Product Recommendation Using Machine Learning a Review of the Existing Techniques

Anam Naz Sodhar[1], Umair Ali Khan[2], Irum Naz Sodhar[3,*], Abdul Hafeez Buller[4] and Jahanzeb Sodhar[1]

[1] Postgraduate Student, Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Sindh-Pakistan
[2]Associate Professor, Quaid-e-Awam University of Engineering, Sciences & Technology, Nawabshah, Sindh-Pakistan.
[3] Lecturer, Department of Information Technology, Shaheed Benazir Bhutto University, Shaheed BenazirAbad, Sindh-Pakistan.
[4] Engineer, Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Sindh-Pakistan
[*]***Corresponding author:*** Irum Naz Sodhar, email: iram10akber@gmail.com

Summary
The popularity of Product-Recommendation (PR) or system of recommendation is rising day by day. Product suggestions are an-ecommerce customization approach which goods are continuously created for a customer on a webpage, application, or email based on data such user characteristics, browsing behavior, or situational context, resulting in an individualized purchasing experience. The system of recommendation used to predict or recommend the product according to the taste of customer. In today's life product recommendation system has been used by different E-Commerce sites. A website that allows people to buy and sell physical things, services, and digital products without having to go to a physical store. Through an e-commerce website, a company can manage orders, payments, shipping and logistics, and customer service. Recommendation can be of any type such as for music recommendation there is Spotify, for movies Netflix, for videos YouTube, play store (for different categories) and so on. For the recommendation of product different filtering methods and algorithms were used, to recommend products according to user's likeness. In this paper discussed about the existing Machine Learning Techniques (MLT) which were used for the product recommendation. Through these techniques the algorithm is used to predict or similar items according to user's likeness based on his information.

Keywords:
Product Recommendation; Machine Learning Techniques; Recommendation system; categories; Algorithms.

1. Introduction

Product recommendation (PR) is a model/system which is used to predict items based on the older search and purchase history of the user. It may not be entirely correct, but they can be little bit like to the user's taste. Recommendation can be of any type based on the user's information. For Example, if you are watching a movie or song on YouTube so when the movie will end you will have similar recommendations to the movie or similar is the case with online shopping, if you will buy something online then you will have similar recommendations based on your past purchase history. A type of filtering such as: Collaborative filters are used to recommend products. It includes two types of user-based filters and element-based filters [1][2]. User-based filters recommend products to use customer purchase information with similar patterns. Item-based filtering is a technique of recommending a product that is physically much like some other product a client has bought inside the beyond [3]. Recommendation system (RS) helps in providing the needed information. The RS can be considered as spam if the recommended item is not needed by the user [4]. The recommendation system is different for each and every person according to their information. This model can be improved by specified given dataset; a given specified recommendation model we can choose to improve the quality of the dataset [4].In this article we will discuss about the possible machine learning techniques which were previously used by the recommendation system model such as: content-based filtering, collaborative filtering, complementary filtering, demographic based filtering, hybrid recommendation systems. This article is basically about the review of the all machine learning techniques used for recommendation model [5][6].

2. Related Work

In author has been done a similar kind of work in this paper a "grocery product classification and recommendation system based on machine learning" [7] in this paper he has discussed how grocery products are being sold online and recommendations has been provided to customers by using collaborative filtering. The product has been recommended due to the likeness of user based on the score of the product. In this article a recommendation system has been developed for product recommendation. User is allowed to register through login by providing his personal details, after the login process user will be able to select product according to his taste and a user likeness profile is created. The user will be asked to answer a series of questions and his likeness will be found according to his answers. In another research paper a model was designed to provide dietary recommendations to patients using machine learning [8][9].

Manuscript received May 5, 2022
Manuscript revised May 20, 2022
https://doi.org/10.22937/IJCSNS.2022.22.5.72

This model provides a deep learning-based solution for a patient's basic medical data set, automatically detecting which foods should be offered based on the patient's illness and monitoring their other characteristics such as age, gender, cholesterol. This study used various deep learning and machine learning techniques such as neural network regeneration (RNN), long term memory (LSTM), closed regression unit (RU), and regression logistics (LR) [10]. In [11] the author proposes a product recommendation system using a sliding window scheme. In this study, the Product Recommendation Model (PRM) uses a combination of information about customer purchases as shown in figure 1[12][13].

