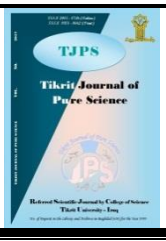
Tikrit Journal of Pure Science (2024) 29 (1):185-195
Doi: https://doi.org/10.25130/tjps.v29i1.1618

TJPS

IASJ
المجلات الاكاديمية العراقية

Tikrit Journal of Pure Science
ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)

Journal Homepage: http://tjps.tu.edu.iq/index.php



A Review of Various Machine Learning Techniques and its Application on IoT and Cloud Computing

Hardi Sabah Talabani[1], Ihsan Hamza Jumaa[2]
[1] Computer Department, College of Science, Charmo University, Sulaimaniyah, Iraq
[2]Information Technology Department, Rwandz Privet Technical Institute, Irbil, Iraq

Keywords: Machine Learning, ML Application, Deep Learning IoT, SVM, ANN, CNN, RNN.

ARTICLEINFO.

Article history:

-Received:	**22 June 2023**
-Received in revised form:	**23 Aug. 2023**
-Accepted:	**24 Aug. 2023**
-Final Proofreading:	**24 Feb. 2024**
-Available online:	**25 Feb. 2024**

Corresponding Author*:
hardi.sabah@charmouniversity.org

ABSTRACT
The employ of Internet of Things has become an integral part of our daily life, especially in developed countries and societies, which in turn are considered to be one of the basic areas on which the mechanisms of their work depend to a large extent the applications of algorithms used in the field of machine learning are available due to the high accuracy that characterizes these applications and the margin of safety that these techniques offer. As a result, scientific research for these applications is increasing every day and leads to different results for these applications in different areas of the Internet of Things and its multiple uses. This study presents an analysis of machine learning techniques and the need for ML and its types. The article focuses on current research on the integration of IoT with cloud computing technology and the benefits of linking cloud computing techniques with IoT systems. An overview of different machine learning algorithms like SVM and neural network algorithms like ANN are discussed. Deep learning algorithms; CNN, RNN, and ensemble learning techniques are reviewed in terms of developed models, goals, applications, and the results achieved. The study offers a comparative analysis of the application of different ML and deep learning algorithms.

Tikrit Journal of Pure Science (2024) 29 (1):185-195
Doi: https://doi.org/10.25130/tjps.v29i1.1618

TJPS

مراجعة لتقنيات التعلم الآلي المختلفة وتطبيقها على إنترنت الأشياء والحوسبة السحابية

[1] هردى صباح الطالباني، [2] احسان حمزه جمعة

[1] قسم الحاسبات، كلية العلوم، جامعة جرمو، السليمانية، العراق

[2] قسم تقنية المعلومات، معهد رواندز التقني الخاص، اربيل، العراق

الملخص

أصبح استخدام إنترنت الأشياء جزءًا لا يتجزأ من حياتنا اليومية، خاصة في البلدان والمجتمعات المتقدمة، والتي تعتبر بدورها من المجالات الأساسية التي تعتمد عليها آليات عملهم إلى حد كبير التطبيقات من الخوارزميات المستخدمة في مجال التعلم الآلي متاحة بسبب الدقة العالية التي تتميز بها هذه التطبيقات وهامش الأمان الذي توفره هذه التقنيات. نتيجة لذلك، يتزايد البحث العلمي لهذه التطبيقات كل يوم ويؤدي إلى نتائج مختلفة لهذه التطبيقات في مجالات مختلفة من إنترنت الأشياء واستخداماته المتعددة. تقدم هذه الدراسة تحليلاً لتقنيات التعلم الآلي والحاجة إلى ML وأنواعه. تركز المقالة على البحث الحالي حول تكامل إنترنت الأشياء مع تكنولوجيا الحوسبة السحابية وفوائد ربط تقنيات الحوسبة السحابية بأنظمة إنترنت الأشياء. تمت مناقشة نظرة عامة على خوارزميات التعلم الآلي المختلفة مثل SVM وخوارزميات الشبكة العصبية مثل ANN. خوارزميات التعلم العميق. تتم مراجعة تقنيات تعلم CNN وRNN والمجموعات من حيث النماذج والأهداف والتطبيقات المطورة والنتائج المحققة. تقدم الدراسة تحليلاً مقارنًا لتطبيق خوارزميات تعلم مختلفة وخوارزميات التعلم العميق.

