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Integration of Machine Learning with Fog Computing for Health Care Systems Challenges And Issues: A Review

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Abstract

Fog computing, a distributed cloud computing model, extends the traditional cloud paradigm to the network's edge, reducing latency and alleviating congestion. It addresses challenges in classical cloud architectures exacerbated by real-time IoT applications, which produce massive amounts of data that traditional cloud computing struggles to process due to limited bandwidth and high propagation delays. Fog computing is crucial in latency-sensitive applications like health monitoring and surveillance, where it processes vast volumes of data, minimizing delays and boosting performance. This technology brings computation, storage, monitoring, and services closer to the end-user, enhancing real-time decision-making capabilities. This paper presents the challenges of IoT applications. It also demonstrates the role of two emerging technologies fog computing and machine learning in health care scenarios.

A. Introduction

The Internet of Things (IoT) is one of the prominence innovations and is considered the future of the internet. It provides complete services to our society to share information and improve the quality of our daily lives. Besides, the IoT moves towards a stage that connects almost everything to everything, such as traditional tools, sensors, actuators, cameras, cars, appliances, and everyday objects used in various domains, such as healthcare, airports, and transportation. Allowing these things to communicate with each other with the minimum human intervention [1][2].

At present, Cloud computing provides several advantages in the term of accessibility, scalability, and pay-per-use features. It also gives us different types of services, such as Platform as a Service(Paas), software as a Service (SaaS), and Infrastructure as a Service(IaaS) [3]. However, IoT integration to cloud computing poses several challenges to the centralized cloud computing paradigm, such as high latency-time, increase bandwidth, and security [4]. So, these IoT devices generate high volumes of data (coming out of IoT sensors and devices) that cannot be processed and moved to by the cloud [5][6].

The cloud is currently used by many healthcare applications to store, process, and retrieve extensive healthcare data generated from IoT devices [7]. Thus, the Internet of Things Healthcare involves many wearable devices and interconnected computers, such as mobile health and remote monitoring of patients with different diseases such as cardiac disease, blood pressure, diabetes, and other chronic diseases [8]. The high amount of IoT data is transferred over servers, allowing servers to overload with high traffic and causing network congestion. Moreover, many healthcare monitoring applications need real-time data analysis, process data, and feedback in a millisecond [9]. The delay caused by sending and executing cloud tasks and then returning the cloud response to the application is very high. So, in healthcare, a little delay could cost the life of a patient [10]. Challenges occur in transmitting real-time healthcare data to end-users from the cloud. These concerns include high computational latency and increased network bandwidth. IoT is not able to send data to end-users in real-time due to these problems [11].

Fog computing can play a critical role in decreasing high traffic and high delay. It can be an excellent solution to improve system performance. Different goals achieve via fog computing, such as enhancing most IoT applications' performance, faster response with sensitive real-time IoT devices with the lowest-delay, and reducing the data size needed to be transported to the cloud [12][13].

Machine learning algorithms also have an essential role in analyzing big data from healthcare services. Therefore, many machine learning methods have been used to classify disease diagnosis or prediction [14]. This paper presents the literature review to underline the role of machine learning methods and fog computing in the healthcare sector [15].

The remainder of this review article is structured as follows. Section II presents a background on the prominent technologies used. Section III shows the role of fog computing and machine learning in the reviewed articles. Section IV discusses the result of the reviewed articles underlined in this paper. Finally, section V presents the conclusion.

B. Background Information

This section concisely discusses the technologies used in his work. It helps you to understand the rest of the paper better.

1. Cloud of Things Challenges

Cloud computing provides many advantages to the client, including pay-per-use scalability, and accessibility features. It is focused on centralization that has massive processing capacity and storage capacities [16][17].

Cloud computing delivers “Everything” as a service. User access can access the application over the internet, known as software as a service and software that can use the cloud’s virtualized tools and services. Examples of infrastructure as a service include A, Amazon Web Services (AWS), Google AppEngine, Aneka, and Microsoft Azure [18][19]. So. New IT business models, such as on-demand, pay-as-you-go and utility computing are made possible by cloud service models.

The cloud computing model aims to improve client devices’ capabilities and capacity by accessing software applications and leased infrastructure instead of owning them. A new way of communication and collaboration and the unique kind of information and services and has been introduced by Cloud Computing [18][20].

