Smart Environment for IoT based Disease Diagnosis Healthcare Framework

Chandan Kumar Roy
Research Scholar, RKDF University, Bhopal,India
Dr. Ritesh sadiwala
Professor, RKDF University Bhopal, India

Abstract:
*The medical facility would not be within walking distance of the natives in most rural areas. As a result, most individuals overlook any minor health problems that manifest themselves early on in the form of changes in vital features such as body temperature, pulse rate, and so on. When their health problems become serious, people seek medical help, which might result in the waste of their own money. This is important to consider, especially when an epidemic spreads in a remote area where doctors cannot reach it. To prevent disease transmission, smart medical IoT-based sensors attached to patients who can be monitored from a distance would be a realistic solution that might save many lives. We present a cloud-centric IoT infrastructure for monitoring human biological signals in this paper, which can continuously monitor the patient's heartbeat, temperature, and other essential parameters in an indoor environment. We suggested a continuous monitoring and control system that utilizes a NodeMCU controller with a Wi-Fi module based on remote correspondence to screen the patient's health and save the patient's information on a cloud server, predicting the severity of future diseases. This IoT-based remote health monitoring system allows authorized individuals to access data stored on any IoT platform, and diseases are diagnosed by doctors from a distance based on the values received***.**

Keywords:*User Diagnosis Result (UDR), Cloud computing Internet of Things (IoT)*

I. INTRODUCTION

Due to the increasing ageing society, new supporting technologies have been introduced quickly in recent years. Indeed, in 2040, 50% of Europe's population is estimated to be over 60 years old, while in the US, one in six will be over 65 in 2020 [1]. Those beyond 85 years frequently need continual surveillance. The care of the elderly has therefore become a very essential and challenging problem. The need for infrastructure improvements, health care and accommodation will increase, together with the number of people with disabilities, such as gait disorders, neurological changes (Parkinson's, Alzheimer's or other dementia diseases), a lack of visual acuity, balance disorders, heart and respiratory misrepresentations, loss of memory and so on. It restricted the elderly to their everyday activities in the setting of large demographic change, according to the help of their companions or families. The challenge is to shift society's perspective that older people must be active and live independently using ICT, with the primary objective of enhancing the quality of life for them. The Ambient Assisted Living (AAL) strategy is a means through which the development of new technology and services may provide a better living for the elderly and people suffering from chronic diseases and disease recovery status. The AAL system has made an optimistic transformation in several health and lifestyle factors. It is based on multiple body temperature, blood pressure, glucose, oxygen, and weight measurement sensors.

This system is appropriate for diabetic and cardiac rhythm patients. Environmental support systems provide clinicians and family members with the ability to remotely monitor their patients [2]. The vision of AAL is being realised through recent advances in IoT healthcare [3]. The authors of [4] studied developing cardiovascular surveillance applications using Arduino. In a study, the application of surveillance is accessible through a computer, so that it is difficult to carry anywhere when practically everything can be done anywhere in the age of industry 4.0. Earlier studies have shown that remote monitoring of patients has a beneficial influence on the preventability and monitoring of temperature and toxic gas conditions in rooms with infectious illnesses such as tuberculosis [5]. They therefore designed this work to construct an IoT-based health surveillance system accessible online through a smartphone. A range of measures, including regular changes in health parameters throughout time and abnormal conditions, are utilised to gather information via the IoT's medical system over a certain time span. In addition, it may use IoT devices and readings of medical sensors within a certain period to diagnose a condition's severity. It carried the procedure of diagnosis of disease out using three subsystems. First, the user sub-system is used for IoT devices and medical sensor readings. They will perform data analysis using the component-based cloud subsystem to diagnose diseases.

Finally, various alert signals are delivered to the responder and caregiver, depending on the findings determined by the cloud subsystem, for future necessary actions.The IoT context employs a long history of continuous measurements in the health field to diagnose a disease for a period of time. The diagnosis in a healthcare environment relies on accumulative measures that are useful and can not be achieved by a single visit to the clinic. The study helps to (i) provide a fog-assisted IoT framework for the m-health perspective for diagnosis of diseases. (ii) The development of a server-side health diagnostics system for computing user diagnostics results (UDR). (iii) Control of the severity of the condition by the use of alert mechanisms. IoT devices give a way to healthy living at a minimal cost. Medical IoT devices which promote patient-centered treatment develop personal healthcare.