1. Introduction:

Machine learning (ML) is the driving force and sub-branch of artificial intelligence and it is the most significant and advanced technology in recent times. The term machine learning was first coined by Arthur Samuel in 1959. Machine learning enables the system to learn on its own, based on the previous information to predict future computations. The primary objective of the machine learning technique is to incorporate programmed learning methodologies for various applications either to understand or study the modifications concerning past information [1]. The advantage of machine learning methodologies is that it employs logical models, decision trees, heuristic algorithms, and data acquisitions for optimizing different ML-based applications. Apart from the stated advantages, ML also provides robust controllability, detectability, and dynamic functionality to the system. In recent times, various research are done on machine learning algorithms that have reduced computational complexities, good stability, and reliability [2]. The different types of machine learning technologies are; supervised learning, unsupervised learning, and reinforcement learning.

- ***Supervised Learning:*** In the supervised learning technique, the "true" or "correct" tags of the input datasets are accessible. Machine learning-based algorithms are trained by applying the "true" input datasets to predict the accurate output. During the training process, the learning algorithms are trained to provide relevant forecasts on the input data and to enhance the estimating capability of the algorithm [3]. The training process adopts the ground truth and re-iterations until the algorithm is met with an estimated accuracy level. In most machine learning algorithms, the objective function and cost function is optimized to reduce the number of possible iterations. The cost function is basically measured as the error between the ground truth and the algorithmic estimation [4]. By optimizing the cost function, the estimating capacity of the algorithms (to predict accurate values) can be improved. Cost function minimization can be performed by employing the gradient descent technique. There are basically two stages in supervised learning; The Training state and the Learning state. The input data sets employed in the training phase are required to contain known values or labels. The algorithms gather the information from the association between the input datasets and known labels to forecast the output values of the tested data. Supervised learning techniques are commonly employed in numerous applications such as; the recognition of phytoplankton species, the classification of data in biomedical applications, and data mapping in landslides.

- ***Unsupervised Learning:*** Unsupervised algorithms do not incorporate any explicit labels related to the training dataset. There is no labeling or classification of the computational algorithms and no availability of previous imprints. The main objective is to compute the presumptions obtained from the input data and to model the concealed or unseen data to monitor the data distribution and to explore more about the data [5]. The clustering technique is the fundamental instance of an unsupervised algorithm. The unsupervised algorithm isolates the input data to identify the data structure from the given input dataset. The clustering technique involves identifying a data structure or pattern in a stream of untagged datasets [6]. For a specific dataset, the clustering algorithm forms an individual group from the given set of information into a K number of clusters. The clusters are formed in such a way that the data points grouped under an individual cluster are similar to other data sets in that cluster and the data points belonging to different clusters are not similar to each other. The K-means algorithm is one of the straightforward clustering algorithms which is an instinctive and iterative algorithm. This algorithm clusters or groups the data by categorizing the datasets into K groups of minimizing the inertia and equal variances [7]. Nonetheless, the K-means algorithm needs to specify the required number of clusters prior to the execution of the algorithm.
- ***Reinforcement Learning:*** In the reinforcement learning technique, the algorithms incorporated try to predict the result for the given problem based on the specific set of tuning parameters. The calculated output is then considered as an input parameter and the new output is evaluated till the optimal output is obtained. Artificial Neural Networks (ANN) and Deep Learning techniques which are discussed in further sections, adopt this learning technique. Reinforcement learning technique is majorly applied in AI gaming, in estimating real-time decisions and skill acquisition [8].

Machine learning is the most advanced technique used for exploring the data to study the 'normal' and 'abnormal' functioning of the IoT components based on device interactions within IoT environment ML technique is capable of anticipating new attacks which takes a cue from previous attacks and they also brilliantly predict new future attacks by learning from previous instances. Machine learning finds its applications in various fields such as; video surveillance, virtual personal assistants, data engineering, smart healthcare, smart grid, financial security, and smart city projects.

