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Book Recommendation Based on Collaborative Filtering Technique

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ABSTRACT

The book recommendationhas been popularly adopted, especially for bookstore websites to improve their books suggestions to customers. The book recommendation system helps people who do not have enough personal experience to assess the alternatives offered by the website. As for the library, the common Online Public Access Catalogue (OPAC) search could not acquire the spersonalisation of data as it is based on the basic search query. Thus, sometimes the users could not obtain the books according to their needs and interests. On the contrary, the book recommendation could produce results that are more spersonalised to the needs of users and could also cultivate a user's reading habit. Tstudy aims to investigate the efficiency of the book recommendation system based on the collaborative filtering technique. Collaborative filtering is one of the most adapted and powerful techniques for the recommendation system. The dataset used in this initial study was obtained from the Kaggle website and had been tested based on the 10-fold cross-validation technique. 1000 data had been chosen randomly, where 90% of the data were specified for the training phase, and another 10% were for the testing phase. The evaluation of the book recommendation prototype was based on the Precision, Recall and F-measure. In this initial research, the book recommender has successfully recommended the books with an acceptable performance of 80.38% F-measure value. However, the accuracy and efficiency of the recommender might further be increased if a larger volume of data is tested. Future works are to test a larger volume of data and investigate other well-known techniques in orderFuture works are to test a larger volume of data and investigate other well-known techniquesto identify the most efficient book recommender, especially for libraries.

Keywords: *recommendation system; book recommender; collaborative filtering; item based; library book searching.*

1. INTRODUCTION

The Book Recommendation system is an application that could give suggestions on the books to choose from based on other people's preferences. Through the recommendation system, people can share the options and the most favoured items offered amongst them to other users [1]. Many websites have implemented book recommendation, and the most outstanding site in the book recommendation system is Amazon Books [2]. Due to the vast number of choices, users or readers sometimes face difficulty of choosing to choose ormaking a decision. Users who want to find the book over the internet would get many suggestions from the search engines. However, the suggestions may not be relevant as the search engines are unable to provide accurate search results according to 'needs or satisfaction [3]. The search engines provide many results, and users face many data to choose. The provided suggestions may not fitmay not fit user preferences and expected outcomes. The same problem also goes for users

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who need to find books in the library. Some readers may come to the library to kill time, and they may find it is difficult to choose the right book to read when there are too many books available. It is common for readers to face the overabundance of information [4]. Thus, this could make the users feel hard to choose a book to read and give up reading if the book is not attractive.

Based on the problems, tools are needed to help users filter information from a vast selection of books. Recommender systems have been introduced to overcome this -overloaded the problem, and enable users to make the appropriate selection of the items or services they need [5]. The book recommendation is how users can search for books and choose a book to read from the recommended lists. The system recommend the books according to the users' needs and interests. As for the library, the book recommendation could be used to recommend information that produces results that are more relevant to the needs of users that are more relevant to users. The difference with OPAC (Online Public Access Catalog) is that the recommender would process the results based on an algorithm, where the data are calculated and predicted. Compared to the OPAC search, the results returned are based on the search query. The search engines usually could resolve information overload problems, but they could not acquire the spersonalisation of data [6]. Based on the advancement of technology, the adaptation of a book recommender could help increase user satisfaction while searching for books in the library. Additionally, it could facilitate users when searching through various books on the shelves and build a user's reading habits [7].

The recommender system operates on sets of data thatisbased on the specific algorithm to provide recommendations. In this study, the collaborative filtering algorithm has been chosen to be implemented for the book recommender. The collaborative filtering technique has been used widely in the recommender system based on its many advantages. One of the advantages is that the algorithm can be executed in domains where there are not many contents related to the item and where the content is difficult to analyse by the computer system, such as opinions and ideas. This study aims to investigate the efficiency of the book recommendation system based on the collaborative filtering technique, which is intended for usage in libraries. The rest of this paper is sorganised as follows. Section 2 provides brief reviews on the book recommendation system for libraries and the collaborative filtering algorithm. Section 3 explains the research methodology, while section 4 presents the results and findings. Finally, section 5 outlines the conclusion and recommendation for future work.

