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Iot and Deep Learning Enabled Framework for Healthcare Emergency Services

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Abstract:

Deep Learning (DL) and the Internet of Things (IoT) are two quickly developing technologies that have the potential to completely transform the healthcare sector. To increase the effectiveness and efficiency of emergency medical response, this research study suggests an IoT and DL-enabled framework for healthcare emergency services. The framework consists of DL algorithms that analyse the data to create precise predictions about medical status and IoT devices that gather real-time data. The suggested approach could speed up responses, enhance patient outcomes, and even save lives.

Keywords: Machine Learning, Deep Learning, DL Enables Framework.

I. INTRODUCTION

Anyone who is seriously sick and needs medical care right away should make an appointment as soon as possible at the emergency room. Today's emergency rooms are run by an authorized emergency physician along with a nurse who has special training in giving urgent care to save a life or limb.

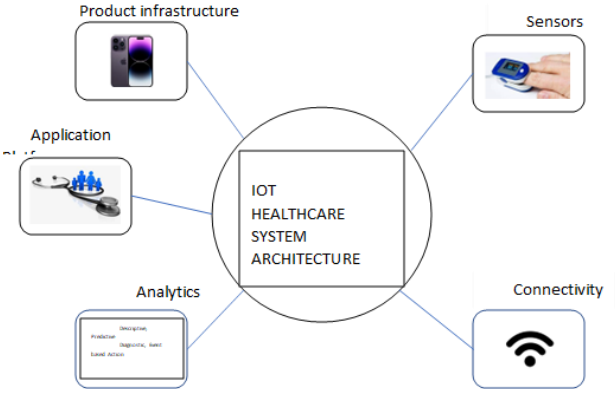
Emergency healthcare services are essential, and EMS's quick response time has the potential to determine life or death. Numerous issues, such as scarce resources, rising demand, and slow response times, confront the current EMS system[12, 13]. Two cutting-edge technologies, the IoT and DL, can be leveraged to address these issues and boost EMS's effectiveness and efficiency. To deliver real-time data analytics and enhance patient outcomes, the suggested framework attempts to take advantage of IoT and DL advantages. Nowadays, the Internet is used by more than two billion customers around the world, and it has become an integral part of our lives. DL makes it possible for medical staff to interact with patients more proactively and with greater awareness. Data learned by machines and software can be useful for doctors to diagnose patients more accurately and can help doctors in finding the most efficient course of treatment for patients and determining the desired outcomes.

- **HEALTHCARE AND THE INTERNET OF THINGS:**

IoT is currently one of the innovative technologies employed in the healthcare industry. IoT has enabled the development of several smart healthcare applications that offer ways to keep our lives secure. This section explains medical IoT gadgets and IoT-aware medical facilities that have given the healthcare industry more "smartness."

- **IoT AWARE HEALTHCARE SYSTEM:**

To give patients a more effective, efficient, and individualized healthcare experience, an IoT-aware healthcare system incorporates Internet of Things technologies into its operations. This technology consists of telemedicine, wearable medical equipment, smart hospital infrastructure, remote patient monitoring, and pharmaceutical administration. Healthcare practitioners can act fast, if necessary, by deploying IoT sensors to remotely monitor patient health data [2]. Wearable technology can track physical activity and assist in spotting potential health problems before they worsen. drug management can track drug adherence and dosage, and smart hospital infrastructure can enhance inventory control and patient safety. Patients may be able to get healthcare services remotely thanks to telemedicine. Patient data must be safeguarded and secured even though an IoT-aware healthcare system has the ability to improve patient outcomes, reduce expenses, and increase productivity.



- **DEEP LEARNING PROSPECTS:**

Artificial intelligence's deep learning subfield offers a lot of potential applications in healthcare emergency systems. Healthcare workers may make better and quicker judgments in emergency scenarios by using deep learning algorithms to analyse vast datasets of medical pictures, sensor data, and electronic health records to detect trends and make precise predictions.