II. BACKGROUND WORKS

This section investigates and implements several IoT-based health surveillance systems and data mining techniques.

In [6], the authors created a low-cost health monitoring system that uses conventional approaches such as sensors, wireless links and other remote gadgets to monitor people with several diseases. Relevant sensors are collected, either used on the body or in living conditions, with rich data to evaluate the patient’s physical and mental status. The emphasis of this study is on the examination of the current e-health monitoring system by integrated systems. The electronic health surveillance system mainly aims at automatically providing patients with a prescription under their condition. Without physical connection, the doctor can continually assess the patient's health. The research seeks to analyse the use of IoT applications in the medical industry and the role they play in enhancing healthcare. The study also examined the use and extent of IoT in medical companies to promote classical approaches in many domains of health and to establish the degree to which IoT has improved the quality of the health services given. The research is based on a descriptive method by an analysis of the literature in this field. The findings of the research related to the use of IoT in health facilities help to perform optimal diagnoses for patients, which shows the quality of the patient’s service. It will also minimise regular patient examinations in the hospital using remote IoT diagnostic applications. A healthcare application will assist in collecting the correct data for the diseases experienced by patients and thus use it in preparing scientific studies to gain more accurate results. The evaluation also introduced the Internet-based patient healthcare monitoring system (HCMS) and the overall framework of patient health monitoring systems online.

In [7], the authors built and then sent data into the network through Wi-Fi modules. This system allows them to monitor the vital sign parameters and communicate data via wireless connection. Data may be accessible and reflect the current status of the patient at any moment. In order for a caretaker or doctor to monitor patient information in real-time using smartphone app software. Overall, the system being built includes the FireBetle ESP32, a DFRobot controller with Wi-Fi modules, a pulse sensor MAX30100 and a body temperature-detector MLX90614 sensor. They added a module for detection of patient positions to the GPS (Global Positioning System) system and an OLED module for data vision (Organic light-emitting diode). The test findings suggest that a 6.5% pulse detection inaccuracy, 4% oxygen detection and 1.7% body temperature were correctly functioning for the system. The location produced by GPS is 7 metres accurate.

In [8], the authors created a new, individualised and multimodal coaching approach for optimal ageing. This technology aids old people by offering them suggestions and ideas for a healthy life, based on data obtained from their regular tasks. This project employs ICT-based technologies to collect data from indoor and outdoor areas and may be extended to cover every inhabitant of a large metropolis or city-wide environment. By using the data collected, the initiative creates a virtual, personal coach to help enhance the well-being of citizens.

In [9], authors are collecting data from indoor users using ICT-based technologies. The major purpose of this strategy is to develop a web-based social network for the promotion of the elderly and good conduct. This web-based system offers information about monitored individuals' health issues. The project collects user information and easily shows it through informal careers, family members and friends. However, the data collected is not gathered from outside areas and is not intended to be used within an urban context because architecture concentrates on data being collected from indoors without giving a scalability process. They shared the results across the web through a remote access point.

In [10], the authors offer a unique strategy using ICT techniques to gather information about elderly people and propose the optimal route to take while moving about the city. They focused these routes on the capacity of the users and took their physical circumstances into account. The platform employs a mobile device to support users on their travels. The proposal solely takes outside areas into consideration. This project does not collect data from inside areas and is not equipped for urban usage since they designed the concept just for a few users.

III. PROPOSED MODEL

Fig. 1 describes the recommended technique. There are three steps in the conceptual framework of IoT-based m-Health monitoring. Phase 1 provides medical equipment and sensors with data about the patient's health. The data obtained is sent through a gateway or local processing unit (LPU) to the cloud subsystem. In Phase 2, medical measurements are used to make cognitive decisions about personal health through the medical diagnostic system. In phase 3, the parents or caregivers are notified about the health of the individual. In the event of an emergency, it will also notify the next hospital of an emergency. For each step, they explain the details in the future:

User subsystem:

Data collection systems for users' health data are available, allowing for smart, miniature, low-power sensors and other medical equipment to be integrated seamlessly. They placed the sensors in, on, or around the body to monitor the operation of the body. In our process, both wearable and implanted sensor devices make up the body sensor network of the individual. With bio sensors like body temperature and blood pressure, each sensor node is integrated.The sensors capture structured and unstructured physical characteristics from the learner and send them to a local processing unit (LPU), or cloud layer gateway, which may be a mobile device or smart-phone. Since heterogeneous IoT devices have multiple internal clock structures, they must synchronise them for prompt cloud-layer processing.