2. LITERATURE REVIEW

2.1 Book Recommendation System for Libraries

The sbook recommendation system or book recommender have been implemented to help users to find books that are in accordance withfollowing their needs and interests from an extensive database [7,8]. The recommendation system is classified under the information retrieval, data mining, and machine learning classes. In general, the recommendation system helps users to get personalizsed personalised recommendations, helping users to make the right decisions. Due to the importance of the recommender, much research shas been done to study the effectiveness of the book recommendation system. This review provides information on the studies of the book recommendation that have been implemented for libraries.

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Research from Thailand has studied the performance of the book recommender using library records from Dhurakij Pundit University in Bangkok, and the results have shown that the recommender could help libraries increase their book sutilisation [9]. Jomsri [7] has stated that book recommendation is one of the solutions for university libraries that possess large volumes of books and reading-intensive users. The findings have shown that the users are satisfied with the book recommendation system that has facilitated them with book searching in the library [7]. Research from Japan has also developed a book recommender to encourage students to read library books as a more reliable source of information [10]. Another research from Thailand has studied the integration of the book recommender with the OPAC for a more efficient search [11]. Based on the literature, the book recommendations system has enhanced the effectiveness of the library system. It could help develop 'users' reading habits [12-14]. Zhao and Zeng [14] have proposed user expression recognition for the book recommender, and the results have been satisfying. The library data that have been used in this research are such as book borrowing records with timestamps [9], similarities of book titles and the number of times a book has been borrowed [15], the bibliographic information of books such as author, category, number of views and year of publication [11].

Table 1 shows the information from the previous research on the book recommendation. The information consistsconsists of the title, objective, technique, result, and reference for each research. Based on the previous research, various algorithms have been adapted in the book recommendation. Among the techniques or algorithms that have been sutilised for the book recommendation are collaborative filtering, association rule mining, support vector machine (SVM) and convolutional neural network (CNN). These techniques have their advantages in solving problems. As for collaborative filtering, the algorithm has been chosen in this research due to its more accessible,more straightforward implementation, yet could generate acceptable performance in the book recommendation. Based on the previous research, the adaptation of the book recommendation has been successful in facilitating library users. The overall performance of the algorithms that have been implemented in the book recommendations for libraries have proven to be accetable and satisfying with good accuracy.

Table 1: Book Recommendations for Libraries

No.	Title	Objective	Technique	Result	References
1	Book Recommendation Model Based on Wide and Deep Model	To propose spersonalised recommendations to the university library lending system	Logistic Regression and Deep Neural Network	Could produce higher accuracy and could solve data sparsity problem	[12]
2	Development of a Book Recommendation Service for Implementation on Android	To improve the book request of a new user	Collaborative filtering technique	Successfully developed book recommender for mobile application	[13]

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3	Library Intelligent Book Recommendation System Using Facial Expression Recognition	To propose a spersonalised book recommendation system through user expression recognition	Convolution neural network	The recommender performance was acceptable	[16]
4	Enhancing the Performance of Library Book Recommendation System by Employing the Probabilistic-Keyword Model on a Collaborative Filtering Approach	To propose the probabilistic-keyword CF method for a library book recommendation system	Collaborative Filtering with probabilistic-keyword model	The proposed method outperformed the benchmark values	[17]
5	Book Recommender System for Wikipedia Article Readers in a University Library	To encourage students to read library books as a more reliable source of information	Convolutional neural network, support vector machine	Cnn performed better as a book recommender	[10]
6	Development of an Open Source Automated Library System with Book Recommendation System for Small Libraries	To develop an - open-source automated library system with a book recommendation	Support Vector Machine	The recommender performed better than other methods	[11]
7	A Collaborative Filtering Based Library Book Recommendation System	To determine the most effective method for generating book recommendations in the library	Collaborative filtering	The accuracy of recommended books was acceptable	[9]
8	FUCL mining technique for book recommender system in library service	To develop the technique which recommends the most suitable books to users	Association rule mining	The technique could produce higher accuracy	[14]
9	Book Recommendation System for Digital Library Based on User Profiles by Using Association Rule	To reduce the time and difficulty of finding the proper books	Association Rule Mining	Users were satisfied with the book recommendation system	[7]
10	Book Recommendation Using Machine Learning Methods	To recommend books through machine learning modules	Support Vector Machines, Random	Book recommender based on SVM performed the best	[15]