Some specific applications of deep learning in healthcare emergency systems include:

- Diagnosing Medical Images: DL algorithms are capable of analyzing CT, MRI, and X-ray images to find anomalies and diagnose diseases like fractures, tumors, and strokes.
- Predicting Adverse Events: Deep learning algorithms can analyse electronic health records and sensor data to identify patients at risk of adverse events such as heart attacks or sepsis, allowing healthcare providers to intervene early and prevent complications.
- Enhancing Decision-Making: Deep learning algorithms can analyse patient data and provide decision support for healthcare providers in emergency situations, helping them make faster and more accurate decisions.
- Monitoring Vital Signs: In order to monitor vital signs like heart rate, blood pressure, as well as oxygen saturation and notify medical professionals if a patient's condition changes, deep learning algorithms can analyze sensor data from wearable devices.

II. LITERATURE REVIEW

In the medical field, Punit Gupta, Deepika Agrawal, Jasmeet Chhabra, as well as Pulkit Kumar Dhir (2018) suggested designing and putting into place an Internet of Things (IoT)-based monitoring system that can be extremely helpful in a variety of emergencies. The article discussed how the INTEL GALILEO 2nd generation developmental board can support intensive medical services like critical care units (CCU) and intensive care units (ICU). The model in this report will be helpful in improving the risks, services, and the outdated, conventional methods of treating victims [3,4]. It is suggested that patients receive better care by using smart watches and electronic gadgets. According to me, the paper omits information about the cost of sophisticated wearable technology because patients from low-income families cannot afford it. It also omits information about services provided in typical situations, such as routine checkups and general health care. IoT adoption in eHealth was suggested by Waqas Aman (2013) in Modelling Adaptive Security in IoT Driven eHealth as a way to improve Healthcare.

Healthcare services have recently undergone a revolution thanks to cognitive smart healthcare, particularly for applications in smart cities. The idea of smart healthcare has changed as a result of cloud computing, IoT, and networked smart health sensors. Intelligent disease detection, response to emergencies, mobile healthcare, smart records of health, smart alerts, smart pill dispensed medication and remote hospital equipment operation and control are some of the healthcare applications that fall under this category [1,2]. An instantaneous response would be provided by such a system in medical emergencies. This pertains to various intelligent medical sensors situated within, on, and surrounding the human anatomy, which acquire and oversee instantaneous multimodal data. 5G technology has been employed by some researchers to improve communication even more in these cognitive healthcare frameworks. They have combined AI technologies, like Kinect, which is widely used for activity recognition, with cognitive healthcare systems. Cooperative IoT devices and smart sensors are essential to cognitive smart healthcare frameworks because they enable the devices to learn about their surroundings and process the information they extract. It ought to function with little assistance from humans and be capable of making wise decisions.

Recently, there has been a lot of interest in smart healthcare systems due to their enormous economic and social benefits. For smart healthcare, numerous research study frameworks and services with an emphasis on IoT–cloud integration have been put forth. To assist patients in utilizing smart devices to find their way to hospitals, a framework for smart healthcare has been proposed. Frameworks for processing and maintaining electronic health records were suggested by a number of studies. A proposed cognitive smart framework for tracking glucose was designed to keep an eye on diabetic patients' activities. Robotic-driven cognitive ambulances are utilized to treat patients with heart attacks who require immediate medical attention. Medical forgery has also been identified by certain frameworks in the field of smart healthcare. The development of automatic EEG diagnosis tools has drawn more attention from researchers as a result of recent advances in machine learning techniques. Many brain illnesses and conditions, including Alzheimer's, stroke, seizures, depression, and brain injuries, are diagnosed. These EEG diagnostic tools are built using a variety of machine learning methods, including neural networks, logistic regression, random forests, support vector machines (SVMs), and principal component analysis. In order to increase the accuracy of EEG classification, researchers have shifted to deep learning methods [14]. EEG pathology detection could assist in identifying patients whose EEG is abnormal and in providing the required assistance. It could also facilitate further analysis of the root cause or diseases.

