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# IOT AND CLOUD BASED HEALTHCARE MONITORING AND DIAGNOSIS USING FUZZY NEURAL NETWORK

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**Abstract**
The healthcare monitoring and diagnostic system has radically changed the manner in which medical care is provided. It has improved patient outcomes, increased productivity, and given people greater control over their treatment. Regular system assessments and enhancements are essential to ensuring the system's correctness and efficacy. Fuzzy neural networks, cloud computing, and Internet of Things have the power to dramatically change healthcare monitoring and diagnosis. Cost-effectiveness, remote monitoring, and real-time data collection are just a few of its many benefits. It is imperative to solve the concerns and problems associated with these systems in order to guarantee the safe and effective use of this technology in healthcare. The recommended method assesses the patient's condition by using sensors for pulse rate, body temperature, and blood pressure. In order to support intelligent decision-making regarding patient care, monitoring, and administration in order to identify potential illnesses and cures, the system makes use of a fuzzy logic framework and information database. Furthermore, the proposed methodology aims to enhance the system's efficacy concerning personnel utilisation, expenses, and patient treatment and monitoring duration. The suggested approach of using sensors for patient monitoring shows sensible accuracy and price savings when compared to the current methods in use. So far, the proposed methodology has proven to be widely applicable and can be adapted to more critical settings such intensive care units, operating rooms, neonates, and patients with higher levels of complexity.

**Keywords-** IoT, Cloud, Fuzzy Neural Network(FNN), Health monitoring.

## INTRODUCTION-

The healthcare monitoring and diagnosis system is a crucial tool in the healthcare industry[1] that is designed to track and monitor the health of patients, provide accurate and timely diagnoses, and improve overall healthcare outcomes[2]. This system utilizes advanced technologies and data analysis to gather and analyze patient information, enabling medical professionals to decide with knowledge and deliver superior care[3].

The system's capability to constantly track patient's health is one of its main advantages. Patients who have long-term medical issues or who are at a higher risk of experiencing health complications should pay particular attention to this. Healthcare practitioners can track vital indications including blood pressure, blood sugar levels, and heart rate in real-time by utilising wearable technology and remote monitoring tools. This makes it possible to identify any changes or anomalies early on, which enables timely management and helps to avoid major health problems[4]. Moreover, the healthcare monitoring and diagnosis system also promotes patient empowerment and engagement. Patients can access their health data and monitor their progress through user-friendly apps and portals. This enables individuals to take an active role in their own medical treatment and make necessary lifestyle changes to improve their health outcomes.

The system also facilitates better communication and collaboration between healthcare providers. With a centralized database and secure sharing of patient information, healthcare professionals can easily access and share data with each other. This ensures a coordinated and efficient approach to patient care, leading to better outcomes[5].

However, like any technology, the healthcare monitoring and diagnosis system also has its limitations. Therefore, it is crucial for healthcare professionals to closely monitor and verify the data being collected by the system[6].

IoT-Internet of Things, is a network made up of several connected devices that can communicate with one another over a computer network [2,10]. We are able to obtain information from sensors that are related to it through this global network. We are able to access this information from anywhere in the globe by using a computer network. With the help of IoTs[11], physical items can be linked to the Internet and systems based on different technologies, like wireless sensor networks and near field communication (NFC), can be built (WSN)[12]. Wireless sensor networks use sensors to collect data from their environment and send it back to the base station[13]. Health monitoring devices are brought into the healthcare system by IoT[15]. With sensors and Internet of Things, health data may be accessible[16]. The purpose of the healthcare system is to assist treat illnesses and promote health[17].

1.1 TECHNOLOGY IS COST-PROHIBITIVE-

Telemedicine solutions are expensive and time-consuming, as healthcare institutions that use them can attest. It takes training to implement a new system, and employees may not always be happy about the change. For practices to reap the rewards of the system, practice managers, nurses, doctors, and other healthcare professionals must become proficient in its use. Over time, more patients and fewer staff members should result in a favourable return on investment for healthcare systems using telemedicine, despite its initial high cost.

As seen in Figure 1, the main elements of healthcare systems include identity, location, sensing, and connectivity. Numerous solutions, including emergency services, big data, wearables, smart computing, sensors, labs on chips, and remote monitoring, are used to create smart healthcare[23].

