



Improving the Product Recommendation System based-on Customer Interest for Online Shopping Using Deep Reinforcement Learning

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Abstract: In recent years, due to COVID-19, the process of shopping has become more restricted and difficult for customers. Based on this aspect, customers are more interested in online shopping to keep the Untact rules and stay safe, similarly ordering their product based on their need and interest with most straightforward and fastest ways. In this paper, the reinforcement learning technique is applied in the product recommendation system to improve the recommendation system quality for better and more related suggestions based on click patterns and users' profile information. The dataset used in this system was taken from an online shopping mall in Jeju island, South Korea. We have compared the proposed method with the recent state-of-the-art and research results, which show that reinforcement learning effectiveness is higher than other approaches.

Keywords: Recommendation system; Reinforcement learning; online shopping

1. Introduction

During the spread of COVID-19 in the world from the last year, online shopping malls have become a famous and easy access platform for users to avoid going outside and follow the security rules easily [1,2]. Similarly, shopping all their needs with spending few minutes on the internet. South Korea is one of the countries, which focuses on this subject on various topics, e.g., ordering clothes, groceries, household stuff, etc. [3,4]. The development of this system is quite high, but still, there are some unsolved problems in this system. One of the problems is the item recommendation, which is based on the user clicks and visited pages. Our main focus in this research is to overcome the problem of recommendation using the reinforcement learning algorithm. The main contribution of this paper summarized as:

- Applying the reinforcement learning algorithm, a learning-based system, updates the process based on user clicks.
- Improving the prediction accuracy based on the hidden information on the dataset.
- Applying the encoding techniques for generating the information randomly.
- Using various analysis techniques for extracting useful information from the dataset.

The rest of this paper is divided as follows: Section 2 presents the brief literature review. Section 3 illustrates the methodology and applied techniques in this research. Section 4 shows the results and comparison, and we conclude this paper in the conclusion section.

2. literature review

This section contains detailed information related to the recent works in the recommendation system.

2.1. Recommendation System

A recommendation system is the primary means of filtering information based on the user’s interest and choice. This system contains the information of user ratings, the experience of the previous shopping’s, comments, pictures, and their shopping cart information [5–7]. There are various types of recommendation processes listed as content-based filtering, knowledge-based recommendation, hybrid recommendation, collaborate filtering, and demographic recommendation.

2.2. User Interest Recommendation

This process is based on the user’s clicks and visited page records. Rarely, the user does not give any review about the received item or put false comments related to the specific item [8,9]. To overcome this issue and improve the recommendation system, this problem can solve by reviewing the user profile and shopping history and extract the rating from user purchased records [10,11].

3. Methodology

In this section, the main objective of this research is presented. Figure 1 illustrates the overview of the proposed system.

