HEALTHCARE APPLICATIONS IN FOG COMPUTING USING MACHINE LEARNING TECHNIQUES

Submitted to

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CERTIFICATE

This is certify that the project entitled

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is a record of the truthful work they did in part fulfilling the requirements for the Bachelor of Engineering degree in Computer Science & Engineering or Information Technology at the KIIT Deemed to be University, Bhubaneswar. This work is carried out in the years 2022–2023, with our oversight.

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ABSTRACT

Healthcare industry faces challenges such as limited resources, high costs, and increasing demand. These challenges make it difficult for healthcare providers to deliver quality care while keeping costs low and meeting patient expectations. To address these challenges, fog computing and machine learning (ML) techniques have been proposed as a solution. Real-time data processing and analysis are made possible by fog computing, a distributed computing architecture that extends the cloud to the network's edge. Large-scale data analysis, pattern recognition, and prediction are all capabilities of machine learning approaches. Fog computing and ML have applications in healthcare, including real-time patient monitoring, predictive maintenance, personalized treatment, and improved data security and privacy. An summary of the difficulties the healthcare sector faces is given in this thesis, along with suggestions on how fog computing and machine learning approaches could help. In addition, it presents case studies, future possibilities for study in this field, and addresses the advantages and difficulties of fog computing in healthcare.

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INTRODUCTION

1.1 Cloud

The term cloud comes in appearance from designing of network or internet. The various devices and internet-works are represented in cloud shape by network engineers. Cloud is available at remote locations. The different types of services over different networks (public or private) are provided by the cloud.

1.2 Cloud Computing

The computation based on the internet is known as cloud computing (CC). It is an online process for storage, processing, accessing the data. CC has various areas such as virtualization, service-oriented architecture (SOA), distributed, and grid computing. The CC heart is virtualization. SOA provides services in cloud computing and parallel computing is govern by distributed and grid computing. The cloud computing models are enhancing the power of academia and industry for storage and computation. The computation and storage infrastructure at in-house is used to shift at remote locations by the cloud computing model. Deployment models and services models strengthen the feasibility of cloud computing and make it reachable to the end-users. The models are as follows.

1.3 Deployment Model

As per the basis of locations and infrastructure, the cloud deployment model (DM)is categorized in four categories. According to the requirement, the user can select the deployment model (Figure 1.1). The DMs are categorized as

1.3.1 Private Cloud

This deployment model is used within the organization. Their services are accessible only in the organization. In this model, security is enhanced as compared with other deployment models. The firewall is used to control the storage and computation services. Here, a single organization can control and supervise the infrastructure examples are Ganeti, Open stack, etc.

1.3.2 Public Cloud

In this model of the cloud services are accessible to all persons. The term external cloud is used as an alternate name of the public cloud. The resources are made available from the internet and make it available in general to all. Privacy and security are major issues for the public cloud. For resolving the security issues, it is a mandatory requirement for users to use the protocol of security prior to the use of cloud services examples are Google drive, AWS.

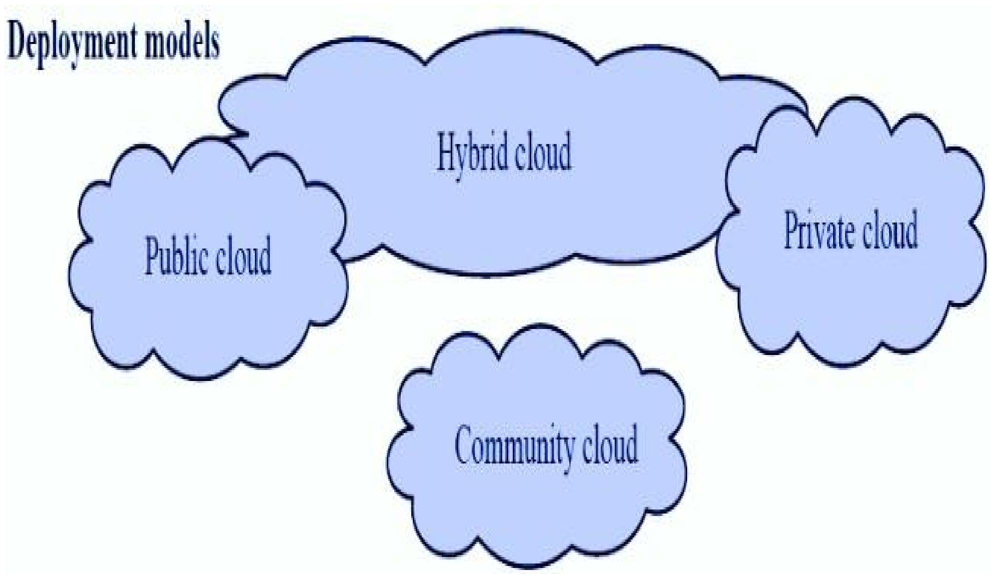


Figure: 1.1 Deployment model

1.3.3 Hybrid Cloud

A hybrid cloud is one that combines elements of both public and private clouds. Applications may exchange data among themselves. An agreement is made between organizations and public service providers to increase the capacity of the private cloud. The private and public cloud works together for an organization after agreement. This agreement is also called service level agreements (SLA). Although the essential, confidential, and important activities are performed on private cloud and unessential and unimportant activities are performed on a public cloud.

1.3.4 Community Cloud

In this deployment model, the system and services are allowed to be accessed by various groups of organizations. The resources of the clouds are shared by the various organizations from a particular community. The participated organizations or third-party is used to control the resources of the cloud.

1.4 Service Models

The service models are providing different services to cloud computing or we can say that cloud computing is completely based on service models (Figure1.2). The service model can be further divided into three different types and they are as follows:

1.4.1 Infrastructure as a Service (IaaS)

In this model, cloud computing providing infrastructures such as hardware, software, and any other component as a service to the user. They also provide virtual storage and machine as a service. IaaS offers high scalability to resources as per the demand of the user. The user gets access to the infrastructure over cloud computing. Previously IaaS is known as Hardware as a Service (HaaS). The dynamic portability of the selection of a CPU, storage capacity is the main advantages of IaaS. Here the pay-as-you-go feature is available for users. Instead of buying hardware users can pay as per their requirement to the cloud service provider to use IaaS as per demand. The user can save their maintenance cost. As the data is on the cloud so it is more secure and safe.

1.4.2 Platform as a Service (PaaS)

In this model, the cloud is providing a platform on which the developer can develop, test, and manage their applications. In PaaS, the cloud providing the services of development, run and test their applications along with storage and other computation services. The service provider is responsible for security, data loss, and operating system. The development of applications becomes easier for developers without worrying about infrastructure and platform. The user has required the only computer with an internet connection to develop the applications. The use of service models of cloud doesn't mean that it is the replacement of the business but the customer can rely on it.