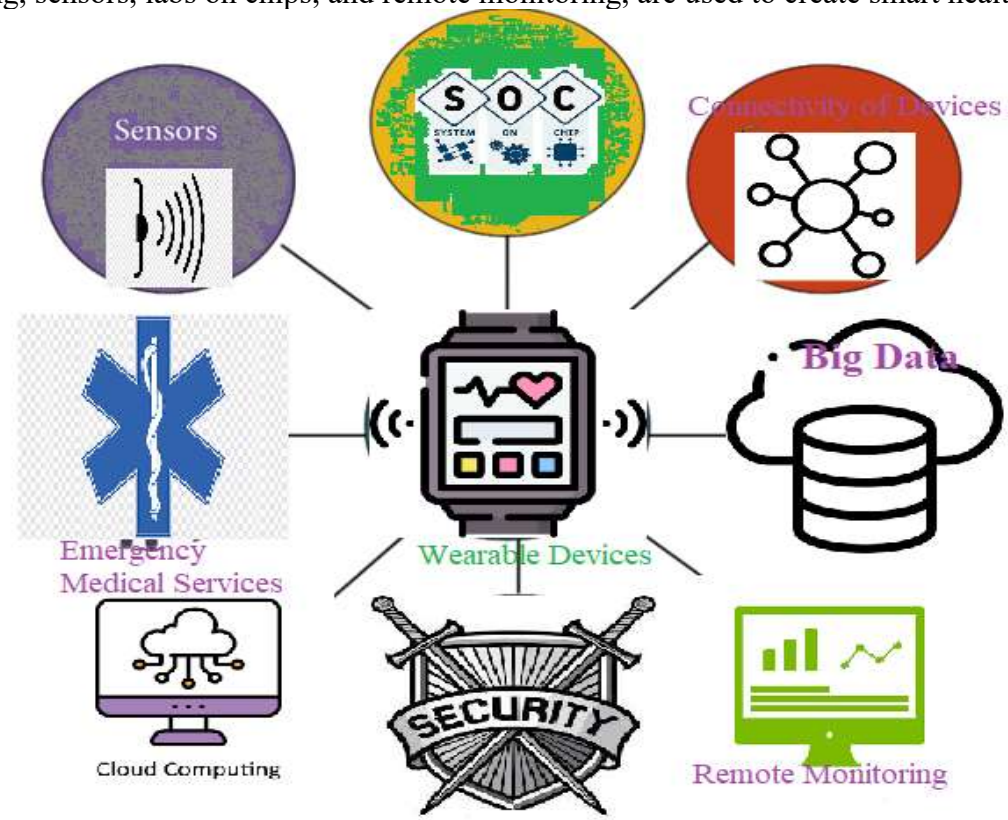


Figure 1- Common elements of IoT-driven smart health care

Telemedicine systems that are based on IoTs are outfitted with networks of body sensors. They contain gadgets with specialised nodes that detect changes in patient data on a periodic basis. Sensors are utilised to gather information for various ventilation-related measures in order to assess the patients' room circumstances. The sensors are designed to evaluate various temperature, pressure, humidity, and other important environmental variable data ranges[24].

These arrangements facilitate remote patient condition monitoring. The technology can keep track of patient histories and deliver information for the hospital on a regular basis. The data can be viewed by hospital professionals, who can also create a treatment strategy for the individual who is being observed. Wireless sensor network-based devices make up the second category of IoT healthcare system equipment[25]. When it comes to the work of managing and monitoring patients in remote areas, the circumstance becomes more complicated than the one described above. IoT is the most affordable and dependable option in some circumstances, but there are more formal objectives that need to be met in order to fully understand how various devices interact with interactive communication systems[26].
Figure 2 shows the function and benefits of IoT nowadays in healthcare[27].

