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Machine learning-based cloud computing and IOT: A review

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Abstract
This study provides an examination of machine learning methodologies and the necessity for machine learning and its many classifications. The article centered around contemporary studies on the amalgamation of IoT with cloud computing technology and the advantages of connecting cloud computing methodologies with IoT systems. The text provides a comprehensive examination of several machine learning methods, such as Support Vector Machines (SVM), and neural network techniques, such as Artificial Neural Networks (ANN). The text examines deep learning algorithms, namely Convolutional Neural Network CNN, Recurrent Neural Network RNN, and ensemble learning approaches, in terms of their produced models, objectives, applications, challenges, and the outcomes they have obtained. The paper provides a thorough examination of the implementation of several machine learning and deep learning algorithms, with a focus on comparing their performance.

Keywords: Machine learning, ML application, deep learning IoT, SVM, ANN, CNN, RNN

Introduction
The use of the Internet of Things (IoT) has become essential in our daily lives, particularly in developed countries and societies. These countries heavily rely on IoT for various functions, and the algorithms used in machine learning play a crucial role in their operations [1]. These algorithms are known for their high accuracy and the safety they provide. Consequently, scientific study on these applications is growing daily and yielding diverse outcomes across many domains of the Internet of Things and its myriad applications. Machine learning ML is a subset of artificial intelligence that concentrates on creating models and systems that empower computer equipment to autonomously learn and enhance their performance without constant human involvement [2]. The history of ML is long and complex as emanating with the idea of artificial Intelligence and automation, the origins of ML may be traced back to the 1950s and 1960s, when researchers aimed to create methods for enabling computer systems to acquire knowledge and insights from both experience and data. Arthur Samuel, an American physicist, is widely regarded as one of the early leaders in the field of ML. He is credited with coining the phrase "machine learning" in 1959.

However, the influence of ML in the Internet of Things IoT is apparent through its ability to enable intelligent analysis and interpretation of data gathered by IoT devices. Furthermore, ML approaches enable IoT analytical systems to acquire patterns and make predictions about future actions, therefore enhancing device efficiency and boosting service quality. Within the realm of cloud computing IoT, ML amplifies the capacity to harness substantial processing capabilities and cloud-based storage. Moreover, ML methods are employed to examine large datasets stored in the cloud and enhance the performance of algorithms and intelligent resource allocation [3] in this study, various machine learning such as, such as Support Vector Machines (SVM) and neural network techniques, such as Artificial Neural Networks (ANN), convolutional neural network (CNN), recurrent neural networks (RNN), and ensemble learning approaches algorithms and their performance in various cloud computing and IoT environments has been presented.

The remaining sections in this study are as follows. Initially, the second and third sections deal with explaining the basics of the concept of both cloud computing and the IoT. However, the fourth section includes presenting the concept of machine learning and its three types. Furthermore, the fifth section it is the literature search strategy that was followed in this study.

Moreover, related to the five algorithms used in the fields of cloud computing and the IoT are discussed in the sixth section. In seventh section the limitations of employing machine learnings is cloud computing and IoT are showed. Finally, in the eighth section, the conclusions of the study were discussed.

Clout Computing

Cloud computing is a significant advancement in contemporary technology, serving as the foundation for delivering computer services and resources via the Internet. Cloud computing is an architecture that provides a variety of computational resources, such as servers, databases and storages, which are accessible over the internet in a uniform manner with IoT integration Figure 1.

First, Cloud computing is based on the pay-per-use principle, where clients are paid only for resources consumed [4]. This makes it cost efficient for a large number of corporations and organizations. In addition, it provides customers with a significant margin of flexibility to either increase or reduce resources based on their current requirements. In addition, cloud computing enhances resource utilization as the resources are automatically allocated depending on specific application requirements. This ensures that the infrastructure is used optimally with minimal computational overhead. Additionally, an internet connection makes remote usage of computing resources possible and provides global technological equality. Thus, such mechanisms allow individuals or institutions to have easy access to data whether they are present in the same location. Moreover, secure data and applications are provided by cloud computing. In an effort to upscale the security threats, service providers offer high-end security technology that provides constant updates. In the end, the cloud computing paradigm supports environmental sustainability through significant savings in energy consumption and carbon emissions. Promoting resource sharing and improving their use efficiency, the environmental footprint of computer systems can be reduced.