1.1 *IoT and Cloud Computing*

The Internet of Things (IoT) and cloud computing are the most significant and advanced technologies in recent times. IoT is an advanced system that is integrated and interrelated to many digital devices, mechanical and electrical machines, and unique identifiers (UID) which is capable of transferring data over a network without human or computer interference. IoT is a network of many interconnected devices embedded with several sensors to collect information at a higher speed. With a system of modest sensors and interconnected things, data assortment on our reality and condition can be accomplished at a higher level. IoT plays a vital role in delivering superclass service in significant applications such as healthcare, finance, data analytics, and smart city services [9]. Many trending technologies such as information technology, data science, and power business intelligence are interrelated and are combined to achieve smart technological advancements in modern-day life. Integration of all these advanced technologies results in a complex networking system while implementing them into a more extensive application [10]. Cloud computing has evolved to include the delivery of infrastructure, platform, software, and, more recently, network 'as a service' encompassing IaaS, PaaS, SaaS, and NaaS [11]. In Saas

applications, there is no requirement for installation, maintenance, and storage of any application and users can access SaaS applications using only internet connectivity. PaaS provides a platform to develop applications with all the required tools and resources. NaaS offers virtual networks to users. End users can access any number of applications and heterogeneous networks with specific network policies. Instead of procuring expensive servers, and storage devices for performing small tasks, users can opt for an IaaS service provider and can outsource. In IaaS, data is stored in IaaS service and the data is universally accessible to all users using internet connectivity [12].

In recent times, there is an expeditious increase in internet users, connecting devices, and in the amount of data used. Storing huge amounts of data is impracticable and processing this huge data increases the complexity of the network systems employing IoT does not provide satisfactory solutions in these scenarios. A new technique involving the integration of IoT and cloud computing known as cloud of things (CoT) is developed for storing and processing huge data [13]. The integration of IoT and cloud computing is represented in Figure 1.1.

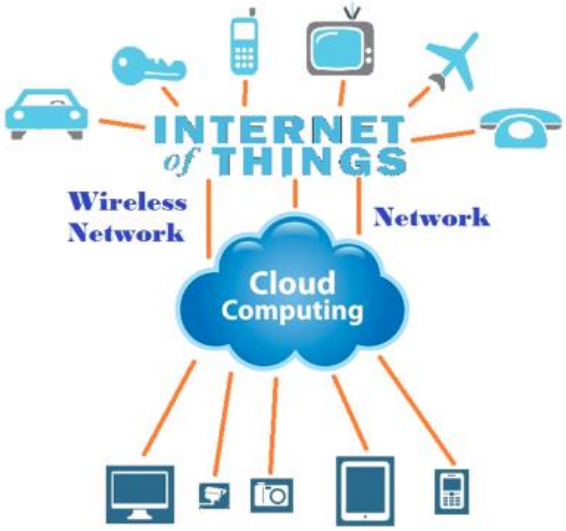


Fig 1.1 Integration of IoT with cloud computing [14]

Mobile Cloud Computing is the new technology obtained by integrating mobile devices with cloud computing technology to transform mobile devices into an inventive approach with enhanced computational power, robustness, increased memory storage and better connectivity Mobile Cloud Computing is the result of multiple interdisciplinary outlooks combining mobile and cloud computing [15]. Many important attributes of the cloud computing technology which are related to the features of IoT are; storage over the Internet, energy efficiency, computation capability, service, and applications over the Internet. Integration of IoT and cloud computation provides an expandable opportunity of diversifying the usage of available technologies provided by the cloud environments [14]. Another advantage of integrating IoT and cloud is that, cloud computing fills the gap left by IoT in terms of data storage and applications over the internet. Though the integration of IoT and cloud computing has several advantages, the security of the data stored in this integration is a major concern. When sensitive IoT devices are integrated with the cloud, there arises security concerns due to the absence of confidence and insecurity in the service provider or lack of information related to service level agreements (SLAs) and data location [16].

