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# Final Assignment Title Recommendation System Using Collaborative Filtering Method for Undergraduate Students of Informatics Engineering

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**Abstract:**
The final project title selection process is a crucial stage for undergraduate students of Informatics Engineering. The difficulty in determining a title that is relevant to their interests and abilities is often an obstacle. This research aims to develop a final project title recommendation system that can assist students in finding suitable research topics. This system utilizes a collaborative filtering approach to analyze historical data on course grades and student preferences. The results show that the item-based collaborative filtering method produces more accurate and relevant recommendations compared to the user-based collaborative filtering method. The RMSE value of the item-based collaborative filtering method (0.4985) is lower than the RMSE value of the user-based collaborative filtering method (0.9759). While the accuracy value of the item-based collaborative filtering method (0.5903) is higher than the user-based collaborative filtering method (0.0153).This system has the potential to optimize the final project title selection process, accelerate study time, and improve the quality of student research.

**Keywords:** Recommendation system, final project, collaborative filtering

## INTRODUCTION

The process of preparing the final project is one of the important stages in the academic journey of students, especially at the undergraduate level. Choosing the right final project title, which is relevant to students' abilities and preferences, has a significant influence on the quality of the final result and the success of the study. A suitable title will motivate students to explore the topic in depth, increase productivity, and ultimately produce quality scientific work.

However, in practice, there are still many students who have difficulty in determining the right final project title. Some of the factors that cause this include the large number of titles. The more title options available, the more difficult it is for students to make a decision, the second is due to a lack of understanding of the field of study. Not all students have a deep understanding of all fields of study in their study program. While the third factor is the limited time factor. The process of searching and selecting titles often takes a long time, making it difficult for students to balance it with other academic activities.

Difficulty in choosing a final project title often results in delays in study completion. Students who struggle to find interesting and relevant topics tend to experience difficulties in the research and writing

process, resulting in the time needed to complete the final project being longer than it should be. Not only does this result in delays in graduation, but it can also increase students' stress levels and frustration.

To overcome these problems, a system is needed that can help students find final project titles that match their abilities and preferences. One approach that can be used is the *collaborative filtering* method. This method has been widely used in recommendation systems in various domains, such as e-commerce and streaming services. The basic principle of this method is to recommend items (in this case, final project titles) to users based on the similarity of preferences with other users or items that have been previously interacted with.

## LITERATURE REVIEW

### Recommendation System

A recommendation system is a system that automatically suggests items (products, services, information) to a user based on that user's preferences, behavior, or characteristics. The main goal of a recommender system is to help users find items that are relevant and interesting to them amidst the many options available.

### Types of Recommendation Systems

- Content-based filtering: This system recommends items based on the similarity between an item that the user already likes and other items that have similar attributes. For example, if a user likes sci-fi movies, the system will recommend other sci-fi movies.
- Collaborative filtering: This system recommends items based on the similarity of preferences between users. There are two main approaches in collaborative filtering:
  - User-based collaborative filtering: Searches for other users who have similar preferences to the target user, and recommends items favored by these similar users.
  - Item-based collaborative filtering: Searches for items that are similar to items the user already likes, and recommends similar items.
- Hybrid filtering: A combination of content-based and collaborative filtering. This approach seeks to combine the strengths of both methods to produce more accurate recommendations.

Recommendation System Application

Recommendation systems have been widely applied in various fields, such as:

- E-commerce: Recommending products to customers based on purchase history, browsing behavior, or demographic characteristics.
- Movies and music: Compile playlists or movie recommendations based on user preferences.
- News and articles: Displays news or articles relevant to the user's interests.
- Social media: Suggests new friends or content that may be of interest to the user.
- Education system: Recommend learning materials that match students' level of understanding and interest.

### *Collaborative Filtering* Method

Basic Principles of *Collaborative Filtering*

*Collaborative filtering* works by analyzing the interaction patterns between users and items. The system attempts to find similarities between users or items to provide relevant recommendations.

Comparison of *User-based* and *Item-based Collaborative Filtering*

- User-based:
  - Pros: Able to capture unique user preferences.
  - Disadvantages: Prone to *sparsity problem* (lack of user interaction data), more complex computation, and difficult to handle new users.
- Item-based:
  - Pros: More computationally efficient, more resistant to *sparsity problems*.
  - Disadvantages: Lacks the ability to capture unique user preferences.

