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E-BUSINESS APPLICATIONS RECOMMENDATION FOR SMES USING ADVANCED USER-BASED COLLABORATION FILTERING

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Abstract. *The adoption of e-business for Small and Medium Enterprises (SMEs) should be easy to use, minimum customization, and not subject to infrastructure procurement. However, each SME has very diverse characteristics, so that one-size-fits-all system is not the right solution. In this study, a recommendation system for e-business applications is proposed for SMEs based on their characteristics. Recommendations are made using advanced user-based collaborative filtering, which is the improvement of the User-based Collaborative Filtering (UCF) algorithm. At UCF, SMEs give the same or similar preferences to an e-business application, and it can be said that SMEs have similar requirements. Thus, those SMEs will likely give the same preference to other e-business applications. In the proposed advanced UCF, besides using SMEs preference data it also uses SME characteristic data to produce recommendations. This approach is used by considering that SMEs that have just used the recommendation system do not yet have a historical preference for e-business applications. For this reason, recommendations can be made by considering the characteristics of the organization. Thus, it is expected that SMEs can use e-business applications that are appropriate to the characteristics of the organization. This approach is expected to increase the adoption of e-business in SMEs.*
Keywords: Advanced UCF, E-business, Collaborative filtering, Recommendation system, SMEs

1. Introduction.

E-business can be defined as the use of information technology or information systems to support business processes in an organization. The use of e-business in an organization can be widely used, including to increase product sales, organizational collaboration, and support the organization's business processes [1]. By utilizing e-business technology, the company will get several benefits, one of which is e-business that has a positive effect on operational competence by facilitating increased gross margin, employee productivity, employee operational management, and operational excellence [2]. Before getting the right e-business application recommendation, company should first determine the business goals and behavior of the business processes, one of which is by using a framework for model-based quality assurance of online business processes [3]. That would be useful in detecting and anticipating any deficiencies in meeting business goals at the

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early stages of business process development where corrective actions can be more easily made.

E-business can be seen as an enabler for business growth, effective competition, and innovation in SMEs. SMEs are often reluctant to adopt e-business based on lack of IT managerial skills. A study revealed that the successful adoption of e-business by organizations is related to the size of the organization [4]. However, this is contrary to [5], which revealed that SMEs adopt e-business in a non-linear fashion. Organizations that use IT as a habit in their organizations will find it easier to adopt e-business than traditional companies. Meanwhile, the area of products and services also influences the adoption of e-business.

Multi-label classification approach had been carried out in previous study [6], used to link an SME profile with several appropriate e-business applications. The features used include the evaluation of the SME characteristics. While the predicted classes are e-business applications that fit certain characteristics. However, in the multi-label classification approach, the value of a class that can be predicted only consists of two values, namely "true" or "false". The class value represents the requirement of SME for the use of an e-business application, which is "needed" or "not required". However, we cannot get more detailed information related to the level of SME requirements for an e-business application. Meanwhile, it is very important to know the level of importance of e-business applications required by SMEs. By using the Kano Model, areas that require more or less investment can be identified. Application quality can be improved this way and user satisfaction can be improved.

In this study a recommendation system for e-business application is proposed for SMEs based on their characteristics. E-business information systems consist of several related e-business applications. An organization can use several e-business applications to support its business processes in several functional areas. Recommendations are made using advanced user-based collaborative filtering, which is the improvement of the User-based Collaborative Filtering (UCF) algorithm. At UCF, giving recommendations is based on that SMEs that give the same or similar preferences to an e-business application are the same, and it can be said that SMEs have similar needs. Thus, the SMEs will likely give the same preference to other e-business applications.

In the Advanced UCF, besides using SME preference data it also uses SME characteristic data to produce recommendations. This approach is used by considering that SMEs that have just used a recommendation system do not yet have a historical preference for e-business applications. For this reason, recommendations can be made by considering the characteristics of the organization. Thus, it is expected that SMEs can use e-business applications that are appropriate to the characteristics of the organization. This approach is expected to increase the adoption of e-business in SMEs.