2. Machine Learning Techniques

2.1 Support Vector Machines (SVM)

The SVM algorithm is one of the progressive ML algorithms adopted for classification and regression techniques. The mechanism of an intelligent transportation system based on IoT and cloud computing techniques was proposed by [17]. The main objective of the proposed research is to develop an intelligent transport system that focuses on accident detection in an IoT platform. The SVM technique is used for detecting accidents in traffic systems. An ant colony algorithm (ACA) is used to modify SVM and the proposed mechanism was analyzed by conducting experiments on real traffic data to predict seven different types of traffic accidents. The data was analyzed using MATLAB and the accuracy of prediction was approximately 95%. Security is one of the major concerns in cloud computing techniques and Denial of Service (DoS) attacks is one of the major attacks in cloud computing (CC). An evaluation of the SVM algorithm in developing a classification model for identifying DoS attacks is proposed by [18]. The main objective of this paper is to develop an efficient model for threat detection (DoS) in cloud computing to protect cloud architecture from vicious attacks employing the SVM algorithm. Experimental results showed significant performance enhancement in DoS attack detection with 100% accuracy. Network security is an important issue in any application. Application traffic concealed under HTTP and HTTPS protocols raises concerns regarding data provenance. Hence an SVM-based internet traffic identification and classification (STIC) technique is proposed by [19] to detect application traffic in software-defined networking (SDN). In the proposed research, the STIC technique was used to determine traffic related to 28 applications like Facebook, YouTube, etc. SVM-based STIC analyzes and identifies all the network packets in various applications and diverts the traffic using virtual LAN (VLAN) thereby enhancing the network security. Results show that classification accuracy and quality-determining accuracy will be approximately 99% and 92.78% respectively. The application of IoT and cloud computing in the smart healthcare system is gaining a lot of importance. An SVM-PSO-based technique is proposed by [20]. The paper presents the application of SVM for detecting gestational Type II diabetes mellitus (GDM) diseases. PSO algorithm is used for the optimization of SVM. An effective SVM-based health monitoring system adopting IoT and cloud computing to access medical data in a remote area is proposed by [21]. The proposed paper develops a smart health monitoring system to send an alert message to the caretaker of patients under emergency conditions. A cloud server stores all the critical data such as the temperature and heartbeat of the patient using sensors. SVM is adopted to analyze the data and to identify any abnormal conditions. An alert message is sent to the caretaker and the nearest hospital using a mobile application.

2.2 Neural Networks

A neural network is a mathematical model consisting of several layers of elements that perform parallel computational operations. Initially, such a structure was created by analogy with the smallest computational elements in the human brain - neurons. The smallest computational elements of an artificial neural network are also called neurons. Neural networks usually consist of three or more layers: an input layer, a hidden layer (or layers), and an output layer, and in some cases, the input and output layers are not counted, and then the layers in the network are calculated by the number of hidden layers. This type of neural network is called a perceptron (a mathematical or computational model for the perception of information by the brain)

2.2.1 Artificial Neural Network

The introduction of IoT and cloud computing in healthcare systems has reinforced various attributes of healthcare applications. Managing a huge amount of big data is an important concern that is taken care of by the cloud computing technique. A new technique developed for analyzing and detecting diabetes is proposed by [21]. The paper proposes a new algorithm known as the Fuzzy Rule-based Neural Classifier to diagnose the disease and its severity. IoT has gained vast attention in the field of smart agriculture. A non-linear prediction model incorporating IoT and ANN algorithms is proposed by [22]. The proposed model acquires data from wireless sensor nodes (WSN) which is analyzed using ANN. Data prediction related to distance and power consumption is accurately predicted by ANN and from the results the prediction accuracy was high compared to other WSN-IoT-based models. The application of IoT-cloud computing technology in threat analysis is discussed by [23]. The paper discusses threat analysis in IoT systems employing a supervised ANN to detect threats and combat them. The algorithm is trained by using traces of internet packages to detect (DDoS/DoS) attacks. ANN classifies normal and vicious packets in the network and eliminates malicious data packages to provide security to the IoT network. Results show an accuracy of 99.4% in detecting DDoS/DoS attacks. The application of ANN in detecting cardiovascular disease is proposed by [24]. The author presents a detailed analysis of decision-making algorithms using ANN to detect cardiovascular disease by using the data collected using sensors.