Commonly Used Algorithms

- User-based:
  - Neighborhood-based: Calculates the similarity between users based on the ratings given on the same item.
  - Model-based: Using modeling techniques such as matrix factorization to predict unknown ratings.
- Item-based:
  - Item-based nearest neighbor: Searches for items that have similar characteristics to items that the user already likes.

Cosine Similarity

- Definition: Cosine similarity is a metric that measures the similarity between two vectors. In the context of *collaborative filtering*, these vectors represent user preferences or item characteristics.
- Calculation: Performed by calculating the cosine of the angle between two vectors. The cosine similarity value ranges from -1 to 1, where a value of 1 indicates perfect similarity.
- Applicability: Used to calculate the similarity between users or items in *collaborative filtering*.

**Performance Measurement**

- RMSE (Root Mean Squared Error): Measures the average difference between predicted and actual values. A small RMSE value indicates a good prediction model.
- Accuracy: The proportion of correct predictions to total predictions.
- Precision: The proportion of correct positive predictions to all positive predictions.
- Recall: The proportion of correct positive predictions to all true positive examples.

- F1-score: Harmonic mean of precision and recall, providing a balance between precision and recall.

## RESEARCH METHOD

In this research, we will develop a final project title recommendation system that utilizes the *collaborative filtering* method. This system aims to help undergraduate students of Informatics Engineering in choosing a final project title that is relevant to their interests and abilities.

### Research Design

This study uses an experimental research design. Thus, we will build and evaluate the performance of the developed recommendation system.

### Object of Research

The research object in this study is undergraduate students of Informatics Engineering in the Informatics Engineering Study Program, Universitas 17 Agustus 1945 Surabaya, 2020 - 2024 period.

### Research Variables

- **Independent Variable:**
  - *Collaborative filtering* methods (user-based, item-based)
  - Similarity calculation algorithm (cosine similarity)
  - Amount of training data
- **Dependent Variable:**
  - Recommendation accuracy (RMSE, MAE)
  - Accuracy, Precision, Recall, F1-score

### Data Collection Methods

The data used in this study are:

- **Student data:** Consists of student identity data, course grades, and research interests. This data will be used to build student profiles.
- **Final project title data:** Consists of a list of available final project titles.

Data related to student grades are grouped into 4 research groups. With this grouping, courses that have relevance to the research group will be made into one research group. The results of the average score from each group will be compared, the higher score will be a reference to the system so that it will produce the main recommendation for students on the given title.

**Table 1. Grouping of courses in the research group**

| No. | Research Group | Course Content |
|---|---|---|
| 1 | Information System | 1. Object-Oriented Programming |
| | | 2. Data Structure |
| | | 3. Database Management |

| | | | |
|---|---|---|---|
| | | 4. | Data Structure |
| | | 5. | Software Testing |
| | | 6. | Data Structures and Algorithms |
| 2 | Image Processing and Artificial Intelligence | 1. | Image Processing |
| | | 2. | Computational Intelligence |
| | | 3. | Data Minning |
| | | 4. | Deep Learning |
| | | 5. | Graphs and Automata |
| | | 6. | Discrete Mathematics and Logic |
| | | 7. | Computational Math |
| | | 8. | Natural language processing |
| | | 9. | Inference Statistics |
| 3 | Hardware, Networking and IoT | 1. | Digital System |
| | | 2. | Computer Architecture and Organization |
| | | 3. | Computer Network System |
| | | 4. | Emerging Technology |
| | | 5. | IoT |
| | | 6. | Robotics |
| | | 7. | Jarkom Administration |
| | | 8. | Cyber Security System |
| 4 | Multimedia and Mobile Applications | 1. | Human and Computer Interaction |
| | | 2. | Computer Graphics |
| | | 3. | Web Programming |
| | | 4. | Game Development |
| | | 5. | Mobile App Development |

**Algorithm and Implementation**

- **Data pre-processing:** The acquired data will be cleaned, converted into a suitable format, and normalized.
- **Model building:** A *collaborative filtering* model will be built based on the processed data.
- **Evaluation:** The built model will be evaluated using predefined evaluation metrics (RMSE, MAE, precision, recall, F1-score).

**Research Flow**

1. **Data collection:** Collected student data, final project titles, and student preferences.
2. **Data pre-processing:** Cleaning and converting data into a suitable format.
3. **Model building:** Build a *collaborative filtering* model using the selected algorithm.
4. **Evaluation:** Evaluate the performance of the model using testing data.

5. **Analysis of results:** Analyze the evaluation results and compare the performance of various methods.