The organization of this paper is composed as follows. Section 1 presents state-of-the-art literature on e-business application recommendation for SMEs. Section 2 presents the basic literature of collaborative filtering algorithms that are widely used in recommendation system. Section 3 explains the use of collaborative filtering in the e-business application recommendation system. This section also explains the use of the Kano Model to determine user preferences for e-business applications based on user requirements and expectations. Section 4 describes the implementation and evaluation of the recommendation system. Finally, Section 5 gives the concluding remark.

2. **Collaborative Filtering.** Recommendation algorithm is currently widely used in web applications to predict user preferences for an item [7]. One algorithm that is widely used to provide recommendations is Collaborative Filtering (CF) [8]. The CF algorithm is based on the assumption that "similar users have similar preferences". In other words, by searching for users who are similar to active users and by checking their preferences,

the recommendation system can predict the preferences of active users for a particular item and provide a ranking list of the items most preferred by active users. CF generally ignores the form and content of these items and can therefore also be applied to non-textual items. Furthermore, CF can detect relationships between items that do not have the same content but are implicitly linked through groups of users who access them [9].

CF algorithm has been successfully applied to several case studies, but there are challenges in its use. First, the traditional CF ignores that the actual recommendation system is faced with individuals who have different personalities. Second, in the case of insufficient data, it will result in less credible recommendations. This is because the quality of CF recommendations is very dependent on the diversity of data used [9]. Then the final challenge is that traditional CF cannot combine user attribute information and user rating, which results in less precise or less personalized recommendations [10].

Traditional CF is implemented through three main steps, which will be explained as follows.

2.1. **User-item matrix.** User rating data can be described as matrix $A_{m,n}$ as follows:

$$\begin{bmatrix} R_{11} & R_{12} & \dots & R_{1n} \\ R_{21} & R_{22} & \dots & R_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ R_{m1} & R_{m2} & \dots & R_{mn} \end{bmatrix} \tag{1}$$

where n represents the number of items and m represents the number of users. R_{ui} shows user u rating on item i.

2.2. **Nearest neighbor query.** A key part of nearest neighbor query is to exploit different methods to calculate the similarity between target users and other users. After that proceed with having the same top users number K to produce the closest neighbor collection to predict the unknown rating. The accuracy of the similarity calculation is the key to the accuracy of the CF algorithm. There are two types of similarity calculation formulas that are most commonly used, which are as follows:

1) Cosine similarity:

$$sim(u,v) = \frac{\sum_{i\in I_{uv}} R_{ui} \cdot R_{vi}}{\sqrt{\sum_{i\in I_{uv}} {R_{ui}}^2}\sqrt{\sum_{i\in I_{uv}} {R_{vi}}^2}} \tag{2}$$

2) Pearson correlation coefficient:

$$sim(u,v) = \frac{\sum_{i\in I_{uv}} \left[\left(R_{ui} - \bar{R}_u\right) . \left(R_{vi} - \bar{R}_v\right)\right]}{\sqrt{\sum_{i\in I_{uv}} \left(R_{ui} - \bar{R}_u\right)^2}\sqrt{\sum_{i\in I_{uv}} \left(R_{vi} - \bar{R}_v\right)^2}} \tag{3}$$

where R_{ui}, R_{vi} represent the ratings of the item i given by users u and v. $\bar{R}_u$, $\bar{R}_v$ represent the average ratings of users u and v. I_{uv} shows a collection of items given a rating by users u and v.

2.3. **Recommendation generation.** After getting the N neighbor set, the next step is to calculate the prediction of the ranking vector from the target user according to the neighbor's data set. The calculations for the predicted score are as follows:

$$P_{u,i} = \bar{R}_u + \frac{\sum_{v\in N} sim(u,v)\left(R_{vi} - \bar{R}_v\right)}{\sum_{v\in N} sim(u,v)} \tag{4}$$

where $sim(u,v)$ represents the similarity between users u and v. N indicates the collection of neighbors of the target user.