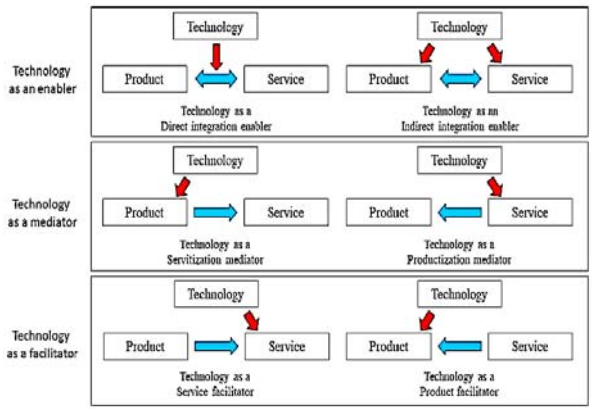

Fig. 1 Product service system [13].

This model is designed to reflect a customer's recent buying habits with a sliding window approach. In [14][15], the author suggests that collaborative filtering techniques have been used to recommend some items such as movie recommendations [16]. In [17], the author suggests that the product is recommended to use an RFID tag, Zigbee. Each product will have an RFID tag that will be available in the store. In [18], the author proposes an intelligent recommendation system using machine learning [19]. The referral system will independently generate recommendations for each specific user based on their past search and purchase history [20].

2.1 Data for product recommendation system

A product recommendation [17] is basically a filtering device that seeks to are looking forward to and show off the gadgets that a consumer would really like to shop for. It also cannot be really correct, however if it indicates you what you like then it`s far doing its mission proper [21].

Recommender systems have become increasingly famous in modern day years, and are implemented in a selection of areas which incorporates movies, song, information, books, research articles, are trying to find queries, social tags, and merchandise in popular. Mostly used in the virtual area, majority of nowadays E-Commerce web sites like eBay, Amazon, Alibaba and so on appoint their proprietary recommendation algorithms with a purpose to higher serve the clients with the products they may be high quality to like [2][22].There are lots extra benefits too, which we cover within the subsequent blogs [23].If setup is configured nicely, it may considerably growth sales, CTRs, conversions, and one of a type vital metrics. Moreover, they`re able to have wonderful outcomes at the purchaser adventure as properly, which interprets into metrics which might be greater hard to degree but are on the other hand of a first-rate deal importance to on line agencies, which includes customer pleasure and retention.
All this is completely feasible with a guidelines engine. Recommendation engines essentially are information filtering device that employ algorithms and information to signify the maximum relevant devices to a specific purchaser or to put it simply, they can be nothing more than an automatic form of a "counter man". You ask him for a product. It not only indicates this product, but also shows related products that you may want to buy. They are knowledgeable in passing promotions and upselling. according to their abilities and tastes. Chatbots are also working on the same run, but they will be a bit smarter and look at each product for a prospect of use or purchase.

Product recommender [18] systems ground items available for buy during net pages, cell apps, within emails, or on any connected screens, alongside kiosks and some of IOT gadgets. One of the most well-known techniques used by the use of shops, recommendations statistics web page visitors to merchandise they may be probably involved in, improving the discovery way and helping them find what they pick out greater correctly.

Today, shops regularly have masses (and occasionally hundreds of thousands) of products in their inventories, making it difficult for customers to dig up precisely what they'll be seeking out and with custom designed hints, manufacturers can help customers without issues find out applicable products based totally on their affinities, tendencies, interests, and behavior, with an surrender purpose of riding earnings, upsells, move-earnings, massive cart sizes, and more common order values (AOVs)[22].

Recommendations are presently utilized by manner of some of the sector’s maximum revolutionary producers. Amazon, for instance, has been refining and tweaking its set of regulations for two a long term. Powered via way of the organization’s exquisite get proper of entry to to huge portions of purchaser facts, its recommendation gadget has genuinely changed the way clients are matched with

merchandise they are maximum in all likelihood involved in buying.

Powered through laptop analyzing, a product recommender device is the technological understanding used to advocate which merchandise are validated to human beings interacting with a logo's digital homes. Fueled via quite a number of algorithmic picks, idea algorithms mine user, product, and contextual records – every onsite and offsite – to current each consumer with a custom designed revel in.

Improving the discovery device, this lets in customers find what they're searching – and every now and then products they don't even recognize they're searching for. In doing so, groups can examine extra about every person's special preferences and pursuits, optimizing normal average performance in actual-time at the same time as simultaneously refining their checking out roadmaps for the lengthy-time period.