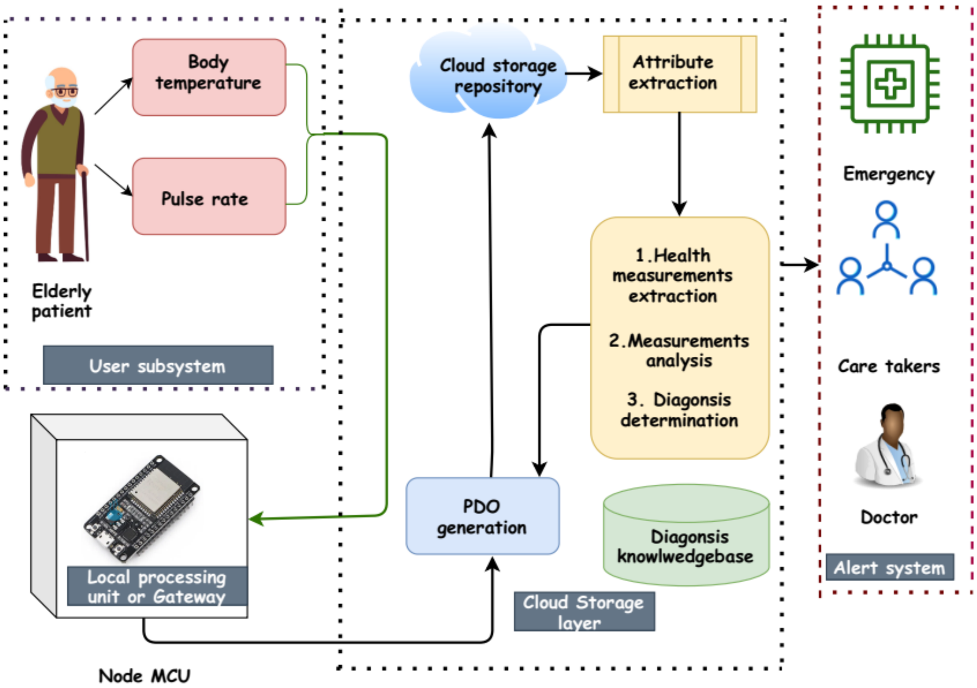

Figure 1: Overview of proposed system

The gateways need to be scheduled to provide temporary synchronization for many datasets before transfer, given the present view where time is an essential feature. Acquired data is communicated using wireless communication media such as 3G/CDMA/GPRS or Wi-Fi networks as depicted in figure 1 to the associated cloud storage repository.

Cloud storage layer:

We stored every user on a cloud-based platform for health-based sensory IoT information. As the data is all too often felt and necessary for various units, we save it as a cloud storage repository on the cloud server. They sent medical measures to a medical diagnostic system that follows the process of analysis and diagnosis to identify the health state of the individual. A user is a person with an IoT-based health application to assess their health status. It may be a particular individual with a certain ID on the server.

Table 1: Health attributes collected by health monitoring system

Users attributes	Description
Age	Age of user in years
Gender	Whether the user is male or female. (0/1)
Weight	Weight of user in kg
BP systolic/ diastolic	Systolic/ diastolic blood pressure (mmHg)
Body temperature	Patient current body temperature
Respiration index	Respiration index calculation.
Family history	User family history related to diseases
History of disease	Users' previous health history
Belongs to high-risk area	Location of the user home. (0/1)

We used this ID for the collection and medical measures of personal information. In addition, the ID number distinguishes an individual from other individuals as records values uniquely. Finally, the user profile might be regarded in a user profile database as sensitive user information. Let User Profile ($USER_i$, PERSONAL $DATA_u$, PROFILE $TYPE_v$) be recorded. This signifies a certain profile kind of PERSONAL DATAU $USER_i$. The user profile contains detailed information about prior health information for the authorities. The user profile type "age" may be considered as a user profile, for example, with personal information "23" and additional records like "heredity disease." The personal data generating details are provided in Table 1.

Isolation is a key approach for gaining data security in multi-occupant data storage. Isolated databases, shared databases with an isolated data table, and shared tables with isolated data access might be used in three different forms. Although the isolated database has maximum data security, the space complexity in data storage and access is quite significant. Shared data tables provide the lowest data security, yet data storage and access are efficient. The Data table is an isolated data security and information access vulnerability.