Internet of things

The Internet of Things (IoT) is a technological paradigm that acts as a bridge between the traditional items and internet so that they could take communication to another level. IoT has been very important in the transition to a more complex and effective digital society. (IoT) can be used in various industries, such as manufacturing healthcare agriculture and smart houses [6].

On the other hand, implementation of IoT technology has tremendous benefits in production and industrial sector. The sensors placed on things, to measure and collect the data go a long way in improving production activities as well other maintenance work. For example, sensors can be used on machinery to detect potential failures early, thereby reducing maintenance costs and enhancing overall performance levels [7]. The medical equipment available in the healthcare environment can be connected to an (IoT) network allowing real-time and remote tracking of patient health issues by physicians as well as patients. Additionally, Smart glucose meters are able to send readings into mobile applications that enable clinicians in analyzing the data and devising appropriate treatment protocols. Currently, smart homes have systems or appliances for remote control via smartphones or voice commands [8]. (IoT) involves the utilization of technologies such as lighting, air conditioning and security systems that can independently communicate according to user expectations thus improving energy efficiency while making life convenient.

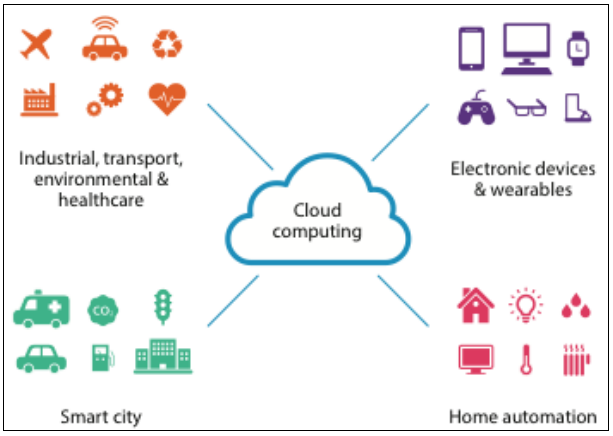

Fig 1: Integration of IoT and Cloud Computing

Machine Learning

ML is a sophisticated branch of artificial intelligence that utilizes algorithms and mathematical models to facilitate computer systems in acquiring knowledge from data and enhancing their performance automatically [9]. ML relies on comprehending models and manipulating data to make informed judgments or precise predictions through the analysis of patterns and correlations within the provided information. Thus, ML allows solutions to dynamically adjust to evolving surroundings and enhance their performance progressively.

This domain encompasses ideas such as artificial neural networks and deep learning, enabling computer systems to execute intricate tasks, such as categorization, prediction, and information extraction from data. However, ML is a rapidly advancing topic that has garnered the interest of researchers and experts across numerous sectors [10]. Furthermore, it plays a crucial role in enhancing efficiency and effectiveness in a wide range of applications. ML includes three main types Figure 2. Depending on the way the learning process is done and how the data is used, as below.

Supervised Learning

Supervised Machine Learning is a highly significant and extensively employed technique in the realm of artificial intelligence, whereby the model possesses the capability to scrutinize data and acquire knowledge from pre-existing instances [11]. This is achieved by supplying the model with a dataset, including anticipated input and outcome pairings. However, the process of supervisory machine learning commences by feeding the model with pre-existing data, which the model then analyzes to acquire a profound comprehension of the correlation between inputs and outputs Figure 3. The model can, after that, be employed to forecast outcomes for novel data that it was not trained on [12].

The primary benefit of supervisory machine learning is in the model's capacity to effectively handle the wide range and intricate nature of data

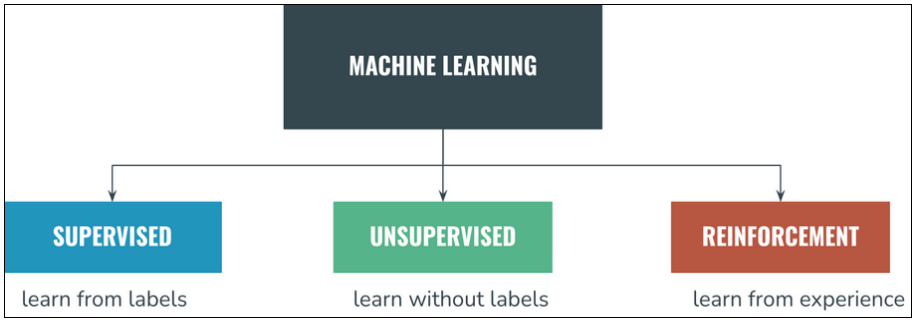

Fig 2: Main Types of Machine Learning

Such a mode of learning could be applied widely in various other domains such as email classification, visual identification and language understanding. However, there are challenges associated with the supervised machine learning process such as huge amounts of consistent data so that it guarantees optimal model performance [13]. To ensure correct results, one must enhance a comprehensive panel of decision takers and precise parameter settlement conducive in creating an efficient model. Supervisory machine-learning technology is therefore considered to be one of the important tools in this artificial intelligence. It provides a new insight to data processing and results in high-accurate predictions.

