An Intelligent Model To Predict Student's Performance Using Machine Learning Techniques

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Abstract- The academic world of today is a complicated and highly competitive one. It is hard to evaluate student performance and provide high-quality education, as well as establish ways for assessing student achievement. In attempt to face the difficulties that students face while pursuing their education, educational institutions must establish student prevention strategies. Students' performance may be predicted using a Decision Tree (DT) model created in this study. The advancement of the learning environment is greatly aided by educational data mining, which contributes modern approaches, strategies, and applications. Students' learning environments may now be better understood via the use of machine learning and data mining approaches that use educational data. Students at trouble and students who drop out may be predicted using a variety of machine learning approaches, including K-Nearest Neighbor, Support Vector Machine, Logistic Regression (LR), and Naive Bayes (NB) algorithms. By using the DT technique to forecast student performance, this suggested model may be able to perform better.

Keywords:- *Intelligent Model, Student's Performance, Machine Learning Techniques*

1 Introduction

Educational Data Mining (EDM) seems to have a substantial impact on contemporary educational advancements. Technology Innovation in learning systems that are suited to the requirements of students have emerged from a broad range of studies. The modern approaches and application techniques of the EDM are critical in improving the educational setting. Students' learning environments may be better understood via the use of EDMs, which evaluate education and machine learning approaches. Data mining (DM) approaches are explored, researched, and implemented in the EDM field, according to [1]. The DM discipline relies on a wide range of strategies to achieve success.. The data mining cycle is used in a comprehensive approach to deriving useful and innovative insights from raw data. The analysis of knowledge discovery using machine learning and statistical methodologies reveals trends that benefit students' learning and academic institutions as a whole.

Today's academic institutions must contend with an environment that is both competitive and complicated. Many institutions encounter issues such as measuring student performance, offering high-quality education, developing systems for evaluating student performance and recognizing future requirements. The university's administration and faculty members both get benefit from the students' performance prediction plans when they are used to construct and modify the preventative strategies at entry-level and in later periods.

E-learning is a fast developing and new sort of good education in which students pursue online courses. There are several e-learning hubs that use EDM to design automated assessment methods, information retrieval, and adaptative systems, also including Intelligent Tutoring Systems (ITS), Learning Management Systems (LMS), and Massive Open Online Courses (MOOC). A student's popularity of the e-learning system, their accuracy in gathering data, and the amount of hours spent

reading and viewing video lectures are all tracked by these sophisticated technologies [2].

Various machine learning approaches are used to examine the collected data in order to enhance the learning platform's usefulness and create interactive features. AI research, according to [3] at the University of Monreal, "seeks to offer knowledge to computers via data, experiences, and intimate contact with the real world," according to Dr. Bengio's statement. The computer is able to adapt to new situations because of the information it has learned. Machine learning (ML) is a subset of artificial intelligence (AI) in which ML systems learn from data, evaluate patterns, and predict future events. The emergence of Deep Learning (DL) approaches is a direct result of the increasing number of data, inexpensive storage, and robust computer systems. Automated machine learning models are able to efficiently and accurately predict larger and more complex datasets while avoiding unanticipated dangers. Because there is no direct connection between students and course instructors in e-learning, it is still considered a demanding learning environment compared to conventional on-campus education. Students and courses may be assessed using long-term log data from e-learning platforms like MOOC, LMS, and Digital Environment to Enable Data-driven (DEED).

Using the resulting log data, machine learning algorithms may help identify at-risk students and the likelihood that they will drop out before it is too late. Traditional on-campus methods of evaluating and forecasting students' grades and test scores have been superseded by this more sophisticated approach. Machine learning algorithms are used by the EDM research community to process and analyze session logs and student databases in order to make predictions about students' success in EDM courses [4].