Seizures have been detected with great success using deep learning. It was suggested to use a CNN with a dropout technique to identify seizures. CNN and multichannel EEG were used in a study to detect seizures. In a different study, autoencoders and CNN were combined to classify EEG data. For EEG pathology detection, we use well-liked pre-trained CNN models (VGG16 and AlexNet), as CNN has been effectively used for a variety of EEG applications [8,9]. In order to identify general features using EEG signals, we first pre-train these CNN models on standard EEG datasets. The CNN models are then trained and fine-tuned using the extracted features on features unique to the Abnormal TUH EEG pathology dataset.

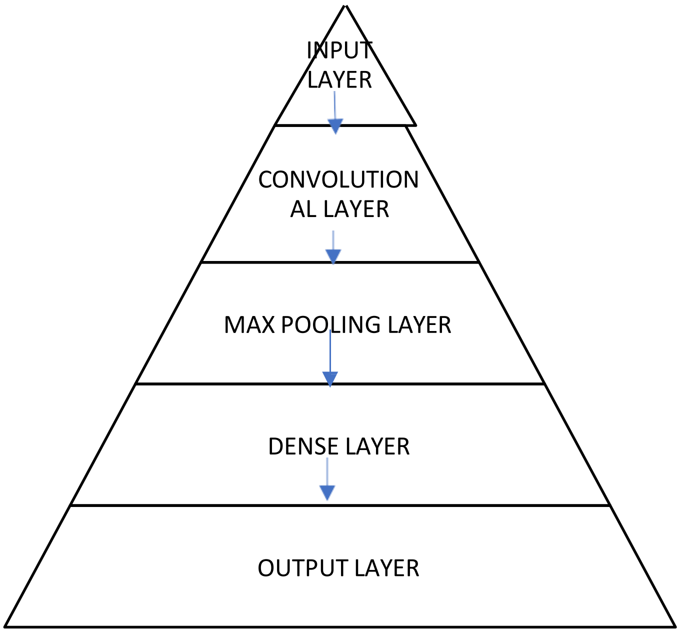
Using an adaptive security model, the researcher discussed adaptive security solutions in IoT eHealth. The risk involved can be estimated and predicted by this model. Security Event Management, or SEM, is the foundation of this model [6]. This covers every aspect of managing and implementing adaptive security in eHealth, including contextual awareness, lightweight analysis, autonomous adaptation, objectivesbased assessment, dynamic assessment, and monitoring.

III. OVERVIEW OF ALGORITHM USED:

In this part, popular H-IoT algorithms are briefly discussed along with a few real-world H-IoT application examples. Both supervised and unsupervised learning algorithms can be used with these approaches, depending on whether the necessary classification labels are present in the input dataset (supervised) or not (unsupervised). Deep learning algorithms are better at utilizing unlabelled data, while machine learning algorithms often prefer labeled data.