And as regards to product recommendations, there can be no archetypal technique entrepreneurs need to use for each widget. Different techniques need to be utilized for unique customers, relying on the amount of statistics handy about the patron, their behavior, and the context of merchandise on a website. This includes internet net page conduct, fame, geo-area, time of day, preceding purchases, and more.

3. Machine Learning Product Recommendation System Techniques

3.1 Content Based Filtering

This kind of filtering shows that which products user's will buy or click and what kind of products they will view, on the basis of user's information a user profile is created and based on his profile information product recommendations can be provided [23]. These frameworks make proposals by using customer's profile information. They estimate that if a customer was keen on something then once again, they want something similar things in future as shown in Figure 2. Similar things are generally assemble based on their highlights. Customer profiles are built using authentic connections or by gathering explicit information about their preferences. There are a number of frameworks, which are not considered to be content-based, that use information from individual and social customers. One problem that arises has to make clear proposals in light of the extremes. Another fundamental problem is that new customers do not have a profile unless it is explicitly requested data. Either way, it's relatively easy to add new things to the framework. We just need to make sure we assign them a meeting as indicated by their highlights [1] [24].

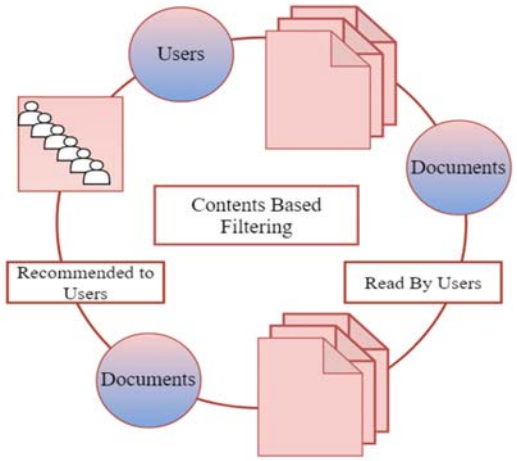

Fig. 2 Contents based Filtering

3.2 Collaborative Filtering

During this filtering, user behavior and preferences are analyzed and then similarities between users are identified. In this way, the model will understand which products users might like based on their similarity to other customers [24]. These types of methods rely on recorded interactions between users and items to generate new recommendations. The main objective of this filtering is the interaction of the user element with similar and user elements, and to make predictions based on their properties. Filtering is divided into two memory-based and model-based methods. The memory-based method works legitimately with estimates of registered partnerships, does not accept any models, and is basically based on finding nearest neighbors (e.g.: it locates the closest customers of an attractive customer and recommends the most popular among these neighbors) Figure 3. The model-based method adopts a basic "generic" model that clarifies the interactions of user factors and tries to figure it out to make new predictions [14][19].

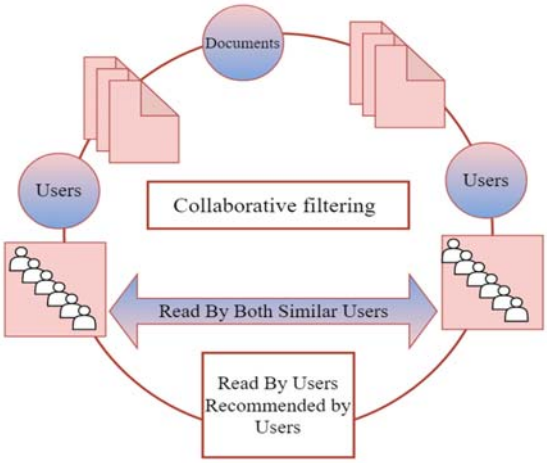

Fig. 3 Collaborative filtering

3-2-1 Types of Collaborative filtering

User-User Collaborative Filtering: Here, we try to collect [17] the customer with the appearance and offer products based on what he has chosen. This algorithm can be very special but it takes a lot of time and resources. This type of filtering requires calculating each buyer pair statistic, which is very time consuming. So, for large base platforms, this set of rules is difficult to localize.

Item-Item Collaborative Filtering: It is very similar [17] to the previous set of rules, however instead of discovering a client seems to be alike, We attempt discovering object seem like alike. Once we've object appear to be alike matrix, we are able to without problems advocate alike gadgets to a patron who has provided any object from the shop. This set of rules requires a long way fewer property than individual-individual collaborative filtering. Hence, for a state-of-the-art consumer, the set of guidelines takes far lesser time than individual-individual collaborate as we don't need all similarity ratings among customers. Amazon uses this method in its advice engine to show off related merchandise which will increase earnings.