3. **E-Business Apps Recommendation System Using Collaborative Filtering.** The aim of the Collaborative Filtering (CF) approach is to provide e-business recommendations that are in accordance with the characteristics of SMEs. CF approach itself consists of several algorithms, namely, item-based collaborative filtering, user-based collaborative filtering, and other algorithms. In this study, a trial of 3 recommendation approaches was conducted to find the approach that was considered the most appropriate as a recommendation for SMEs. The approach used is as follows:

1) Item-based Collaborative Filtering (ICF), namely an SME that has a preference for an e-business application may also need a similar e-business application, so that the same preferences will be obtained for the two e-business applications.
2) User-based Collaborative Filtering (UCF), namely SMEs that give the same or similar preferences to an e-business application are the same, and it can be said that SMEs have similar needs. Thus, the SMEs are likely to give the same preference to other e-business applications.
3) Advanced User-based Collaborative Filtering (Advanced UCF), which in addition to using SME preference data also uses SME characteristic data to produce recommendations. This approach is used by considering that SMEs that have just used a recommendation system do not yet have a historical preference for e-business applications. For this reason, recommendations can be made by considering the characteristics of the organization.

When calculating the similarity between users, the Pearson correlation coefficient outperforms the similar algorithm [10, 12]. Thus, in this paper we only discuss the calculation of similarity based on the Pearson correlation coefficient.

3.1. **Item-based collaborative filtering.** In Item-based Collaborative Filtering (ICF), as illustrated in Figure 1(a), the assumption used is that an SME that has a preference