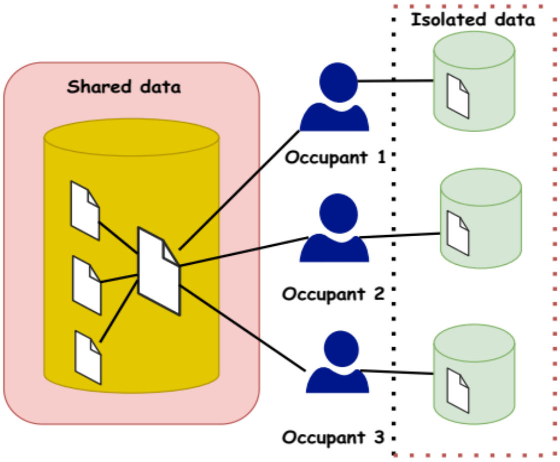

Figure 2: Isolated and shared data in multi-occupant storage

Regarding the efficiency and security of data access, two-stage tenants are specified in our Cloud storage layer design, as illustrated in Figure 2. We allocated health agencies to employees on the first level. At this level, isolated databases are used to segregate from those created by other agencies the data produced by a particular health agency. The approved healthcare agencies must guarantee the security of access to data using separate databases. In the second stage, we allocated individual patients' occupancy IDs. We stored the same data produced by the same medical agencies in shared tables. The clinical data of certain occupancy-linked patients can only be accessed by authorised persons. Because of the large numbers of people in need of health services, shared tables at this level will offer faster access to data than isolated databases or tables.

Alert generation:

User diagnostic result-based data is used in the health domain to provide alerts to doctors and caregivers. We provide patient data ($Patient_i$, T_{start}, T_{end}) $\rightarrow$ ($DESS_p$, Level, Probability) as input for generating alerts or emergencies. This completely covers the patient's data history and the probability of the disease, $DESS_p$, indicated in our technique as $P(DESS_p)$. The start T_{start} of the diagnostic method delivers information about starting and continuing to T_{end} time. The $DESS_p$ property is used as the disease type, and the disease stage is optional, and the level attribute determines the likelihood of disease and its reliability. First of all, a UDR from the diagnostic module will be obtained. If the probabilistic UDR instance value is less than the specified threshold value, then register the health status of the individual as "safe".

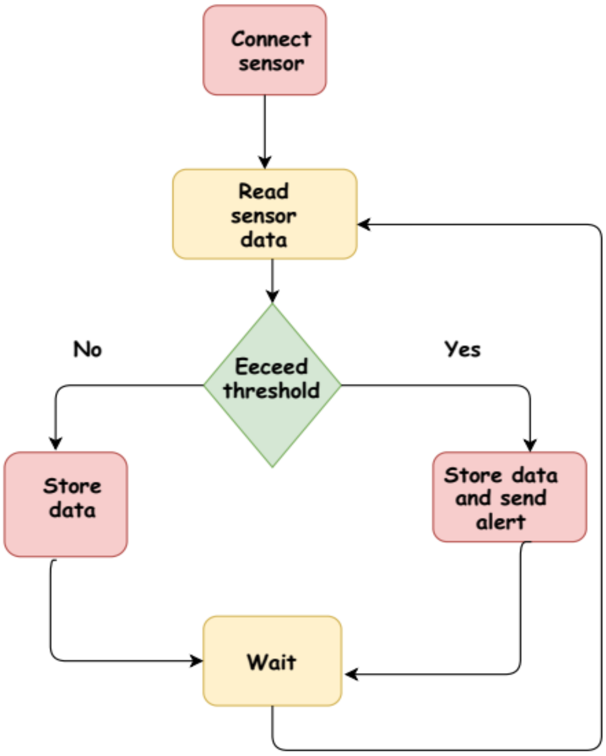

Figure 3: Flow chart of diagnosis module

When the probability value, on the other hand, exceeds the predetermined threshold value, the health of the people is “unsafe”, as illustrated in Figure 3. In addition, the implementation of thethreshold (α) based alert system is as follows:

Algorithm 1: Diagnosis of disease using the proposed technique.

Input:A data file with numeric values

Output: Set of patients records **{**Type of disease ,level of severity, probability}

Begin

{

// In the case of a specific confidence interval,doscale_basedstudy.