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	Based on Library Loan Records and Bibliographic Information	Forest, and Adaboost

2.2 Collaborative Filtering Technique

Collaborative Filtering is a domain-independent prediction technique for content that metadata cannot simply and adequately explain. A Collaborative filtering algorithm aims to propose a new item or predict the utility of certain items to specific users based on previous user creation and the opinion of other like-minded users [18]. Collaborative Filtering techniques work by building a database (user-item matrix) priority for items by users. It then matches users with interests and preferences to match the similarities between their profiles to make recommendations. The user builds a group called a neighbourhood. A user gets suggestions for items they have not rated before but which has been positively evaluated by users in the neighbourhood. The recommendation made by Collaborative Filtering can either be predictions or recommendations. Prediction for active users is by calculating the weighted average for all similar user ratings, while the recommendations are based on other people with similar interests. The accuracy of the recommendation system depends on how best the other user chooses, which is similar to the user who wants the recommendation [6].

The Collaborative Filtering technique can be divided into two types:model-based and memory-based. Model-based Model-based Collaborative Filtering methods typically achieve less accurate predictions on dense data sets but perform better on sparse data sets [19]. Collaborative Filtering methods typically achieve less accurate prediction on dense data sets but perform better on sparse data sets [19]. Model-based approaches do not use the entire data set to calculate prediction. As an alternative, it develops a data model based on a training set and uses the model to predict future ratings. As an alternative, it develops a data model based on a training set and uses the model to predict future ratings. Memory-based Collaborative Filtering uses user-based or item-based correlation based on user rating behaviour to recommend or predict ratings for users on future items. Correlation can be measured with various distance metrics, such as ' 'Pearson's correlation coefficient, Cosine distance, and Euclidean distance. It can execute with the high accuracy of recommendations, and new data can also be easily applied to the recommendation.

In this research, the item based Collaborative Filtering algorithm has been selected to implement the book recommender. Based on the previous research, it has been proven that the algorithm could be applied in various areas, make a high-quality recommendation for extensive data, and solve problems such as data sparsity, accuracy, and big-error prediction [20]. The item-based Collaborative Filtering algorithm could also perform better than user-based and could solve the challenges of data sparsity and scalability [21].

3. METHODOLOGY

3.1 Experimental Data

In this research, the book recommender was tested with the initial dataset obtained from the Kaggle website. Kaggle is a data repository website that provides various public datasets for data science works. The Goodbooks dataset contains 10000 data from popular books, but only 1000 have been selected randomly for the experimental data due to the limitation of the

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computer specifications for processing. Although the number of the data selected is smaller, it is still acceptable for this initial study. The data had been trained and tested based on a 10-fold cross-validation technique. In this research, the dataset was divided into 90 to10 ratios, where 90% of the data were specified for the training phase, and another 10% were for the testing phase. There are 7 variables in the dataset that have been used in the book recommendation. Table 2 shows the variables for the books and their ratings. The variables are the user id, book id, ISBN, book title, book author, year of publication and book rating. The data types of the variables are Integer and String.

Table 2: Variables for the Book Recommendation

	Variable	Data Type
Books	Book ID	Integer
	ISBN	String
	Book Title	String
	Year of Publication	Integer
	Book Author	String
Ratings	User ID	Integer
	Book Rating	Integer

The system's input is the book title, and the ' 'book's rating would be processed based on the adjusted cosine vector metric for finding similarities among the book items. Equation (1) shows the adjusted cosine vector metric [19].

$$sim(t,r) = \frac{\sum_{i=1}^{m}(R_{it}-A_i)(R_{ir}-A_i)}{\sqrt{\sum_{i=1}^{m}(R_{it}-A_i)^2\ (R_{ir}-A_i)^2}} \quad (1)$$

Based on (1), R_{it} is the rating of target item t by user i, R_{ir} is the rating of remaining item r by user i, A_i is the average rating of user i for all other items, and m is the number of all ratings to item t and item r.