2 Literature Review

Thirteen situations were compiled to examine student behaviors using GUHA and Markov Chain-based analysis in VLE systems [5] . Students' assignment grades and the VLE activity log, a record of their interactions with the VLE system, comprised the dataset utilized for this study. The LISp-Miner tool was used to carry out the implementation. They found that both strategies were effective in revealing new information about the dataset. A Markov Chain-based graphical model may aid in the understanding of this concept by providing a visual representation of it. The above-mentioned techniques help to support the intervention strategy at the sub-station level. Predicting a student's academic success is easier when behavioral data is processed.

Machine learning approaches were used by [6] to examine the early prediction of student progress. Social characteristics, such as educational attainment and employment position; gender; status; disability; and course traits were examined for successful prediction in the review. The Open University of New Zealand provided these characteristics for the dataset. Student achievement is determined by using machine learning techniques for feature selection. There were three significant factors that contributed to the achievement of students: ethnicity, course program, and course block.

The combinational incremental ensemble of classifiers for student performance prediction [7]. Three classifiers are merged in the proposed method, with each classifier calculating the prediction output. The overall forecast is selected through a voting system. Such a method is useful for continually created data, and each classifier predicts the result when a new sample is received. Voting is used to pick the final forecast. The training data for this review comes from Hellenic Open University. There are 1347 instances of writing assignment marks in this dataset, each with four characteristics and four features. In this method, the models are trained using the training set, and then tested using the test set, sequentially. Classifiers are automatically picked based on the accuracy of their predictions when a new observation is made.

To measure the efficiency of the Student Evaluation of Teaching Effectiveness (SETE) exam employed statistical methodologies such as NN and Bayesian data reduction approaches [8]. SETE was not shown to be a reliable predictor of online teaching efficacy or student learning, according to the finding [9] offered a decision support system for a tutor to forecast student achievement in another review by Kotsiantis. Consideration of student demographic data, logs from the e-learning system as

well as academic information is included in this evaluation. The dataset contains 354 students' data, each of which has 17 characteristics. According [10], students' achievement may be predicted using ML classification algorithms. It's made up of two sections. The first set of data comes from a survey that was done in 2010–2011 at the University of Tuzla. Students from the department of economics in their first year took part in the discussion. The enrollment database is used to get the second set of information. Collectively, the collection comprises 257 instances with 12 characteristics. As an implementation tool, Weka software was employed by the researchers. Classifiers are rated based on their accuracy, time to mastery, and rate of mistake. In less than a second of training time, the NB achieves an accuracy rate of 76.65%, with significant error rates and using data mining techniques and ML algorithms like NB, KNN, SVM etc, also Purvarichal University, India, provided the data for their study, which included 50 student records with eight features a piece [11].

A machine learning approach was suggested by [12] to identify the fear of failure in graduation, using this methodology, data from two schools in two districts were gathered. For binary classification, these ML methods are assessed using precision, recall, accuracy, and AUC. Using the categorization model described above, each student is rated according to their risk score. Random Forest was shown to be the most effective method. Precision and recall are used to rank the best algorithms. Five key stages for instructors are suggested by the authors of the framework to understand the most probable error. Students may be ranked based on the likelihood that their scores will be incorrect if the FP-Growth algorithm is used to find common patterns in their data, or they can be graded based on the likelihood that their scores will be accurate regardless of whether or not the framework is correct.

Most of the approaches have been used while employing and constructing several smart as well as intelligent frameworks like machine learning approaches [13-23] ,Fuzzy Inference systems [24-27], Particle Swarm Optimization (PSO) [28], Fusion based approaches [29-39], transfer learning [40] and MapReduce that may provide assistance in designing emerging solutions for the rising challenges in designing smart cloud-based monitoring management systems.

Most of researchers have tried to improve the health care of patients using machine learning techniques [42-48,55-56] empowered with blockchain technologies [51,63-66], cloud computing [49,54,59-62],Internet of things [57-62],smart cities [41,51,53-54]but still it needs motivation for the future directions to improve the healthcare system.