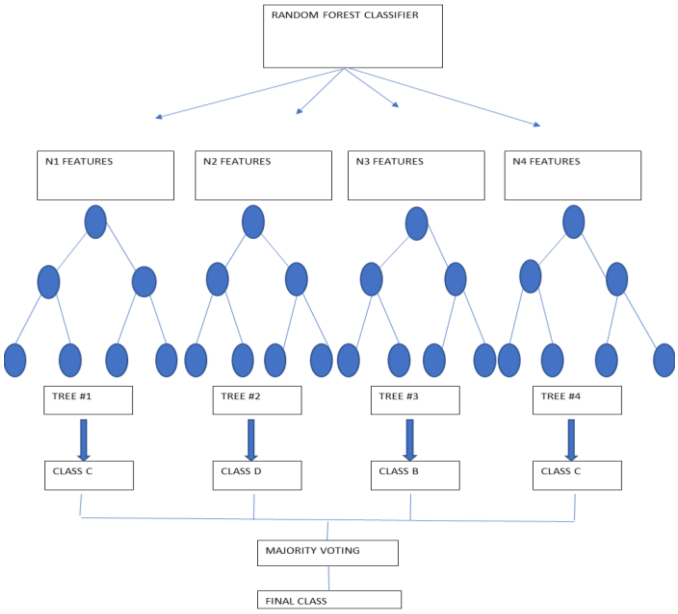
- **CONVNET:**

Convolutional Neural Network (ConvNet/CNN) is a deep learning algorithm that can learn to recognize different objects and parts of an image and tell them apart by giving them weights and biases.
Other classification algorithms need a lot more work before they can be used. Primitive methods involve hand-engineered filters; however, ConvNets can be trained to learn these characteristics with sufficient training.
ConvNet architecture was based on the structure of the brain's visual cortex and is similar to how neurons in the brain are connected.
By applying pertinent filters to an image, a ConvNet can effectively capture the temporal and spatial connections present in the image.
ConvNet's job is to ease up the images without forfeiting any of the features that are important for making a perfect prediction.



- **RANDOM FOREST:**

An ensemble learning method called random forests, which is also called random decision forests, works by creating a lot of decision trees during the training phase. These trees are used for tasks like classification and regression techniques. For classification tasks, the random forest gives you the class that most of the trees pick.



- **VGG NET:**

Visual Geometry Group, or VGG, is a common deep CNN build that has many layers. The number of layers in VGG-16 or VGG-19, that are made up of 16 or 19 convolutional layers, is what "deep" means. On top of the VGG architecture, new object recognition algorithms are built.

- **XG BOOST:**

An XGBoost library that is free to use has a C++ framework for controlling gradient-boosting, languages such as Java, Python, R, Julia, Perl, and Scala. It works with Linux, macOS, and Windows. The project description, it aims to provide a "Scalable, Portable and Distributed Gradient Boosting Library".

A model with an ensemble-wide fixed set of parameters (Random Forest) will not learn as well from streaming data as one whose parameters change itself iteratively (XGBoost). Dealing with Unbalanced Data: The XGBoost model does better than RF when there is a class imbalance.

- **ARTIFICIAL NEURAL NETWORK:**

An artificial neural network (ANN) is a type of ML model that copies how the human brain learns.. It consists of an input layer that accepts the data to be processed, multiple processing layers that process the data, and an output layer that provides the results. The hidden layers in artificial neural networks (ANNs) take in intermediate inputs, give each one a random weight and bias, and compute multiple weighted sums. These are subsequently processed through layers containing weights and sums until they reach the final layer, which determines the output using an activation function. In case the outputs are inaccurate, they are redirected to the earlier layers through backpropagation, where the weights are adjusted based on a cost function until the answers are obtained with a satisfactory level of precision.

- **COGNITIVE AUTOMATION:**

AI includes cognitive automation as a subset. With the aim of mimicking human intelligence, it makes use of cutting-edge technologies such as mining data, emotion recognition, natural language processing, and cognitive reasoning. With the use of technology, cognitive automation attempts to mimic human intelligence in problem-solving. It serves as a driving force behind the more effective and refined responses produced by an AI device.

IV. DIAGNOSIS:

The current section provides a summary of the use cases for diagnostics wherein AI & IoT have been proposed or put into practice. In most cases, a diagnosis is made by determining the type of illness the patient is currently experiencing by examining the symptoms that are recorded by sensors.

- **Covid 19 Detection:**

The significance of early detection and prompt response to infectious diseases has been made clear by the COVID-19 pandemic. COVID-19 testing, which enables medical workers to promptly identify and isolate infected people, has been a significant instrument in this battle. The COVID-19 test is available in a variety of formats, including PCR, antigen, and antibody testing. These tests employ several techniques to find the virus or antibodies in a patient's body. Testing has been essential in halting the virus's spread and will continue to be a vital weapon in the war against COVID-19.