After finding the similarity among items, the next step is to compute the predicted rating of the books based on the weighted sum formula in (2).

$$P(i,t) = \frac{\sum_{all\ similar\ items,N}(S_{t,N} * R_{i,N})}{\sum_{all\ similar\ items,N}(|S_{t,N}|)} \quad (2)$$

The predictions, $P_{i,t}$ *in the* formula calculates the predictions on item t for a user i by calculating the number of the ratings given by the user on the items similar to t. Each rating is weighted by the corresponding similarity $sim(t,r)$ between items t and r. This approach tries to capture how users are actively giving the rating to similar items. The number of similarities weighs the total in terms of scale to ensure the forecast is within a predetermined range [18].

3.2 Conceptual Framework

The book recommendation framework consists of three main phases: the input phase, processing phase, and output phase. Figure 1 shows the conceptual framework of the book recommendation using the Item Based Collaborative Filtering technique. Based on the figure, the framework of the prototype starts from the user input, the book title. The back end engine would then process the data entered based on the 3 steps. The first step is to find the similarity values between the books based on the adjusted cosine vector metric. After the similarity of

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items has been calculated, the books that have been selected are the ones with the similarity values, which could exceed the threshold value of 0.7. The threshold value selected was 0.7 for better comparison and selection [21]. When the similarity exceeds a certain threshold, the items are considered neighbours. The next step is to compute the prediction of the books based on the weighted sum formula. The final step is to process and produce the list for the book recommendation. Based on the previous calculations, the recommendation select 10 books with high predicted ratings. The final output or results contain the information on the ISBN, title, author and year of publication of the recommended books.

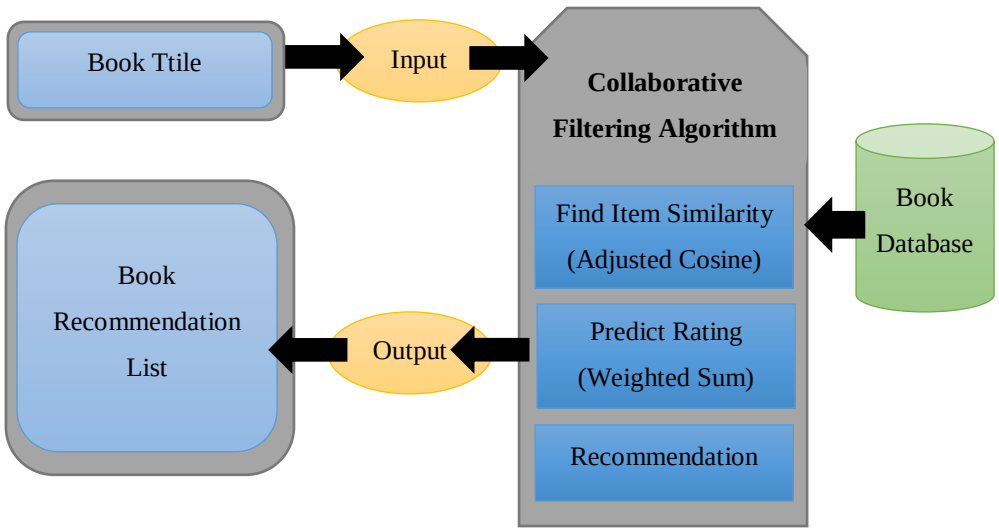

Figure 1: Book Recommendation Conceptual Framework

3.3 Performance Evaluation

The performance evaluation for the Item-based Collaborative Filtering Algorithm is based on the Precision, Recall, F-measure and Mean Absolute Error (MAE) metrics. These metrics are used to measure the accuracy and efficiency of the recommender [22]. The precision is the ratio correctly predicted books to be the total of all predicted books. A recall is the ratio of correctly predicted books to all observations or books. The two metrics abov,, precision and recall rate, are used for F-Measure evaluation. F-measure is the combination of precision and recall metrics weighted to calculate the accuracy of the recommender. As for MAE, it calculates the errors in the measurement between the predicted values and the absolute values. The following Equations (3), (4), (5) and (6) show the formula for the Precision, Recall, F-measure and MAE, respectively.