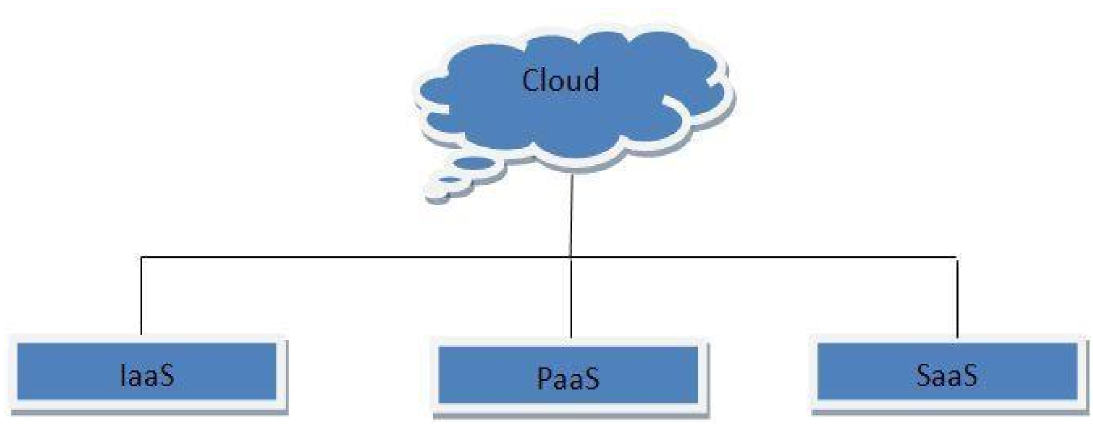


Figure1.2 Service model

1.4.3 Software as a Service (SaaS)

SaaS is based on a software distribution approach. In this service model, the cloud service provider hosts the application and makes these applications available to end-user using the internet. SaaS is also the main service model as other models. Internet and the network have a very important role to provide the service around the world. Here, the service providers control the entire process. The customer can get access only through a web browser. The application executes on the cloud. Users can use it by getting a paid license subscription. The user of SaaS doesn't require installation in a computer system.

1.5 Use of cloud computing in Healthcare

A critical role for cloud computing in the healthcare industry .It is a developing industry. There are no set restrictions. The healthcare information can be accessed from the use of cloud computing. It is user-friendly. Nowadays, the healthcare sectors using online services. By the use of cloud computing, the patient can contact doctors online and doctors can access the patient record online. The unnecessary visits to the doctor can be avoided. The doctor can check the record online and provide consultation to the patients. The main task is to provide a better quality of services to both doctors and patients. The quality of services considers the parameter such as performance, latency, and rate of data transfer for patient health monitoring. The lives of a patient can be saved by the use of cloud technology if the information at right time reaches to a doctor. In cloud computing, the distribution of health data is done all over the world. And these data can be accessed by the use of the internet with mobile or computer from everywhere. A healthcare agency utilizes cloud computing for designing of "Healthcare Monitoring System (HMS)". It is also called the "Cloud Healthcare Monitoring System (CHMS)".These systems provide computing services such as storing, pre- processing, processing, monitoring, and controlling, Cloud computing services are cost-effective and it can be easily adaptable by healthcare stakeholders'. ,suggested that cloud computing provides controlling and accessibility to the patient's record. It is very simple to access patients' records at any time from all over the world.

Three different service models are offered by cloud computing i.e. IaaS, PaaS, and SaaS. All HMS uses these models to provide the services. In current scenarios, the growth of healthcare data is very huge. There is some industry that domain area is healthcare with cloud computing, like Netgain is the industry based on cloud technology and providing health services using the ITIaaS service model. Netgain uses to develop HMS with the security of data. Microsoft Health Vaults was also a healthcare based company and it is based on the SaaS service model. There aremany more examples of a healthcare company; they are providing different services to the customer.Following are the basic reasons to use cloud computing in healthcare.

1.6 Fog Computing

In 2012, Cisco introduced the concept of "fog computing" (FC). It alludes to a distributed computing architecture that includes computing power, storage space, and networking services between data centres and endpoints. Fog computing is intended to operate more closely with edge devices than cloud computing, which is centralised. It serves as a catalyst for the Internet of Things (IoT) and sensor technologies, acting between the cloud and end devices, rather than replacing cloud computing.

1.7 Fog Computing Architecture

Fog computing architecture is shown in Figure 1.3. Fog computing has three-layered architecture. The fog layer is an intermediary layer or bridge layer between cloud and end-devices.

1.7.1 Bottom-most layer

In this layer of architecture, contain end devices, or IoT-devices or sensors, etc. These devices are collecting the data. And it sent the collected data to the middle layer for further processing.