Results for COVID-19 identification using a specially designed convolutional neural network (CNN) architecture have been encouraging. When compared to other conventional approaches, the accuracy in one study was over 93%, which is a significant improvement. A large set of chest X-rays and CT scans were used to teach the CNN architecture how to tell the difference among COVID-19 and other lung diseases. For early intervention and stopping the spread of the virus, the use of CNNs can offer a quicker and more precise way of COVID-19 detection. Even more sophisticated and precise detection techniques may be created as a result of additional study and development in this field.

- **Brain Tumour detection:**

Tumors in the brain are abnormal cell growths that form there. They can be carcinogenic and more aggressive than benign tumours, which can be either. Headaches, seizures, impaired vision, memory loss, and trouble with coordination are just a few signs that a brain tumour may be present. Chemotherapy, radiation therapy, and surgery may all be used as treatment options for brain tumours. For the greatest results, brain tumours must be identified and treated as soon as feasible. It's critical to seek medical care right away if you exhibit any of the symptoms linked to brain tumours.

100% accuracy on a tiny test set of only 10 photos is not always a good indication of how well a model will work. It is crucial to test the model on a bigger dataset in order to evaluate the model's true accuracy, even though it is possible that the accuracy gained is accurate. It's also crucial to keep in mind that overfitting can happen when a model is trained on a limited dataset, which leads to high accuracy on the training set but poor generalisation of new data. To confirm that the model is indeed useful for the use case intended, it is crucial to test it on a bigger and more varied dataset.

- **Breast Cancer Detection:**

The brain and central nervous system are both affected by brain cancer, a dangerous and frequently fatal condition. It can come from cancer cells that have spread from other parts of the body or from the brain itself. Headaches, convulsions, vision problems, and difficulties thinking or speaking are some signs of brain cancer. Surgery, radiation therapy, and chemotherapy are available treatments for brain cancer. The prognosis for people with brain cancer might differ based on the type of cancer, where it is in the disease, and other variables. For better results, early detection and treatment are essential.

Random Forest appears to have been employed for a specific use case and obtained an accuracy of about 91.81%. A well-liked machine learning technique called Random Forest can be applied to both classification and regression tasks. To generate a final prediction, the predictions from many decision trees are combined. The model's accuracy demonstrates that it is functioning well on the provided dataset, but it's crucial to take additional metrics like precision, recall, and F1 score into account to obtain a more thorough assessment of the model's performance. To ensure the model's dependability and generalizability, it's also crucial to make sure it is adequately verified and tested on fresh data.

- **Alzheimer Detection:**

Alzheimer's disease is a deteriorating brain disorder that affects memory, behavior, and thought processes. It is the most prevalent and currently incurable cause of dementia in older persons. Symptoms typically appear gradually and intensify with time, making it more difficult to carry out daily chores and ultimately resulting in loss of independence. There is no proven cure for Alzheimer's disease yet, but there are numerous treatments that can help manage symptoms and make life better for people who have it. Exercise, a balanced diet, and social interaction can all help lower one's risk of acquiring Alzheimer's.
CNN is a type of DL algorithm that is often used to sort images into groups. In the context of healthcare, CNNs can be trained to analyze medical images and identify patterns and abnormalities. For example, a CNN could be trained to identify signs of Alzheimer's disease in brain scans.
When training a CNN for this use case, the input would be a set of brain scans, and the output would be a classification of whether the scan shows signs of Alzheimer's. The CNN would be trained on a large dataset of labeled brain scans, with the goal of minimizing the discrepancy between the actual and anticipated output.
The accuracy achieved in this use case was around 73.54%, which means that the model was able to correctly classify approximately 73.54% of the brain scans in the test dataset. While this accuracy is not perfect, it is still a significant improvement over manual diagnosis and has the potential to be a valuable tool in the early detection and intervention of Alzheimer's disease.