Cloud computing currently needs to become a reliable platform for healthcare IoT applications. It is used to store, process, and analyze healthcare data produced by IoT devices [21]. Networked healthcare aims to facilitate healthcare services anytime and anywhere globally, irrespective of patients’ location and mobility. Mobile cloud computing could accomplish future healthcare requirements by allowing healthcare services and data processing to be delivered anytime, anywhere [22][23]. However, the current cloud fails to meet the need for network latency, bandwidth.

Furthermore, IoT applications where Internet connectivity is weak or operations are time-sensitive, centralized cloud architecture is not suitable. For instance, there are many situations where a little delay could cost a patient’s life inpatient care [24].

The emerging IoT brings numerous new issues that cannot be effectively solved by today’s cloud. Several fundamental challenges of IoT are described as follows [25][26].

- **Latency Constraints:** Many IoT applications, such as real-time healthcare applications, often require latencies below less than a second between the fog node and the sensor.
- **Network Bandwidth Constraints:** IoT healthcare devices generating a vast amount of data, transfer all the data to the cloud, and respond from the cloud will need high bandwidth.
- **Resource-Constrained Devices:** There will be severely restricted resources for many IoT devices. Examples include data collectors, controls, actuators medical devices,and Sensors are some examples. To

meet all their computing needs, many resource-restricted devices will not depend exclusively on their limited resources.

- **IoT Security Challenges:** The security issues will arise while the number of connected IOT devices increases. It will become difficult to keep and manage security software on the devices up to date and security credentials.

2. Fog Computing

Fog Computing has been defined as an extension of the classical cloud to edge network [12]. Using fog computing aims to process the time-sensitive application to the edge (close the end device). At the same time, other services can be achieved over the cloud. Issues related to security, latency, location awareness, and several other problems are resolved using fog-computing infrastructure [27][28]. Thus, fog can reduce the volume of data sent to the cloud and reduce IoT applications' response time. Data reduction over the cloud helps enhance the Quality of Service (QoS), reducing latency and increasing network bandwidth [29]. Furthermore, Fog computing is vital for applications requiring real-time data for their operations and very low latency [30].

Fog computing provides many advantages over the cloud in the respective of healthcare services:

- Data were stored and processed locally instead of transmitted into the cloud; this resulted in a decreased volume of data sent to data centers and reduced overall costs [4].
- Latency will be decreased while processing data will perform locally in the fog node during transmission, which is beneficial for lowering delay in time-sensitive applications [12].
- Delivering a better privacy service to the users, as patients' data can be processed locally rather than moving them to the cloud. This benefit of fog computing can dramatically increase the confidentiality and security of medical data [12].
- Fog servers require low bandwidth for communication and real-time data available to doctors without internet connectivity [31].

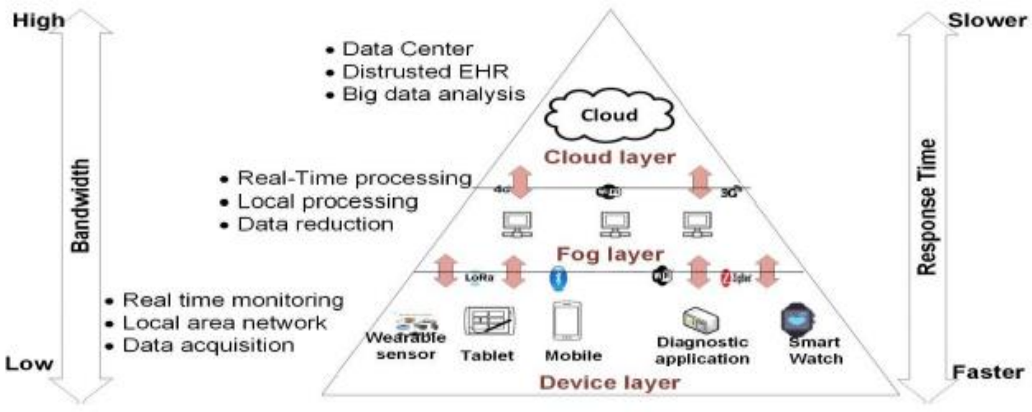

Figure 1. Fog computing in remote monitoring systems [12].