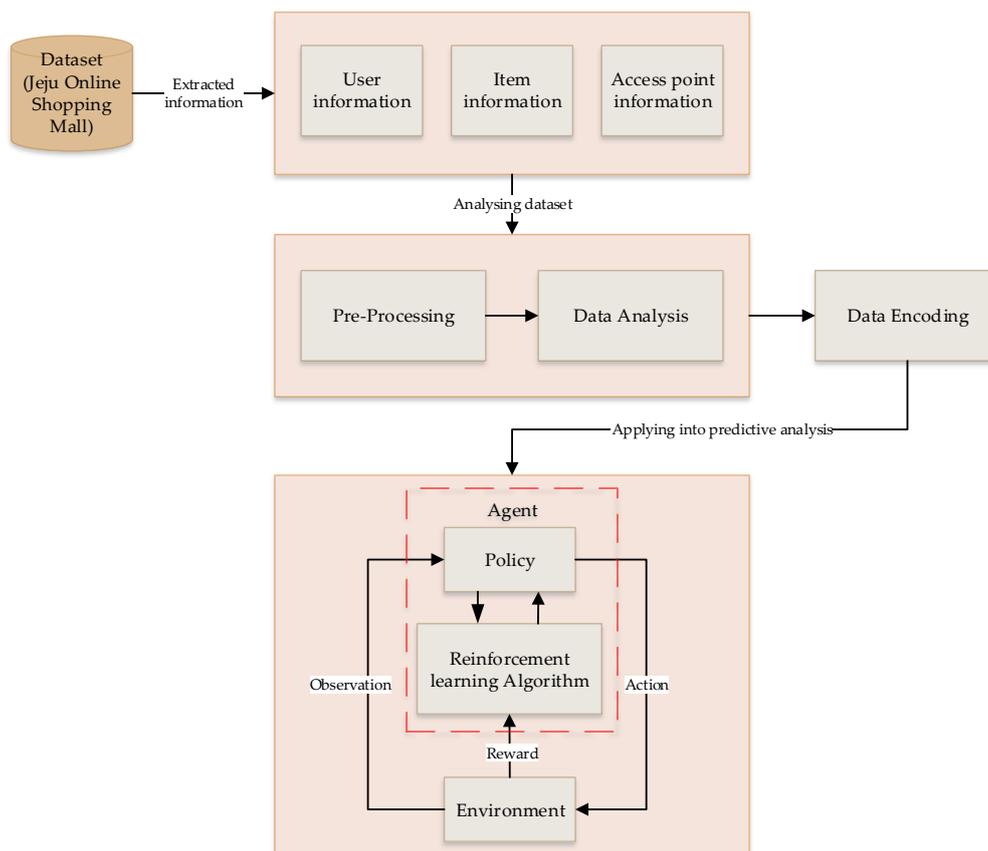


Figure 1. Overview of the proposed system

This system presents three main layers presented as a data layer, analysis layer, and prediction layer. The first layer contains the data information in this process and extracts useful information such as user profile information, the purchased items, and access point information. The extracted dataset moves to the second layer for applying the pre-processing techniques and data analysis. The

techniques used for data analysis are time-series analysis, user interest analysis based on the records of the purchased products and the user ratings, and the access page analysis, which shows the visited web pages and the user click information. Finally, the prediction layer which applied the reinforcement learning technique to predict the user purchased items. The reinforcement learning algorithm is the learning technique that improves the system based on the user rating information. If the user rating is good, the system recommends an item based on the clicked product, but if the rating is bad, the system recommends the new item until getting the user's positive response.

3.1. Data

In this section, the shopping mall dataset is presented in detail. Table 1 shows the data information. there are a total of two columns that represent the data type and detail.

Table 1. Dataset detail information

Data type	Explanation
Total number	305,975
Total purchased items	15,000
Unique items	2168
Unique item ID	2593
Unique users	62,497
Train set	70%
Test set	30%

4. Implementation

In this section, the product recommendation's final result is analyzed and listed in detail figures and tables. Section 4.1 shows the encoding results. Section 4.2 shows the comparison of the proposed system with other approaches.

4.1. Encoding

This section presents the encoding method which applied in this system. Word2vec generates the vector space from the dataset. The main reason for applying this technique to extract the closest items based on the user click preferences.

4.2. Result Comparison

This section presents the performance result of the Reinforcement Learning (RL) algorithm. Figure 3 shows the Mean Absolute Error (MAE), Mean Square Error (MSE), and Root Mean Square Error (RMSE) records.

Table 2 shows the comparison of related studies in the recommendation system. We have compared four other techniques with the proposed system, which this study got the highest score than others.

Table 2. Result comparison of recent studies

C-Mean	XGBoost	PMF	EHCF	RL
0.79	0.89	0.72	0.794	0.92

5. Conclusions

Due to the recent pandemic, which the whole world has serious challenging with, the recommendation system for online shopping malls makes shopping in every aspect easier for customers