3 Proposed Methodology

In scenarios related to the education, having the capacity to evaluate the performance of a student is of utmost significance. The academic success of students is determined by a number of different aspects, including personal, social, psychological, and other environmental influences. Educational establishments such as schools and universities are increasingly using the practice of machine learning to forecast the performance of their students. With the use of educational mining, analysts may now evaluate student data and notify students about any potentially dangerous tendencies. As a result, analysts can provide students further counselling or training. It is recommended that this study work be done to construct an automated student performance prediction system employing the student performance parameters dataset. This system will predict the performance of students according to the proposed model, which can be shown in Figure 1.

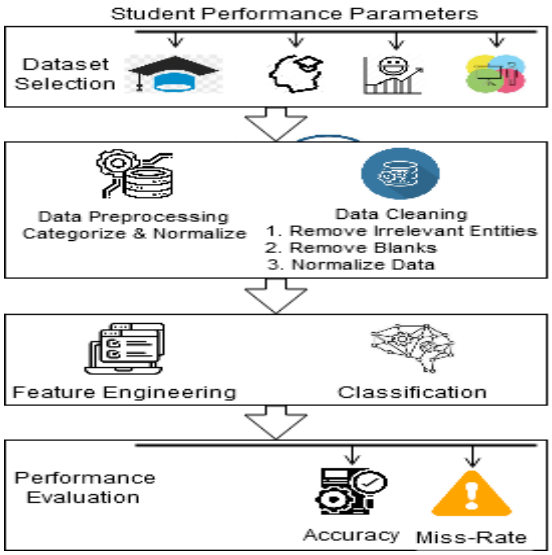

Figure 1: Proposed Methodology

Figure 1 illustrates that the suggested method for predicting student performance is dependent on the gathering of data from several input sensors that are associated with the student performance characteristics. The data that was obtained from the performance parameters is then sent on to the next stage, which is the following step, where it is transmitted for the purpose of preprocessing, where the missing data is addressed by utilizing normalization. The feature engineering process begins with the preprocessed data as its starting point. The process of choosing, altering, and converting raw data into features that may be utilized in supervised learning is referred to as feature engineering. This process is also known as feature extraction. It's possible that designing and training improved features will be required in order to make machine learning effective for tackling new challenges. After the feature engineering has been completed, the data will be delivered to be classified. For the purpose of organizing data into classes and categories, classification methods are used. It is applicable to both structured and unstructured data and may be carried out on either kind. There are three different approaches to classification: binary classification, multiclass classification, and multilabel classification. Following that, in the very last phase, after classification, it is determined whether or not the suggested system is accurate and what its rate of missing data.

4 Limitations and Future Recommendations

Classification is the activity that is used most often in educational institutions as a method to forecast the performance of students. There are various different categorization tasks algorithms that have been used to make predictions about the performance of the pupils. Random Forest (RF), Artificial Neural Networks (ANN), Naive Bayes (NB), K-Nearest Neighbor (KNN), and Support Vector Machine (SVM) are some examples of the methods that are used (SVM). Previous studies have shown that these algorithms have certain limits when it comes to reaching accuracy, and they do not accomplish accuracy very well. The authors made their predictions about the students' performance using the Random Forest (RF) approach, and they attained an accuracy of 86 percent. This study builds an intelligent model to forecast student performance by making use of the Decision Tree (DT) technique in order to get higher improvements in accuracy. It's possible that this model will produce greater results in its ability to anticipate how pupils will do. In the future, a technique known as Explainable Artificial Intelligence (EAI) may be used, with the potential to further improve these results.

Reference

[1] Slater, S., Joksimović, S., Kovanovic, V., Baker, R.S., Gasevic, D., 2017. Tools for Educational Data Mining: A Review. J. Educ. Behav. Stat. 42, 85–106.