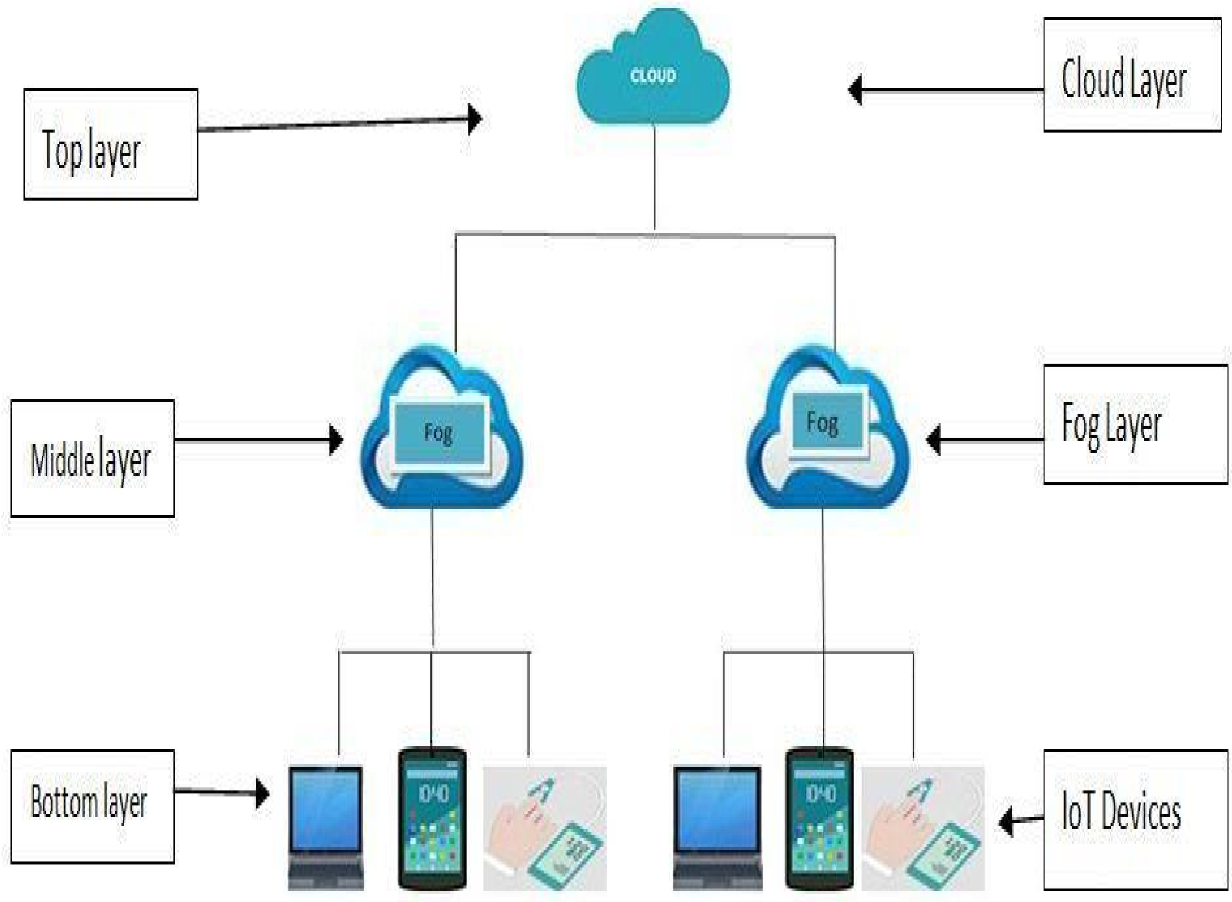


Figure 1.3 Fog Architecture

1.7.2 Middle layer

When the data is received from the bottom-most layer, the middle layer starts to process the data. After the computation of data, the data is transferred to the upper layer.

1.7.3 Upper layer

Upper layer is the cloud layer. In cloud layer, the received data from the middle layer will be stored in storage devices and these stored data are accessible to end-user for further processing like billing and summarization.

1.8 Usage and Advantages of fog computing in healthcare over cloud computing

The cloud is located at large distance from end-user. So in the processing of patient data consume more time. Fog computing is processing the patients' data closer to the edge network. So the patient data is processed early as compared to the processing of data in cloud computing. Due to the fast processing of data doctor's can respond early and end-user can analyze the complete data so early. Cloud computing fails on some issues such as processing of data and the obstacle in transfer of data over cloud computing and finally the results will come to the end-user is not acceptable. In critical cases, a small delay due to any reason (likes as power or network or cloud failure) can be a reason of death. These are the main issues of cloud computing in healthcare that need to be rectified.

The aforementioned issues are rectified by using fog computing. It acts as a bridge between cloud computing and end-devices or IoT sensor devices. As per the sensed patient data criticalness, health gateway processes the data on either on cloud or fog. Emergency may be addressed experts who use the fog barrier have a minimum of latency to collect information. For optimal performance and response time, a solid communication infrastructure is always required to achieve the best results. Fog computing is used for an interactive environment to facilitate device access to basic requirements when using the cloud.Fog computing is an expansion of cloud computing technology to the edge of network. The main idea is to migrate some data center task of cloud computing to fog nodes. Fog Computing enables timely and consistent service delivery while overcoming cloud computing issues such as cost-overhead, latency or jitter while transferring information to the cloud. It has a distributed architecture that improves storage, computing and network resources along the cloud computing. It allows to access such resources (storage and computational) for healthcare usage. Consequently, cloud and fog computing is passionately associated with an IoT field. In fog computing, the fog layer solves most of the problems of Health Industry in conjunction with cloud computing, the analytic of the big data, AI, and machine learning. FC offers several majoradvantages over cloud computing approaches.

1.9 Machine learning

Machine learning (ML) is to teach computers and act like people, and to improve their learning autonomously over time by providing required data and information in the form of observations and interactions in the real world. The types of machine learning are:

1. Supervised learning: This is a type of learning that provides the necessary input and output data. An input and output data are marked for classification and form the basis for training for future processing of data. This leaning technique consists of target that must be predicted by a particular set of predictors (independent variables). The input functions are mapped to output function by the use of independent set of variable. The process of training continues till the desired accuracy is achieved by the model on the training data. Support vector machine, Naïve Bayes, Random forest algorithm, and K-nearest neighbor algorithm, etc are example of supervised learning algorithm.
2. Unsupervised learning: Unsupervised learning trains an algorithm with unclassified and unmarked information, without guidance the algorithm to work on this information. The fundamental thought behind unsupervised machine learning is to open the machines to huge volumes of different data, and to train deduce from the information. Notwithstanding, the machines should initially be programmed to learn from information. Clustering and associations are two important groups for this learning. Principal component analysis (PCA), K-means algorithms, and a priori algorithms are example of unsupervised machine learning.
3. Reinforcement learning: In this learning, it is a method to train the models to get the maximum reward point by performing an action in the environment through an agent.

1.10 Usage and advantages of machine learning in fog computing for healthcare application

One area where technology might enhance workflow and raise the possibility of better patient care is machine learning. We can better inform clinicians about patient care with the help of such preliminary advanced analytics. The rapid population growth, it is difficult to record and analyze the huge volume of patient information. Machine learning allows for automatically recognize and process these data, making the healthcare applications more dynamic and productive. Healthcare with machine learning technology provide advancement in medical science and it also provide the platform for analysis of complicated medical data. Machine learning in healthcare aims to develop new automated technology in healthcare that will serve better. The goal of machine learning is to build a machine successful, efficient, and reliable than ever before. Doctor's brain and their knowledge is works as tool of machine learning in healthcare.Since a patient in every case needs a human contact and care. Machine learning and no other technology can change it**.** The machine leaning can offer the best service as follows.

1. Identification, prediction of diseases and their diagnosis: Identification, prediction of diseases and their diagnosis is the most important healthcare application of machine learning. Many of the chronic diseases (such as cancer, diabetics, and heart, etc) can identify and diagnosis by machine learning at early stage.
2. Discovery of new drugs:Early drug detection is another area that can benefit greatly from machine learning. Machine learning helps to research and development cell to discover new sequence of drugs.
3. Medical Imaging diagnosis: Machine learning is providing diagnosis on the basis of medical images. Different images of same pattern are analyzed and diagnoses accordingly.
4. Personalized care treatment : By integrating predictive analysis and personal health, personalised medicines are not only more successful, but also aged for future research and a better understanding of the condition.