$$Precision = \frac{Z}{X+Z} \times 100\% \quad (3)$$

$$Recall = \frac{Z}{Y+Z} \times 100\% \quad (4)$$

$$F - measure = 2 \times \frac{Precision \times Recall}{Precision + Recall} \quad (5)$$

$$MAE = \frac{\sum_{i=1}^{n} |y_i - x_i|}{n} \quad (6)$$

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Based on Equations (3) and (4), Z presents the number of books that the users are interested in while X is the number of books that users are not interested. As for Y, it indicates the number of books that are not relevant to the recommended list [23]. Based on Equation (6), y_i represents the predicted value, while x_i represents the actual value. In obtaining the MAE, n represents the number of input tested.

4. RESULTS AND DISCUSSION

This section provides the results of the evaluations on the book recommendation system based on the Item-based Collaborative Filtering Algorithm. The evaluations of the book recommendation prototype are based on the Precision, Recall, F-measure and Mean Absolute Error (MAE).

4.1 Precision, Recall and F-Measure

In this research, the training and testing were done based on the 10-fold cross-validation technique. The dataset was divided into 10 subsets, where 9 of the subsets were set for the training and another 1 subset was for the testing. In each experiment, the training was done using the 9 subsets specified for the learning process. After the training process, the testing phase was conducted using the remaining subset. Each subset eventually had the chance to be tested with the different folds in each experiment. In each fold, 100 datasets had been specified for the testing. There was 10 user inputs that had been tested for each fold, and the mean results were calculated [23]. In each fold, the mean value of Z, X, and Y from the 10 user10-user input was calculated and recorded in Table 3. Table 3 shows the Precision, Recall and F-Measure results from each of the 10-fold the dataset. The average results from each testing were also calculated and recorded in the table.

Table 3: Results of the Precision, Recall and F-measure evaluations

Fold	Z	X	Y	Precision (%)	Recall (%)	F-measure (%)
1	7	3	0	70	100	82.35
2	6	4	1	60	85.71	70.58
3	7	3	0	70	100	82.35
4	7	3	1	70	87.50	77.78
5	8	2	0	80	100	88.89
6	6	4	0	60	100	75.00
7	7	3	1	70	87.50	77.78
8	7	3	0	70	100	82.35
9	7	3	1	70	87.50	77.78
10	8	2	0	80	100	88.89
Average				**70**	**94.82**	**80.38**

Based on Table 3, the average precision of the book recommendation from the 10-fold cross-validation testing is 70%. The precision result is calculated from the correct predictions over the overall predictions. Therefore, this precision represents the quality of the positive prediction performance of the recommender. The precision results of the book recommendation are considered acceptable as the recommender could predict the exciting books to the user with 70% precision.

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As for the recall, the average result calculated for the recommender is 94.82%. The result is also obtained from the correct prediction results but divided by the total of relevant and irrelevant predictions. The recall represents the percentage of relevant items produced by the recommender. Both of the precision, and recall results have to be obtained to calculate the F-measure.

The F-measure is used to compute the ' 'recommender's accuracy, calculated from the weighted average of the precision and recall. Based on Table 3, the average F-measure for the book recommendation is 80.38%. This result is also considered acceptable, as the higher the F-measure value represents, the better quality of the recommender. Figure 2 shows the F-measure values obtained from the 10-fold cross-validation testing. In the folds, the book recommender produced the F-measure with excellent and acceptable percentage values of more than 70%. Based on the F-measure results, the book recommender had successfully produced 80.38% of accuracy and efficiency of the book recommendations based on the collaborative filtering technique.