Other Simpler algorithms: There is one of a kind technique [17] like marketplace basket evaluation, which generally does no longer have excessive predictive strength than the algorithms defined above.

Personalized Video Ranker: AI-based completely [19] recommender structures are extensively applied in online streaming structures, which incorporates Spotify, Google Play Music, and Internet video services like Netflix, to remedy the hassle of choice, which clearly arises from the consumer's exposure to tens of tens of thousands and thousands of audio tracks and films. If the hassle of choice is not solved, a regular Netflix member ought to change to every exclusive provider after perhaps 60 to ninety seconds of choosing and reviewing 10 to 20 titles. As a quit end result, the overall performance of recommender structures becomes fundamental to customer retention and delight in OTT (Over-the-pinnacle) services. This hassle has been addressed in collaborative and content material primarily based absolutely filtering based mostly on statistical and ML (Machine Learning) strategies. For instance, recommender systems based totally mostly on collaborative filtering will compare bands and tracks listened by using unique customers, and then advocate track that doesn't show up in the person's library however is listened through way of the utilization of various customers with comparable hobbies [25]. But, is one-length-fits-all strategy like this sufficient to address all feasible content material usage scenarios?

Unfortunately, in masses of cases, a unmarried set of regulations does now not suffice to control numerous character alternatives and make the maximum superb use of on hand content material. More so, with the growing catalogue of multimedia content material cloth, content material businesses are suffering to strike the right stability among custom designed and non-personalized recommendations [26][27].

Netflix recommendation Infrastructure is a tremendous example of a working solution to this task. The tool is based mostly on a mixture of supervised (category, regression) and unsupervised (dimensionality cut charge with the useful resource of compression and clustering) algorithms that generate personalized and non-customized guidelines [28][29][13][30]. Highly personalized film recommendations show up in Genre rows and 'Because You Watched' lists displayed at the user's home web page. At the equal time, Netflix constructs a 'Top Picks' list of what is famous at Netflix , and 'Trending Now' row with a focus on the stylish viewing dispositions. Each belief row is generated with the aid of a specialized set of regulations.

Genre rows are created thru a personalized video ranker (PVR) set of guidelines that takes the first rate suits from the entire catalogue of movies for all and sundry in a customized manner. PVR-primarily based totally lists are greater environment high-quality if mixed with 'un-personalized popularity' fits. Top N ranker that produces suggestions in the 'Top Picks' row combines custom designed filtering with the maximum well-known videos of the catalogue. In one-of-a-type phrases, it specializes within the head of the score and selects movies that terrific wholesome character alternatives. In its flip, 'Trending Now' row identifies seasonal tendencies (which include the uptick in Christmas and New Year's Eve films in the surrender of the yr) and non-permanent dispositions

precipitated by using the use of crucial occasions, such as hurricanes or presidential election. Finally, 'Because You Watched' lists are the maximum custom designed due to the fact they anchor hints to a single video watched via manner of the man or woman. The method inside the again of the 'Because You Watched' row uses video similarity algorithms colloquially referred as 'sims' that computes a ranked listing of similar.

A combination of these algorithms creates a completely whole combine of custom designed and un-personalized recommendations that makes Netflix so environment pleasant in maintaining contributors. Also, the gadget saves Netflix $1 billion every year for unique cause. The difficulty is, with satisfactory-tuned hints there can be no want inside the big increase of the real video catalogue. The recommender gadget can definitely unearth video content material that is probably in any other case in no manner watched with the aid of manner of users. In this way, recommender systems that make a cocktail from custom designed and un-personalized algorithms spread viewing at some point of films heaps extra calmly than un-personalized score-based totally structures or structures that hire a unmarried algorithm for all use instances [31].

Candidate Generation Network: The candidate generation [20] network deploys deep neural networks to analyse each user's records inclusive of likes, comments, and most-consumed digital content, etc. Resultant, it predicts future consumer preferences with precision and relevance the usage of Google Brain's Tensor Flow to train DNNs. Coupled with a rating network, the candidate generation network extracts richer aspects for every content material to rank the recommendations. YouTube is one of the personalizing and digital media content material leaders that deploys candidate generation network to interact its users [32].