5. Smart health records: Although technology has contributed to making the data entry process easier, maintaining health records is a comprehensive process that still takes a lot of time. It is true. The main task of machine learning in healthcare is to simplify the process and save money, precious time, and effort.
6. Clinical trial and research : ML has various prospective applications in clinical trials and research. The use of machine learning-based predictive analyzes can help identify potential candidates for clinical trials looking to collect a variety of differentdata, such as past doctor visits, social media, and more. Machine learning was also usedto provide real-time monitoring and control to help study participants access data, determine the optimal sample size for testing, and take advantage of the strength of electronics recordings to reduce data errors.

STUDIES

2.1 Fog computing in healthcare

In this section of the review work, the research articles related to fog computing in healthcare are considered. Duration of a decade from 2009 is considered for the study.

Cao et al., (2015)developed a monitoring of patient in real-time environmentand used to detect falls using a fog computation model called U-Fall. U-Falls divides the detection task between different devices (such as smart phones attached to end users at network edge) and the cloud server.

Dubey et al., (2015) proposed the architecture of the fog computing system. They proposed the architecture to authenticate and evaluate the primary health information. In this system, instances of the internal computation were limited by resources. Critical models were identified using examples and then placed in the cloud. The System's key objective is to computes large amounts of data through fog resources with low power consumption.

A distributed fog computing method has been proposed by **Fratu et al.,2015**, in support of chronic obstructive pulmonary disease (COPD) and public having milderdementia. They used eWall to meet requirement of the process for monitoring. Fog computing decrease the communications congestion and protects patient confidentiality.

Ahmad et al. (2016) Given that privacy and security are crucial components of health applications, a fog computing framework has been proposed that utilises the fog between the cloud and the endpoints as an intermediary layer.

Cloud Access Security Broker (CASB) framework has been used at the network edge to improve the security and protection of patient information. The framework was implemented using a standard method. Data has collected from various sources and it can be supported with structure and associated coding values.The performance of applications can be affected by Latency-sensitive healthcare data.**Chakraborty et al., (2016)** a fog-based computing platform for processing response time sensitive health data was discussed. A large, geographically dispersed medical application has been controlled using a programming model. By using the model, user can maintain data consistency, accurateness and reduce service deliverance time.

Moosavi et al., (2016)user devices and large geographical devices are protected by Fog Computing, real-time transmission, mobility support, interoperability, heterogeneity and pre- procedure with respectful interaction of the cloud. It consist amixture of devices and sensors are worked as computation and storage unit.Fog computing ensures that all of the above features ensure that fog computing is the right technology for unique functions of the medical IoT framework.A comprehensive security program has also been proposed by them. By establishing a network of interrelated intelligent gateways, these systems of security reduces communication traffic by up to 26% and communication latency between intelligent gateways and end-users by up to 16%.

Alam et al., (2016) presented a basic concept for block offloading mechanism to the decentralized distribution of fog mobile network on a geographically distribution. The reinforcement learning method was used to transfer blocks into a distributed multi-agent domain. As a result it showeda decrease in latency and processing times.

To monitor the patient is the most significant methods in IoT health systems. **Gia et al., (2017)** has presented a patient motoring system based on fog environment that supports convenient remote monitoring. The system is composed of elegant portals and effective IoT-sensors. ECG signals, temperature of body and respiratory rate are recorded by the sensors and wirelessly sent toward the gates to generate notifications after automatic analysis. The inexpensive health surveillance system has been proposed and provides low cost remote monitoring. The health monitoring system consisted of efficient sensor nodes and intelligent gateways. Sensor nodes could record wirelessly transmits respiratory rate, ECG signals and temperature of body through a smart gateways and producing notifications.

Diagnosis of patients by means of Chikungunya virus (CHV) in a fog environment health care system is suggested by **Sood & Mahajan, (2017)**. Wearable IoT sensors, fog, and clouds make up the system's three main layers. Chikungunya virus detection and management are done using the system. Fuzzy-C means (FCM) were used to diagnose the affected patients, along with urgent alarms.

For early detection of heart attacks and brain strokes, an application that was based on time-sensitivity data were proposed by **Zohora et al., 2017**, which use fog computing to alert users as quickly as feasible In the application, Fog computing reduces time of execution, usage of network and cost of power consumptions. Researchers have been used and applied smart gateways in fog computing or to connect certain fog nodes in the application of healthcare. A model has been proposed that develops two algorithms: first, it collects fog nodes when the user is in the overlapping part of the fog computing, and the next algorithm resolves the circumstances when the user changes position; the shortest route in the nebula can be establish through an incorporated portal linked to each device.

Vora et al., (2017)presented a fog computation model for monitoring of patients in ambient assistant living (FAAL) has been proposed. They collected the movement data of patients through sensors and through body area networks. The reduction in load of communication infrastructure is achieved by proposing an data transmission clustering algorithm. They measured the performance for reduce the load on the transmission infrastructure in which a cluster of nodes are attached via a cloud interface. They measured the performance of proposed work with parameter such as latency and data-overloading.

Ozdemir et al., (2017) an architectural approach has been proposed for an autonomous health management method. In this method, it focuses on the use of the Autonomous Health Management System (AHMS), It was a fog computing concept, which had the task to identify falls, report them and take emergency measures to save lives whereas the situation needs it.

Real-time Heart Attack Mobile Detection Service (RHAMDS) has been proposed by **Ali & Ghazal, (2017)** to shorten the emergency response time for patients with myocardial infarction. RHAMDS are designed to be implemented in fog and are linkedwith an SDN controller. The article introduces the network structure, flow of work, and model variables.

Wu et al., (2017) talk about the requirements for an Information-Centric Social Network (ICSN); the authors have integrated the fog computing security service (FCSS) into ICSN. The ICSN demands delivery plan, data flow, low latency, and effective end-to-end communication. Fog computing is a technique used in the ICSN that encourages data and computation to travel from remote servers to the network edge. ICSN services are secured using content analysis based on fog..

Atlam et al., (2018) highlighted that, fog computing differs from conventional IoT healthcare solutions. The system architecture based on fog is able to withstand the challenges of many healthcare systems such as scalability, power awareness, mobility, and consistency at the fog computer engineering level.

The intelligent e-health portal was developed in Fog environment by **Nagesh et al., (2018)** tosupport health services on the Internet of Things and provide real-time data computation, analysis of data and storage (locally). The smart-e-health portals have been distributed and geolocated. Each gateway is responsible for managing multiple IoT devices openly linked to a patient. The system can monitor patients regardless of their movements. Power, mobility and dependability problems can be solved successfully in a fog-based system.

The Hybrid Clinical Decision Support System (HPCS) infrastructure was developed by **Liu et al. (2018)**, which were proposed for use on fog cloud computing.They considered data mining for design the system a simple approach that allows monitoring the conditions of patient in real-time.

Additionally, ASAS(Anonymous and Secure Aggregation Scheme) based on fog computing has been presented for use in cloud computing, where the final node data is collected by a fog node and sent to a server located in the public cloud.