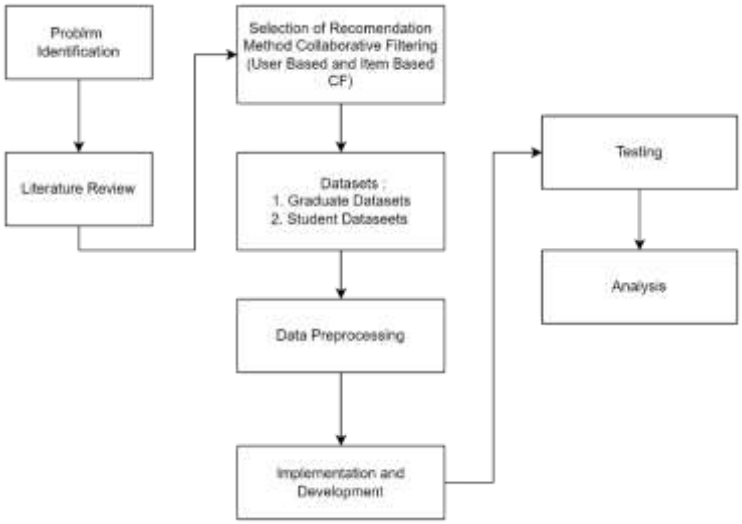


**Figure 1. Research flow**

The application of the collaborative filtering method in this final project title recommendation system can be described in Figure 1.

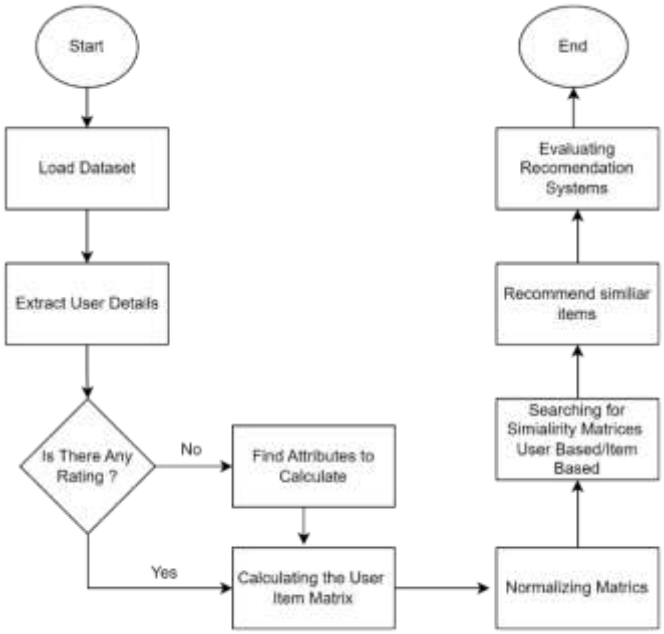


**Figure 2. Collaborative Filtering method approach**

**Scope and Limitation**

- **Scope:** This research focuses on developing a final project title recommendation system using the *collaborative filtering* method for undergraduate students of Informatics Engineering.

- **Limitation:** This research only considers historical data of course grades and student interests as factors determining recommendations. External factors such as current research trends, student activities in campus activities are not considered in this research.

## RESULT AND DISCUSSION

### Experiment Results

In this research, some data was utilized. The research also obtained the results as presented below.

- **Data Statistics**

**Table 2. Statistical Results of Data**

| No. | Item data | Description |
|---|---|---|
| 1 | Judiciary Student Data | Period 2020-2024 |
| 2 | Student GPA Data | Period 2020-2024 |
| 3 | Research Group Data | 4 Groups |

- **Comparison of Method Performance**

**Table 3. RMSE testing of item-based collaborative filtering method**

Hasil Pengujian untuk Nilai:

| Iterasi | Accuracy | Precision | Recall | F1 Score | RMSE | WR |
|---|---|---|---|---|---|---|
| 1 | 0.5266 | 0.6208 | 0.5928 | 0.5759 | 0.6054 | 1.0000 |
| 2 | 0.5536 | 0.6284 | 0.6840 | 0.5363 | 0.4850 | 1.0000 |
| 3 | 0.5474 | 0.6301 | 0.6669 | 0.6865 | 0.4687 | 1.0000 |
| 4 | 0.5082 | 0.6289 | 0.5405 | 0.6156 | 0.4550 | 1.0000 |
| 5 | 0.6048 | 0.5698 | 0.5731 | 0.7077 | 0.5033 | 0.9149 |
| 6 | 0.6387 | 0.6014 | 0.6113 | 0.6521 | 0.5403 | 0.9571 |
| 7 | 0.6096 | 0.5838 | 0.6410 | 0.5995 | 0.4826 | 0.9865 |
| 8 | 0.6058 | 0.6963 | 0.7306 | 0.6300 | 0.4761 | 0.9202 |
| 9 | 0.5731 | 0.6048 | 0.5754 | 0.5806 | 0.5599 | 1.0000 |
| 10 | 0.6170 | 0.5774 | 0.6700 | 0.6005 | 0.4551 | 0.9210 |
| 11 | 0.6081 | 0.5835 | 0.6953 | 0.7033 | 0.4194 | 0.9439 |
| 12 | 0.5973 | 0.5703 | 0.6220 | 0.5948 | 0.4952 | 1.0000 |
| 13 | 0.5579 | 0.6609 | 0.5747 | 0.7185 | 0.5622 | 0.9943 |
| 14 | 0.5629 | 0.5534 | 0.6548 | 0.6096 | 0.5275 | 1.0000 |
| 15 | 0.5726 | 0.5496 | 0.6207 | 0.6683 | 0.4341 | 1.0000 |
| 16 | 0.6796 | 0.5295 | 0.6229 | 0.5841 | 0.4873 | 1.0000 |
| 17 | 0.6222 | 0.5606 | 0.5860 | 0.6824 | 0.4976 | 1.0000 |
| 18 | 0.6236 | 0.6516 | 0.5913 | 0.5727 | 0.5193 | 1.0000 |
| 19 | 0.5654 | 0.5823 | 0.6029 | 0.6921 | 0.5093 | 0.9338 |
| 20 | 0.6065 | 0.5988 | 0.5524 | 0.6059 | 0.4666 | 0.9819 |
| 21 | 0.5907 | 0.6847 | 0.5929 | 0.6136 | 0.4782 | 0.9747 |
| 22 | 0.6151 | 0.6144 | 0.6151 | 0.5681 | 0.4708 | 1.0000 |
| 23 | 0.6021 | 0.6192 | 0.6195 | 0.6320 | 0.5091 | 0.9913 |
| 24 | 0.5655 | 0.5502 | 0.6620 | 0.6496 | 0.5136 | 1.0000 |
| 25 | 0.6030 | 0.5799 | 0.5621 | 0.5566 | 0.5417 | 0.9753 |

Rata-rata hasil untuk Nilai:

| | Accuracy | Precision | Recall | F1 Score | RMSE | WR |
|---|---|---|---|---|---|---|
| 0 | 0.5903 | 0.6012 | 0.6184 | 0.6255 | 0.4985 | 0.9798 |

**Table 4. Testing the user-based collaborative filtering method**

Hasil Pengujian untuk Input:

| Iterasi | Accuracy | Precision | Recall | F1 Score | RMSE | WR |
|---|---|---|---|---|---|---|
| 1 | 0.0527 | 0.0000 | 0.0000 | 0.0000 | 0.9706 | 0.0709 |
| 2 | 0.0000 | 0.1058 | 0.0000 | 0.0375 | 0.9927 | 0.0000 |
| 3 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0060 | 0.0000 |
| 4 | 0.0842 | 0.0500 | 0.0849 | 0.0000 | 1.0068 | 0.0000 |
| 5 | 0.0000 | 0.0049 | 0.0077 | 0.0000 | 1.0033 | 0.0000 |
| 6 | 0.0128 | 0.0242 | 0.0669 | 0.0184 | 0.9935 | 0.0552 |
| 7 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8901 | 0.0660 |
| 8 | 0.0000 | 0.0159 | 0.0112 | 0.0631 | 0.9069 | 0.0056 |
| 9 | 0.0573 | 0.0000 | 0.0000 | 0.0000 | 0.9804 | 0.0000 |
| 10 | 0.0000 | 0.0754 | 0.0000 | 0.0000 | 1.0230 | 0.0000 |
| 11 | 0.0000 | 0.0000 | 0.0000 | 0.0488 | 0.9514 | 0.0491 |
| 12 | 0.0000 | 0.0000 | 0.0000 | 0.0967 | 0.9920 | 0.0468 |
| 13 | 0.0000 | 0.1319 | 0.0447 | 0.0000 | 0.9847 | 0.0367 |
| 14 | 0.0339 | 0.0091 | 0.0005 | 0.0281 | 0.9129 | 0.0000 |
| 15 | 0.0000 | 0.0302 | 0.0000 | 0.0000 | 0.9603 | 0.0075 |
| 16 | 0.0000 | 0.0000 | 0.0000 | 0.0037 | 0.9710 | 0.0000 |
| 17 | 0.0000 | 0.0215 | 0.0423 | 0.0073 | 0.9840 | 0.0012 |
| 18 | 0.0000 | 0.0000 | 0.0546 | 0.0452 | 1.0994 | 0.1140 |
| 19 | 0.0000 | 0.0000 | 0.1256 | 0.0000 | 1.0122 | 0.0000 |
| 20 | 0.0075 | 0.0966 | 0.0643 | 0.0000 | 0.9802 | 0.0000 |
| 21 | 0.0000 | 0.0000 | 0.0000 | 0.0755 | 1.0178 | 0.0683 |
| 22 | 0.0537 | 0.0000 | 0.0000 | 0.0000 | 0.9141 | 0.0016 |
| 23 | 0.0000 | 0.0296 | 0.0036 | 0.0236 | 1.0529 | 0.0099 |
| 24 | 0.0816 | 0.0311 | 0.0000 | 0.0000 | 0.8869 | 0.0000 |
| 25 | 0.0000 | 0.0273 | 0.0000 | 0.0000 | 0.9056 | 0.0000 |