- **Diabetes Detection:**

High blood sugar levels are the hallmark of diabetes, a chronic disease that over time may cause major health issues. Unlike Type 2 diabetes, which is brought on by a mix of genetic and environmental factors, Type 1 diabetes is brought on by an autoimmune reaction that kills the pancreatic cells that produce insulin. To effectively manage diabetes, a mix of food, exercise, and medication must be used. Diabetes can cause consequences like cardiovascular disease, nerve damage, and renal damage if it is not controlled. These issues can be avoided with regular blood sugar monitoring and treatment, which can also enhance general health.
Random Forest is a ML technique that is used in studies on regression and classification. Multiple decision trees are combined in this form of ensemble learning technique to increase accuracy and decrease overfitting. It is unknown what problem the Random Forest technique was used to solve or what the input data were in the context of the use case.
A 66.8% accuracy score, though, raises the possibility that the model isn't operating as well as it could. This accuracy score may or may not be suitable for the given issue. To make sure the optimal model is chosen for the particular use case, it is crucial to assess the model's performance using various metrics and compare it to other models.

- **Pneumonia Detection:**

A bacterial, viral, or fungal infection of the lungs is known as pneumonia. It can be a dangerous condition, especially for small children, the elderly, and those whose immune systems are already compromised. Coughing, fever, and breathing problems are just a few symptoms. Antibiotics or antiviral medications, relaxation, and plenty of fluids are frequently used as treatments. Vaccination against bacterial pneumonia and maintaining good cleanliness to stop the spread of respiratory viruses are two prevention methods. It's important to seek medical attention if you think you or somebody you love may have pneumonia in order to prevent complications.
An accuracy of roughly 83.17% was attained after the CNN model was trained using a dataset of pertinent

medical photos. This indicates that the model has an accuracy rate of 83.17% in properly identifying the presence or absence of certain medical problems.

The effectiveness of machine learning models might vary based on the amount and quality of the training dataset, the particular use case, and other factors, so even if this is a promising outcome, it is crucial to keep it in mind. The model may need to undergo additional testing and improvement to increase its accuracy and guarantee its usefulness in clinical situations.

- **Heart Disease Detection:**

Heart disease is the leading cause of death worldwide. It addresses a broad range of cardiac conditions, such as coronary artery disease, heart failure, and arrhythmias. Heart disease risk factors include smoking, being overweight, having high blood pressure, having elevated cholesterol, and having diabetes. Maintaining a nutritious diet, exercising frequently, and quitting smoking are all examples of prevention techniques. Medication, dietary modifications, and even surgery are all possible forms of treatment. Understanding the early symptoms and indications of heart disease is essential, including chest pain, breathlessness, and dizziness, and to get medical help if necessary.

For this use case, it has been shown to be effective with an accuracy of 86.96%. It's crucial to remember that a model's accuracy does not always imply how successful it is. To assess the effectiveness of the model, other metrics such as precision, recall, and F1-score should be considered. Additionally, it's crucial to check that the model can generalise adequately to fresh data and isn't overfitting the data. The model can be further tuned and optimized to increase its performance.

V. CHALLENGES AND LIMITATIONS

Although deep learning has a lot of potential to transform healthcare emergency services, there are also a number of difficulties and restrictions to take into account when putting such a framework into practice.

The requirement for a sizable quantity of high-quality data to train the deep learning models is a significant difficulty. When it comes to emergency services, the availability of such data may be constrained, which makes it challenging to create precise models. Additionally, it's possible that the data used to train the models don't always accurately reflect the wide variety of people and illnesses seen in actual emergency situations.

The models' interpretability presents another difficulty. Because it can be challenging to comprehend how deep learning models make their predictions or choices, they are frequently referred to as "black boxes". In the healthcare industry, where decision-making requires interpretability and explainability, this lack of transparency may be a deterrent to adoption.