Dinh et al., (2018) proposed a low-priced deployment plan for IoT based services in haze and cloud networks. They presented the scheme for measuring the functionality of virtual networks function (VNF) through the potential to enhance the availability of software functions chaining (SFC). They had covered problems associated to software and hardware failures and resource constraints in fog computing.

According to **Li et al. (2018),** the service popularity-based smart resources partitioning (SPSRP) approach was developed in response to the growing popularity of IoT and fog computing. The inefficiency of resource use and data processing at fog nodes was demonstrated by them. The suggested strategy aims to improve fault tolerance of IoT and fog servers, as well as reduce latency and response times.

Mahmoud et al., (2018)presented the issues of maximum latency and huge data transfers in the healthcare sector. So the authors came up with cloud-fog service as well as reference architecture for healthcare systems. They were analyzed the outcomes to optimize data transmission, minimize latency and reduce power consumption. The results showed improvements in terms of profitability, power consumption and network latency.

A hybrid bio-inspired algorithm is proposed by **Rafique et al., (2019)** in IoT-fog-cloud environment for reducing the time of execution and response. The hybrid algorithm consists of optimization of cat and particle swarm algorithm. The algorithm has been adapted the changes to manage resource accessibility and scheduling activities in fog nodes.The fog computing method for cloud storage was proposed by **Ahsan et al. (2019).**The authors highlighted the many problems related to security and protection of data in cloud computing. User confidentiality is paramount for cloud servers. Thus, the Xor grouping has been used to save data from unauthorized admittance and malicious attacks. They verified their outcomes against the processing time of the data packet. They used a novel hash-based technique to identify data modifications with the greatest potential.

One study that looked at the possibility of fog computing for remote health monitoring was released in the **Journal of Medical Systems in 2020**. In order to aid in the early diagnosis of health problems, the study suggested a Fog-based system that can analyse physiological data from wearable sensors in real-time. The application of fog computing for the privacy of health care data was examined in another study that was published in the IEEE Journal of Biomedical and Health Informatics. In order to lower the danger of data breaches and ensure data privacy, the study suggested a Fog-based system that can handle delicate health care data locally without transferring it to a central server.

Sarabia et al. 2021 reported high accuracy in the fall detection using their proposed intelligent fog-cloud computing framework. The framework utilizes deep learning and machine learning techniques to detect falls in real-time.The proposed framework was evaluated using a publicly available dataset, which contains sensor data collected from different individuals performing different activities, including falls. The evaluation results showed that the proposed framework achieved high accuracy in fall detection, with a precision of 98.4% and a recall of 98.9%.

Ahmed Elhadad et al.(2022) presented a fog computing-based architecture for health monitoring that makes use of fog gateways for clinical decision-making using sensor data from wearable devices. The system uses sensors to detect a patient's vital indicators, including blood pressure, temperature, and ECG. The gathered data is protected using watermarking and encryption methods before being temporarily stored in the fog server until network access is established. In an emergency, the information is sent over the cloud to medical professionals or carers. The suggested framework offers a safe and dependable answer for clinical judgement and remote patient monitoring while protecting patient confidentiality and data security.

2.2 Machine learning in healthcare

In this section of the review work, the research articles related to machine learning in healthcare are considered. Duration of a decade from 2009 is considered for the study.

Rughani et al., (2010) proposed a model to predict traumatic brain injury (TBI) with the use of an artificial neural network (ANN). ANN is trained accordingly. Their research shows that, alongside classic regression models (with the same limited clinical information), artificial neural networks consistently and significantly perform better than experienced and trained professionals

Liu et al. (2011) developed a model for predicting brain death in patients with head injuries using the ensemble artificial neural network (EANN) machine learning technique. The study created two models using 11 and 14 input parameters, respectively, and it classified data with a high degree of accuracy (92%). This study showed how machine learning algorithms have the ability to properly forecast patient brain death, which can help healthcare professionals make well-informed decisions about patient treatment. Additionally, the use of machine learning methods in healthcare can enhance patient outcomes and the overall effectiveness of the healthcare system. This model show significant improvement in prediction in brain death. Speed and reliability can allow time to act before cardiovascular collapse and imminent physicaldeath shortly thereafter.

A machine learning algorithm is presented with **Parthiban & Srivatsa (2012)** to classify and study of chronic diabetic diseases with Naïve Bayesian algorithm and SVM.Machine learning algorithms are successfully employed in this model. Accuracy received as 74% and 94.6% for Naïve Bayes and SVM respectively. The result shows that SVM algorithm is good for identification of chronic diabetic disease. They also predicted the probability of diabetic patients get heart disease on the basis of the parameters such as age, gender, blood sugar, and blood pressure. This model gives the early detection of diabetics and chances of heart diseasefor diabetic patients.

Sartakhti et al., (2012) proposed a method using machine learning for diagnosis of hepatitisdisease. The method used Support Vector Machine (SVM) in conjunction with Simulated Annealing (SA) method. 10-fold cross validation is used for classification validation in this model. The model achieved 96.25% accuracy. This is very useful tool for physicians and can take very perfect and accurate decisions. The accuracy seems very good.

Kumari & Chitra, (2013) developed a model to classify diabetes disease. The model usedSupport Vector Machine (SVM)machine learning approach.The cost and performance ofmodel is good. The model diagnoses the diabetic patients. The accuracy is 78% of the SVM model. As per the experimental result we can say that the model is good for detection of diabetic in patients.

George et al., (2013) suggested an automated method to segment cell nuclei on FNAC mammograms to detect cancer. Four machine leaning algorithms examined on four different kinds of data sets. Support Vector Machine (SVM), Probabilistic Neural Network (PNN), Multi-layer Perception (MLP), learning Vector Quantization is used for evaluation of method. A comparative study is being analyzed of machine learning algorithm to evaluation of FNAC mammograms. The SVM provides the 99.7% accuracy and it is better than any other algorithms.

Senturk & Kara,(2014) proposed a model for prediction of breast cancer. The authors used seven different machine learning techniques such as Naïve Bayes (NB), decision tree (DT), K-nearest-neighbor (KNN), support vector machine (SVM), logistic regression (LR), multilayer perception (MLP) for early detection of breast cancer. They collected the differentsample data for the execution of the model. The results shows with accuracy 96.2%, 94.7%,95.5%, 96.5%, 96%, 96.2% for NB, DT, KNN SVM, LR, and MLP respectively. The experimental result shows that support vectors machine having best result over other machinelearning techniques for early detection of breast cancer in patients.

Otoom et al., (2015) proposed a mobile application for diagnosis and monitor the patients inreal-time and suffering with coronary artery disease (CAD) as well as suffering from heart disease. They build an intelligent classifier to predict heart disease and the prediction is completely based on clinical data of doctors. Collection of data is done by sensors. They alsoprovided alarm notification in emergency cases of patients. 88.3% and 84% accuracy is achieved by support vector machine and BaysNet. This outcome shows that SVM has very good efficiency.