3.3 Knowledge-based Recommendation Systems

Knowledge-based engines [20] are some of the earliest recognize recommender structures backed by using a rich variety, velocity, and variant of datasets. They seize digitally saved information in a company's backend to fit unique consumer queries by using decoding its intents, context, and entities. This form of advice device with laptop getting to know extracts a company's area know-how that is ruled by way of 'if-this-then-that' rules. The USP of a knowledge-based suggestion device is that it can be continuously accelerated now not by means of the user's records however its interplay with the system. This can occur thru the underlying 'critique method' that allows customers to assign comments to hints for enhancing search results[33][34][35].

3.4 Hybrid Recommendation Systems

In this type of filtering two or more than two systems will be combining together to get more accurate and better results[36]. Hybrid filtering is combination of content base filtering and collaborative Figure 4. They can be implemented by making content-based and collaborative based predictions separately and they combine them [14] [33].

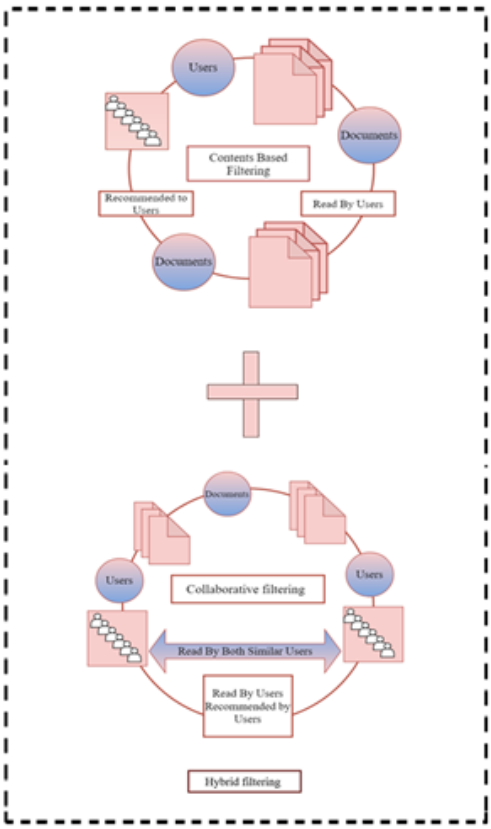

Fig. 4 Hybrid filtering

4. Critical Analysis

The product recommendation can also face some issues such as: unsympathetic start, data sparsity, accuracy and scalability. One problem that needs to be making a speech of product recommendation frameworks today is the adaptability of algorithm with huge, genuine world datasets. It's conceivable that a product recommendation will function admirably and produce exact outcomes with little datasets yet may begin creating wrong or wasteful outcomes with huge ones. Also, a few calculations are computationally costly to run – the bigger the dataset, the more it will take, and the more it will cost the business to

investigate and make suggestions from it. Propelled, huge scope evaluation strategies are required to manage both issues [37][19][38].We need to design a product recommendation algorithm to make accurate recommendations. The filtering method will depend on what kind of project is, and we need to make correct choices. Because, it will directly affect the business and satisfaction of our customers [39].

5. Recommendations

As we are familiar with the term product recommendation, which is already discussed above, a lot of work has been done on product recommendation by using machine learning techniques [40]. But in past product also can be recommended by not only machine learning techniques but also other techniques were used such as Zigbee, RFID tags, Deep learning, data mining, data augmentation. Sometimes the predictions can be wrong [41]. So, it's better other than depending on old techniques new techniques new algorithms and models should be designed for the recommendation of a product.

6. Conclusion and future work

In our daily life the use of internet is increasing and everything is possible through internet money sharing, online shopping and much more. The focus of this paper is on product recommendation. For recommendation of product different algorithm and machine learning techniques were used. Through these techniques the algorithm is used to predict or similar items according to user's likeness based on his information. Even sometimes if the recommended product isn't due to the likeness of the user the whole recommendation system can be considered as a spam, because each and every person has specific likes or dislikes so a model is designed keeping in view to avoid such kind of things in future. No new techniques were proposed in this article, this paper is basically a review of the previous machine learning techniques which were used for product recommendation.

References

[1] M. Balabanovi and Y. Shoham, "content-based, collaborative recommendation," Commun. ACM, vol. 40, no. 3, pp. 66--72, 1997.

[2] S. Gadde, J. Amutharaj, and S. Usha, "Data Security on Cloud by Cryptographic Methods Using Machine Learning Techniques," vol. 22, no. 5, pp. 342–347, 2022.