When applying a deep learning framework to healthcare emergency services, ethical and legal issues must also be considered. It is crucial to abide by data protection rules and put in place suitable security measures because the usage of sensitive patient data causes privacy and security concerns. Additionally, to ensure fair access to emergency services for everyone, difficulties with prejudice and fairness in the models may exist.

The significant computational resources needed for deep learning might also be a drawback in places with limited resources, such as emergency departments. In time-sensitive emergency scenarios, the models might not be practical because they would need a lot of processing power and time to operate.

In conclusion, there are several difficulties and constraints that must be taken into account, even if deep learning offers a lot of potential to improve healthcare emergency services. When adopting a deep learning-enabled framework in healthcare emergency services, it's crucial to consider the necessity for significant amounts of high-quality data, interpretability, ethical and regulatory considerations, and computational resources.

VI. FUTURE SCOPE:

ML algorithms will be able to use larger and more varied datasets as technology develops to detect and diagnose an even broader spectrum of ailments. These models can detect and forecast diseases even more precisely with the addition of more data. ML algorithms, for example, can be utilized to analyse X-ray scans and other diagnostic procedures to find diseases like lung cancer and tuberculosis.

Machine learning models can identify diseases as well as give patients useful details about recommended safety measures and treatment alternatives. The app can offer individualised advice on lifestyle modifications or medications that can help prevent or treat the disease by analysing the patient's data. Patients may be empowered to choose their treatments with knowledge and be able to play a more active role in their own health as a result.

Another crucial component of using machine learning in healthcare is storing detection records. With the ability to watch the development of an illness over time, medical professionals can keep an eye on the efficacy of therapies and make any required adjustments. Doctors can intervene sooner and administer more effective treatment, which can improve patient outcomes and lower healthcare costs, by identifying and diagnosing diseases early.

But like with any technology that handles private medical information, security and privacy must come first. Compliance with data protection legislation and the implementation of suitable security measures are required for the use of machine learning algorithms in healthcare. The advantages of technical breakthroughs must be balanced with the ethical issues that must be considered.

In conclusion, machine learning in healthcare has a bright future. Machine learning algorithms have the potential to completely transform the healthcare industry thanks to their capacity to analyse larger and more varied datasets, offer individualised suggestions, and maintain detection records. To retain trust and assure adherence to data protection rules, it is crucial to make sure that patient privacy and data security are preserved.

VII. RESULTS

The paragraphs go over many use cases for identifying diseases using various models and methods. Examples include using VGG-16 for feature extraction in one situation and specially designed CNN architectures in another. For some use scenarios, various machine learning models, like Random Forest and XGBoost, were also applied. Each use case's accuracy was different, with some obtaining high accuracy—like 100%—and others having low accuracy, like 66.8%. The complexity of the isease and the caliber of the dataset utilised both had an impact on the accuracy obtained for each use case.

Even though some use cases achieved very high accuracy, larger datasets must be evaluated on the models to ensure that the accuracy is applicable to a wide range of scenarios. Combining several models and techniques can also improve the precision and reliability of disease detection systems. In order to select the optimum strategy for certain use cases in disease detection, careful evaluation and comparison of various models and methodologies are required.

Sr. no.	DISEASE	ACCURACY
1.	COVID 19	93%

2.	Heart Disease	86.96%
3.	Brain tumour	99%
4.	Breast Cancer	91.81%
5.	Alzheimer	73.54%
6.	Pneumonia	83.17%
7.	Diabetes	66.8%

VIII. CONCLUSION

The efficiency and effectiveness of emergency medical response could be enhanced by the proposed IoT and DL-enabled infrastructure for healthcare emergency services. The platform makes use of IoT and DL advantages to deliver accurate forecasts regarding patient status and real-time data analyses.

The use of deep learning in emergency medical services has the potential to completely change how doctors diagnose and treat patients. Healthcare professionals may examine big and complicated datasets using the strength of deep learning algorithms to make more precise diagnoses, offer individualised treatment options, and track the development of diseases.