A machine learning based algorithm was proposed by **Iyer et al., (2015)** for prediction of chronic diabetic disorder in pregnant women. They analyzed the pattern of data through various machine learning algorithms. They used Naïve Bayes and J48 decision tree method and implemented these methods on a per-existential data-set. The authors provided thesummary of the reason for diabetics. The algorithm is used to effectively early detection of diabetics' symptom. The adequacy of the proposed model is shown by experimental results for the prediction of accuracy the Naïve Bayes provides 79.56% and the decision tree achieved 76.95% as an accuracy.

Williams et al., (2015) highlighted the breast cancer risks prediction using Naïve Bayes and J48 decision tree method in United States on Nigerian patients. They showed through the experimental results that J48 decision tree is better algorithm for prediction of breast cancer risks over Naïve Bayes machine learning algorithm and also having very low error rate in prediction as compared to Naïve Bayes. WEKA tool is used to perform the experiment. Theyreceived 94.2% as an accuracy with J48 decision tree and 82.8% with Naïve Bayes.

Khalilabad et al., (2016) presented a model known as Micro-array image for diagnosis of cancer.

They identify the cancer by using fully automated classification in that micro-array images of cancer. Micro array is very useful technique for extraction of datasets (genome), Three steps are involved in extraction such as grinding, gene collection from DNA and classification. This model used decision tree method and the proposed model achieved 95.23% accuracy.

Alarabeyyat et al., (2016) proposed two methods, in first method used pattern and feature extraction by using an imaging technique, and second method is used to prediction of breast cancer through artificial neural network and logistic regression method. They process 209 images and proposed model achieved 93% accuracy.

A hybrid model for the early detection of breast cancer that serves as a diagnostic aid is proposed by **Carvalho et al., (2016).** The author suggested using a hybrid structured model in methods to achieve greater accuracy than using a single Bayesian network. To identify the most influential factors in breast cancer Multi-criteria decision analysis (MCDA) is being used. The author practically performed the test on a data set of 699 states and 9 attributes. The model gave an accuracy of 95.7%.

Bhardwaj et al., (2017) highlighted that machine learning is likely to have a limited social impact on health care. Machine learning helps reduce rising healthcare costs and improve patient-doctor interactions. The cost of healthcare is reduced for both patients and side. Machine learning solutions are widely used in healthcare. Some of these health care servicesinclude a large number of individual patient prescriptions and procedures, as well as additional patient care that determines whether follow-up examinations should be logged.

MCA (2017) claimed that the use of machine learning algorithms is important, particularly in clinical applications that entail sophisticated genomics and protoplasmic measurements. These algorithms are capable of managing enormous volumes of data and recognizing difficult patterns. These algorithms are frequently used in the identification and diagnosis of numerous disorders. Machine learning algorithms are capable of making decisions about patient treatment plans at a higher level by suggesting the development of an efficient healthcare system.

Using a variety of machine learning methods, including Decision Tree, C4.5, K-means Algorithm, Support Vector Machine (SVM), Naive Bayes (NB), Artificial Neural Network (ANN), Classification and Regression Tree (CART), Random Forest, and Regression, **Hazra et al. (2017)** investigated the early prediction of heart disease. They improved the accuracy of their heart disease prediction by integrating various approaches. But how well the combinations are chosen will determine how accurate the prediction is. Their research showed how machine learning algorithms can accurately predict cardiac disease, which may make it easier for medical professionals to spot patients who are at high risk of getting the condition early on. By identifying these patients, healthcare professionals would be able to take preventative actions to delay the start of heart disease or successfully treat the condition, improving patient outcomes. Future research on the use of machine learning techniques to predict heart disease and other cardiovascular diseases may be built on the findings of this study.

Kavakiotis et al., (2017) systematically review recent machine learning applications in diabetes research in concerning to prediction, identification, diagnose. These studies reflect research efforts (and developments) undertaken in a wide range of health fields (diabetes and cancer) and demonstrate the willingness of the scientific community to use machine learning approaches and methods to handling major health problems.

Azimi et al., (2017) proposed a hierarchical computing architecture (HiCH) model. This model is based on IoT-system for healthcare monitoring of patient, this computing architecture is novel with suitable execution of machine learning and managing a close-loop technique. The model is made with the advantages of cloud and fog computing.

Ponce & de, (2017) suggested the potential for classifying breast cancer using artificial hydrocarbon networks (AHN). In artificial hydrocarbon networks, a machine learning algorithm is precisely turned into a tree-based and rule-based model. Normally, AHN describes a chemical mechanism within an organic molecule for the development of a tumor in the breast. The main two process used as data similarity and classification of cluster in AHN classifier. The experimental result shows 97.58% accuracy.

Uyar & Ilhan, (2017) proposed a machine learning model based on genetic algorithm for diagnose of heart disease. The author used recurrent fuzzy neural networks (RFNN) to identify the heart disease. They used 297 data set for this purpose out of which they trained 252 data set and used 45 data set for testing purpose. The model achieved 97.78% accuracy.

Awan et al., (2019)proposed a predictive model for readmission or death of patient's after getting discharge from hospital for heart failure (HF). They collected the data set of Australian patients having age greater than 65 years and admitted in hospital for HF during the year 2003-2008. The authors used multi-layer perception model for prediction. The proposed model performs at a 66% efficiency.

"Prediction of Alzheimer's disease using deep learning architecture" **by B. Roy et al. (2019)**: The researchers used a deep learning architecture to predict the onset of Alzheimer's disease in patients using FDG-PET of the brain while analyzing their brain scans . The model achieved high accuracy of 82% specificity at 100% sensitivity in predicting the onset of Alzheimer's, demonstrating the potential for machine learning in early disease detection.

Ahmed et al.(2020) proposed a model to Predict Mortality in Paralytic Ileus Patients Using

Electronic Health Records named " SRML-Mortality Predictor". The framework consists of several stages, including data preprocessing, feature extraction using auto encoders, supervised learning with a Random Forest (RF) algorithm, and unsupervised learning with a Self-Organizing Map (SOM) algorithm. The performance of the SRML-Mortality Predictor was evaluated on a dataset of 1,363 patients with paralytic ileus. The results showed that the framework achieved an accuracy of 89.52% in predicting mortality.

Xiaoyong Pan, et al.(2020) proposed a deep-learning model called ToxDL for predicting protein toxicity. The proposed model consists of a deep neural network that is trained using backpropagation and stochastic gradient descent on a large dataset of protein sequences and their corresponding toxicity labels. The model was evaluated on a benchmark dataset of 2,448 proteins with known toxicity labels. The results showed that ToxDL achieved an accuracy of 92.19% in predicting protein toxicity. The model can be a useful tool for drug discovery and toxicology research, as it can aid in identifying potential toxic proteins and improving drug safety.