3. Role of Machine Learning in Health Care

Machine learning methods have an essential role in big data analysis [32]. Different data types, including clinical data, sensor data, Omics data, etc., have been viewed in the healthcare sector. So, the processing of it became impossible for humans. Consequently, ML offers a technique for detecting large data patterns and algorithms to predict patients' possible results [14].

Machine learning algorithms are divided into three main categories, which include the following:

1. **Supervised learning:** methods are classified as supervised learning while they need labeled data in their learning stage. Examples of supervised machine learning methods commonly used for healthcare applications are Support Vector Machine, Naive Bayes, Random, Logistic Regression, Forest, Artificial Neural Networks, etc [33][34].
2. **Unsupervised Learning:** Algorithms that do not need labeled data in their training phase. The outcome can not be categorized as yes/no by these algorithms but can be grouped into classes. Some examples of unsupervised ML algorithms frequently used for healthcare applications include K-Nearest Neighbor, K-means clustering, Principal Component Analysis, etc [33].

   3. Reinforcement Learning: Algorithms that develop a system that enhances its efficiency by taking environmental feedback and taking initiatives to strengthen it. It is an act of learning from the environment by engaging with it without human support [14][35].

C. Integration of Machine Learning With Fog Computing in The Healthcare Systems

This section reviews literatures that discusses the convergence of machine learning with fog computing to enhance the efficiency of IoT healthcare applications concerning computation, bandwidth, network latency, and security. Machine learning methods such as Support Vector Machines (SVM) and Convolutional Neural Networks (CNN) have been particularly effective. These methods are utilized to classify and analyze data directly at the edge of the network, addressing applications in disease identification, image recognition, and traffic engineering.

Security and Privacy: A number of studies have highlighted the security enhancements that fog computing brings to IoT, particularly in safeguarding patient data. By processing data locally, fog computing minimizes the exposure of sensitive information, mitigating privacy risks associated with centralized cloud storage [36].

Handling High Network Latency and Bandwidth Constraints: Fog computing significantly reduces the need for high bandwidth and addresses latency issues by performing data processing tasks closer to the data source. This proximity allows for quicker response times and more efficient handling of large data volumes, critical in healthcare settings [37].

Data Volume Reduction: By processing data locally in fog nodes, the volume of data that needs to be sent to the cloud is drastically reduced. This not only conserves bandwidth but also enhances the speed of data analysis and decision-making processes.

Real-Time Disease Detection: The integration of fog computing with machine learning enables real-time disease detection with low latency, which is vital for continuous remote monitoring of patients with acute conditions such as cardiovascular diseases. Early detection is crucial in reducing mortality rates and cutting down healthcare costs associated with chronic illnesses [38][39].

D. Related Works

Kumar et. al. in (2019)[40], proposed a Privacy-Aware Disease Prediction Support System. It presented a key agreement protocol based on bilinear pairing cryptography to secure users' sensitive information through fog computing. The combinatorial benefits of two distinct approaches, such as the Fuzzy k-nearest neighbor (FKNN –CBR) classifier and case-based reasoning classifier, can generate improved classification outcomes with enhanced accuracy and create better results for prediction. Diverse classification techniques were used to classify healthy individual and liver disorder patients such as Single Layer Neural Network, Support Vector Machine, Naïve Bayesian and FKNN –CBR. The FKNN –CBR model reached high accuracy was 96.74% compared to other methods, which was 91.67%, 93.88%, and 96.13%. The proposed prediction model's efficiency and performance are evaluated and conducted on the Indian Liver Patient dataset.

Liu et. al. in (2019)[41], proposed a framework for a hybrid privacy-preserving clinical decision support system, called HPCS. The proposed approach can be used to monitor health status and disease prediction. Fog server uses a data mining method to facilitate the secure monitoring of patients' health condition in real-time. They also used advanced differential privacy approaches for achieving better privacy protection that can provide data immunity against vulnerabilities. This study uses a Single-Layer Neural Network (SLNN)) to process and monitor health with good privacy-protection of patients in real-time. It also uses a Multiple-Layer Neural Network (MLNN) in the cloud) to identify the disease with high-accuracy. The model was evaluated based on the Breast Cancer Data Set.

Bagula et. al. in (2019)[42], proposed the Cyber-Healthcare framework Low Income Areas of the Developing World, which can define the patient's medical status recognition based on vital signs of human beings to achieve patient treatment prioritization. Single hidden layer neural network (SNN), deep neural network (DNN), multi-variate linear regression (MLiR), and multi-variate logistic regression (MLoR) algorithms were used in this work to complete patient's prioritization.

