A

PROJECT REPORT

ON

IOT ASSISTED HEALTH MONITORING SYSTEM USING MACHINE LEARNING

Submitted in

Partial fulfilment of the requirement

For the degree of

Bachelor of Technology

in

ELECTRONICS ENGINEERING

DEPARTMENT OF ELECTRONICS ENGINEERING

RAJKIYA ENGINEERING COLLEGE, KANNAUJ

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DEPT. OF ELECTRONICS ENGINEERING

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DECLARATION

We hereby to declare that the project report entitled - **"IOT assisted Health Monitoring System using Machine Learning"**, which is being submitted for the fulfilment of the 7th-8th semester in Electronics Engineering to **Rajkiya Engineering College, Kannauj (UP)** is an authentic record of our genuine work done under the guidance of our Mentor Prof. **Mr. Amit Kr. Chauhan**, Department of Electronics Engineering, Rajkiya Engineering College, Kannauj.

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CERTIFICATE

It is to certify that **Ayushi Verma, Ankit Chandra, Bhavesh Yadav, Yash Gupta** students of Electronics Engineering Department, Rajkiya Engineering College, Kannauj have completed the Project on "**IOT assisted Health Monitoring System using Machine Learning**" for the fulfilment of the 7th-8th semester of Bachelor of Technology (Electronics Engineering) Degree of REC, Kannauj. This is a record of a student's own study carried under my supervision and guidance.

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We express our satisfaction on the completion of this project report submission as a part of the curriculum for the degree of Bachelor of Technology, Electronics Engineering.

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ABSTRACT

Recent studies have shown that many deaths occur as a result of inadequate monitoring and untimely care, but the development of smart devices and technology has significantly impacted day-to-day life. Health monitoring systems are now more effective and precise thanks to the convergence of Internet of Things (IoT) and Machine Learning (ML) technology.

This research examines the potential for IoT and ML to alter healthcare practises through a thorough analysis of their use in health monitoring. IoT and machine learning have developed into useful technologies for tracking and analysis of the health data in real-time as a result of the growing need for effective healthcare management. Consequently, these advanced health monitoring technologies will enhance life quality and reduce healthcare costs while also helping to check a person's physical state. It examines several Internet of Things (IoT) health monitoring tools and sensors that gather current health information. ML algorithms are used for extracting valuable insights from the obtained health data. It also emphasises how crucial feature engineering and data pre-processing are to optimising ML models for precise predictions. Experimental results have proved that machine learning algorithms are accurate and practically useful. These system can lessen blunders through casting off human factors from the system, consequently enhancing efficiency.

This paper outlines the advantages and drawbacks of applying and integrating Internet of things and machine learning together to monitor health status and makes suggestions for further study. Overall, this report offers insightful information on how IoT and ML are being applied to health monitoring, demonstrating their enormous potential to transform healthcare practises, enhance patient outcomes, and promote proactive and individualised healthcare interventions. Ultimately, the proposed approach could lead to better patient outcomes, lower healthcare expenditures, and better healthcare delivery.

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Abbreviations

IOT	Internet of Things
ML	Machine Learning
Wi-fi	Wireless Fidelity
CNN	Convolutional neural networks
ECG	Electrocardiograph
KNN	K- nearest neighbor
SVM	Support Vector Machine

CHAPTER 1 : INTRODUCTION

Nowadays, health related issues have become very common, people should be more cautious about their health and as well as try to maintain a daily routine check-up. According to a study from 2020 that appeared in the journal The Lancet, poor healthcare access and care quality were responsible for over 1.3 million deaths in India in 2018. Access to healthcare is frequently severely hampered by inadequate infrastructure. This includes lack of healthcare facilities, such as hospitals, clinics, and medical equipment, as well as inadequate road and transportation systems that make it challenging for people to get to medical centers. Another significant issue facing healthcare systems worldwide is lack of funding. Governments might not put a high priority on spending on healthcare, or they might not have the money to do so. With the emerging health IoT concept, greater focus will be placed on the service quality, user experience quality, and other critical IoT assessment indicators, as well as how to implement some of the most recent technologies. An essential technological challenge is about implementing the newest technologies and study findings to raise the level of service in the health IoT [1], [2].

The term "Internet of Things" (IoT) refers to a wide range of devices and information-exchange channels. Health care and prosperity will benefit tremendously as this innovation progresses. Today, the term "Internet of Things" (IoT) refers to the idea that everything should be connected to the internet [3].

Access to healthcare services and facilities is frequently constrained or nonexistent in rural areas of the world. Effective health monitoring and management are severely hampered by this lack of access, which results in poor healthcare delivery and subpar patient outcomes. Remote areas often suffer from a shortage of healthcare professionals, such as doctors, nurses, and specialists. The people living in these areas cannot receive prompt interventions, regular health monitoring, or expert medical advice due to a lack of skilled personnel.

1.1 Basic Health Monitoring System

Health monitoring is the systematic and ongoing process of evaluating and recording a person's vital signs and health condition to spot any changes or variations from the usual range. It involves the gathering, examination, and interpretation of several data points concerning a person's physiological, physical, and mental health. For the best healthcare management, health monitoring strives to identify prospective health risks, track the evolution of existing conditions, and encourage preventive measures.