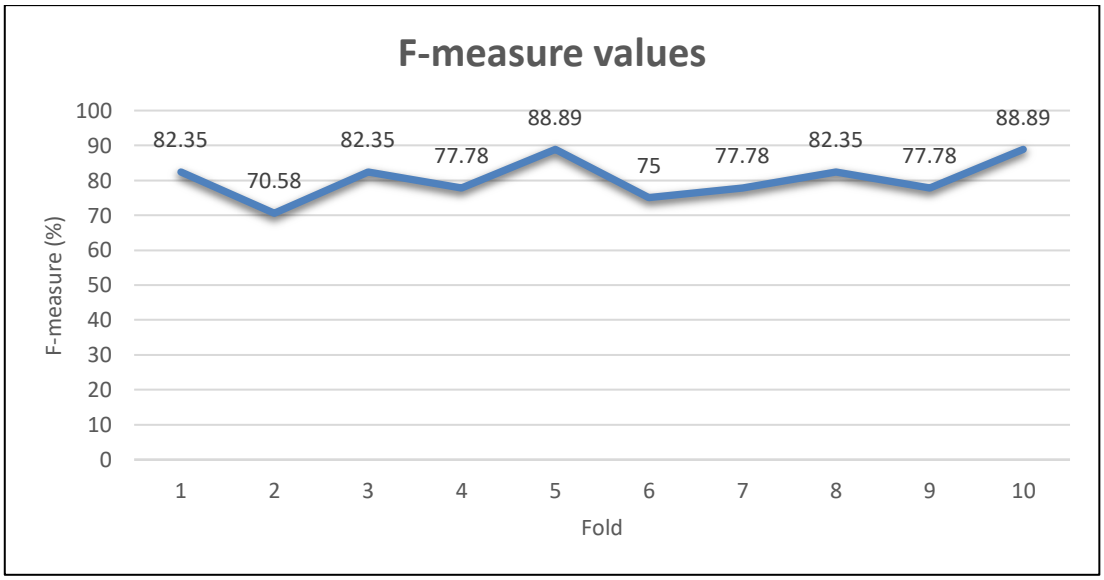

Figure 2: F-measure values from the 10-fold cross-validation testing

4.2 Mean Absolute Error (MAE)

The mean absolute error (MAE) has been obtained by calculating the errors of each of the predictions over all the input in the testing. This MAE represents the average prediction error of the book recommendation. Figure 3 shows the MAE from each of the 10-fold cross-validation testings. The lower the value of MAE, the better the efficiency of the recommendation would be. Based on the figure, the lowest MAE is 0.2, obtained at folds 5 and 10. In this research, the overall average value of MAE is acceptably low, with a 0.3 value. This indicates that the book recommender based on the collaborative filtering technique, could produce a good performance in the book recommendation predictions due to the low MAE computation.

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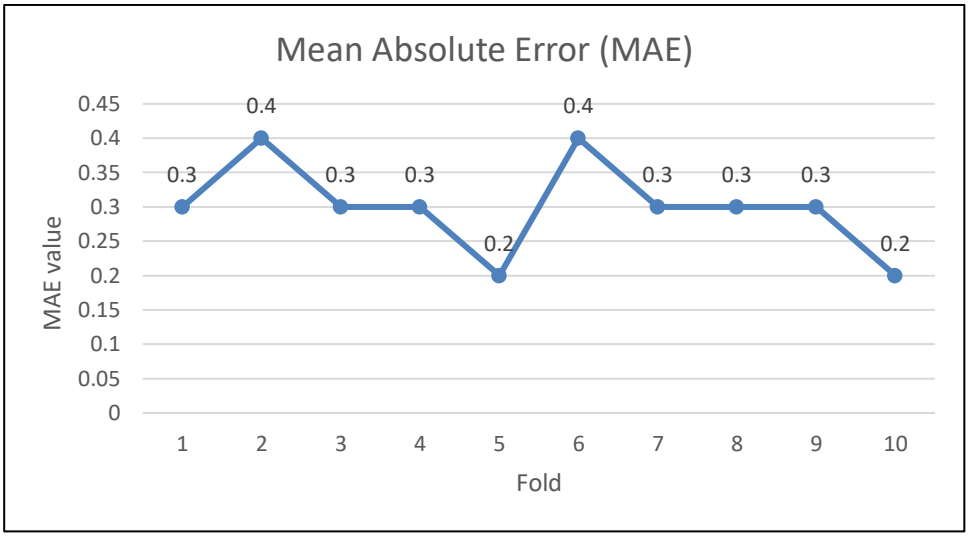

