0 | **0.65** | |
| | User (2) | 3 | 1 | 2 | 3 | User (2) | -1 | 0 | 1 | 0.11 | |
| | User (3) | 4 | 2.7 | 4 | 5 | User (3) | -1.20 | 0.10 | 1.10 | **0.65** | **4.4** |
| | User (4) | | 3 | 5 | 2 | User (4) | -0.33 | 1.67 | -1.33 | | |
| | User (5) | 3 | 5 | 3 | 2 | User (5) | 1.67 | -0.33 | -1.33 | -0.24 | |
| | User (6) | 5 | 4 | 4 | 3 | User (6) | 0.33 | 0.33 | -0.67 | 0 | |

Table 4 above shows the recommendation results for users who have not provided ratings for certain items. User (2) has not rated item (2), while user (3) has not rated item (1). After going through the series of calculations


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explained earlier, the similarity between user (3) and user (2) is obtained. As a result, on the homepage of user (2), item recommendations from item (2) will be displayed, which was rated 1 point by user (3). On the other hand, user (4) has similarities with user (1) and user (3). Therefore, on the homepage of user (4), item recommendations from item (1) will be displayed, which were rated 5 and 4 points by user (1) and user (3) respectively.

### 3.3 MAE and RMSE test results

This study utilizes MAE and RMSE testing as evidence of the accuracy or precision of the implemented collaborative filtering algorithm's predictions within the system. To conduct the testing, the author used the three sets of predicted rating calculations that were explained earlier.

**Table 5.** Test Table

| User | Actual Rating | Predicted Rating |
|---|---|---|
| User (1) | 4 | 3.5 |
| User (3) | 2 | 3 |
| User (4) | 5 | 4.5 |

The first step is to calculate the MAE value using equation (4). So that the calculation results are obtained as follows:
User testing (1) : |4 - 3.5| = 0.5
User testing (2) = |2 - 3| = 1
User testing (3) = |5 – 4.5| = 0.5

After obtaining the results of testing for each user, based on the data from table 5 above, you can sum up these calculation results to obtain the total absolute difference. Then, divide the total absolute difference by the number of test data points to calculate the average absolute difference.
User testing (1) = (4-3.5)^2 = 0.25
User testing (2) = (2-3)^2 = 1
User testing (3) = (5-4.5)^2 = 0.25

After obtaining the squared calculation results from the previous data, you can sum up these calculation results to obtain the total squared difference[28]. Then, divide the total squared difference by the number of test data points to calculate the mean squared difference.

$$RMSE = \frac{0.25+1+0.25}{3} = 0{,}58$$

From the MAE and RMSE testing conducted, it can be concluded that the MAE result is 0.67 and the RMSE result is 0.58. These testing results are considered good because the rating values range from 1 to 5 points only. Therefore, an average prediction error of around 0.58 and 0.67 points is considered very small when compared to the scale of 1 to 5 points.

### 3.4 Application Implementation

The implementation of the application provides an overview of the Android-based application interface pages both from the user side and from the admin side. The following is the interface page of the expert system application for diagnosing kuc disease, ordering food menus, and system recommendations.

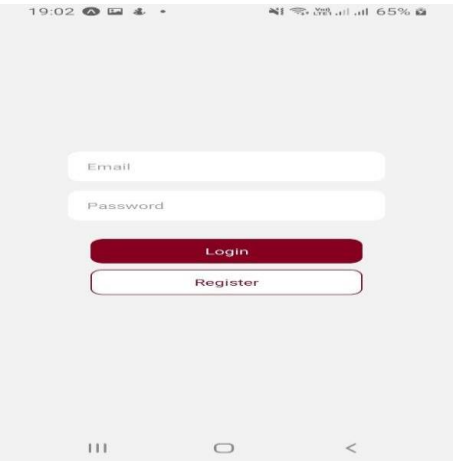


**Figure 2.** Login page

Image 2 shows the main Login page for both user and admin. The Login page serves as the initial interface for users and admins to access the food menu ordering application's dashboard, which has been implemented according to the research objectives.


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**Figure 3.** App homepage display

Image 3 depicts the homepage where the user can view recommended menus and place food orders based on the highest-rated recommendations that align with their preferences.


**Figure 4.** Menu Input Food Rating

Figure 4 is a page that will appear when the user has finished making a payment, and the system will automatically ask the user to provide a rating regarding the order menu he ordered, the results of this twig will be the data value which will be repeated calculations to determine the value of the recommendation menu twig for the next to other customers.

## 4. CONCLUSION

The food menu ordering and recommendation application has been successfully developed, implementing a collaborative filtering algorithm specifically user-based collaborative filtering as its recommendation system. The results of this research provide benefits to users by offering a reliable application for food ordering, making it easier for them to choose menu items through the recommendation system. The accuracy of the collaborative filtering algorithm was evaluated using MAE and RMSE tests. The MAE test yielded a score of 0.67, while the RMSE test yielded a score of 0.58. Both test results are considered excellent when compared to the rating range


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of only 1 to 5 points. This implementation can contribute to improved sales and enhancements at Makecents Coffee. A suggestion for further research is to conduct objective testing on the compatibility of recommendations with restaurant menu data that has a wide range of variations. This can be achieved by combining Collaborative Filtering algorithms with algorithms that compare based on content or restaurant type, such as content-based recommendation algorithms. Additionally, exploring model-based Collaborative Filtering approaches like Funk Singular Value Decomposition (Funk SVD) and combining them with K-Means algorithm for order categorization could also be worth investigating.

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