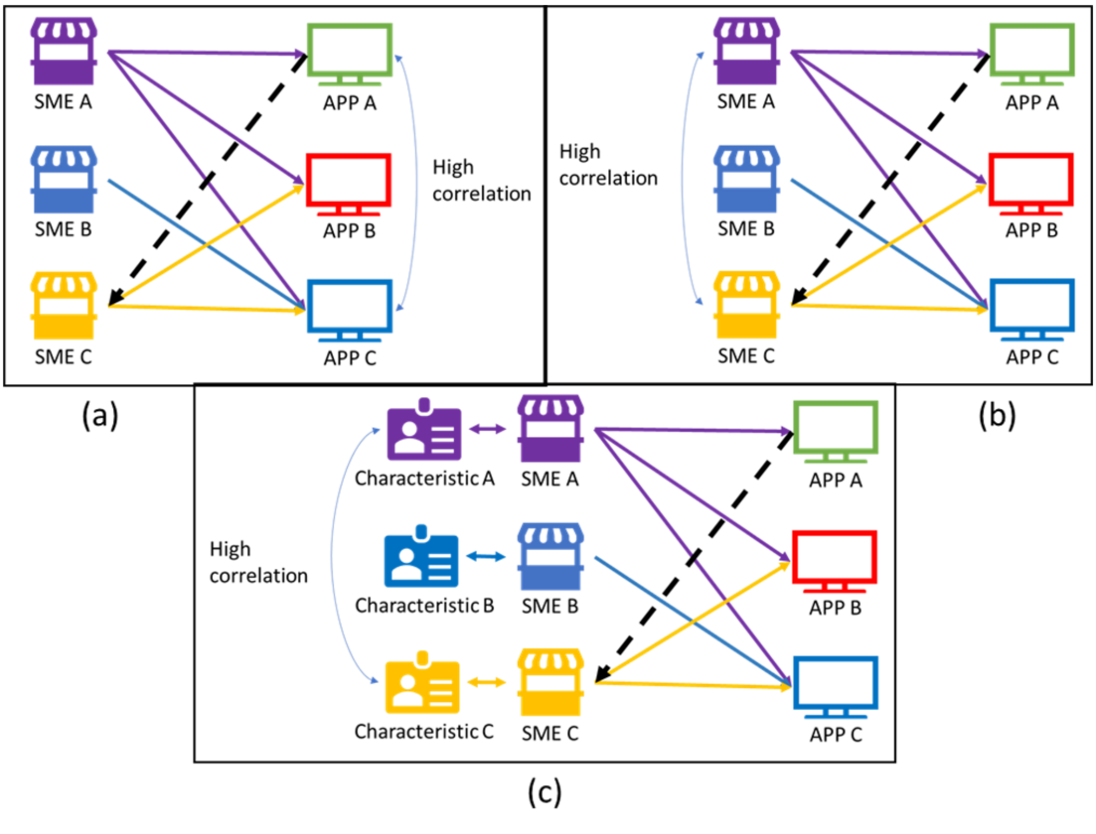

FIGURE 1. (a) Item-based collaborative filtering; (b) user-based collaborative filtering; (c) advanced user-based collaborative filtering

for an e-business application might also need a similar e-business application, so that the same preferences are obtained for both e-business applications.

Item-based CF consists of three basic steps, as follows [13]:

1) Building an e-business application environment that is most similar to e-business application targets (predicted e-business applications). This is done by calculating the similarity, $sim(u, v)$, between application u and application v. To calculate similarity, the Pearson correlation coefficient algorithm is used, as explained in the previous section.
2) The second step is to predict the preferences of SMEs to an e-business application that has never been given a preference value before.
3) The final step is to build a list of recommendations based on the prediction results of e-business application preferences.

3.2. **User-based collaborative filtering.** In User-based Collaborative Filtering (UCF), as illustrated in Figure 1(b), SMEs that give the same or similar preferences to an e-business application are the same, and it can be said that the SMEs have similar needs. Thus, the SME is likely to give the same preference to other e-business applications.

User-based CF consists of three basic steps, as follows [13]:

1) Building an environment of SMEs that is the most similar to the targeted SME (SME which will be given recommendations). This is done by calculating the similarity, $sim(u, v)$, between the SME u and the SME v. To calculate similarity, the Pearson correlation coefficient algorithm is used, as explained in the previous section.
2) The second step is to predict the preferences of SMEs to an e-business application that has never been given a preference value before.
3) The final step is to build a list of recommendations based on the prediction results of e-business application preferences.

3.3. **Advanced user-based collaborative filtering.** In Advanced User-based Collaborative Filtering (Advanced UCF), as illustrated in Figure 1(c), besides using SME preference data it also uses SME characteristic data to produce recommendations. This approach is used by considering that SMEs that have just used a recommendation system do not yet have a historical preference for e-business applications. For this reason, recommendations can be made by considering the characteristics of the organization. Following are the steps of collaborative filtering algorithm based on user attributes and user ratings [10]:

1) Perform user preferences similarity matrix calculations based on preference information from SMEs.
2) Perform a user attribute similarity matrix calculation based on characteristic information from SMEs.
3) Perform final similarity calculations from SMEs.
4) Using the similarity generated in step 3), select neighbors that are similar to the top K for SMEs, and do a ranking prediction.
5) Select the top N items with the highest predictive score, resulting in a collection of recommendations for SMEs.

At this stage an analysis of the preferences of e-business application needed by SMEs was done using Kano Model. The process begins with preparing a list of requirements from e-business applications. Using the Kano Model, for each e-business application, a pair of functional and dysfunctional questions are created, as shown in Table 1. Functional questions represent user responses if an application is available on an e-business system. In contrast, dysfunctional questions represent user responses if an application is not available on e-business systems [11]. User must provide one of 5 answer choices for each question.