[2] Hernández-Blanco, A., Herrera-Flores, B., Tomás, D., Navarro-Colorado, B., 2019. A Systematic Review

of Deep Learning Approaches to Educational Data Mining. Complexity 2019.
[3] Bengio, Y., Lecun, Y., Hinton, G., 2021. Deep learning for AI. Commun. ACM 64, 58–65.
[4] Vesin, B., Mangaroska, K., Giannakos, M., 2018. Learning in smart environments: user-centered design and analytics of an adaptive learning system. Smart Learn. Environ. 5.
[5] Albreiki, B., Zaki, N., Alashwal, H., 2021. A systematic literature review of student' performance prediction using machine learning techniques. Educ. Sci. 11.
[6] Mohd, T., Masrom, S., Johari, N., 2019. Machine learning housing price prediction in petaling jaya, Selangor, Malaysia. Int. J. Recent Technol. Eng. 8, 542–546.
[7] Hellas, A., Ihantola, P., Petersen, A., Ajanovski, V. V., Gutica, M., Hynninen, T., Knutas, A., Leinonen, J., Messom, C., Liao, S.N., 2018. Predicting academic performance: A systematic literature review. Annu. Conf. Innov. Technol. Comput. Sci. Educ. ITiCSE 175–199.
[8] Alyahyan, E., Düştegör, D., 2020. Predicting academic success in higher education: literature review and best practices. Int. J. Educ. Technol. High. Educ. 17.
[9] Namoun, A., Alshanqiti, A., 2021. Predicting student performance using data mining and learning analytics techniques: A systematic literature review. Appl. Sci. 11, 1–28.
[10] Okoli, C., 2015. Communications of the Association for Information Systems A Guide to Conducting a Standalone Systematic Literature Review Recommended Citation Okoli, Chitu (2015) "A Guide to Conducting a Standalone Systematic Literature Review C ommunications of the A I . Commun. Assoc. Inf. Syst. 37, 43.
[11] Ghosh, P., Azam, S., Karim, A., Jonkman, M., Hasan, M.Z., 2021. Use of Efficient Machine Learning Techniques in the Identification of Patients with Heart Diseases. ACM Int. Conf. Proceeding Ser. 14–20.
[12] Vineeth, N., Ayyappa, M., Bharathi, B., 2018. House Price Prediction Using Machine Learning Algorithms. Commun. Comput. Inf. Sci. 837, 425–433.
[13] Ali, N., Ghazal, T.M., Ahmed, A., Abbas, S., Khan, M. A., Alzoubi, H.M., Farooq, U., Ahmad, M., Khan, Muhammad Adnan, 2022. Fusion-based supply chain collaboration using machine learning techniques. Intell. Autom. Soft Comput. 31, 1671–1687.
[14] Ali Raza, S., Abbas, S., M. Ghazal, T., Adnan Khan, M., Ahmad, M., Al Hamadi, H., 2022. Content Based Automated File Organization Using Machine Learning燗pproaches. Comput. Mater. Contin. 73, 1927–1942.
[15] Asif, M., Abbas, S., Khan, M. A., Fatima, A., Khan, Muhammad Adnan, Lee, S.W., 2021. MapReduce based intelligent model for intrusion detection using machine learning technique. J. King Saud Univ. - Comput. Inf. Sci.
[16] Aslam, M.S., Ghazal, T.M., Fatima, A., Said, R.A., Abbas, S., Khan, M.A., Siddiqui, S.Y., Ahmad, M., 2021. Energy-efficiency model for residential buildings using supervised machine learning algorithm. Intell. Autom. Soft Comput. 30, 881–888.
[17] Chayal, N.M., Patel, N.P., 2021. Review of Machine Learning and Data Mining Methods to Predict Different Cyberattacks, Lecture Notes on Data Engineering and Communications Technologies.
[18] Dekhil, O., Naglah, A., Shaban, M., Ghazal, M., Taher, F., Elbaz, A., 2019. Deep Learning Based Method for Computer Aided Diagnosis of Diabetic Retinopathy, in: IST 2019 - IEEE International Conference on Imaging Systems and Techniques, Proceedings. Institute of Electrical and Electronics Engineers Inc.
[19] Fatima, S.A., Hussain, N., Balouch, A., Rustam, I., Saleem, M., Asif, M., 2020. IoT enabled Smart Monitoring of Coronavirus empowered with Fuzzy Inference System. Int. J. Adv. Res. Ideas Innov. Technol. 6, 188–194.
[20] Ghazal, T.M., Noreen, S., Said, R.A., Khan, M.A., Siddiqui, S.Y., Abbas, S., Aftab, S., Ahmad, M., 2022. Energy demand forecasting using fused machine learning approaches. Intell. Autom. Soft Comput. 31, 539–553.
[21] Khan, M.F., Ghazal, T.M., Said, R.A., Fatima, A., Abbas, S., Khan, M. A., Issa, G.F., Ahmad, M., Khan, Muhammad Adnan, 2021. An iomt-enabled smart healthcare model to monitor elderly people using machine learning technique. Comput. Intell. Neurosci. 2021.
[22] Muneer, S., Rasool, M.A., 2022. A systematic review : Explainable Artificial Intelligence (XAI) based disease prediction 1, 1–6.
[23] Saleem, M., Abbas, S., Ghazal, T.M., Adnan Khan, M., Sahawneh, N., Ahmad, M., 2022. Smart cities: Fusion-based intelligent traffic congestion control system for vehicular networks using machine learning techniques. Egypt. Informatics J.