2.2.2: Deep Learning

Deep learning belongs to a group of ML technologies. DL techniques are mainly employed for processing non-linear systems, pattern recognition, classification, and feature learning. The application of convolutional neural networks (CNN) in evaluating the performance of phone recognition is studied by [25]. CNN was used for speech recognition as CNN is adaptable for handling large vocabulary as it demonstrates multiple layers of convolution. A brief analysis of the CNN application in face recognition is proposed by [26]. CNN is analyzed concerning the forward process and backpropagation. CNN is subjected to analyze image displacement, invariance, and feature detection of an image. CNN in the proposed research performs parallel computing to enhance the face recognition process. The feasibility of adopting the CNN algorithm for diagnosing lung cancer is proposed by [27]. The paper presents the design and implementation of CNN and the result was compared with a conventional computer-aided diagnosis (CADx) system. CNN helps the system learn on its own based on previous encounters. Results showed an enhancement of 79% compared to (the CADx) system. An advanced approach for detecting various cardiovascular diseases like myocardial infarction (MI) is discussed by [28]. The proposed approach implements a CNN algorithm for the automatic detection of MI using ECG signals. CNN classifies normal heartbeats and ECG beats and from the results, it was observed that the proposed CNN provides an accuracy of 93.53% and 95.22% (With noise and without noise respectively). The application of CNN in real-time applications such as vehicle and lane detection is presented in [29]. In the proposed research, CNN is trained for detecting objects and predicting

path depths using 17 thousand frames of images, and from the results it was demonstrated that the proposed model shows good performance in vehicle and lane detection. Deep learning is used in smart power generation systems. The application of RNN in controlling HVAC systems is presented in [30]. In the proposed paper, an intelligent controller is developed using the integration of IoT and cloud computing. RNN is adopted to estimate the occupant's number and set points based on the Predicted mean vote (PMV) for HVAC systems. The developed intelligent controller was analyzed concerning heating, ventilation, and cooling, and the accuracy of occupancy was found to be 92.48% with an error of 3.81%. With the increase in the application of IoT, managing huge amounts of data is a challenging task. Implementation of RNN in data analytics for processing big data is proposed by [29]. RNN is mainly adopted for feature learning from the existing data. The temporal pattern of stored data enables RNN to handle big and distributed data which provides excellent results compared to other deep learning algorithms. The potential of applying RNN in determining malware threats is proposed by [31]. The paper presents the application of RNN in detecting malware in an ARM-based IoT environment. The performance of the developed model is evaluated using Long Short Term Memory (LSTM) configurations and the results show an accuracy of 98 % compared to other deep learning algorithms presented in the study. Pattern recognition in heterogeneous IoT is a difficult task as it is dependent on various factors. A collaborative model using RNN is adopted for identifying the suitable model without training the edge sides proposed by [32]. The proposed method identifies the suitable model by exploiting privacy issues by incorporating edge computing. The overall accuracy was increased by 94%. Spam detection in social media is a complex task due to the huge amount of data flow. A semi-supervised methodology for detecting spam is proposed by [33]. The proposed technique is based on an ensemble learning technique for spam detection which uses Probabilistic Data Structures (PDS) for effective spam detection. Results show significant enhancement in the performance of spam detection employing an ensemble learning technique. An edge-computing framework employing the Healthfog technique for integration of ensemble deep learning in edge computing devices for automated analysis of heart diseases was proposed by [34] The proposed method shows high accuracy 95% when applied and the prediction accuracy was high compared to other deep learning techniques. An effective ensemble classifier for the prediction and diagnosis of chronic illnesses such as cancer, diabetes, etc was presented

by [35] The proposed research uses the ensemble method of tree-based classification-Random Forest algorithm to analyze the data and to predict diseases and to monitor the system for stroke patients using IoT. The results show an accuracy of 93% in predicting the disease occurrences and ensemble classifiers are more effective than other algorithms in prediction.