Table 1. Example of functional and dysfunctional questions for e-business applications

	Question	Answer
Functional	How do you feel if the application to manage income, expenses and other financial activities is **available**?	1) I **like** it that way 2) It **must be** that way 3) I am **neutral** 4) I can **live with** it that way I **dislike** it that way
Dysfunctional	How do you feel if the application to manage income, expenses and other financial activities is **not available**?	1) I **like** it that way 2) It **must be** that way 3) I am **neutral** 4) I can **live with** it that way I dislike it that way

Table 2. Kano evaluation matrix [14]

Question		**Dysfunctional**				
		Like	Must-be	Neutral	Live with	Dislike
Functional	Like	Q	A	A	A	O
	Must-be	R	I	I	I	M
	Neutral	R	I	I	I	M
	Live with	R	I	I	I	M
	Dislike	R	R	R	R	Q

Then the questions are categorized, as shown in Table 2 to determine which category the product/service belongs to.

In the Collaborative Filtering (CF) calculation, the value from the Kano classification will be converted to a number to make the calculation easier. Reverse (R) classification is converted to value 1. Indifferent (I) classification is converted to value 2. Must-be (M) classification is converted to value 3. One-dimensional (O) classification is converted to value 4. Attractive (A) classification is converted to value 5. Meanwhile, Questionable (Q) classification is not included in calculations.

From the results of Kano evaluation, we can get an overview of the preferences of SMEs related to the requirements of e-business applications. Based on the Kano evaluation matrix, requirements are grouped into six categories, namely attractive, one-dimensional, must-be, indifferent, reverse, and questionable. Based on the results of the Kano evaluation matrix, we can determine user preferences for e-business applications based on user requirements and expectations. Thus, the recommendation of Advanced UCF calculation results is expected to match the requirements and expectations of SMEs, and can optimally support SMEs business processes.

4. **Implementation and Analysis.** In this process, a trial of the three collaborative filtering approaches described previously was carried out. This trial is conducted to find out which algorithm is considered the most appropriate to be implemented to provide e-business application recommendations in accordance with the characteristics of SMEs. The algorithm used is

1) Item-based collaborative filtering
2) User-based collaborative filtering
3) Advanced user-based collaborative filtering

4.1. **Evaluation of recommendation system.** To evaluate prediction results, prediction accuracy metrics are used to measure the extent to which the recommendation system can predict user ratings. This metric is very useful for systems that display rating predictions to users [13]. There are two types of predictive accuracy metrics that are widely used, namely

1) Mean Absolute Error (MAE)

$$MAE = \frac{1}{N}\sum_{i=1}^{N}\left|R_{u,i} - \hat{R}_{u,i}\right| \tag{5}$$

2) Root Mean Square Error (RMSE)

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}\left(R_{u,i} - \hat{R}_{u,i}\right)^2}{N}} \tag{6}$$

where $R_{u,i}$ and $\hat{R}_{u,i}$ are the actual rating and prediction rating. N is the total amount of test data. The smaller the MEA or RMSE value, the more precise the recommendations given.

4.2. **Performance comparison of collaborative filtering algorithm.** To show the performance of the three CF approaches, ICF, UCF, and Advanced UCF, a comparison of the three approaches was performed. Under the same conditions, the smaller the MAE value, the better the performance of an algorithm. In this performance test, all 50 SMEs data are used.

Based on test results by comparing MAE values, as shown in Figure 2, it can be seen that the Item-based Collaborative Filtering (ICF) algorithm has the lowest error compared to the other two approaches. These results indicate that the ICF algorithm is very suitable for SME data that is very diverse and has its own characteristics. SMEs have their own e-business application needs, so they cannot be compared to other SMEs. When using the User-based Collaborative Filtering (UCF) or Advanced UCF algorithm, the error or prediction error is higher, because the need for e-business applications for an SME is not necessarily suitable if it is recommended for other SMEs.