[24] Areej Fatima 1, M., Adnan Khan 1, Sagheer Abbas 1, M.W. 1, 2019. Evaluation of Planet Factors of Smart City through Multi-layer Fuzzy Logic (MFL) 11, 51–58.
[25] Asadullah, M., Khan, M.A., Abbas, S., Alyas, T., Saleem, M.A., Fatima, A., 2020. Blind channel and data estimation using fuzzy logic empowered cognitive and social information-based particle swarm optimization (PSO). Int. J. Comput. Intell. Syst. 13, 400–408.
[26] Ihnaini, B., Khan, M. A., Khan, T.A., Abbas, S., Daoud, M.S., Ahmad, M., Khan, Muhammad Adnan, 2021. A Smart Healthcare Recommendation System for Multidisciplinary Diabetes Patients with Data Fusion Based on Deep Ensemble Learning. Comput. Intell. Neurosci. 2021.
[27] Saleem, M., Khan, M.A., Abbas, S., Asif, M., Hassan, M., Malik, J.A., 2019. Intelligent FSO Link for Communication in Natural Disasters empowered with Fuzzy Inference System. 1st Int. Conf. Electr. Commun. Comput. Eng. ICECCE 2019 1–6.
[28] Iqbal, K., Khan, M.A., Abbas, S., Hasan, Z., 2019. Time complexity analysis of GA-based variants uplink MC-CDMA system. SN Appl. Sci. 1, 1–8.
[29] Gai, K., Guo, J., Zhu, L., Yu, S., 2020. Blockchain Meets Cloud Computing: A Survey. IEEE Commun. Surv. Tutorials 22, 2009–2030.
[30] Ma, F., Sun, T., Liu, L., Jing, H., 2020. Detection and diagnosis of chronic kidney disease using deep learning-based heterogeneous modified artificial neural network. Futur. Gener. Comput. Syst. 111, 17–26.
[31] Muneer, S., Raza, H., 2022. An IoMT enabled smart healthcare model to monitor elderly people using Explainable Artificial Intelligence (EAI) 1, 16–22.
[32] Sharma, P., Jindal, R., Borah, M.D., 2021. Blockchain Technology for Cloud Storage. ACM Comput. Surv. 53, 1–32.
[33] Tabassum, N., Ditta, A., Alyas, T., Abbas, S., Alquhayz, H., Mian, N.A., Khan, M.A., 2021. Prediction of Cloud Ranking in a Hyperconverged Cloud Ecosystem Using Machine Learning. Comput. Mater. Contin. 67, 3129–3141.
[34] Taher M. Ghazal, et al., n.d. A review on security threats, vulnerabilities, and counter measures of 5G enabled Internet-of-Medical-Things. Inst. Eng. Technol. 16, 421–432.
[35] Bukhari, M.M., Ghazal, T.M., Abbas, S., Khan, M.A., Farooq, U., Wahbah, H., Ahmad, M., Adnan, K.M., 2022. An Intelligent Proposed Model for Task Offloading in Fog-Cloud Collaboration Using Logistics Regression. Comput. Intell. Neurosci. 2022.