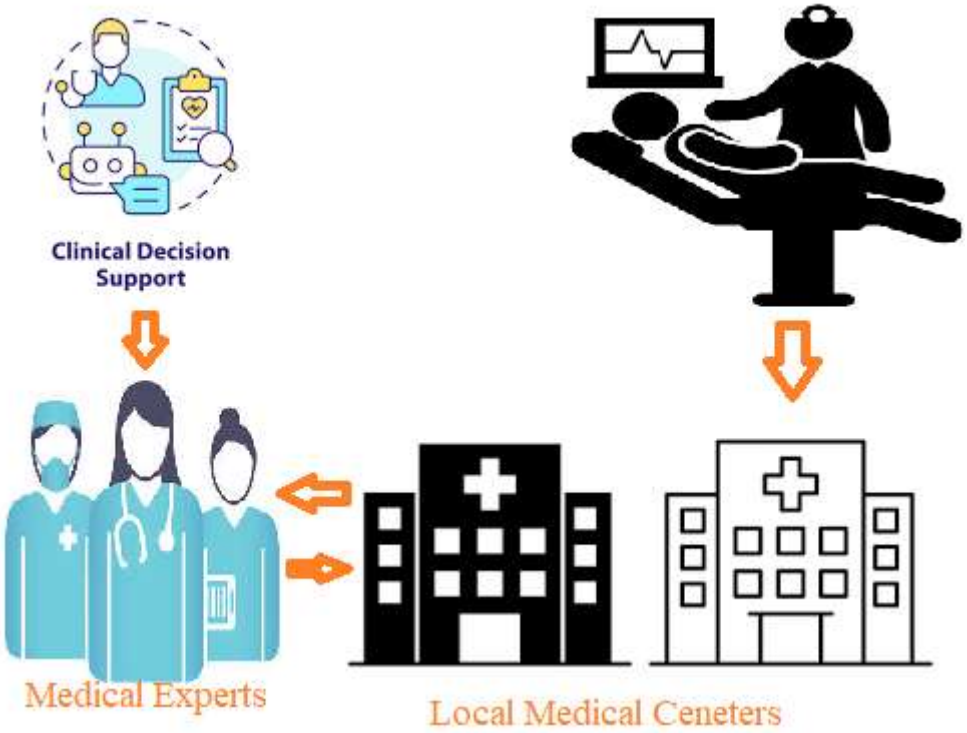

Figure 2- Structure of IoT in healthcare

Keeping an eye on the patient all the time is difficult because their health is monitored on a screen. Thus, sensors such as blood glucose, body posture, temperature, pulse rate, and ECG can be used to evaluate the patient's current state in this instance[28]. The sensors are linked to Arduino sensors, which, once attached to the main Arduino board, collect data and transmit it to the server. The doctor who gives prescription advise receives the information from this website[29].
A smart healthcare framework is essentially a technological advancement that makes patient treatments feasible and raises quality of life. The e-health idea, which encompasses various technologies such as digital record administration, smart home amenities, and intelligent and medically connected gadgets, is also included in the notion of smart health.

- Modern healthcare facilities are a major difficulty, particularly in poor nations where there are insufficient superior medical centres and doctors in remote places. Health has profited from artificial intelligence's revolution in many other areas of life. Several issues plague the store-and-forward architecture of the current conventional telemedicine method:
- A nearby health facility with committed personnel is required.
- Medical equipment is required in order to compile patient reports.

- A 24- to 48-hour window within which to obtain a diagnosis and prescription information from a primary care physician.
- Local health centres' expenses.
- A Wi-Fi connection is required[33].

This research proposes an innovative and intelligent healthcare system that leverages contemporary technology such as machine learning and IoT. This system has the intelligence to use a medical decision support system to sense and process patient data. For those living in remote places, this technology offers an affordable alternative.

**LITERATURE SURVEY**

According to Kazi K (2023)[09], the incubation period for Covid-19, which can extend up to 14 days, typically lasts 5 days for an infected individual before symptoms manifest. Fever, dizziness, headaches, dyspnea, dry coughs that finally produce phlegm, and, in rare instances, loss of taste and smell are the primary symptoms of a Covid-19 infection. It is imperative to keep a close eye on the patient under home quarantine. The recommended plan keeps an eye on breathing rate, body temperature, heart rate, and oxygen levels—all of which are indicators of COVID-19. On the other hand, our suggested Internet of Things (IoT)-based patient health monitoring system merely tracks and measures body temperature; older patients' heart rates are also monitored. For such patients/people, a system must be built. The information that must be gathered includes temperature, oxygen level, sweat, heart rate, respiration, and so forth. The healthcare system involves tracking and analysing the various COVID-19 symptoms that manifest in the human body. For our investigation using our proposed approach, we take one healthy individual and one COVID-19 patient on the same day. Wi-Fi and Internet of Things are used to keep all patient data on the server. Values are wirelessly transferred to a hospital or COVID centre in the vicinity. The central server stores this data as well.

This work provided the fundamental idea for a machine learning (ML)-based system that predicts the likelihood of developing heart disease by employing ML techniques to detect heart illness in the near future. There are less synthesized papers in this discipline, despite the growing quantity of empirical studies on the subject, especially from developing nations. This cutting-edge technology helps heart-care agencies make better judgments regarding how they can best assist their customers by using data gathered from past events to forecast future trends and results. Forecasting in the healthcare industry can help doctors diagnose patients more accurately and quickly. Medical personnel are better able to identify and treat patients with higher efficiency and accuracy when they anticipate potential medical events. Better patient outcomes and even cost savings could result from this.. The included papers in this study concentrate on utilizing machine learning algorithms to anticipate the cardiac healthcare system (HHS). For registration and notification, we used the K-means Elbow approach; for HHS, we used a decision tree; and for immunization reminders, we used MySQL.