Traditional methods of health monitoring mainly include manual measurements and evaluations carried out by healthcare professionals or patients themselves. By performing physical examinations, healthcare practitioners evaluate a person's general health. They check vital signs such breathing rate, temperature, blood pressure, and heart rate. For the purpose of monitoring a person's health, keeping track of their medical history is essential. It entails recording medical issues from the past and present. Healthcare providers can use this information to track long-term health changes and make educated decisions.

Effective health monitoring can aid in maximising the use of healthcare resources and enhancing system efficiency. Healthcare expenses related to hospitalisations and costly treatments can be decreased by identifying and addressing health conditions early on. Furthermore, prompt treatments and proactive preventative care may be able to lessen the financial burden that chronic diseases place on healthcare systems.

With the development of telehealth and remote monitoring technology, health monitoring has taken on increased significance. Real-time monitoring of health data and remote consultations between patients and healthcare professionals are made possible by IoT-enabled devices, wearable sensors, and mobile health applications. This ensures continuous care and lessens the need for frequent in-person visits, which is especially advantageous for people with limited mobility, chronic diseases, or those living in remote places.

1.2 Advanced Health Monitoring System

The healthcare industry is currently one of the largest in the world. It consists of tens of thousands of basic, secondary, and tertiary care hospitals, clinics, and other healthcare facilities. Instead of merely being free from disease, Human health can be defined as the degree to which an individual continues to be able to adapt to his or her surroundings on a physical, emotional, mental, and social level. The application for remote health monitoring at home combines biosensors , wireless communication technology, and cloud computing to upend the conventional model of health monitoring model and establish itself as a key area of IoT health development [4].

An advanced technological tool that can be used to track and monitor someone's health status in real-time is a smart health monitoring system. In order to gather, analyze, and interpret health-related data, this system typically consists of wearable sensors, mobile devices, and cloud-based analytics platforms [5],[6]. The health monitoring system monitors numerous health criterion like oxygen saturation, blood- pressure, pulse rate, blood glucose levels, and many more. Later the data is examined to identify any potential health risks and present health condition of an individual. Smart health monitoring systems can be applied in many different contexts, including homes, clinics, and even hospitals. They are especially helpful for patients who have long-term illnesses like diabetes, heart disease, or hypertension since they enable ongoing monitoring and, if necessary, early intervention.

The monitoring system's primary goal is to continuously track every significant patient health and room condition parameters 24/7, with or without the Wi-Fi. Moreover, the monitoring system has an enhanced automatic alerting system that can follow a patient's location in an emergency and function with or without an internet connection. Patients can also press the emergency alert button to send notification when in need. Patients themselves, parents and physicians monitor the patient's current health status simultaneously. In addition, the system is capable of storing a individuals prior health records, which doctors and nurses can access as needed, helping them make best decisions about their patients.

The system includes hardware which constantly monitors the patient and the software to display the health status of patient. The sensor assigned to the monitoring system detects the patient's readings and transmit them to the processing unit. The patient's body temperature, heart rate or pulse rate, oxygen saturation or Spo2 level, ECG, respiration rate, room temperature, room humidity, and CO_2 gas level are the specific health parameters for the majority of common health concerns. The device then displays the health data that has been processed, and the processing unit periodically sends data over Wi-Fi or a cellular network to a cloud server.

The cloud stores all the information in the patient database. It detects irregular health data and display alerts that include the patient's location as well to track the live location of the patient. The flow of information from the patient's body or environment to the final end user, who manages the patient’s medical data, is shown by the block diagram shown in figure 1 [7].

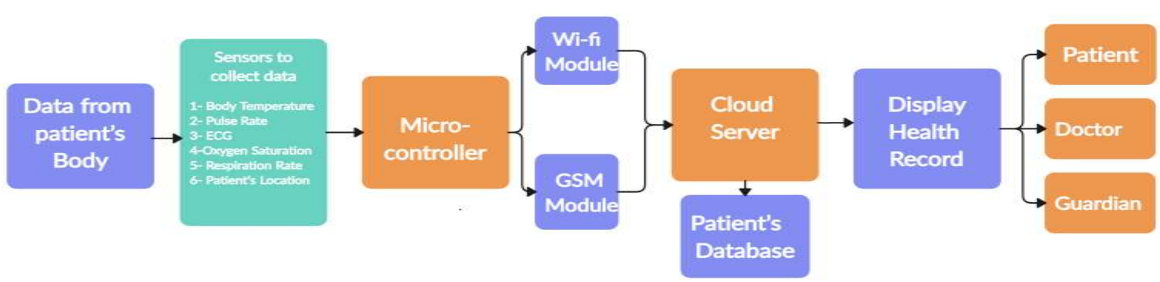


Figure 1 Block diagram of the Smart Health Monitoring System

The benefits of smart health monitoring systems include improved patient outcomes, lower healthcare costs, and better patient satisfaction. In addition, they can also be used to facilitate telemedicine and remote patient monitoring, which is particularly helpful for people who live in rural or distant places.