[36] Khan, Z., 2022. Used Car Price Evaluation using three Different Variants of Linear Regression 1, 40–49.
[37] Naseer, I., 2022. Removal of the Noise And Blurriness using Global & Local Image Enhancement Equalization Techniques 1.
[38] Siddiqui, S.Y., Haider, A., Ghazal, T.M., Khan, M.A., Naseer, I., Abbas, S., Rahman, M., Khan, J.A., Ahmad, M., Hasan, M.K., Mohammed, A., Ateeq, K., 2021. IoMT Cloud-Based Intelligent Prediction of Breast Cancer Stages Empowered with Deep Learning. IEEE Access 9, 146478–146491.
[39] Ubaid, M., Arfa, U., Muhammad, H., Muhammad, A., Farooq, S., Saleem, M., 2022. Intelligent Intrusion Detection System for Apache Web Server Empowered with Machine Learning Approaches 1.
[40] Abbas, A., Abdelsamea, M.M., Gaber, M.M., 2020. Classification of COVID-19 in chest X-ray images using DeTraC deep convolutional neural network. Appl. Intell.
[41] Abbas, A., Abdelsamea, M.M., Gaber, M.M., 2020. Classification of COVID-19 in chest X-ray images using DeTraC deep convolutional neural network. Appl. Intell.
[42] Fatima, A., Khan, M. A., Abbas, S., Waqas, M., Anum, L., & Asif, M. (2019). Evaluation of Planet Factors of Smart City through Multi-layer Fuzzy Logic (MFL). ISeCure, 11(3).
[43] Batool, T., Abbas, S., Alhwaiti, Y., Saleem, M., Ahmad, M., Asif, M., & Elmitwally, N. S. (2021). Intelligent Model Of Ecosystem For Sm.art Cities Using Artificial Neural Networks. INTELLIGENT AUTOMATION AND SOFT COMPUTING, 30(2), 513-525.
[44] Ihnaini, B., Khan, M. A., Khan, T. A., Abbas, S., Daoud, M. S., Ahmad, M., & Khan, M. A. (2021). A smart healthcare recommendation system for multidisciplinary diabetes patients with data fusion based on deep ensemble learning. Computational Intelligence and Neuroscience, 2021.
[45] Hanif, M., Naqvi, R. A., Abbas, S., Khan, M. A., & Iqbal, N. (2020). A novel and efficient 3D multiple images encryption scheme based on chaotic systems and swapping operations. IEEE Access, 8, 123536-123555.
[46] Iqbal, N., Abbas, S., Khan, M. A., Alyas, T., Fatima, A., & Ahmad, A. (2019). An RGB image cipher using chaotic systems, 15-puzzle problem and DNA computing. IEEE Access, 7, 174051-174071.