However, if looking back at the purpose of this recommendation, namely to increase the use of e-business for SMEs so that SMEs can get benefit for the organization, then the recommendations given are considered necessary to consider the preferences of other

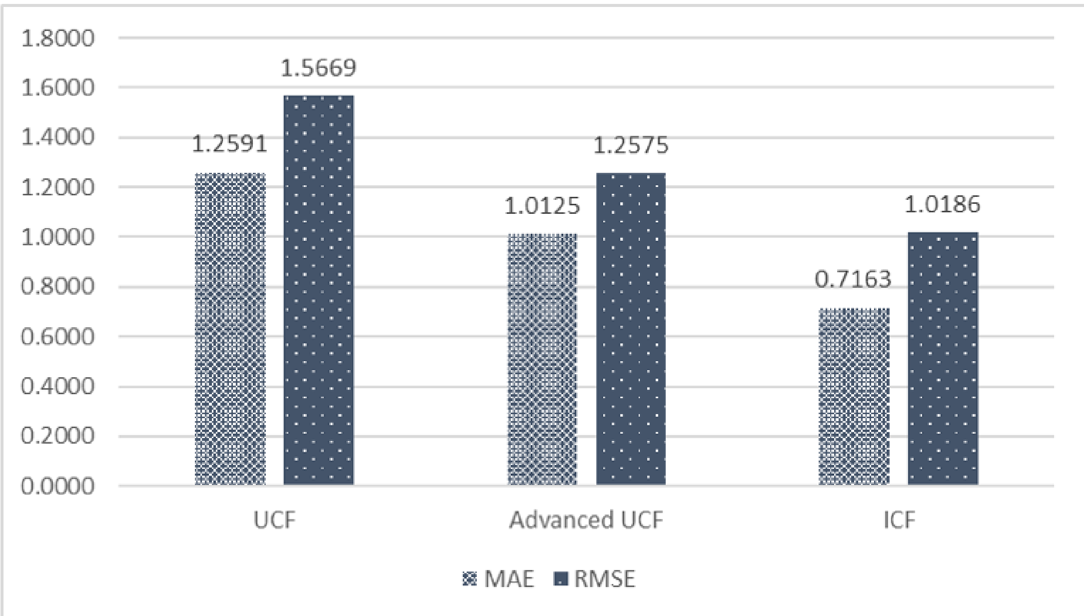

Figure 2. Performance of the three collaborative filtering approaches

SMEs that have successfully implemented e-business (based on success stories). Therefore, the approach that is considered more appropriate is actually UCF. However, not only considering preferences but it is also necessary to consider the characteristics of SMEs. Thus, SMEs can follow the use of e-business applications from other SMEs that have similar characteristics. Evaluation related to this will be discussed in the next section.

4.3. **Performance comparison in cold start conditions.** In the previous section, a comparative test of the performance of 50 SMEs data has been conducted. In this testing, the SMEs data are sorted, where the data used for the trial are only SME data that have a relatively high impact factor on other data. The data used are data that have greater impact factors equal to 35. The total data used after sorting is 35 data.

The purpose of this test is to find out the comparison of algorithm performance to provide recommendations based on SME data that has benefited from the use of e-business applications for its business. This is indicated by the relatively higher impact factor assessment. Thus, other SMEs are expected to follow the use of e-business applications from SMEs that have succeeded in gaining benefits (based on success stories).

However, the next challenge is the problem of cold start, which is a condition where the recommendation system does not have enough information to provide recommendations for users. This condition occurs when the user uses the recommendation system for the first time, where the user has not provided preference data in advance on the recommendation system [9]. This condition may arise in the ICF and UCF algorithms, where the data used to process recommendations only consider the e-business application preference data by the user. However, the Advanced UCF cold start conditions can be overcome because in addition to considering the preferences of e-business applications from users, it also considered characteristic data from SMEs. Thus, the Advanced UCF can provide recommendations that are more effective and can handle cold start conditions.

The results of MAE and RMSE comparisons for the three algorithms are shown in Figure 3. Comparisons are made by analyzing the error rate based on the amount of data used for the recommendation process. Based on trials carried out, the Advanced UCF algorithm is proven to be able to overcome the cold start conditions that occur when the amount of data used is still small. As the amount of data increases, the error rate in the Advanced UCF algorithm tends to decrease.