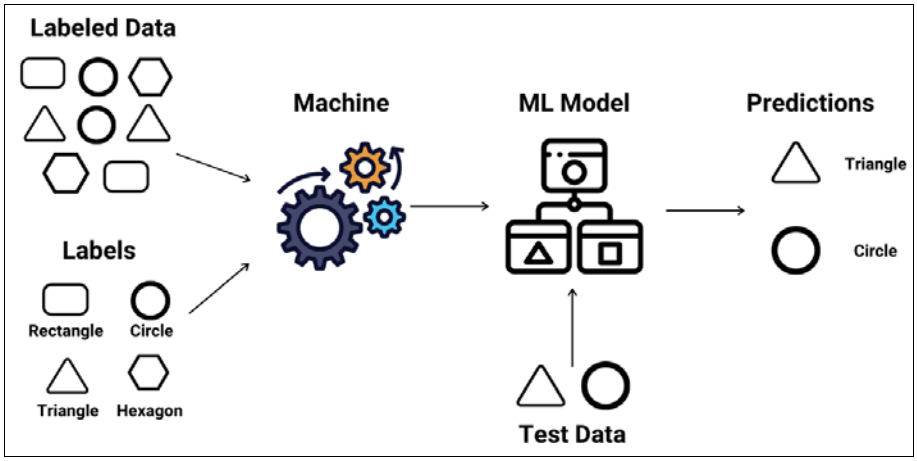

Fig 3: Supervised Learning

Unsupervised Learning

One of the major divisions in artificial intelligence is unsupervised machine learning, which describes analysis of input based on nondetermined output Figure 4. Unsupervised machine learning is a basic method for getting patterns and information containing inside the data.

In unsupervised machine learning, data clustering algorithms are used to cluster the data into subgroups based on their characteristics [14]. This helps to detect patterns and natural groupings within similar groups. Principal Components Analysis is used to reduce the dimensionality and identify major factors that show high variance in data. A well-known instance of the application unsupervised machine learning is found in image processing where these approaches may be utilized to study visual inputs and classify images with similarities [15].

Additionally, unsupervised machine learning method is applied to the study of text data in order to classify texts by topics or linguistic patterns used. On the other hand, unsupervised machine learning has great prospects in understanding data and drawing conclusions without any human's intervention. This feature allows for large-scale data analysis and improves efficiency on different applications.

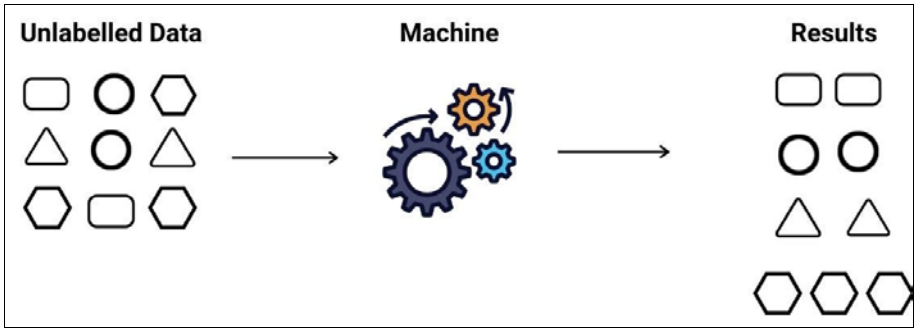

Fig 4: Unsupervised Learning

Reinforcement Learning

Reinforcement machine learning focus on how computers learn by interacting with their surrounding environment. This method has much in common with the way humans learn through direct experiences and are subsequently confronted by the consequences of those encounters. In this variant of machine learning, an algorithm acts as a being that learns through activities and later gets either reward or sanction. The interactive environment is crucial in improving the model's abilities. The agent interacts with the surrounding and endeavors to improve its performance by obtaining rewards while avoiding punishments [16]. For instance, in gaming applications, the model may represent an independent agent that develops capacity to make rational choices aimed at achieving a specific goal like winning a game.