Julia Diaz-Escobar, et al.(2021) proposed a deep-learning model for the detection of COVID-19 using lung ultrasound (LUS) imagery.The model consists of a deep CNN that is trained on a large dataset of LUS images. The dataset used in the study consisted of 324 LUS images from 82 patients, including 23 COVID-19 positive patients and 59 COVID-19 negative patients. The images were labeled by radiologists based on the presence or absence of COVID-19-related lung abnormalities. The model achieved an accuracy of 93.52% in detecting COVID-19. The model also showed promising results in identifying different types of COVID-19-related lung abnormalities, such as bilateral pleural line irregularities, subpleural consolidations, and B-lines.

"A Machine Learning Framework for Personalized Treatment Planning in Cancer Care" by **Liu et al. (2021)**: This paper proposes a machine learning framework for personalized treatment planning in cancer care. The framework uses patient-specific data, such as tumor characteristics and medical history, to develop a personalized treatment plan that maximizes treatment efficacy while minimizing toxicity. The framework achieved an accuracy of 90% in predicting patient outcomes, demonstrating the potential of machine learning algorithms in developing personalized treatment plans for cancer patients

2.3 Advantages of Machine Learning in Healthcare Applications

There are several advantages of using machine learning in healthcare, including:

1.Improved diagnostic accuracy: Massive amounts of data can be analyzed by machine learning algorithms, which can then find patterns that might be hard for people to notice. This may result in earlier and more precise disease diagnosis.

2.Individualize treatment programme: In order to develop individualize treatment regimens that are catered to each patient's needs, machine learning algorithms can analyse patient data. Improved patient outcomes and more efficient therapy may result from this.

3.Predictive analytic: In order to pinpoint people who have a high risk of contracting specific diseases, machine learning algorithms can analyse patient data. Early interventions and preventive strategies are now possible, which can enhance patient outcomes and lower healthcare expenditures.

4.Drug discovery: In order to find prospective new medication candidates, machine learning algorithms may analyse vast amounts of data. This could hasten the process of discovering new drugs and result in more potent treatments for sickness.

5.Reduced administrative burden: Numerous administrative tasks, including appointment scheduling and processing of medical claims, can be automated using machine learning algorithms. As a result, efficiency may increase and the administrative burden on healthcare professionals may decrease.

6.Improved patient experience: Machine learning algorithms can analyze patient feedback and identify areas for improvement in the healthcare system. This can lead to a better patient experience and improved patient satisfaction.

7.Enhanced data security: Machine learning algorithms can help identify potential data breaches and improve data security measures, protecting sensitive patient information.

Overall, machine learning has the potential to transform healthcare by improving diagnostic accuracy, personalizing treatment plans, predicting disease outcomes, accelerating drug discovery, reducing administrative burden, and improving patient experience.

2.4 Challenges Faced By Machine Leaning in Healthcare

While machine learning (ML) has many benefits for the healthcare industry, there are also a number of obstacles, such as:

1.Data quality: The accuracy and completeness of healthcare data is critical for effective machine learning. However, healthcare data can be messy, incomplete, and inconsistent, which can impact the accuracy of ML algorithms.

2.Data privacy and security: Healthcare data is often sensitive and contains personal information, making it crucial to maintain strict data privacy and security measures. ML algorithms must comply with regulatory requirements and ensure that data is kept secure and confidential.

3.Interpret-ability: Machine learning algorithms can be difficult to interpret, especially when used for complex healthcare applications. This can make it challenging for healthcare providers to understand and trust the results produced by these algorithms.

4.Bias and fairness: ML algorithms can produce biased results if they are trained on unrepresentative data. This can lead to unfair treatment of certain patient groups and reduce the effectiveness of these algorithms.

5.Integration with existing systems: Healthcare organizations often have complex IT systems in place, and integrating ML algorithms with these systems can be challenging. Ensuring compatibility and interoperability can be a significant obstacle.

6.Legal and ethical considerations: Concerns about responsibility, informed consent, and algorithmic accountability are only a few of the moral and legal issues that the use of machine learning in healthcare brings up. To prevent potential legal and reputation risks, healthcare organizations must carefully handle these problems.

7.Adoption: Even though machine learning has the potential to improve healthcare, some people are still reluctant to adopt it. Healthcare professionals may be hesitant to trust a machine learning algorithm over their own clinical judgment, and integrating machine learning into existing workflows can be challenging.

In conclusion, the challenges of machine learning in healthcare are significant but not insurmountable. Addressing these challenges will require collaboration between healthcare professionals, data scientists, and policymakers to ensure that the benefits of machine learning in healthcare are realized.