Shukla et. al. in (2019)[7], proposed. An analytical model of 3-tier fog computing architecture to overcome the drawback of high network latency and bandwidth issues in the healthcare. This enhancing fog computing architecture can minimize the total network latency by using reinforcement learning and fuzzy logic algorithms.

Muhammed et. al. in (2019)[43], proposed a ubiquitous healthcare framework, called UbeHealth, to solve latency, bandwidth networking issues. The proposed framework was also improving network quality of service by using three different components. Big data and HPC technologies used DLNTAP to predict network traffic to optimize data rates, routing decisions, and data caching in the future. The DLNTC component classified the traffic flow application protocols to allow UbeHealth to meet the application's better communication requirements to maintain a high quality of services and perceive malicious traffic and irregular information. In contrast to conventional cloud-based networked healthcare systems, the proposed method has reduced latency by 50 %. In this study, two types of Deep Learning algorithms were used, which are (MLP) Recurrent Neural Network and (RNN)Multi-Layer Perceptron

El-rashidy et. al. in (2019)[12], proposed a framework to control a person with COVID-19 in real-time; doctors can monitor patients' correct decisions. The recommended framework contains three layers: a patient layer, a cloud layer, and a hospital layer. In the patient layer, the patient is tracked through wearable sensors and a mobile app. Data transmission and storage issues were solved in a fog network architecture and the cloud layer. The detection process is done base on neural network-based deep learning.

Moreira et. al. in (2019)[44], proposed a machine learning technique named average one-dependence estimators. This technique is used to analyze pregnancy data in real-time, which comes from IoT devices and gateways. This procedure is beneficial for decentralized pre-processing of data at the edge of the network instead of transferring a massive amount of data to the cloud.

Azimi et. al. in (2019)[45], proposed approach provides real-time and continuous patient monitoring, prediction, and alerts in emergency cases for many patients hurting from acute diseases such as different heart conditions.

Azimi et. al. in (2019)[46], proposed a hierarchical architecture for Healthcare IoT called Hierarchical Fog-Assisted Computing (HiCH) for IoT-based health monitoring systems to combine the advantages of cloud computing and fog and paradigms. This study had two significant contributions. Hierarchical computing architecture was mainly a contribution for partitioning and executing machine learning data analytics. The second contribution was a closed-loop management technique permitted by autonomic system adjustment concerning the patient's situation. The suggested framework benefits from cloud computing and fog features and announces a tailored management approach for healthcare IoT systems. It demonstrated the efficacy of the recommended framework via a comprehensive performance and achieved 0,936% accuracy. Assessment and evaluation performance was focused on arrhythmia identification for patients with CardioVascular Diseases.

Sarabia et. al. in (2019)[47], presented a novel system based on cloud computing and fog technologies to combine big data and IoT platforms. It provides new opportunities to detect sleep apnea diagnoses, usually suffers from the elderly in real-time. This system is built based on the two machine learning includes linear regression and logistic regression and.

Devarajan et. al. in (2019)[32], a fog-assisted intelligent system is proposed to detect and control Parkinson's disease at an early phase. The proposed approach employs a combinatorial advantage of case-based reasoning classifier. Fuzzy k-nearest neighbor is to classify Parkinson patients from healthy individuals. The proposed model's efficiency and performance are experimentally assessed on the UCI-Parkinson dataset and 94.87% classification accuracy.

Vijayakumar et. al. in (2019)[48], also proposed a fog-based intelligent system to detect and control mosquito-borne diseases at the early stage. Use the fuzzy k-nearest neighbor machine learning technique to differentiate the various mosquito-borne illnesses based on the patient's symptoms. The proposed FKNN model produces high classification accuracy of 95.9%.

Scire et. al. in (2019)[49], implemented a framework based on wearable devices for automated heartbeat identification and arrhythmia classification. In the MIT-BIH arrhythmia database, we assessed the end-to-end approach's ability to define heartbeats and their category into four groups: regular beats, VEBs, SVEBs, and fusion of normal and VEBs. The resulting device achieves an accuracy of 0.987 on identifying heartbeats and an accuracy of 0.805 on arrhythmia classification. These findings indicate the available computational power at the edges of The network can be used to produce outcomes similar to state-of-the-art techniques while significantly enhancing the overall use of the network at the same time.