Nevertheless, a built-in challenge in reinforcement machine learning is how the need to devise an effective reward framework that forces the model into making appropriate choices and meeting its objectives. Moreover, there exists a balance between discovery of new opportunities and use of expertise that has been gained. As an advanced field of study, reinforcement machine learning possesses huge potential in improving computer systems applied to areas like gaming, robotics and industrial process control.

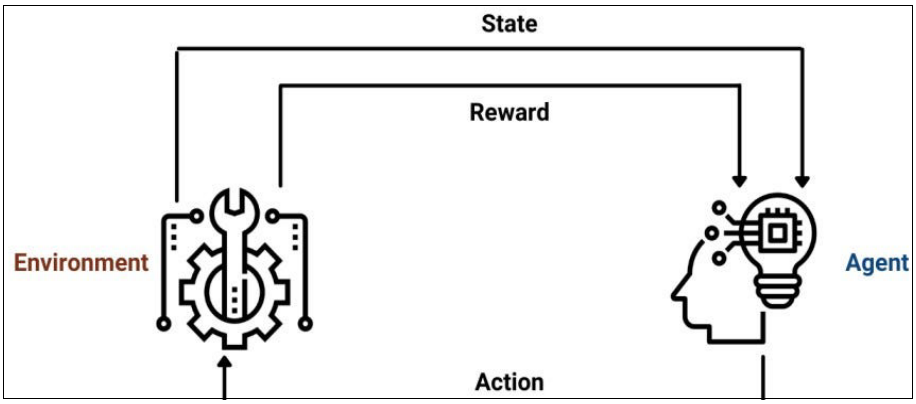

Fig 5: Reinforcement Learning

Literature search strategy

The search strategy used for this review has been drawn from established academic frameworks. The overall aim was to focus on a widespread collection of literature associated with the application of machine learning in IoT and its different settings during these last eight years. A systematic review of academic databases including Science Direct, Google Scholar, IEEE Xplore and Scopus was conducted to ensure inclusion of sources outside the traditional boundaries seen in a typical academic domain.

The search terms included several variations of "machine learning", "Internet of Things", and keyword phrases related to cloud computing. Additionally, we used free text search terms such as "machine learning in the Internet of Things" and "machine learning in cloud computing," to identify papers which talked about topics that were closely related. Using this method, we were able to critically analyze the different features of machine learning techniques in IoT and cloud computing.

Machine learning algorithms in cloud computing and IOT

In this part, the machine learning algorithms in different fields of cloud computing and IoT are evaluated and compared by reviewing numerous previous works on these topics as well their prospects. The inspiring methods are analyzed and evaluated with the help of showing how accurate an algorithm's performance is, as well discussing goals that were supposed in applying algorithms.

Support Vector Machine in Cloud Computing and IoT

One of the most commonly used ML techniques is Support Vector Machine SVM which finds application in a number of areas such as classification, and statistics. This approach uses complicated learning mechanisms, which then classifies data into two distinct sets depending on support points in the domain. The effectiveness of SVM comes from the fact that it can handle non-linear data and understand complex correlation between points, making it an able tool for addressing issues present during categorization and analysis [17]. Proposed an intelligent transportation system that uses IOT and cloud computing technology. The main objective of the proposed research is aimed at developing a sophisticated transportation system that precisely identifies accidents within an (IoT) infrastructure. SVM algorithm is used for the identification of accidents in traffic systems. To improve the prediction of seven categories of traffic accidents by (SVM), an ant colony algorithm is applied. This method is assessed through experiments using real traffic data. The data analysis was performed using MATLAB, and the prediction accuracy level was approximately 95%. Security is one of the biggest concerns in cloud computing, where DoS attacks are common threats [18] suggests an evaluation of the SVM algorithm's efficiency in forming a classification model for DoS attacks detection. The main objective of this work is to present the highly efficient model for detecting and mitigating DoS attacks in cloud computing. But this model uses (SVM) technique to protect the cloud architecture from malicious attack. The experimental results showed a significant increase in the detection of Denial of Service (DoS) attacks, achieving an error-free accuracy percentage at 100%. The security of networks is one of the most important issues in any application. Thus, the hiding of application traffic as HTTP and in particular HTTPS protocols produces various issues around data origins. Thus, [19] has provided the SVM-based internet traffic identification and classification (STIC) approach to detect application traffic in SDN. The STIC approach was used in this study to determine the traffic generated by 28 applications, including Facebook and