[47] Alhaidari, F., Almotiri, S. H., Al Ghamdi, M. A., Khan, M. A., Rehman, A., Abbas, S., & Khan, K. M. (2021). Intelligent software-defined network for cognitive routing optimization using deep extreme learning machine approach.

[48] Tabassum, N., Ditta, A., Alyas, T., Abbas, S., Alquhayz, H., Mian, N. A., & Khan, M. A. (2021). Prediction of cloud ranking in a hyperconverged cloud ecosystem using machine learning.

[49] Asif, M., Khan, M. A., Abbas, S., & Saleem, M. (2019, January). Analysis of space & time complexity with PSO based synchronous MC-CDMA system. In 2019 2nd international conference on computing, mathematics and engineering technologies (iCoMET) (pp. 1-5). IEEE.

[50] Saleem, M., Abbas, S., Ghazal, T. M., Khan, M. A., Sahawneh, N., & Ahmad, M. (2022). Smart cities: Fusion-based intelligent traffic congestion control system for vehicular networks using machine learning techniques. Egyptian Informatics Journal.

[51] Khan, A. H., Khan, M. A., Abbas, S., Siddiqui, S. Y., Saeed, M. A., Alfayad, M., & Elmitwally, N. S. (2021). Simulation, modeling, and optimization of intelligent kidney disease predication empowered with computational intelligence approaches.

[52] Naz, N. S., Khan, M. A., Abbas, S., Ather, A., & Saqib, S. (2020). Intelligent routing between capsules empowered with deep extreme machine learning technique. SN Applied Sciences, 2(1), 1-10.

[53] Abbas, S., Khan, M. A., Athar, A., Shan, S. A., Saeed, A., & Alyas, T. (2022). Enabling smart city with intelligent congestion control using hops with a hybrid computational approach. The Computer Journal, 65(3), 484-494.

[54] Abbas, S., Ahmed, K., & Farooq, U. A QUANTUM INSPIRED SPARSE DISTRIBUTED MEMORY (QI-SDM) MODEL FOR CLEAN PATTERNS RETRIEVAL. Islamic Countries Society of Statistical Sciences, 627.

[55] Alanazi, S., & Elmitwally, N. S. Modelling Intelligent Driving Behaviour Using Machine Learning.

[56] Ghazal, T. M., Munir, S., Abbas, S., Athar, A., Alrababah, H., & Khan, M. A. Early Detection of Autism in Children Using Transfer Learning.

[57] Abbas, S., Ahmed, K., & Farooq, U. A QUANTUM INSPIRED SPARSE DISTRIBUTED MEMORY (QI-SDM) MODEL FOR CLEAN PATTERNS RETRIEVAL. Islamic Countries Society of Statistical Sciences, 627.

[58] Abbas, S. (2016). Intelligent Agent Navigation using Quantum Sparse Distributed Memory Model (QuSDM) (Doctoral dissertation, National College of Business Administration and Economics).

[59] Atta, A., Abbas, S., Khan, M. A., Ahmed, G., & Farooq, U. (2018). Computer and Information Sciences.

[60] Asif, M., Abbas, S., Khan, M. A., Fatima, A., Khan, M. A., & Lee, S. W. (2021). Computer and Information Sciences.

[61] Farooq, M. S., Khan, M. A., Abbas, S., Athar, A., Ali, N., & Hassan, A. (2019). Technical Papers Session IV: Skin detection-based pornography filtering using adaptive back propagation neural network.

[62] Yasir, A., Ahmad, A., Abbas, S., Inairat, M., Al-Kassem, A. H., & Rasool, A. (2022, February). How Artificial Intelligence Is Promoting Financial Inclusion? A Study on Barriers of Financial Inclusion. In 2022 International Conference on Business Analytics for Technology and Security (ICBATS) (pp. 1-6). IEEE.

[63] Farooq, M. S., Khan, S., Rehman, A., Abbas, S., Khan, M. A., & Hwang, S. O. (2022). Blockchain-Based Smart Home Networks Security Empowered with Fused Machine Learning. Sensors, 22(12), 4522.

[64] Kanwal, A., Abbas, S., Ghazal, T. M., Ditta, A., Alquhayz, H., & Khan, M. A. (2022). Towards Parallel Selective Attention Using Psychophysiological States as the Basis for Functional Cognition. Sensors, 22(18), 7002.

[65] Asif, R. N., Abbas, S., Khan, M. A., Sultan, K., Mahmud, M., & Mosavi, A. (2022). Development and Validation of Embedded Device for Electrocardiogram Arrhythmia Empowered with Transfer Learning. Computational Intelligence and Neuroscience, 2022.

[66] Rehman, A., Abbas, S., Khan, M. A., Ghazal, T. M., Adnan, K. M., & Mosavi, A. (2022). A secure healthcare 5.0 system based on blockchain technology entangled with federated learning technique. Computers in Biology and Medicine, 150, 106019.