2.2 PROPOSED SMART HEALTHCARE SYSTEM'S ARCHITECTURE-

Observed patient conditions, such as heart rate, body temperature, and pulse, can inform the decisions made by the proposed smart healthcare system. Another energy-efficient feature of this design is that not all of the sensors are always on. The sensors' lifetime, expenses, and utilisation will all be controlled by the system's algorithm. The recommended method addresses the issue of remote patient monitoring and provides the necessary medical attention from hospital professionals.

Figure 3displays the suggested system's architecture.

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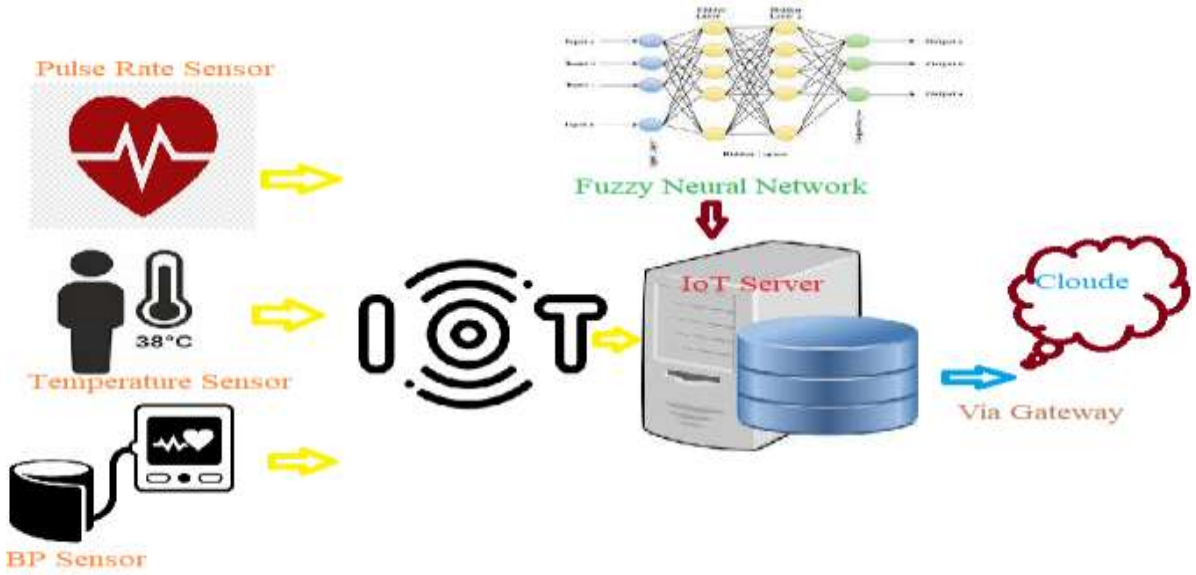


Figure 3- Proposed Smart healthcare system architecture

Figure 3's architecture has been updated to include more information. One innovative concept that enhances the efficacy of telemedicine for rural regions is the integration of sensors with decision support systems.

*Gathering Information for a Smart Health System via Sensors –*

The suggested system will be created to apply an innovation in a distant clinic with the aid of the Internet of Things. The device will transmit data to the relevant hospital doctor, including the patient's blood pressure, body temperature, and heartbeat. The doctor will use the data to assess the patient's condition and advise the staff of the remote clinic. The architecture of the suggested system is shown in Fig.5 in a physical form with all required parts. The three sensors that make up the system are the heartbeat, pulse rate, and body temperature sensors.

The system of fuzzy logic used in this intelligent health tracking and administration system for decision-making is described in the following subsection.

*Smart Healthcare Observation and Management Using Fuzzy Logic-*

The following issues are addressed by combining multiple models in order to address the shortcomings of a single model. A hybrid system is created when many concepts are integrated to provide a practical answer to the issue. Fuzzy logic system with NN-neural networks, which are embodiedby FuzzyNeural Network(FNN), are combined to create a hybrid system that measures indoor air quality.

The fuzzy neural network is the result of these constraints. Neural network patterns are the source of fuzzy system rules.

This procedure starts with a "fuzzy neuron," which goes through the following two steps in its operation:

(i) Development of a model of fuzzy neurons.
(ii) The structure and algorithm which integrate fuzziness within neural system are developed.

Figure 4 shows that a neural network that generates neural outputs is supplied with neural inputs. The inferential rules that govern the fuzzy interface, known as neural outputs, are kept within the framework as a database, used to make decisions, and supply the neural network with prior information in the form of learning algorithms. It is challenging to include particular data onto NN-neural network to make learning methods more clear. Since fuzzy rules are elucidated and offer superior performance, fuzzy systems are employed in constrained environments where acquiring knowledge is a challenging

undertaking. Fuzzy rules originate using numerical data in order should deal with these problems when developing solutions.