YouTube. The SVM-based STIC system employs VLAN to identify network packets while scanning various applications so redirecting traffic by simultaneously enhancing the security of networks. The results show that the classification accuracy and detection of quality will be about 99% and 42.78%, respectively. Use of IoT and cloud computing in the smart healthcare system is becoming increasingly important [20] proposes an SVM and PSO approach. The study shows how (SVM) was used to diagnose GDM disorders. Using the PSO method, (SVM) is optimized. This proposed a health monitoring system based on an IoT and cloud computing frameworks for gathering medical data in remote locations by using the efficient SVM algorithm. The proposed research seeks to establish an intelligent health monitoring system that will enable the caregiver of patients get alerted promptly during emergencies. For patients, a cloud server holds securely important data retrieved from sensors such as temperature and cardiac readings. The SVM is used to analyze the data in detecting any unusual situation. The mobile app alerts the caregiver and nearest medical facility through a notification.

Artificial Neural Network in Cloud Computing and IoT

ANN, or artificial neural networks, refer to one family of machine learning technologies that models the brain structure and operating mechanism for understanding things as well making new ones. This method relies on a system of intertwined processor units (nodes-neurons) that receive training based on data with the purpose to identify patterns and choose. ANNs have the ability to process non-linear data and adapt with any changes in their environment making them most effective tools for pattern analysis and prediction, including ML domain but also natural language processing or image classification. The integration of IoT and cloud computing into the healthcare system has significantly improved several aspects of health care applications. The big data management problem is one of the most important challenges that can be successfully solved with cloud computing technology [21]. Suggests a unique approach to evaluate and diagnose diabetes. The study presents a new approach called the Fuzzy Rule-based Neural Classifier for identifying and assessing the grade of such condition. The (IoT) has attracted much interest in the field of smart farming [22] comes out a prediction layout which generates non-linear synthesis of IoT and ANN algorithms. The proposed method gathers the data from WSN and processes it with ANNs. The trained (ANN) correctly estimates data on distance and power consumption. ANN prediction accuracy is higher in comparison with other previous models based on WSN-IoT. Concerning threat analysis, [23] discusses the use of IoT-cloud computing technologies. The paper analyzes the threat analysis in IoT systems by using a supervised (ANN) to identify and counter possible hazards. The technique is trained with the help of internet packet traces to identify (DDoS/ DoS) attacks. A (ANN) is used for classifying the packets as normal or adversarial in network, eliminating any data packet which might be malicious to ensure security of a given IoT networks. The findings show a 99.4% detection accuracy for detecting DDoS/Dos attack patterns cardiovascular disease detection using (ANN) is proposed by [24]. The author conducts a complex analysis of decision-making (ANN) algorithms for the detection of heart disease. This is done by using sensor- collected data.

Convolutional Neural Network in Cloud Computing and IoT

CNN is a cutting-edge technique in the domains of machine learning and computer vision which its technique is specifically tailored to process data with intricate structures, such as photos and videos. CNN utilizes neural filtering layers and deep learning techniques to efficiently extract and analyze visual features. This makes it highly effective in areas like image recognition and automatic classification, and it significantly contributes to the progress of image processing methodologies as well as comprehending visual content [25]. Investigates the utilization of (CNN) for assessing the efficacy of phone recognition. The CNN model was employed for voice recognition due to its adaptability in managing a vast vocabulary, which is facilitated by the utilization of several layers of convolution [26] offers a concise overview of the utilization of CNN in facial recognition. An analysis is conducted on CNN with regard to the forward process and backpropagation. CNN is utilized to assess the displacement of images, their invariance, and the identification of picture features. The suggested research utilizes parallel computing on CNN to optimize the face recognition process [27] proposes the possibility of utilizing the CNN algorithm for the diagnosis of lung cancer. The study outlines the development and execution of a (CNN) and compares its findings with those of a traditional computer-aided diagnosis (CADx) system. CNN facilitates autonomous learning by using past experiences. The results demonstrated a 79% improvement in comparison to the CADx system [28] discusses a sophisticated method for identifying different cardiovascular disorders such as myocardial infarction (MI). The suggested methodology employs a (CNN) algorithm to automatically diagnose Myocardial Infarction (MI) by analyzing Electrocardiogram (ECG) signals. Then the results of normal heartbeats and ECG beats were classified based on CNN which indicated that proposed CNN attained 93.53% and 95.22% accuracy (With noise & without noises). The utilization of CNNs in real-time settings, such as automobile and lane detection is shown. The future research is focused on training a (CNN) to detect objects and predict the depth of roads based with 17, 00 picture frames. The study results demonstrate high performance of the proposed model in classifying vehicles, lanes and deep learning-based smart power generating systems.