Outcome_Scale = perform Scale Analytics

Unbalanced Scale_Outcome = Scale_Outcome. Length( );

// In the case of a specific confidence interval, do pattern_ based study.

Pattern_Outcome = perform Pattern Analytics;

UnbalancedPattern_Result = Pattern_ Outcome. Length( );

// In the case of a specific confidence interval, do frequency_ based study.

Frequency_Outcome = perform Frequency Analytics;

Unbalanced Frequency_Outcome= Frequency_Outcome. Size ( );

If(UnbalancedScale_Outcome = UnbalancedScale_Outcome Range or Unbalanced
Pattern_Outcome = Unbalanced PatternResult Range or Unbalanced
Frequency_Outcome = Unbalanced
Frequency_Outcome Range)
PDO. append (Disease, Level, Probability);
GotoPDO;
}
End

1. When the system provides a warning alert signal ($Patient_i$_HEALTH = Unsafe), AND (P ($DESS_p$) < α) that indicates the emergency status of patient's health to the doctors. This information is useful for the individual to prevent any future occurrences.
2. If AND (P ($DESS_p$) > α) ($USER_i$_HEALTH = Unsafe), generate emergency status for the local hospital to manage an emergency. The alerts are also sent to physicians and caregivers via separate devices.

Algorithm 2 outlines the method of alerting. The generation of alerts is fully dependent on the UDR matrix of the diagnostic instance. The name of the illness offers the doctor and the caregiver certain information about the current health state. In addition, if there is an emergency, a notice will be sent to the emergency health care provider to ensure the appropriate handling of medical emergencies in adjacent hospitals and doctors. This IoT diagnostic approach also allows the caregiver and doctor to spend more time with the patient. Finally, the approach proposed enables the doctor to detect the condition in its early stages, allowing action to be taken to improve the patient's health.

Algorithm 2: Alert Generation in Proposed system.
Input: PDO :($Patient_i$, T_{start}, T_{end}) → ($DESS_p$, Level, Probability)
Step 1: Recover patient probabilistic values for $DESS_p$mostly during start and end timesT_{start} and T_{end}.
Step2: If (probabilistic value > threshold value), then goto **Step 4** else
goto Step 3.
Step 3:$Patient_i$_HEALTH = Safe;
UpdatePDOsubsequently N time slot; Go to Step 1;
Step 4: $Patient_i$_HEALTH = Unsafe;
If ($Patient_i$_HEALTH = Unsafe) AND (P($DESS_p$) < α)
Process of Warning alert to patient family members, goto Step 1;
Else if ($USER_i$_HEALTH = Unsafe) AND (P($DESS_p$) > α)
Create an emergency alert signal for responders that includes the patient's current health records.
Step 5: Send updatedPDO( ) to the concerned Doctor and Care-Takers.
Step 6: Exit

IV. RESULTS AND DISCUSSION

The IoT home monitoring framework allows patients to be provided with healthcare at home, to improve substantially, access their own health information and record it using an intelligent device, and to call their doctor. Healthcare professionals may access the records of patients' tremor findings, enhance diagnostic accuracy and enhance the effectiveness of healthcare at anytime and anywhere. Domestic health surveillance systems for disordered patients are able to enhance health care and offer an efficient and cost-effective method. The monitoring of patients over a certain period to evaluate the severity of the symptoms helps to diagnose Parkinson's disease differently from other comparable disorders. As shown in Table 1, the medical server has a sizable database. When the information is sent to the medical server, it first checks whether the patient has any previous medical records, then adds the new evidence to that record and sends it to the doctor. If a patient does not have the same previous medical records, the server generates a new ID and stores the data in its database.

Table 1: Data record of patient

Parameter type	**Datatype**
Identification of Patient	Int
PatientBody Temperature	Float
PatientPulse rate	Float

The database stores the data from the sensors, particularly the body temperature and pulse rate sensors. The range of body temperature is defined in Table 2. The temperature range's membership function, as shown in Figure 4, can be stated as follows:

$$Low = \begin{cases} 1, x < 35.9℃ \\ 0, x > 35.9℃ \end{cases}$$

$$Normal = \begin{cases} 1, 35.9℃ \le x \le 38.9℃ \\ 0, x > 38.9℃ \ \& \ x < 35.9℃ \end{cases}$$

$$High = \begin{cases} 1, x > 38.9℃ \\ 0, x < 38.9℃ \end{cases}$$

Table 2: Body temperature of a Patient/user

Body Temperature	**State**
35.9 –38.9 °C	Normal
>38.9 °C	High
<35.9 °C	Low

Figure 4 shows the body temperature of a patient or userthat shows temperature range on the x-axis in terms of membership function. In the similar way y-axis specifies the state of a patient (i.e, low, normal and high). When the temperature range falls in high state, there could be emergency alert generation to doctor or caretakers.