[3] B. Sarwar, G. Karypis, J. Konstan, and J. Riedl, "Item-based collaborative filtering recommendation algorithms," Proc. 10th Int. Conf. World Wide Web, vol. 285–295, 2001.

[4] B. N. R. Chagas, J. Viana, O. Reinhold, F. M. F. Lobato, A. F. L. Jacob, and R. Alt, "A literature review of the current applications of machine learning and their practical implications," Web Intell., vol. 18, pp. 69–83, 2020, doi: 10.3233/WEB-200429.

[5] M. Al-Akhras, M. Alawairdhi, A. Alawairdhi, and S. Atawneh, "Using Machine Learning To Build A Classification Model For Iot Networks To Detect Attack Signatures," Int. J. Comput. Networks Commun., vol. 12, no. 6, pp. 99–116, 2020, doi: 10.5121/ijcnc.2020.12607.

[6] T. K. Le and S. C. Hui, Machine Learning for Food Review and Recommendation, vol. 1, no. 1. Association for Computing Machinery, 2022.

[7] V. Duarte, S. Zuniga-Jara, and S. Contreras, "Machine Learning and Marketing: A Literature Review.," SSRN Electron. J., pp. 1–19, 2022, doi: 10.2139/ssrn.4006436.

[8] J. F. Hair and M. Sarstedt, "Data, measurement, and causal inferences in machine learning: opportunities and challenges for marketing," J. Mark. Theory Pract., vol. 29, no. 1, pp. 65–77, 2021, doi: 10.1080/10696679.2020.1860683.

[9] I. N. Sodhar, A. H. Jalbani, M. I. Channa, and D. N. Hakro, "Parts of Speech Tagging of Romanized Sindhi Text by applying Rule Based Model," vol. 19, no. 11, pp. 91–96, 2019.

[10] H. Tuinhof, C. Pirker, and M. Haltmeier, Image-based fashion product recommendation with deep learning, vol. 11331 LNCS. Springer International Publishing, 2019.

[11] H. Kim, G. Yang, H. Jung, S. H. Lee, and J. J. Ahn, "An Intelligent Product Recommendation Model to Reflect the Recent Purchasing Patterns of Customers," Mob. Networks Appl., vol. 24, no. 1, pp. 163–170, 2019, doi: 10.1007/s11036-017-0986-7.

[12] L. Chen, R. Li, Y. Liu, R. Zhang, and D. M. K. Woodbridge, "Machine learning-based product recommendation using Apache Spark," 2017 IEEE SmartWorld Ubiquitous Intell. Comput. Adv. Trust. Comput. Scalable Comput. Commun. Cloud Big Data Comput. Internet People Smart City Innov. SmartWorld/SCALCOM/UIC/ATC/CBDCom/IOP/SCI 2017 - , pp. 1–6, 2018, doi: 10.1109/UIC-ATC.2017.8397470.

[13] M. C. Chiu, J. H. Huang, S. Gupta, and G. Akman, "Developing a personalized recommendation system in a smart product service system based on unsupervised learning model," Comput. Ind., vol. 128, p. 103421, 2021, doi: 10.1016/j.compind.2021.103421.

[14] K. Choi, D. Yoo, G. Kim, and Y. Suh, "A hybrid online-product recommendation system: Combining implicit rating-based collaborative filtering and sequential pattern analysis," Electron. Commer. Res. Appl., vol. 11, no. 4, pp. 309–317, 2012, doi: 10.1016/j.elerap.2012.02.004.

[15] P. Malekpour Alamdari, N. J. Navimipour, M. Hosseinzadeh, A. Asghar Safaei, and A. Darwesh, "Image-based Product Recommendation Method for E-commerce Applications Using Convolutional Neural Networks," Acta Inform. Pragensia, vol. 11, no. 1, pp. 15–35, 2022, doi: 10.18267/j.aip.167.

[16] S. S. Choudhury, S. N. Mohanty, and A. K. Jagadev, "Multimodal trust based recommender system with machine learning approaches for movie recommendation," Int. J. Inf. Technol., vol. 13, no. 2, pp.

475–482, 2021, doi: 10.1007/s41870-020-00553-2.

[17] A. Mushtaq and H. Kanth, "A New Technology of Smart Shopping Cart using RFID and ZIGBEE," Int. J. Recent Innov. Trends Comput. Commun., vol. 5, no. 2, pp. 256–259, 2017, [Online]. Available: http://www.ijritcc.org.