Borthakue et. al. in (2019)[50], recommended to use fewer resource machine learning on Fog devices kept close to the wearable for mart healthcare. It also proposed a Fog Computing architecture for identifying patterns in pathological speech data acquired from patients with Parkinson's disease (PD) using unsupervised K-means clustering. The proposed Smart-Fog architecture may be useful for health conditions such as speech disabilities and speech disorders.

Farahani et. al. in (2019)[51], explored the integration of machine learning (ML) and Internet of Things (IoT) to enhance healthcare. It proposes a novel architecture that processes medical data across IoT devices, edge computing, and cloud platforms to reduce latency and increase efficiency. The paper emphasizes the concept of collaborative intelligence, where distributed machine learning optimizes resources and personalizes treatment. A case study on ECG-based arrhythmia detection demonstrates the architecture's effectiveness, achieving high accuracy in real-time medical monitoring. The authors argue that this integrated approach can transform traditional healthcare into a more responsive, patient-centered system. Overall, the article highlights a significant shift towards technologically advanced, personalized healthcare solutions enabled by the synergy of IoT and machine learning.

Tuli et. al. in (2019)[52], introduced a framework that combines IoT, fog computing, and deep learning to improve heart disease diagnosis. By processing data close to its source, HealthFog reduces latency and enhances accuracy with ensemble deep learning techniques. This integration showcases how advanced computing can revolutionize rapid and precise medical diagnostics.

Qaisar et. al. in (2019)[53], explored the integration of fog computing with deep learning to enhance machine health monitoring. It presents fog computing as a solution to overcome the limitations of cloud computing in handling the vast data from IoT devices, reducing latency, and enhancing real-time processing. By processing data locally at the network edge, this approach optimizes bandwidth, enhances data security, and ensures efficient, real-time machine health prognosis. This hybrid method marks a significant advancement in industrial IoT, offering a scalable solution for predictive maintenance.

Singh et. al. in (2020)[54], integrated Artificial Intelligence smart health framework and fog are presented to prevent and protect from COVID-19 infection at an early stage. The proposed approach predicts the COVID-19 condition by observing their signs and creating an emergency alert and medical reports to the user and doctors/experts. The system could process the health data of users' in real-time with very low latency. For detecting and enhancing the accuracy of COVID-19 prediction, The advantages of three machine learning techniques are combined: Naive Baye's (NB), Random Forest, and Generative adversarial networks. In the proposed ensemble-based classifier, a recall value of 0.93 and an F - Measure of 0.871 is accomplished.

Tuli et. al. in (2020)[55], developed a system called HealthFog. It uses to an automatic heart patient for the data diagnosis system. Edge devices built up the system and deployed it as a real-life application for monitoring Heart Disease patients. So It provides healthcare as a fog service that requires very high compute resources and minimum accuracy.

Yasser et. al. in (2020)[29], a new proposed COVID-X platform was developed as a universal Health-Fog system for automated diagnosis, care, and prevention of people with COVID-19 using deep learning. As a fog service, Health-Fog provides healthcare and manages the data of COVID-19 patients coming from various IoT devices effectively.

Ijaz et. al. in (2020)[56], explored the integration of fog computing with wearable health technologies to enhance data processing and reduce latency. The article advocates for a tri-fog health architecture that utilizes advanced machine learning algorithms to improve real-time health monitoring and emergency responses. By analyzing data closer to the source and efficiently managing erroneous and duplicate data, the proposed system demonstrates significant improvements in the speed and accuracy of health status detection. This approach represents a pivotal enhancement in the use of IoT for smart healthcare applications.

Kishor et. al. in (2021)[57], explored the use of fog computing to reduce latency in healthcare systems. By processing data closer to its source, the proposed system demonstrates substantial improvements in speed and efficiency through the use of a k-fold random forest algorithm. The findings highlight fog computing's potential to enhance real-time health monitoring and emergency response services.

Priya et. al. in (2021)[58], explored the integration of fog computing and Artificial Neural Networks (ANN) to enhance asthma monitoring and prediction. The proposed system utilizes IoT devices for real-time data collection, processed by fog computing for quick response, and analyzed using ANNs to predict asthma attacks with an accuracy of 86%. This technological integration aims to reduce emergency incidents and hospitalizations, marking a significant advancement in real-time healthcare monitoring and patient care management. The paper demonstrates the potential of combining fog computing and machine learning to improve outcomes in chronic disease management.