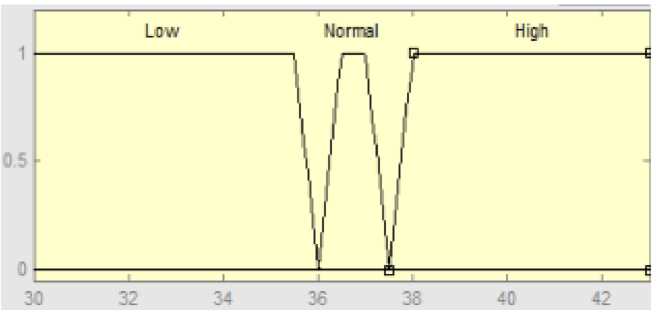

Figure 4: Body Temperature membership function

Consequently, to identify the patient's health status, a variety of pulse rate measurements are taken into account, as shown in Table 3. The pulse rate's membership function in Figure 5 is as follows:

$$Low = \begin{cases} 1, x < 58 \text{ BPM} \\ 0, x > 58 \text{ BPM} \end{cases}$$

$$Normal = \begin{cases} 1, 58 \text{ BPM} \leq x \leq 105 \text{ BPM} \\ 0, x > 105 \text{ BPM} \; \& \; x < 58 \text{ BPM} \end{cases}$$

$$High = \begin{cases} 1, x > 105 \text{ BPM} \\ 0, x < 105 \text{ BPM} \end{cases}$$

Table 3: Pulse rate of a Patient/user

Pulse rate	**State**
58 BPM - 105 BPM	Normal
>105 BPM	High
<58 BPM	Low

Figure 5 shows the pulse rate of a patient or userthat shows pulse rate range on the x-axis in terms of membership function. In the similar way y-axis specifies the state of a patient (i.e, low, normal and high). When the pulse rate falls in in low or high state, there could be emergency alert generation to doctor or caretakers.

Figure 5: Pulse rate membership function

The guidelines for diagnosing the patient's disease are applied based on these various ranges of values. The following membership function is used to diagnose the output health state: Figure 6 depicts a healthy, unwell person with hypothermia, fever, and the need for a thorough medical evaluation. The output health state's membership function is defined as follows:

$$Checkup = \begin{cases} 1, x < 22 \\ 0, x > 22 \end{cases}$$

$$Unwell = \begin{cases} 1, 22 \le x \le 44 \\ 0, x > 44 \ \& \ x < 22 \end{cases}$$

$$Hypothermia = \begin{cases} 1, 44 \le x \le 66 \\ 0, x > 66 \ \& \ x < 44 \end{cases}$$

$$Healthy = \begin{cases} 1, x > 88 \\ 0, x < 88 \end{cases}$$

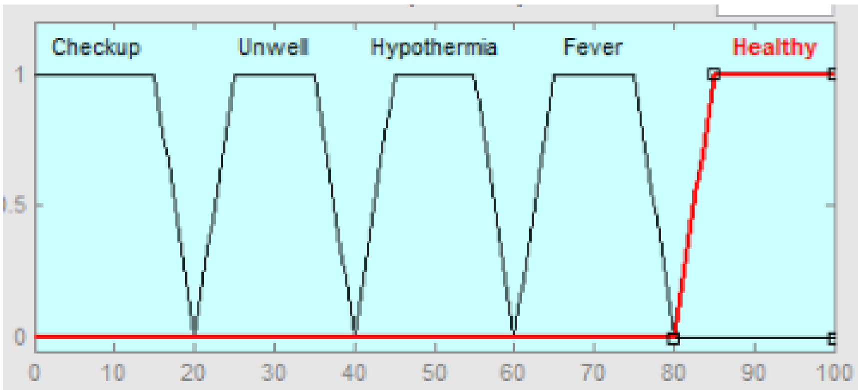

Figure 6: Output Health State membership function

The rules for diagnosing the output health condition are as given in Table 4.