3. Comparative Analysis

***Table 1**: Comparative Analysis with related works*

References	Methodology	Application and objectives	Results/ Observation	Future scope
Liang, 2015	SVM technique optimised by ant colony algorithm	Intelligent transport system for accident detection.	The proposed SVM model provides approx 95% accuracy in predicting possible accidents	Application of SVM-ACA model to explore various other problems.
Liu et al., 2015	CNN	Face recognition and parallel computing	Results demonstrate that the efficiency of computational speed is 99%	CNN produces coarse-grained parallelism. Different DL techniques can be explored for achieving fine-grained parallelism
Javed et al., 2016	RNN	Intelligent controlling of HVAC systems	The accuracy of occupancy was 92.48% with an error of 3.81%.	RNN can be implemented for estimating power consumption by sensor in IoT environment
Masetic et al., 2017	SVM algorithm with Tshark and GA for feature extraction	Security enhancement in cloud computing techniques by identifying DoS attacks.	SVM showed significant improvement in classifying DoS attacks with 100% accuracy	SVM-GA based technique can be applied for detecting other prominent malware attacks in cloud architecture
Liu et al., 2018	SVM algorithm based STIC technique	Network security enhancement by determining application traffic in various applications.	Classification accuracy and quality determining accuracy using SVM-STIC was found to be 99% and 92.78% respectively	Probability-based Bayesian classification algorithm, andtree-based decision tree algorithm can be used for improving network security mechanism
Kumar et al., 2018	Fuzzy-based neural classifier	Data analysis in healthcare applications.	Experimental analysis showed better accuracy of approx 95% in disease prediction compared to other techniques	Adopting cryptographic algorithms to improve data security in medical applications
Aliev, 2017	ANN	Data prediction in smart agriculture related to power consumption and maximum distance.	Prediction accuracy using ANN algorithm is approx 92%	Application of ANN in various fields such as finance, neuroscience and physics
Hodo et al., 2016	ANN	Threat analysis and detection of DDoS and DoS attacks	Results show an accuracy of 99.4% in detecting DDoS/DoS attacks	Analysis of attacks using R CNN and DNN
Acharya et al., 2017	CNN	Automatic detection of myocardial infarction	An accuracy of 93.53% and 95.22% was achieved in detecting MI	Big-data technique can be adopted to handle huge data generated by CNN

References	Methodology	Application and objectives	Results/ Observation	Future scope
HaddadPajouh et al., 2018	RNN	Malware detection in IoT environment	The results show an accuracy of 98 % in malware detection	The proposed model can be extended in real time cyber threat detection
Moon et al., 2019	RNN	Edge computation to recognise suitable model for security in IoT environment	The accuracy of model detection was found to be 94%	The model can be applied to identify data trends under abnormal signal generation conditions.
Mauldin et al., 2019	Ensemble deep learning	In Depth analysis of DL combined with ensemble techniques (Stacking and Ada boosting)	The accuracy of ensembling deep models was 98% compared to single deep learning models	Implementation of best ensembling technique for fall detection analysis.
Tuli et al., 2020	Ensemble deep learning	An automated detection and analysis of heart diseases	The proposed method shows prediction accuracy of 95%	Integration of other deep learning techniques with ensembling techniques to develop an efficient health monitoring system.

4. Conclusion

In this paper, the impact of machine learning and deep learning on cloud computing and IoT is presented. Where the focus was on the impact of applying models of each of SVM and ANN of machine learning algorithms, as well as each of CNN, RNN, and Ensemble learning of deep learning algorithms on cloud computing and IoT technologies by analyzing the performance of each model and comparing it with the models of the other mentioned algorithms and their future scope and accuracy in this fields.

References:

[1] Rana, A. K., Salau, A. O., Gupta, S., & Arora, S. (2018). a survey of machine learning methods for IoT and their future applications. *Amity Journal of Computational Sciences*, *2*(2), 1-5.

[2] Al-Garadi, M. A., Mohamed, A., Al-Ali, A. K., Du, X., Ali, I., & Guizani, M. (2020). A survey of machine and deep learning methods for internet of things (IoT) security. *IEEE Communications Surveys & Tutorials*, *22*(3), 1646-1685.