While implementing a deep learning-enabled framework in healthcare emergency services has drawbacks, such as the need for a lot of high-quality data, interpretability issues, ethical and legal issues, and computational resources, these drawbacks can be overcome with careful planning, teamwork, and investment.

Overall, deep learning in healthcare emergency services has the potential to significantly improve patient outcomes and save lives. Healthcare professionals must adopt these new tools and technologies as they develop to better care for patients in dire circumstances. By doing this, we can bring about a new era of individualised, data-driven healthcare that enhances results and spares lives.

The approach may speed up responses, enhance patient outcomes, and perhaps save lives. The framework, however, also confronts several difficulties.

IX. REFERENCES:

1. H. K. Bharadwaj et al., "A Review on the Role of Machine Learning in Enabling IoT Based Healthcare Applications," in IEEE Access, vol. 9, pp. 38859- 38890, 2021, doi: 10.1109/ACCESS.2021.3059858.
2. M. Pouryazdan, C. Fiandrino, B. Kantarci, T. Soyata,
D. Kliazovich and P. Bouvry, "Intelligent Gaming for Mobile Crowd-Sensing Participants to Acquire Trustworthy Big Data in the Internet of Things," in IEEE Access, vol. 5, pp. 22209-22223, 2017, doi: 10.1109/ACCESS.2017.2762238.
3. Md. Motaharul Islam, Zaheed Ahmed Bhuiyan, "An Integrated Scalable Framework for Cloud and IoT Based Green Healthcare System", IEEE Access, vol.11, pp.22266-22282, 2023.
4. Gaurang Bansal, Karthik Rajgopal, Vinay Chamola, Zehui Xiong, Dusit Niyato, "Healthcare in Metaverse: A Survey on Current Metaverse Applications in Healthcare", IEEE Access, vol.10, pp.119914- 119946, 2022.
5. Long Liu, Zhichao Li, "Permissioned Blockchain and Deep Reinforcement Learning Enabled Security and Energy Efficient Healthcare Internet of Things", IEEE Access, vol.10, pp.53640-53651, 2022.
6. Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., Ayyash, M.: Internet of Things
7. A survey on enabling technologies, protocols, and applications. IEEE Commun. Surv. Tutor.
8. Akram Galal, Xavier Hesselbach, "Machine Learning Models for Traffic Classification in

Electromagnetic Nano-Networks", IEEE Access, vol.10, pp.38089- 38103, 2022.

9. Kondaka, L.S., Thenmozhi, M., Vijayakumar, K. et al. An intensive healthcare monitoring paradigm by using IoT-based machine learning strategies. Multimed Tools Appl 81, 36891–36905 (2022).
10. M. Alhussein, G. Muhammad and M. S. Hossain, "EEG Pathology Detection Based on Deep Learning," in IEEE Access, vol. 7, pp. 27781-27788, 2019, doi: 10.1109/ACCESS.2019.2901672.
11. Zobaed, S.M., Hassan, M., Islam, M.U. and Haque, M.E., 2021. Deep learning in IoT-based healthcare applications. In *Deep Learning for Internet of Things Infrastructure* (pp. 183-200). CRC Press.
12. Bhadoria, Riddhi Kumari, et al. "IoT-based location-aware smart healthcare framework with user mobility support in normal and emergency scenario: a comprehensive survey." *Healthcare Paradigms on the Internet of Things Ecosystem* (2021): 137-161
13. Alhussein, M., Muhammad, G., & Hossain, M. S. (2019). EEG pathology detection based on deep learning. *IEEE Access*, *7*, 27781-27788.
14. Mohanta, B., Das, P., & Patnaik, S. (2019, May). Healthcare 5.0: A paradigm shift in digital healthcare system using artificial intelligence, IoT and 5G communication. In *2019 International conference on applied machine learning (ICAML)* (pp. 191-196). IEEE.