2.5 Comparison Table

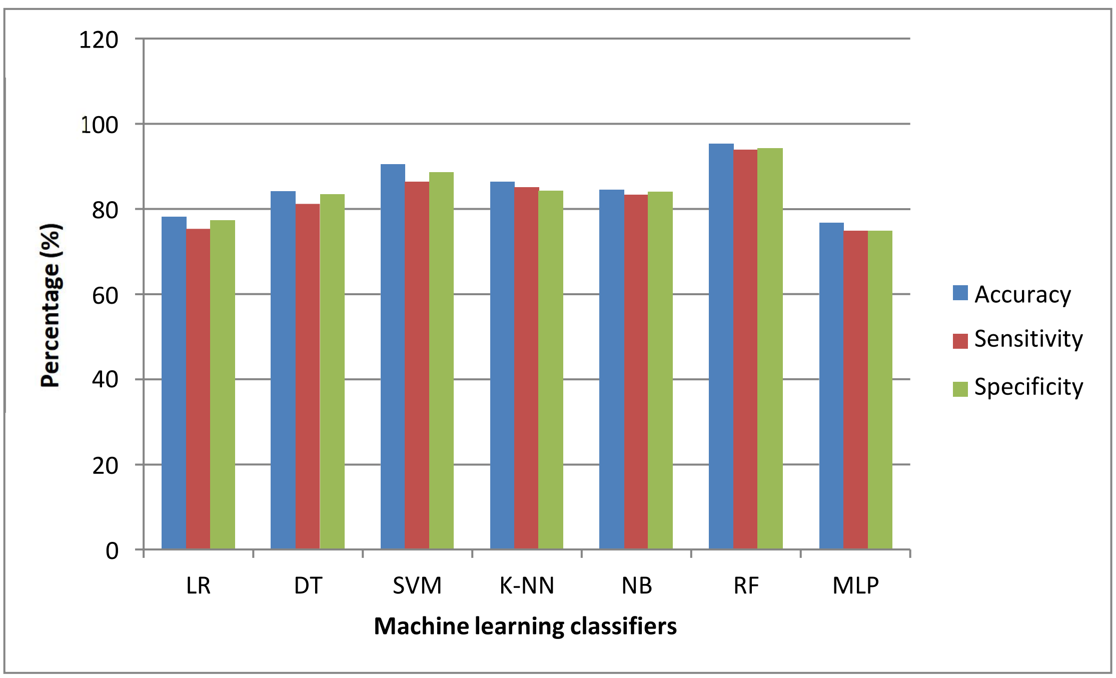
	Fog Computing In Healthcare	Machine Learning In Healthcare
Efficiency	In calculations, each parameter must be close to the right value or the accepted standard, which emphasizes the importance of exact parameter values. It emphasizes the necessity of precise calculations and error-free outcomes.	This is a critical factor for any ML model used in healthcare. The accuracy of a model refers to how closely its predictions match the actual outcomes. In healthcare, accuracy is essential for ensuring that patients receive the correct diagnosis and treatment.
Rigor/ Recollect	Two crucial criteria for assessing models and algorithms are recall and precision. Precision is the percentage of algorithm results that are related to a certain subject or topic, whereas recall measures the percentage of all relevant results that the algorithm properly detected.	Precision and recall are measures of a model's ability to correctly identify relevant cases. The effectiveness of models and algorithms is measured using two key metrics: recall and precision.Recall examines the proportion of genuine positive results among all positive outcomes, whereas precision assesses the proportion of genuine positive results among all instances of genuine positive results.. These metrics are especially important in healthcare, where false positives or false negatives can have serious consequences.
Ascendabilit y	A scalable system can adapt itself with higher operational demands such as an increase in the number of service requests or application of resources, and can maintain or improve the level of efficiency and performance.	As healthcare organizations grow and collect more data, they need ML services that can scale with them. The ability of an ML service to handle larger and more complex datasets is an important factor.
Security	Protecting the available fog/cloud data from potential attackers via secure mechanisms and device authentication at each gateway is the main security challenge in fog computing. The installation of an intrusion detection system (IDS) at every level of the platform is required to handle this problem [116].	In healthcare, patient data is highly sensitive and must be safeguarded against misuse or unauthorized access. The security and privacy features of an ML service should be evaluated to ensure that patient data is kept secure and confidential.
Reliability	In healthcare, reliability is critical. Fog computing services must be highly available and able to handle	In healthcare, reliability is critical. ML services must be highly available and able to handle unexpected failures. This

	unexpected failures.This requires a robust infrastructure with redundant components and fail over mechanisms.	requires a robust infrastructure with redundant components and fail-over mechanisms.
Latency	In healthcare, low latency is essential for real-time applications, such as tele-medicine and remote monitoring. Fog computing can help reduce latency by processing data closer to the source, rather than transmitting it to a central location for processing.	The network latency between the ML service and the application requesting the service is another important factor. This refers to the time it takes for data that will be sent back and forth from the ML service to the application. In healthcare, low network latency is important for real-time applications that require immediate feedback

2.6 Machine Learning Tools Graph

Classifier	Accuracy (%)	Sensitivity (%)	Specificity (%)	MCC (%)	AUC (%)
LR	78.2	75.3	77.2	84.5	82.42
DT	84.25	81.22	83.42	88.37	85.16
SVM	90.50	86.36	88.60	90.2	91.5
K-NN	86.37	85.10	84.35	87.35	88.62
NB	84.54	83.25	84.10	87.41	89.32
RF	95.30	93.85	94.2	95.4	96.45
MLP	76.86	74.92	74.8	82.51	84.12

The above table represents the performance characteristics of the framework when numbers of features are taken 4.Here, seven healthcare data classification learning methods were applied: logistic regression, decision trees, support vector machines, K-Nearest Neighbour approach, naive bays, random forest, and multi-layer perceptron.. The framework was validated through k-fold (k=10) cross-validation techniques. The accuracy of the framework ranges from 67.54% to 92%. The performance of the classification algorithm is measured based on accuracy, sensitivity, specificity, MCC, and AUC. It is found that sensitivity ranges from 67.1 % to 94.6%, specificity ranges from 75% to 87.3%, MCC ranges from 60.6% to 91%, and AUC ranges from 81.3% to 92.3%.



CONCLUSION

In summary, healthcare applications in fog computing utilizing ML approaches have enormous potential to revolutionize the healthcare sector by enhancing patient care, decreasing costs, and improving efficiency. While ML techniques can analyse enormous amounts of patient data to develop individualized treatment plans and enhance disease diagnosis, fog computing can move computing power closer to the edge of the network, enabling real-time analysis and decision-making.To fully realize the benefits of fog computing in healthcare, however, a number of obstacles must be removed, including those related to data security and privacy, standardization of data formats, and integration of multiple healthcare systems. A large investment in infrastructure and qualified employees is also necessary for the application of fog computing and ML approaches in the healthcare industry.

Despite these difficulties, the advantages of fog computing and ML techniques in healthcare are substantial and will only increase with the development of technology. In order to improve patient outcomes and healthcare delivery in general, future research should concentrate on creating creative applications and addressing the difficulties of applying fog computing and ML approaches in healthcare.

INDIVIDUAL CONTRIBUTION REPORT:

HEALTHCARE APPLICATIONS IN FOG COMPUTING USING MACHINE LEARNING TECHNIQUES

ANISH ANMOL
2005291

Abstract: This report explores the potential of fog computing in healthcare applications, with a focus on utilizing machine learning (ML) techniques. The paper begins by providing an overview of fog computing and its benefits over traditional cloud computing in healthcare. It then develops into various use cases of fog computing in healthcare, including remote patient monitoring, real-time disease detection, and personalized medicine. ML techniques such as deep learning, neural networks, and decision trees are explored for their potential in these use cases. The report also examines the challenges and opportunities associated with implementing fog computing solutions in healthcare. Ultimately, this report demonstrates the potential of fog computing and ML techniques in transforming the healthcare industry and improving patient outcomes.

Individual contribution and findings: First of all , I want to extend my sincere gratitude to our guide for assigning us this wonderful topic. As a member of this project group, my role centered around finding about different data sets available on how Machine Learning is helpful and used in Healthcare Applications by thoroughly going through various research papers available. During this project, I gained a lot of knowledge, sharpened and broaden my skill set.

Individual contribution to project report preparation: Studies(2.2,2.3,2.4,2.6), Conclusion

Full Signature of Supervisor: ……………………………….

Full signature of the student: ………………………………..

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Individual contribution to project report preparation: Introduction, Studies(2.1,2.5)

Full Signature of Supervisor: ……………………………….

Full signature of the student: ………………………………..

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