[3] Shanthamallu, U. S., Spanias, A., Tepedelenlioglu, C., & Stanley, M. (2017, August). A brief survey of machine learning methods and their sensor and IoT applications. In *2017 8th International Conference on Information, Intelligence, Systems & Applications (IISA)* (pp. 1-8). IEEE.

[4] Jader, R., & Aminifar, S. (2022). Predictive Model for Diagnosis of Gestational Diabetes in the Kurdistan Region by a Combination of Clustering and Classification Algorithms: An Ensemble Approach. *Applied Computational Intelligence and Soft Computing*, *2022*.

[5] Mahdavinejad, M. S., Rezvan, M., Barekatain, M., Adibi, P., Barnaghi, P., & Sheth, A. P. (2018). Machine learning for Internet of Things data analysis: A survey. *Digital Communications and Networks*, *4*(3), 161-175.

[6] Aery, M., & Ram, C. (2017). A Review on Machine Learning: Trends and Future Prospects. *An International Journal of Engineering Sciences*, *25*.

[7] Jader, R., & Aminifar, S. (2022). Fast and Accurate Artificial Neural Network Model for Diabetes Recogni-tion. *NeuroQuantology*, *20*(10), 2187-2196.

[8] Zantalis, F., Koulouras, G., Karabetsos, S., & Kandris, D. (2019). A review of machine learning and IoT in smart transportation. *Future Internet*, *11*(4), 94.

[9] Dorri, A., Kanhere, S. S., Jurdak, R., & Gauravaram, P. (2017, March). Blockchain for IoT security and privacy: The case study of a smart home. In *2017 IEEE international conference on pervasive computing and communications workshops (PerCom workshops)* (pp. 618-623). IEEE.

[10] Kumar, N. M., & Mallick, P. K. (2018). Blockchain technology for security issues and challenges in IoT. *Procedia computer science*, *132*, 1815-1823.

[11] Jader, R. F., Abd, M. H. M., & Jumaa, I. H. (2022). Signal Modulation Recognition System Based on Different Signal Noise Rate Using Artificial Intelligent Approach. *Journal of Studies in Science and Engineering*, *2*(4), 37-49.

[12] Rui, J., & Danpeng, S. (2015, June). Architecture design of the Internet of Things based on cloud computing. In *2015 Seventh International Conference on Measuring Technology and Mechatronics Automation* (pp. 206-209). IEEE.

[13] Aazam, M., Khan, I., Alsaffar, A. A., & Huh, E. N. (2014, January). Cloud of Things: Integrating Internet of Things and cloud computing and the issues involved. In *Proceedings of 2014 11th International Bhurban Conference on Applied Sciences & Technology (IBCAST) Islamabad, Pakistan, 14th-18th January, 2014* (pp. 414-419). IEEE.

[14] Stergiou, C., Psannis, K. E., Kim, B. G., & Gupta, B. (2018). Secure integration of IoT and cloud computing. *Future Generation Computer Systems*, *78*, 964-975.

[15] Fortino, G., Guerrieri, A., Russo, W., & Savaglio, C. (2014, May). Integration of agent-based and cloud computing for the smart objects-oriented IoT. In *Proceedings of the 2014 IEEE 18th international conference on computer supported cooperative work in design (CSCWD)* (pp. 493-498). IEEE.

[16] Saha, S., & Soumitra, S. (2019). *Secured Integration of IoT and Cloud Computing* (Doctoral dissertation).

[17] Abdulhadi, H. M. T., & Talabani, H. S. (2021). Comparative study of supervised machine learning algorithms on thoracic surgery patients based on ranker feature algorithms. *UHD Journal of Science and Technology*, *5*(2), 66-74.

[18] Mašetić, Z., Kečo, D., Doğru, N., & Hajdarević, K. (2017). SYN flood attack detection in cloud computing using support vector machine. *TEM Journal*, *6*(4), 752.