[18] A. Yewatkar, F. Inamdar, R. Singh, Ayushya, and A. Bandal, "Smart Cart with Automatic Billing, Product Information, Product Recommendation Using RFID & Zigbee with Anti-Theft," Procedia Comput. Sci., vol. 79, pp. 793–800, 2016, doi: 10.1016/j.procs.2016.03.107.

[19] B. Ramzan et al., "An Intelligent Data Analysis for Recommendation Systems Using Machine Learning," Sci. Program., vol. 2019, 2019, doi: 10.1155/2019/5941096.

[20] B. Zhou and T. Zou, "Competing for Recommendations: The Strategic Impact of Personalized Product Recommendations in Online Marketplaces," in SRN, pp. 1–47.

[21] I. N. Sodhar, A. H. Jalbani, A. H. Buller, M. I. Channa, and D. N. Hakro, "Sentiment analysis of Romanized Sindhi text," J. Intell. Fuzzy Syst., vol. 38, no. 5, pp. 5877–5883, 2020, doi: 10.3233/JIFS-179675.

[22] I. N. Sodhar, A. H. Buller, and A. N. Sodhar, "Identification of Online Statistical Translation and Text Issues in Communication Technologies," Int. J. Adv. Trends Comput. Sci. Eng., vol. 10, no. 2, pp. 446–452, 2021.

[23] M. Crawford, T. M. Khoshgoftaar, J. D. Prusa, A. N. Richter, and H. Al Najada, "Survey of review spam detection using machine learning techniques," J. Big Data, vol. 2, no. 1, 2015, doi: 10.1186/s40537-015-0029-9.

[24] S. V. Urkude, Hasanuzzaman, V. R. Urkude, and C. S. Kumar, "Comparative Analysis on Machine Learning Techniques: A case study on Amazon Product Reviews," Int. J. Mech. Eng., vol. 6, no. 3, pp. 739–744, 2021.

[25] P. Bedi and R. Sharma, "Trust based recommender system using ant colony for trust computation," Expert Syst. Appl., vol. 39, no. 1, pp. 1183–1190, 2012, doi: 10.1016/j.eswa.2011.07.124.

[26] S. Bandyopadhyay, S. S. Thakur, and J. K. Mandal, "Product recommendation for e-commerce business by applying principal component analysis (PCA) and K-means clustering: benefit for the society," Innov. Syst. Softw. Eng., vol. 17, no. 1, pp. 45–52, 2021, doi: 10.1007/s11334-020-00372-5.

[27] I. H. Sodhar et al., "Information Communication and Technology Tools Integration in Higher Education," Int. J. Progress. Sci. Technol. (IJPSAT, vol. 15, no. 1, pp. 127–133, 2019, [Online]. Available: https://www.researchgate.net/publication/333984007.

[28] I. N. Sodhar, J. A. Hussain, A. H. Buller, and A. N. Sodhar, "Tokenization Of Sindhi Text On Information Retrieval Tools," PAKISTAN J. Emerg. Sci. Technol., vol. 1, no. 1, pp. 10–16, 2020.

[29] I. N. Sodhar, H. Bhanbhro, Z. H. Amur, A. H. Jalbani, and A. H. Buller, "Sindhi Language Processing on Online SindhiNLP Tool," vol. 4, no. 3, pp. 4–7, 2020.

[30] Y. S. Reddy and P. P. Govindarajulu, "An Efficient User Centric Clustering Approach for Product Recommendation Based on Majority Voting: A Case Study on Wine Data Set," IJCSNS Int. J. Comput. Sci. Netw. Secur., vol. 17, no. 10, p. 103, 2017.

[31] E. Perraud, "Machine learning algorithm of detection of DOS attacks on an automotive telematic unit," Int. J. Comput. Networks Commun., vol. 11, no. 1, pp. 27–43, 2019, doi: 10.5121/ijcnc.2019.11102.

[32] T. H. Hai, L. H. Hoang, and E. nam Huh, "Network Anomaly Detection Based On Late Fusion Of Several Machine Learning Algorithms," Int. J. Comput. Networks Commun., vol. 12, no. 6, pp. 117–131, 2020, doi: 10.5121/ijcnc.2020.12608.