Bhatia et. al. in (2022)[59], presented an innovative approach using IoT, fog computing, and cloud technologies to enhance encephalitis monitoring and prevention. The authors propose a Tri-logical IoT-Fog-Cloud (TIFC) model that improves data accuracy and efficiency through real-time processing and analysis. Utilizing a Temporal-Recurrent Neural Network (T-RNN) combined with Self-Organized Mapping (SOM), the system forecasts and visualizes disease outbreaks geographically. Their findings demonstrate superior performance in accuracy and reliability compared to other models, emphasizing the system's capability to provide timely health decisions and alerts. This integration of advanced technologies illustrates a significant advancement in healthcare monitoring systems, highlighting its potential to reduce the public health impact of diseases like encephalitis.

Verma et. al. in (2022)[60], explored the integration of fog computing, IoT, and deep learning to enhance real-time healthcare monitoring and diagnosis, particularly for heart diseases. The research highlights how this integration reduces latency and increases data processing speed, crucial for timely medical interventions. The proposed FETCH system, evaluated through performance metrics like response time and accuracy, demonstrates significant improvements in predicting health conditions, showcasing a transformative approach to healthcare technology

Elhadad et. al. in (2022)[61], The article discusses the potential of fog computing to revolutionize healthcare monitoring systems by enhancing real-time data processing and notification capabilities. It emphasizes that by decentralizing data processing to fog nodes closer to data sources, healthcare systems can achieve significantly reduced response times and enhanced data security—key factors in critical healthcare scenarios. This method addresses the inherent limitations of cloud computing, such as high latency and bandwidth constraints, which can be detrimental in emergency medical situations. The proposed fog computing framework ensures that healthcare providers can deliver timely and efficient care, improving overall patient outcomes. By demonstrating practical implementations and benefits, the article advocates for a shift towards more agile and responsive healthcare technologies, suggesting that fog computing could be a cornerstone in the next generation of healthcare infrastructure, leading to more proactive and patient-centered care.

Table 1. Summary of Articles on Integrating Machine Learning with Fog Computing in Healthcare Systems, Highlighting Each Paper's Contribution by Publication Year

Reference	Research Problem & Fog Node Application	Pros.	Cons.	Primary ML Technique(s)	Outcome/Result
Kumar et. al. (2019)[40]	Disease prediction for liver, privacy protection	Hybrid Reasoning	System Complexity	Case-based Reasoning, Fuzzy k-NN	96.74%
Liu et. al. (2019)[41]	Breast cancer prediction, real-time health status tracking	Privacy Preservation	Data Dependency	SLNN, MLNN	97.4%
Bagula et. al. (2019)[42]	Real-time condition recognition with lightweight equipment	Comprehensive Evaluation	Domain Specificity	Multivariate Regression, DNN	-
Shukla et. al. 2019[7]	Minimize network latency in healthcare systems	Real-time Applicability	Technical Demands	FuzzyLogic, Reinforcement Learning	-
Muhammed et. al. (2019)[43]	Enhanced network quality for healthcare systems	Resource Efficiency	Complex Protocols	Deep Learning	-

El-rashidy et. al. (2019)[12]	Real-time COVID-19 patient monitoring	Hybrid Architecture	System Dependency	Deep Learning	97.95%
Moreiraet et. al. (2019)[44]	Real-time pregnancy data analysis	Real-time Processing	Computational Overhead	Averaged one-dependence estimators	-
Azimi et. al. (2019)[45]	Real-time patient monitoring for acute diseases	Privacy-Preserving	Technical Complexity	SVM, k-NN, Neural Networks	97%
Azimi et. al. (2019)[46]	Edge network data analytics for cardiovascular diseases	Secure Outsourcing	Data Sensitivity	Linear SVM	93.6%
Sarabia et. al. (2019)[47]	IoT data processing for real-time event detection (Sleep apnea)	Non-linear Functionality	Complex System Architecture	Logistic Regression, Linear Regression	-
Devarajan et. al. (2019)[32]	Early detection of Parkinson's disease	Innovative Framework	Deployment Complexity	Fuzzy k-NN, Case-based Reasoning	94.87%
Vijayakumar et. al. (2019)[48]	Early detection of mosquito-borne diseases	Scalable Design	High Technical Requirements	Fuzzy k-NN	95.9%
Scire et. al. (2019)[49]	Heartbeat detection and arrhythmia classification	Machine Learning Use	Data Privacy Issues	k-NN	98.7%
Borthakue et. al.	Parkinson's disease	Latency Reduction	Complex Architect	K-means Clustering	-