[19] Liu, C. C., Chang, Y., Tseng, C. W., Yang, Y. T., Lai, M. S., & Chou, L. D. (2018, July). SVM-based classification mechanism and its application in SDN networks. In *2018 10th International Conference on Communication Software and Networks (ICCSN)* (pp. 45-49). IEEE.

[20] Kennedy, J. J., Selvam, R. P., & Palanisamy, V. Cloud-Centric IoT based Decision Support System for Gestational Diabetes Mellitus using Optimal Support Vector Machine. *International Journal of Recent Technology and Engineering (IJRTE) ISSN*, 2277-3878.

[21] Kumar, A., Chattree, G., & Periyasamy, S. (2018). Smart healthcare monitoring system. *Wireless Personal Communications*, *101*, 453-463.

[22] Aliev, K. (2017). Internet of things applications and artificial neural networks in smart agriculture. *Politecnico di Torino: Turin, Italy*.

[23] Hodo, E., Bellekens, X., Hamilton, A., Dubouilh, P. L., Iorkyase, E., Tachtatzis, C., & Atkinson, R. (2016, May). Threat analysis of IoT networks using artificial neural network intrusion detection system. In *2016 International Symposium on Networks, Computers and Communications (ISNCC)* (pp. 1-6). IEEE.

[24] Shahid, N., Rappon, T., & Berta, W. (2019). Applications of artificial neural networks in health care organizational decision-making: A scoping review. *PloS one*, *14*(2), e0212356.

[25] Deng, L. (2014). A tutorial survey of architectures, algorithms, and applications for deep learning. *APSIPA transactions on Signal and Information Processing*, *3*, e2.

[26] Liu, T., Fang, S., Zhao, Y., Wang, P., & Zhang, J. (2015). Implementation of training convolutional neural networks. *arXiv preprint arXiv:1506.01195*.

[27] Sun, W., Zheng, B., & Qian, W. (2016, March). Computer aided lung cancer diagnosis with deep learning algorithms. In *Medical imaging 2016: computer-aided diagnosis* (Vol. 9785, pp. 241-248). SPIE.

[28] Acharya, U. R., Fujita, H., Oh, S. L., Hagiwara, Y., Tan, J. H., & Adam, M. (2017). Application of deep convolutional neural network for automated detection of myocardial infarction using ECG signals. *Information Sciences*, *415*, 190-198.

[29] Huval, B., Wang, T., Tandon, S., Kiske, J., Song, W., Pazhayampallil, J., ... & Ng, A. Y. (2015). An empirical evaluation of deep learning on highway driving. *arXiv preprint arXiv:1504.01716*.

[30] Javed, A., Larijani, H., Ahmadinia, A., & Gibson, D. (2016). Smart random neural network controller for HVAC using cloud computing technology. *IEEE Transactions on Industrial Informatics*, *13*(1), 351-360.

[31] HaddadPajouh, H., Dehghantanha, A., Khayami, R., & Choo, K. K. R. (2018). A deep recurrent neural network based approach for internet of things malware threat hunting. *Future Generation Computer Systems*, *85*, 88-96.

[32] Moon, J., Kum, S., & Lee, S. (2019). A heterogeneous IoT data analysis framework with collaboration of edge-cloud computing: Focusing on indoor PM10 and PM2. 5 status prediction. *Sensors*, *19*(14), 3038.

[33] Singh, A., & Batra, S. (2018). Ensemble based spam detection in social IoT using probabilistic data structures. *Future Generation Computer Systems*, *81*, 359-371.

[34] Tuli, S., Basumatary, N., Gill, S. S., Kahani, M., Arya, R. C., Wander, G. S., & Buyya, R. (2020). HealthFog: An ensemble deep learning based Smart Healthcare System for Automatic Diagnosis of Heart Diseases in integrated IoT and fog computing environments. *Future Generation Computer Systems*, *104*, 187-200.

[35] Ani, R., Krishna, S., Anju, N., Aslam, M. S., & Deepa, O. S. (2017, September). Iot based patient monitoring and diagnostic prediction tool using ensemble classifier. In *2017 International conference on advances in computing, communications and informatics (ICACCI)* (pp. 1588-1593). IEEE.