Recurrent Neural Network in Cloud Computing and IoT

RNNs is a mathematical solution within ML that operates on sequential inputs. They demonstrate specific capacity of dealing with context and adapt to temporal dynamics. Unlike LSTMs, RNNs use their internal memory to update variables that are a part of the sequence. This is why they can be applied to tasks such as speech analysis and time series prediction. RNNs have also significantly improved other fields such as language translation and deep learning. The application of (RNN) for controlling HVAC systems is presented in [30]. The proposed article seeks to develop an intelligent controller which involves IoT and cloud computing. The (RNN) is used to predict the number of inhabitants and their desired settings for HVAC systems from using the PMV method. Analyzing the advanced intelligent controller in terms of heating, ventilation and cooling it obtained a 92.48% accuracy on occupancy with minimal error at just 3.1%. The problem of addressing large

amounts data increases as the use of IoT continues to increase in popularity [29] suggests the use of RNN in data analytics to manage huge amount of information. RNN is mostly used for feature extraction from previous data. The temporal arrangement of stored data allows (RNNs) to effectively process large and dispersed datasets, leading to superior performance compared to other deep learning techniques [32] proposes the utilization of RNN for identifying malware risks. The study demonstrates the utilization of (RNN) for the purpose of identifying malicious software in an Internet of Things (IoT) environment that is based on the ARM architecture. The efficacy of the generated model is assessed using Long Short-Term Memory (LSTM) configurations, and the findings demonstrate a 98% accuracy when compared to other methods of deep learning outlined in the paper. Pattern identification in heterogeneous IoT is a formidable challenge due to its reliance on several parameters. The authors of [31] suggest a collaborative model utilizing RNN to select the appropriate model without training the edge sides. The proposed method identifies the most suitable model by using privacy concerns with edge computing. A 94% increase was observed in the total accuracy. Detection of spam in social media proves to be an uphill task because the amount of data processed is very huge.

Ensemble Learning in Cloud Computing and IoT

Ensemble Learning is an elaborate method that integrates several algorithms to improve the accuracy of prediction models. This approach is based on combining different resolutions from separate models and this increases the accuracy and robustness. As a result, it enhances the system's predictive capabilities and its overall effectiveness [34] suggests a semi-supervised method for spam detection. The recommended method uses an ensemble learning approach for spam detection in which Probabilistic Data Structures (PDS) is used to improve the accuracy of spam classification. The findings show a significant enhancement in the performance of spam recognition with an ensemble learning technique. The results indicate a significant enhancement in the efficacy of spam detection by the utilization of an ensemble learning approach [34] proposed an edge-computing architecture that use the health fog technique to include ensemble deep learning into edge-computing devices. The objective of this framework is to mechanize the examination of heart diseases. When applied, the recommended method achieves a remarkable accuracy of 95%, exceeding the prediction accuracy of existing deep-learning algorithms [35] presented a highly effective ensemble classifier for precise prediction and diagnosis of chronic illnesses, such as cancer, diabetes, and other similar conditions. The authors in their implementation uses the Random Forest algorithm that is a classification method based on decision trees for data analysis and disease prediction. Additionally, it uses IoT technology for monitoring the system in people with strokes. The studies showcase 93% accuracy of the predictions concerning illness occurrences, with ensemble classifiers being relatively more effective than other methods.

Table 1 is the summary of applications for a set of machine learning algorithms and their performances in diverse cloud environment.