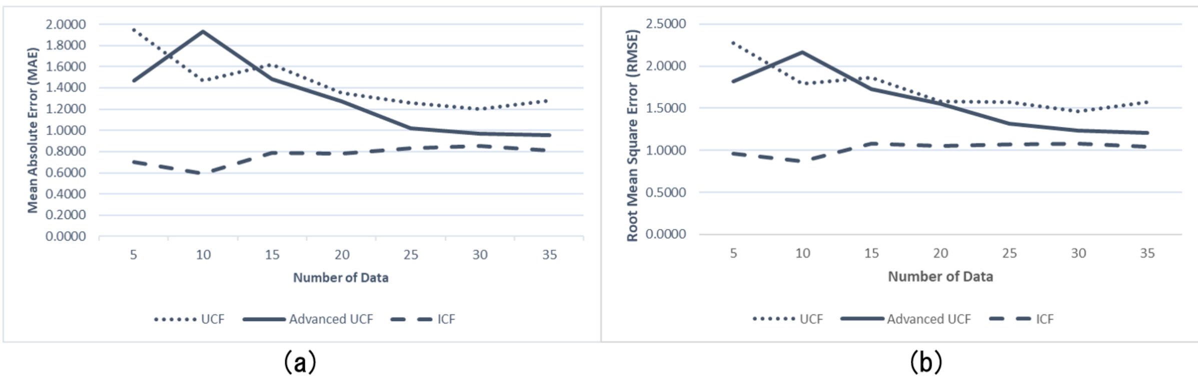

FIGURE 3. MAE and RMSE comparison in cold start condition

In Figure 3, it is not sufficiently proven that the Advanced UCF algorithm is superior to UCF and ICF in cold start conditions. This is because the data used in this study are still limited. However, on this graph, it can be observed that the Advanced UCF graph has an error that decreases as the data increases. Thus, it can be assumed that if the data used is added, the Advanced UCF error graph will decrease again. This will be re-evaluated as a future study of this research.

5. **Conclusions.** In developing the appropriate e-business application recommendation model for SMEs, at this study implementation and evaluation of three algorithms are conducted, namely Item-based Collaborative Filtering (ICF), User-based Collaborative Filtering (UCF), and Advanced User-based Collaborative Filtering (Advanced UCF). In the ICF and UCF approaches, e-business application recommendations can only be given based on the preference needs of e-business applications obtained from Kano Model data processing. Both of these approaches have limitations, namely if there has never been a preference data for e-business application needs (or when SMEs used the recommendation system for the first time), then the recommendation system does not yet have enough information to provide recommendations. Therefore, an algorithm improvement is needed, where the characteristics of SME are also considered in providing recommendations.

The Advanced UCF algorithm is an improvement of the UCF algorithm that considers the characteristics of SMEs in providing recommendations. The UCF is the basis for the developed algorithm because the algorithm is considered more appropriate to be used in this SME case study. The purpose of the recommendations given is to increase the use of e-business for SMEs so that SMEs can get benefit for the organization. Therefore, the recommendations given are considered necessary to consider the preferences and other characteristics of SMEs that have successfully implemented e-business (based on success stories).

As future work, the resulting recommendation model will be used to develop a methodology for developing e-business software product lines based on the characteristics of SMEs using the Software Product Line Engineering (SPLE) approach. The proposed methodology adopts the stages of the process in general SPLE. In the domain requirements engineering sub-process, a list of software requirements is obtained from e-business application recommendations and e-business application features. This will make it easier for users to get applications that suit their needs.

REFERENCES

[1] S. Wang, L. Li, K. Wang and J. D. Jones, E-business systems integration: A systems perspective, *Inf. Technol. Manag.*, vol.13, no.4, pp.233-249, DOI: 10.1007/s10799-012-0119-8, 2012.