Rata-rata hasil untuk Input:

| | Accuracy | Precision | Recall | F1 Score | RMSE | WR |
|---|---|---|---|---|---|---|
| 0 | 0.0153 | 0.0261 | 0.0203 | 0.0179 | 0.9759 | 0.0213 |

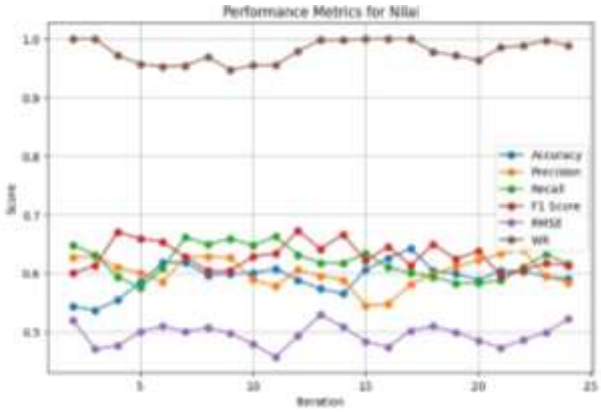


**Figure 3. Visualization graph of method performance comparison**

**Table 5. Comparison of testing item and user-based collaborative filtering methods**

Hasil Pengujian untuk Input:

| Iterasi | Accuracy | Precision | Recall | F1 Score |
|---|---|---|---|---|
| 1 | 0.0527 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.0000 | 0.1058 | 0.0000 | 0.0375 |
| 3 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 4 | 0.0842 | 0.0500 | 0.0849 | 0.0000 |
| 5 | 0.0000 | 0.0049 | 0.0077 | 0.0000 |
| 6 | 0.0128 | 0.0242 | 0.0669 | 0.0184 |
| 7 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 8 | 0.0000 | 0.0159 | 0.0112 | 0.0631 |
| 9 | 0.0573 | 0.0000 | 0.0000 | 0.0000 |
| 10 | 0.0000 | 0.0754 | 0.0000 | 0.0000 |
| 11 | 0.0000 | 0.0000 | 0.0000 | 0.0488 |
| 12 | 0.0000 | 0.0000 | 0.0000 | 0.0967 |
| 13 | 0.0000 | 0.1319 | 0.0447 | 0.0000 |
| 14 | 0.0339 | 0.0091 | 0.0005 | 0.0281 |
| 15 | 0.0000 | 0.0302 | 0.0000 | 0.0000 |
| 16 | 0.0000 | 0.0000 | 0.0000 | 0.0037 |
| 17 | 0.0000 | 0.0215 | 0.0423 | 0.0073 |
| 18 | 0.0000 | 0.0000 | 0.0546 | 0.0452 |
| 19 | 0.0000 | 0.0000 | 0.1256 | 0.0000 |
| 20 | 0.0075 | 0.0966 | 0.0643 | 0.0000 |
| 21 | 0.0000 | 0.0000 | 0.0000 | 0.0755 |
| 22 | 0.0537 | 0.0000 | 0.0000 | 0.0000 |
| 23 | 0.0000 | 0.0296 | 0.0036 | 0.0236 |
| 24 | 0.0816 | 0.0311 | 0.0000 | 0.0000 |
| 25 | 0.0000 | 0.0273 | 0.0000 | 0.0000 |