[33] U. Javed, K. Shaukat, I. A. Hameed, F. Iqbal, T. M. Alam, and S. Luo, "A Review of Content-Based and Context-Based Recommendation Systems," Int. J. Emerg. Technol. Learn., vol. 16, no. 3, pp. 274–306, 2021, doi: 10.3991/ijet.v16i03.18851.

[34] W. Z. Zhu Dongliang, Wen Yi, "Review of Recommendation Systems Based on Knowledge Graph," Data Anal. Knowl. Discov., vol. 5, no. 12, pp. 1–13, 2021.

[35] I. N. Sodhar, A. H. Jalbani, M. I. Channa, and D. N. Hakro, "Romanized Sindhi Rules for Text Communication," vol. 40, no. 2, pp. 298–304, 2021, doi: 10.22581/muet1982.2102.04.

[36] A. Balaram and S. Vasundra, "A Hybrid Soft Computing Technique for Software Fault Prediction based on Optimal Feature Extraction and Classification," vol. 22, no. 5, pp. 348–358, 2022.

[37] I. N. Sodhar, A. H. Jalbani, M. I. Channa, and D. N. Hakro, "Identification of issues and challenges in romanized Sindhi text," Int. J. Adv. Comput. Sci. Appl., vol. 10, no. 9, pp. 229–233, 2019, doi: 10.14569/ijacsa.2019.0100929.

[38] P. K. Jain, R. Pamula, and G. Srivastava, "A systematic literature review on machine learning applications for consumer sentiment analysis using online reviews," Comput. Sci. Rev., vol. 41, p. 100413, 2021, doi: 10.1016/j.cosrev.2021.100413.

[39] S. Yi and X. Liu, "Machine learning based customer sentiment analysis for recommending shoppers, shops based on customers' review," Complex Intell. Syst., vol. 6, no. 3, pp. 621–634, 2020, doi: 10.1007/s40747-020-00155-2.

[40] G. Suresh, D. A. S. Kumar, D. S. Lekashri, D. R. Manikandan, and C.-O. Head, "Efficient Crop Yield Recommendation System Using Machine Learning For Digital Farming," Int. J. Mod. Agric., vol. 10, no. 1, p. 2021, 2021, [Online]. Available: http://modern-journals.com/index.php/ijma/article/view/688.

[41] M. N. Mohammad, C. U. Kumari, A. S. D. Murthy, B. O. L. Jagan, and K. Saikumar, "Implementation of online and offline product selection system using FCNN deep learning: Product analysis," Mater. Today Proc., vol. 45, no. xxxx, pp. 2171–2178, 2021, doi: 10.1016/j.matpr.2020.10.072.

Engr. Anam Naz Sodhar received her Bachelor's Degree (2018) in Telecommunication Engineering from Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Sindh, Pakistan. Upon the completion of her Bachelor, Anam Naz continued her study and registered for Master of engineering in Computer Communications & Networks at QUEST, Nawabshah, Sindh, Pakistan

Dr. Umair Ali Khan is currently working as Associate Professor in the department of Artificial Intelligence, Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Pakistan. He has Ph.D in Intelligent Power Management in Portable Devices (2013) from Pervasive Computing Group, Alpen-Adria University, Klagenfurt, Austria. MS in Intelligent Transportation Systems (2010) from Intelligent Transportation Systems Group, Alpen-Adria University, Klagenfurt, Austria. B.E in Computer Systems Engineering (2004) from Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Pakistan.

Dr. Irum Naz Sodhar is currently working as Lecturer at Shaheed Benazir Bhutto University, Shaheed BenazirAbad, Sindh, Pakistan. She received her Doctor of Philosophy degree (2021) in Information Technology, Master's Degree (2016) in Software Technology and Bachelor's Degree (2013) in Computer Science from Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Sindh, Pakistan.

Dr. Abdul Hafeez Buller received his Doctor of Philosophy degree (2019) in Structural Materials (Recycled Concrete), Master's Degree (2014) in Structural Materials (Recycled Concrete) and Bachelor's Degree (2010) in Civil Engineering from Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Sindh, Pakistan. Upon completion of his B.E, Dr. Buller started his career as Engineer at QUEST Nawabshah.

.

Engr. Jahanzeb Sodhar received his Bachelor's Degree (2020) from Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Sindh, Pakistan. Upon the completion of her Bachelor, Jahanzeb continued his study and registered for Master of engineering in at QUEST, Nawabshah, Sindh, Pakistan.