Table 4: Rules for Diagnosing Disease

Pulse rate	**Body Temperature**		
	Low	**Normal**	**High**
Low	Health Checkup	Unwell	Health Checkup
Normal	Hypothermia	Healthy	Fever
High	Health Checkup	Unwell	Health Checkup

The health state of a severely ill patient may be continuously checked using this simple yet efficient device. It can be used to monitor the health of elderly people who have frequent heart or blood pressure problems. The health-related data, such as pulse rate and temperature, is updated and logged onto the ThingSpeak platform on a regular basis. That data may be used to keep track of the patient's medical history, and the data can be shown graphically using a dashboard as shown in Figure 7.

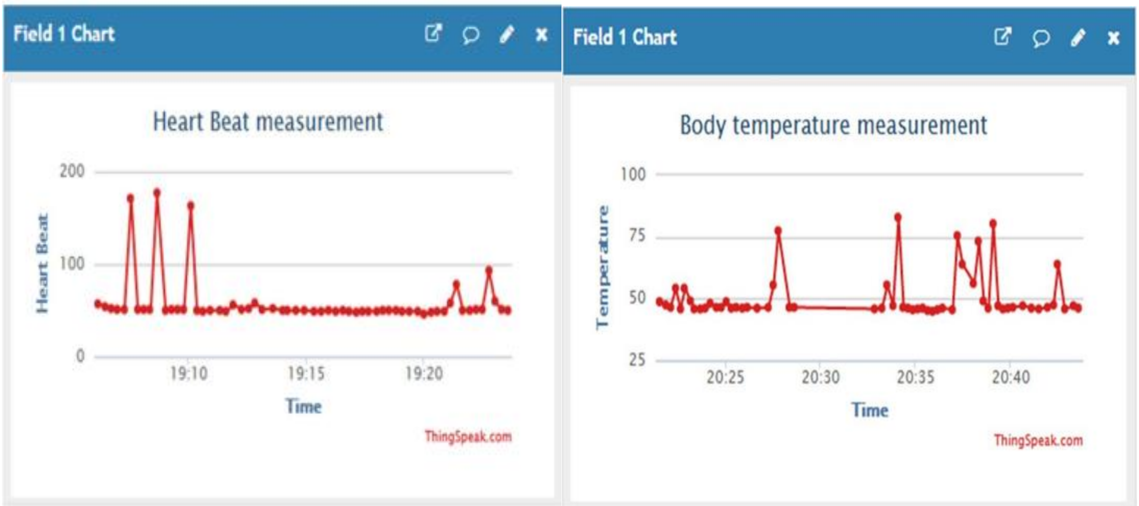

Figure 7: Response of the measured data (a) Heart beat from ThingSpeak (b)Body Temperature from ThingSpeak

Figure 8 shows the use of MATLAB that can be used to analyseThingSpeak data. We can use the findings of our investigation to trigger web requests, including an email request from ThingSpeak alerting doctors who can help them.

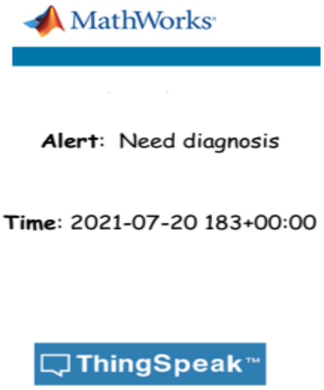

Figure 8:Email Notification to the concerned doctor

V. CONCLUSION

The main concentration in the paper is about the designing of an IoT based Disease Diagnosis Healthcare framework for payients who stay at home that generates patient diagnostic outcomes (PDO) with the help of nedical sensor health measures. The system may thus initiate certain actions (for example, in order to alert family or medical personnel) when health problems emerge (e.g, abnormal temperature or pulse rate). An IoT-based health monitoring system was created in this paper. The system keeps track of the user's body temperature and heart rate. The suggested prototype was measured simultaneously and sent the temperature and pulse data to the Thingspeak server for logging. Because the readings were validated, the results indicate that they are accurate. As a result, these advances can assist physicians in remotely monitoring their patients, while other users can better monitor their patients' health. The suggested study opens the door to a low-cost, high-efficiency elderly patient monitoring system over long distances.

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