Hasil Pengujian untuk Nilai:

| Iterasi | Accuracy | Precision | Recall | F1 Score |
|---|---|---|---|---|
| 1 | 0.5266 | 0.6208 | 0.5928 | 0.5759 |
| 2 | 0.5536 | 0.6284 | 0.6840 | 0.5363 |
| 3 | 0.5474 | 0.6301 | 0.6669 | 0.6865 |
| 4 | 0.5082 | 0.6289 | 0.5405 | 0.6156 |
| 5 | 0.6048 | 0.5698 | 0.5731 | 0.7077 |
| 6 | 0.6387 | 0.6014 | 0.6113 | 0.6521 |
| 7 | 0.6096 | 0.5838 | 0.6410 | 0.5995 |
| 8 | 0.6058 | 0.6963 | 0.7306 | 0.6300 |
| 9 | 0.5731 | 0.6048 | 0.5754 | 0.5806 |
| 10 | 0.6170 | 0.5774 | 0.6700 | 0.6005 |
| 11 | 0.6081 | 0.5835 | 0.6953 | 0.7033 |
| 12 | 0.5973 | 0.5703 | 0.6220 | 0.5948 |
| 13 | 0.5579 | 0.6609 | 0.5747 | 0.7185 |
| 14 | 0.5629 | 0.5534 | 0.6548 | 0.6096 |
| 15 | 0.5726 | 0.5496 | 0.6207 | 0.6683 |
| 16 | 0.6796 | 0.5295 | 0.6229 | 0.5841 |
| 17 | 0.6222 | 0.5606 | 0.5860 | 0.6824 |
| 18 | 0.6236 | 0.6516 | 0.5913 | 0.5727 |
| 19 | 0.5654 | 0.5823 | 0.6029 | 0.6921 |
| 20 | 0.6065 | 0.5988 | 0.5524 | 0.6059 |
| 21 | 0.5907 | 0.6847 | 0.5929 | 0.6136 |
| 22 | 0.6151 | 0.6144 | 0.6151 | 0.5681 |
| 23 | 0.6021 | 0.6192 | 0.6195 | 0.6320 |
| 24 | 0.5655 | 0.5502 | 0.6620 | 0.6496 |
| 25 | 0.6030 | 0.5799 | 0.5621 | 0.5566 |

**Table 6. average value of Accuracy, Precision, Recall and F1 Score testing**

| CF Method | Accuracy | Precision | Recall` | F1 Score |
|---|---|---|---|---|
| Item Based | 0.5903 | 0.6012 | 0.6184 | 0.6255 |
| User Based | 0.0153 | 0.0261 | 0.023 | 0.0179 |

**Discussion**

Based on the experimental results, the *item-based collaborative filtering* method performs better than the *user-based* method in terms of prediction accuracy, as indicated by the lower RMSE value. This is likely due to the *sparsity problem* in the data used, so the *item-based* method, which is more resistant to *sparsity problems*, gives better results.

**CONCLUSION**

This research successfully developed a *collaborative filtering-based* final project title recommendation system for undergraduate students of Informatics Engineering. This system is designed to assist students in choosing a final project title that is relevant to their interests and abilities. The evaluation results show that the *item-based collaborative filtering* method provides better performance than the

*user-based collaborative filtering* method with a value of 0.4985 or lower than the *user-based collaborative filtering* method.

**Implications**

The development of this recommendation system has several implications:

- **Time efficiency:** Students can save time in finding a suitable final project title.
- **Increased relevance:** Recommended final project titles have higher relevance to students' interests and abilities.
- **Increased motivation:** Students will be more motivated to work on their final project if the topic chosen matches their interests.
- **Improving the quality of the final project:** By choosing a relevant title, students are expected to produce a better quality final project.

**Suggestions for Future Research**

This research still has some limitations that can be the direction of development for further research, among others:

- **Feature development:** The system can be developed by adding new features such as recommendations based on trending topics or recommendations based on students' programming skills.
- **Use of more complex algorithms:** The use of *hybrid* algorithms that combine *content-based filtering* and *collaborative filtering* to improve recommendation accuracy can be considered.
- **Improved data quality:** The quality of the data used greatly affects the performance of the system. Therefore, efforts should be made to improve the quality of the data used.
- **More comprehensive evaluation:** Evaluations can be conducted by involving more users and using different scenarios.

The final project title recommendation system developed in this research is a good first step in helping undergraduate students of Informatics Engineering in choosing research topics. With further development, this system is expected to be a useful tool in improving the quality of higher education.

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