[2] J. Benitez, Y. Chen, T. S. H. Teo and A. Ajamieh, Evolution of the impact of e-business technology on operational competence and firm profitability: A panel data investigation, *Inf. Manag.*, vol.55, no.1, pp.120-130, DOI: 10.1016/j.im.2017.08.002, 2018.

[3] M. Alhaj, K. Mallur, B. Stepien and L. Peyton, Model-based quality assurance of online business processes, *International Journal of Innovative Computing, Information and Control*, vol.15, no.6, pp.2071-2083, 2019.

[4] V. A. Mabert, A. Soni and M. A. Venkataramanan, The impact of organization size on enterprise resource planning (ERP) implementations in the US manufacturing sector, *Omega*, vol.31, no.3, pp.235-246, DOI: 10.1016/S0305-0483(03)00022-7, 2003.

[5] P. O. H. Putra, Z. A. Hasibuan and P. O. A. Sunarya, Depicting e-business application adoption for small and medium enterprises (SMEs): The e-business triangle model, *2017 Int. Conf. Comput. Eng. Des.*, DOI: 10.1109/CED.2017.8308135, 2017.

[6] N. M. S. Iswari, E. K. Budiardjo, H. B. Santoso and Z. A. Hasibuan, E-business application recommendation for SMEs based on organization profile using random forest classification, *The 2nd International Seminar on Research of Information Technology and Intelligent Systems*, 2019.

[7] Z. Xie, L. Jiang, T. Ye and X. Li, Based on local densities in low-dimensional space, *Int. Conf. Database Syst. Adv. Appl.*, vol.2, no.4, DOI: 10.1007/978-3-319-18123-3, 2015.

[8] J. Tang, X. Hu and H. Liu, Social recommendation: A review, *Soc. Netw. Anal. Min.*, vol.3, pp.1113-1133, DOI: 10.1007/s13278-013-0141-9, 2013.

[9] M. Grčar, D. Mladenič, B. Fortuna and M. Grobelnik, Data sparsity issues in the collaborative filtering framework, in *Advances in Web Mining and Web Usage Analysis. WebKDD 2005. Lecture Notes in Computer Science*, O. Nasraoui, O. Zaïane, M. Spiliopoulou, B. Mobasher, B. Masand and P. S. Yu (eds.), Berlin, Heidelberg, Springer, DOI: 10.1007/11891321_4, 2006.

[10] L. Li, Y. Zhou, H. Xiong, C. Hu and X. Wei, Collaborative filtering based on user attributes and user ratings for restaurant recommendation, *Proc. of 2017 IEEE the 2nd Adv. Inf. Technol. Electron. Autom. Control Conf. (IAEAC2017)*, pp.2592-2597, DOI: 10.1109/IAEAC.2017.8054493, 2017.

[11] A. Hannan, J. Ahmad and A. Basit, Value based requirements classification of software product using fuzzy Kano Model, *New Horrizon*, vol.83, no.4, 2015.

[12] V. U. Thompson, C. Panchev and M. Oakes, Performance evaluation of similarity measures on similar and dissimilar text retrieval, *The 7th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management*, 2015.

[13] A. Gunawardana and G. Shani, Evaluating recommender systems, in *Recommender Systems Handbook*, F. Ricci, L. Rokach and B. Shapira (eds.), Boston, MA, Springer, DOI: 10.1007/978-1-4899-7637-6_8, 2015.

[14] E. Temel, E. Çakir and G. Akel, Classification of customer requirements using Kano Model: A research on shopping malls, *The 2nd International Congress on Business Administration and Economy*, Tokyo, Japan, 2017.

[15] T. Chen and L. He, Collaborative filtering based on demographic attribute vector, *Int. Conf. Futur. Comput. Commun. (FCC2009)*, pp.225-229, DOI: 10.1109/FCC.2009.68, 2009.