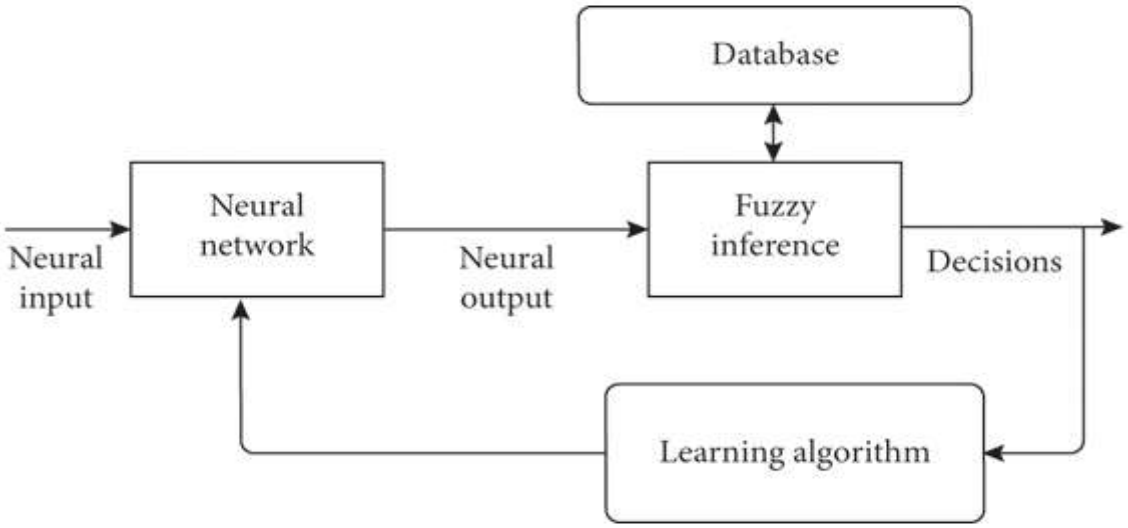


Figure 4- FNN Model

2.2 RESULTS AND DISCUSSION-

The integration of IoT and cloud-based systems has created new opportunities enabling healthcare monitoring and diagnostics, as a result of the growing use about connected devices and the developments in cloud computing. The capacity to gather patient data in real-time is one of the key benefits of employing cloud-based and IoT technology in healthcare. Vital signs, medication compliance, and other health-related data may be included in this data. After that, this data is sent to the cloud, where medical experts can access, store, and analyse it.

The use of fuzzy neural networks in these systems allows for more accurate and efficient analysis of the collected data. Fuzzy neural networks are able to handle uncertain and imprecise data, which is common in healthcare monitoring. This makes it easier for for precise diagnosis and treatment recommendations to be made by medical professionals.

Another advantage of using IoT and cloud based systems is the reduced cost and time for healthcare services. Patients no longer have to physically visit a hospital or clinic for routine check-ups. Patients besides save time and money by doing this, but healthcare personnel also have less work to do.

However, there are also some concerns and challenges that come with the use of IoT and cloud based systems in healthcare. Security and privacy of patient data is a major concern. With sensitive health information being transmitted and stored in the cloud, there is a risk of data breaches and unauthorized access. Robust security measures must be in place to ensure the protection of patient data.

***Performance Measures-***

The formula in (1) is used to compute the results' percent error. In this case, tentative accuracy is the accomplished accuracy of the experiments, and the acceptable value is the necessary accuracy.

$$\text{percent\_error} = \frac{\text{accepted\_value} - \text{experiemtnal\_value}}{\text{total\_value}} \times 100. \qquad (1)$$

**CONCLUSION**

The way healthcare is provided has been completely transformed by the healthcare monitoring and diagnosing system. It has raised productivity, enhanced patient outcomes, and given patients more control over their healthcare. To guarantee the system's efficacy and accuracy, it is crucial to assess it

frequently and make improvements. We may anticipate this system playing an even larger part in healthcare in the future as a result of the ongoing technological improvements. The combination of fuzzy neural networks with cloud-based systems and the IoT has the potential to completely transform healthcare diagnosis and monitoring. It has many advantages, including cost-effectiveness, remote monitoring, and real-time data collecting. To ensure the safe and efficient use of this technology in healthcare, it is crucial to address the issues and problems related to these systems. The suggested approach uses blood pressure, pulse rate, and body temperature sensors to evaluate the state of the patient who is being watched.

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