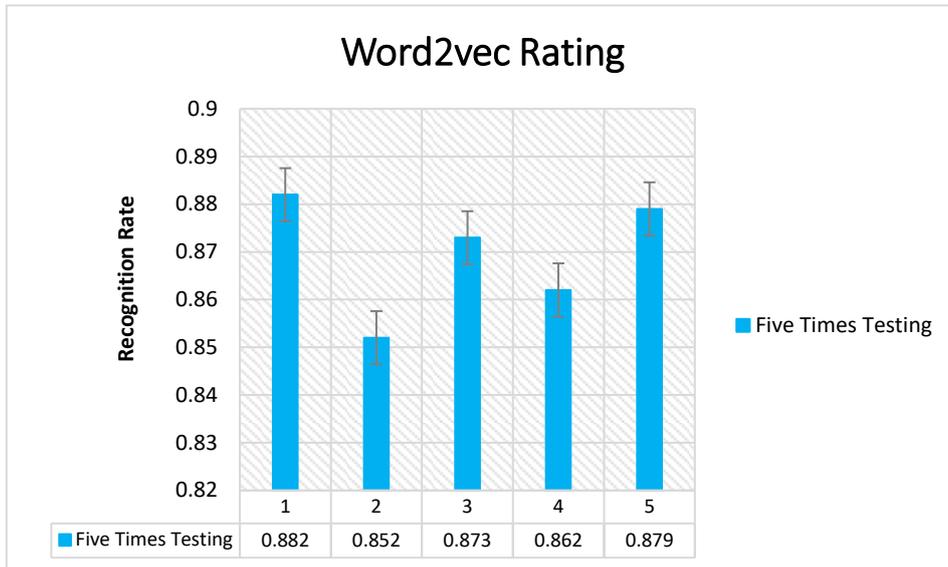


Figure 2. Recognition rate of encoding approach

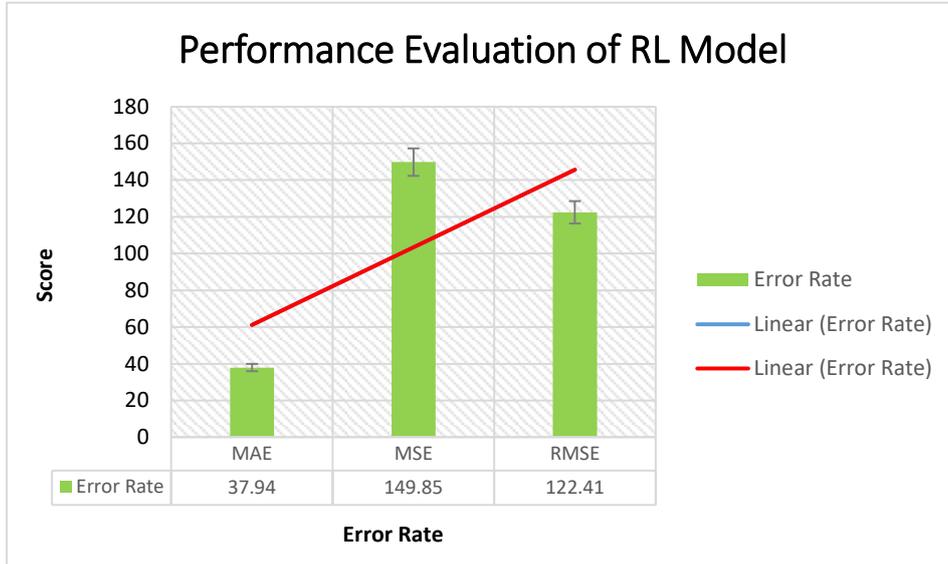


Figure 3. Performance evaluation of predictive RL algorithm

that they purchase based on their need and interest. In this research, the main focus is to recommend the product to the user based on the user click information by using the reinforcement learning technique, the learning-based approach. We compared the achieved results with other recent approaches in the recommendation system, and the proposed result has a relatively higher output than other state-of-art. For future work, we are planning to enhance our system with other techniques and improve this system's results.



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References

1. Lee, H.I.; Choi, I.Y.; Moon, H.S.; Kim, J.K. A Multi-Period Product Recommender System in Online Food Market based on Recurrent Neural Networks. *Sustainability* **2020**, *12*, 969.
2. Shahbazi, Z.; Byun, Y.C. Toward Social Media Content Recommendation Integrated with Data Science and Machine Learning Approach for E-Learners. *Symmetry* **2020**, *12*, 1798.
3. Logesh, R.; Subramaniaswamy, V.; Malathi, D.; Sivaramakrishnan, N.; Vijayakumar, V. Enhancing recommendation stability of collaborative filtering recommender system through bio-inspired clustering ensemble method. *Neural Computing and Applications* **2020**, *32*, 2141–2164.
4. Zhang, Z.P.; Kudo, Y.; Murai, T.; Ren, Y.G. Enhancing recommendation accuracy of item-based collaborative filtering via item-variance weighting. *Applied Sciences* **2019**, *9*, 1928.
5. Shahbazi, Z.; Hazra, D.; Park, S.; Byun, Y.C. Toward Improving the Prediction Accuracy of Product Recommendation System Using Extreme Gradient Boosting and Encoding Approaches. *Symmetry* **2020**, *12*, 1566.
6. Zhang, Z.; Kudo, Y.; Murai, T. Neighbor selection for user-based collaborative filtering using covering-based rough sets. *Annals of Operations Research* **2017**, *256*, 359–374.
7. De Meo, P.; Fotia, L.; Messina, F.; Rosaci, D.; Sarné, G.M. Providing recommendations in social networks by integrating local and global reputation. *Information Systems* **2018**, *78*, 58–67.
8. Shahbazi, Z.; Jamil, F.; Byun, Y. Topic modeling in short-text using non-negative matrix factorization based on deep reinforcement learning. *Journal of Intelligent & Fuzzy Systems*, pp. 1–18.
9. Bhatta, R.; Ezeife, C.; Butt, M.N. Mining Sequential Patterns of Historical Purchases for E-commerce Recommendation. International Conference on Big Data Analytics and Knowledge Discovery. Springer, 2019, pp. 57–72.
10. Yu, W.; Zhang, H.; He, X.; Chen, X.; Xiong, L.; Qin, Z. Aesthetic-based clothing recommendation. Proceedings of the 2018 World Wide Web Conference, 2018, pp. 649–658.
11. Shahbazi, Z.; Byun, Y.C. Product Recommendation Based on Content-based Filtering Using XGBoost Classifier. *Int. J. Adv. Sci. Technol* **2019**, *29*, 6979–6988.