(2019)[50]	identificatio n		ure		
Farahani et. al. (2019)[51]	Patient-centric healthcare transformati on	Hybrid Techniques	Implemen tation Challenge s	CNN	96%
Tuli et. al. (2020)[55]	Heart disease diagnosis improvemen t	Real-time Capability	Security Concerns	Bagging classifier	95%
Qaisar et. al. (2019)[53]	Machine health prognosis in healthcare	Ubiquitous Access	Complex Setup	CNN, RNN	-
Singh et. al. (2020)[54]	COVID-19 infection prediction	Edge Computing	High Resource Need	Random Forest, Naive Bayes, GANs	Recall: 0.93, F: 0.871
Tuli et. al. (2020)[55]	Heart disease analysis in real-time healthcare	Deep Learning Use	Complex Integratio n	Deep Learning Framework	-
Yasser et. al. (2020)[29]	Early detection of COVID-19, progression monitoring	End-to-end Framework	Privacy Concerns	DCNNs	-
Ijaz et. al. (2020)[56]	Reduce latency in healthcare, decision-making	Low Computatio nal Cost	Limited Scope	RK-PCA, FaMOORA, 2L-2HMM	92%
Kishor et. al. (2021)[57]	Healthcare latency reduction, real-time analytics	High Accuracy	Dependen ce on Data	k-fold Random Forest, IMDS	92%
Priya et. al. (2021)[58]	Asthma prediction accuracy	Hierarchical Architectur	Complex Deployme	ANN, BPNN	86%

	improvemen t	e	nt		
Bhatia et. al. (2022)[59]	Encephalitis outbreak monitoring, decision support	Autonomy in Managemen t	Dependen cy on Infrastruc ture	T-RNN, SOM	-
Verma et. al. (2022)[60]	Reduce latency and inefficiency in healthcare	Fog and Cloud Benefits	Potential Privacy Issues	Random Forests, Gradient Boosting	-
Elhadad et. al. (2022)[61]	Immediate notification handling in healthcare monitoring	Local Computing	Complex Setup	Algorithmic Pattern Recognition	-

E. Discussion

This study has shown that fog computing has been successfully deployed in the healthcare system. Fog computing had a crucial role in solving privacy, low latency, network bandwidth and security problems in the health care domain, as shown in Table 1. It is considered a promising technology that contributes significantly to supporting IoT healthcare and monitoring applications because these applications are real-time monitoring and latency-sensitive are essential in healthcare applications.

Fog nodes were able to enhance IoT application efficiency. Thus, the fog reduced the volume of data sent to the cloud and minimized response time for IoT applications. It was also capable of improving network bandwidth and decreasing latency. For instance, in the health care scenario, the fog will receive patient's data from their wearable, analyze the data based on dome machine learning methods and make the best result available. Further, not only the speed of analysis real-time application is essential and but also the accuracy of analysing data is vital.

Alongside, Machine-learning methods significantly impact healthcare for analyzing clinical data to detect or predict the different diseases. Several frameworks proposed to enable real-time monitoring of patients at any time and anywhere in the world regardless of patients' location and mobility. The framework targeted to deliver early detection and isolation for an infected patient, keep tracking their contacts to guarantee safety, and classify the patient as either infected or normal. Detecting disease in the early stage is crucial to decrease the mortality rate and healthcare expenses related to several illnesses.

F. Conclusion

Various studies present the evolution of machine learning and fog computing in the Healthcare domain. Fog nodes aim to improve IoT applications' efficiency in computation, bandwidth, network latency, and security. Fog computing is useful for healthcare applications due to its features such as location awareness, reduced latency time, mobility, quick responses, low bandwidth, supports real-time applications, Wide-spread geographical distribution, heterogeneity, and scalability. Besides, many machine learning methods were used to increase IoT devices' efficiency and accuracy for detecting and motoring healthcare services remotely.

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