Table 1: Summary of Machine Learning Algorithm Applications in Various Cloud Computing and IoT Environments

Ref	ML Algorithm	Objective	Results	Application	Future scopes
[17]	SVM based ACA	accident detection/ prediction	predicting possible accidents accuracy was 95%	Intelligent transport systems	Employing the SVM-ACA model to investigate diverse challenges.
[26]	CNN	Speeding up parallel computing	computational speed was 99%	Face recognition	CNN has a high degree of parallelism at a coarse-grained level. Various deep-learning algorithms can be investigated to achieve precise and detailed parallelism.
[30]	RNN	controlling HVAC systems	92.48% of occupancy accuracy	Heating, ventilation, and air conditioning systems	RNN may be utilized to estimate the power consumption of sensors within the IoT context.
[18]	SVM with Tshark and GA	Security improvement by detecting DoS attacks.	100% classification accuracy of DoS attacks	DoS attacks detection	The application of the SVM-GA-based approach is suitable for identifying many notable malware assaults in the cloud environment.
[19]	SVM-based STIC method	Enhancing security rate in multiple applications in Network traffic	99% Classification accuracy and 92.78% quality determining accuracy.	Network traffic development	The utilization of a probability-based Bayesian classification algorithm and tree-based decision tree algorithm can enhance the efficacy of the security of network procedures.
[20]	SVM based PSO	Healthcare monitoring in IoT domains	accuracy 95% accuracy of disease prediction	Healthcare applications	Implementing cryptographic techniques to enhance the privacy of information in healthcare applications
[32]	RNN	Security enhancement in IoT domains	98% accuracy of malware detection	Malware detection	The suggested methodology has the potential to be expanded for real-time detection of cyber threats.
[31]	RNN	Security enhancement Edge computation	94% accuracy of model detection	Edge computing	This approach utilized to detect data patterns in situations when anomalous signal production occurs.
[34]	Ensemble deep learning	Improving an analytical automated model for heart diseases	95% accuracy in heart disease prediction	Heart diseases detection	Incorporate further deep learning methods with ensemble techniques in order to create a very effective health surveillance platform.

[35]	Ensemble deep learning	Monitoring system for stroke patients in an IoT environment	accuracy of 93% in predicting the diseases	Medical monitoring system	Application of optimal ensemble method for disease detection analysis.

Machine learning Limitations In Cloud Computing and IoT: Due to the tremendous progress and continuous development that occurs on a daily basis in cloud computing and IoT. In addition, the huge amount of structurally and source-different data is transmitted through these two fields. There must be various challenges facing machine learning algorithms to analyze such data that depend on the algorithm's working mechanism and the tasks assigned to it. Table 2 includes research that highlighted the various challenges facing the selected algorithms.

Table 2: Various Machine learning Limitations In Cloud Computing and IoT

Ref.	ML Algorithm	limitation	Domain	Description
[36]	SVM	Scalability	Cloud Computing	SVM implementations may have difficulty handling large datasets, which reduces their scalability in a cloud computing environment.
[37]	SVM	Model complexity	IoT	The heterogeneous dataset in IoT may need very complex classification models. Modifying and configuring SVM models to achieve this complexity can be a challenge.
[38]	ANN	Connection delay	Cloud Computing	Users may experience delays in data transfer between servers and cloud models, affecting the performance of the neural network system.
[39]	ANN	Resource constraints	IoT	Processing power and memory in smart sensors and connected devices. The need to improve the energy efficiency of integrating neural models with power-constrained IoT devices.
[40]	CNN	Resource Costs	Cloud Computing	Running CNN models in cloud computing involves high resource costs, as users have to pay additional costs for computing resources and data storage
[41]	CNN	Moving from the traditional form of the network	IoT	Some of the CNN designs may not fit well in IoT environment where some new model can be designed that takes into account with IoT constraints.
[42]	RNN	Computational requirements	Cloud Computing	Computational costs of RNNs rise in tandem with growing volumes of data and model complexity. You may require a massive amount of computing resources, which could be problematic in cloud environments that might be limited.
[43]	RNN	Long-Term Dependencies	IoT	The behavior of RNNs is determined by their difficulty in handling long-distance temporal relationships, for models find it hard to remember information over a longer time span. This suggests that they shall have difficulties interpreting object behavior in a long-term view.

Conclusions

This paper analyzes the effect that machine learning and deep learning have on cloud computing and IoT. The major aim is to critically examine the impacts of using Support Vector Machine (SVM) and Artificial Neural Network (ANN) models from a machine learning standpoint, while also evaluating how Convolutional Neural Network model interacts with Recurrent neural Network (RNN), considers Ensemble learning models about cloud computing and IoT technologies. The study is an in-depth analysis of how well each model has performed with various issues being addressed as the models for algorithms discussed above are compared. In addition, the paper discusses the future scalability and accuracy of these models in cloud computing and IoT domains.

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