Figure 3: MAE from the 10-fold cross-validation testing

4.3 Book Recommendation List Interface

The book recommendation interface and the back-end process were developed based on the Java programming language. Java has been chosen due to the being platform-independent, robust, secure, and used in various application developments. Figure 4 shows the sample output interface for generating the book recommendation list. In the prototype, the recommendation would list 10 books with information such as user ID, ISBN, title, author and year. The recommended books are generated after the book's title has been entered by the user. Based on Figure 4, the recommender had predicted 10 books that might be interesting to user 143 based on the collaborative filtering technique.

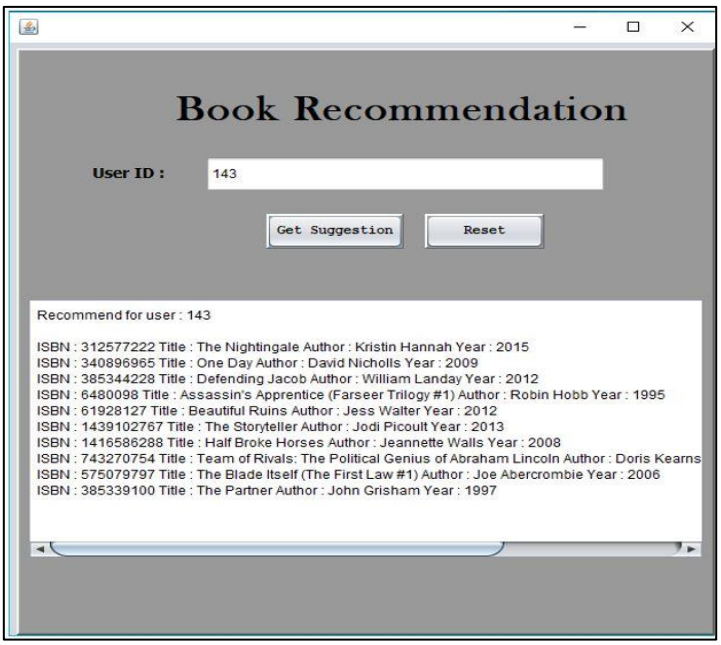

Figure 4: Sample book recommendation list interface

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5. CONCLUSION

This research has developed and tested the book recommendation based on the Item Based Collaborative Filtering technique. The recommendation system has successfully predicted the recommended books with the acceptable F-measure value of 80.38%. In this initial study, a small number of data has been tested due to the limitation of the computer processing capability. s. The common search engine in the library cannot produce results based on the personalisation of data. Based on the finding, the book recommendation could provide an alternative way for libraries to help users with the books searching and also to attract more readers. The book recommendation could filter and recommend the books which are predicted to be more satisfying with the user preferences and interest. Libraries could sutilise the current technology by integrating the recommender with the OPAC system. For future work, a larger volume of data would be tested using a higher specification of computer processing. The book recommender accuracy and efficiency mightbe increased if a larger volume of data is used in the experimental study. This is predicted due to the previous reported high capability of the collaborative filtering algorithm in processing a larger volume of data. This research also wishes to collect and apply the real dataset from the UiTM library. In terms of the implementation, more techniques such as the - content-based filtering, hybrid filtering technique and other machine learning techniques such as SVM and CNN could also be tested and compared for efficiency validation. Future research would evaluate more algorithms for the performance comparison to find the most efficient book recommender, especially for libraries.

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