A smart health monitoring system typically comprises a combination of hardware and software components that work together to gather and analyze health-related data. The combination of Iot and Machine Learning together to can make the health monitoring system more accurate and precise. It is a complex eco-system of hardware and software components that collaborate to offer real-time health analysis and monitoring. The main components often included in such a system are- Wearable Sensors, Mobile Devices, Cloud-based analytics platforms, Communication networks and user interfaces.

Chapter 2 : LITERATURE REVIEW & PROPOSED WORK

2.1 Literature Review

One of the biggest sectors in the world now is healthcare. It consists of tens of thousands of hospitals, clinics, and other healthcare facilities that offer primary, secondary, and tertiary care. Prof. Dipti Patil et al. [8] proposed that by using the data mining techniques, we can convert health care data in a more useful way. Using preprocessing techniques to filter out undesirable data and retrieve useful information from the vast volumes of hidden data the data base provides. In recent years, various strategies have been put out to address the difficulties associated with storing and processing fast and continuous streams of data. Streaming data applications cannot do the many data file scans required by traditional OLAP and data extraction. The process of extracting knowledge structures from infinite streams of data that are represented by models and patterns is known as data stream mining.

Prof. Dipti Patil at el [8] proposed two main clustering algorithms namely, K-means algorithm and density based clustering. The K-means clustering technique cannot handle outliers and is not practical for finding clusters of any shapes. To overcome the issues faced using k-means clustering algorithms, density stream come into face. In this, data is clustered using density-based approach. This approach computes the grid density and transfers each input data record into a grid. The density determines how the grids are grouped. Data density and cluster structure can be generated and adjusted in real time using algorithms that work effectively and efficiently. The results of the experiments have demonstrated that the D stream algorithm outperforms the k-means algorithm in terms of quality and efficiency. It is also much easier to locate clusters of arbitrary shapes and to recognise the changing characteristics of real-time data streams.

Shaira Tabassum et al. [9] collected data on specific parameters such as age, gender, kind of chest discomfort, resting blood pressure, cholesterol, fasting blood glucose, resting ECG, and maximal heart rate to predict and prevent heart diseases. During implementation, infrared sensor was used to collect cholesterol from the body. Oscilloscope was used to find the accurate ECG signals and attention was paid on electrodes to place them precisely to obtain the accurate signal. The paper proposes using a microcontroller unit together with sensors and modules. The mobile phone receives data from the hardware components via a Bluetooth module, and machine learning techniques are then used to these parameters to produce the desired result.

We see diabetes, which usually affects people over the age of 45, but now a days is prominently seen in teenagers and young adults. It occurs when your blood glucose or blood sugar is too high. Ginhawa is an Arduino-based device equipped with an MQ-138 sensor which is a type of metal oxide semiconductor based gas sensor that is highly sensitive to acetone in blood. It provides non-invasive way of identifying if a person has a high level of glucose in their blood. The device detects acetone and analyzes the concentration based on its output voltage and the result is displayed on the OLED display. Humidity and temperature sensors are also used to measure environmental humidity and personal temperature. You can find results using various other factors such as BMI. Later these results are fed into the system and are applied with ML algorithms. The datasets should be large enough to increase the accuracy of the result. The algorithm used should be of higher accuracy, and consequently, using machine learning, we can determine whether a person has diabetes or not. [10].

Increase in number of cases of obesity is playing a huge role in load-bearing on joints. Among every joint in our body the most critical and important joint is the knee joint due to huge amount of pressure on it and load with every other use of the lower limbs increases its risk of injury. Abu Ilius Faisal et al. [11] offered a simple-to-use, low-cost knee monitoring system which could monitor the health status of knee joint. It would be very helpful for the people who have pain in their joints, the elderly people, people undergoing rehabilitation. The knee joint monitoring device that uses various sensors can be used constantly without interfering with people's daily activities. The system is made up of sensors for inertial motion, temperature, pressure, and skin conductance and can measure knee movements as well as other physiological traits including skin temperature, conductance, and muscle pressure around the knee joint. The medical professionals may be able to utilise these characteristics to assess a person's overall knee health and mobility. The MetaWear CPro IMU sensor (Inertial measurement unit) by monitoring rotation and acceleration gives mechanical data such as motion, knee angle and orientation. For knee skin temperature measurement we use a 135-104LAG-J01 discrete Thermistor with proper technical specifications. A force sensitive resistor FSR® 402 Short with proper technical specifications is used for measurement of pressure on the muscles around the knee. Skin conductance, a measure of localised sweat gland activity that is correlated with skin tension and perspiration, was measured using a two-electrode-based GSR(Galvanic skin response) sensor. As the activity of the sweat glands increases, the skin conductance also rises. All the sensors are located at the front of the monitoring device, which is worn around the knee joint. The collected records are analysed and preprocessed to obtain usable joint parameters to asses the mobility status of the user using the monitoring device. Knee angle is estimated and compared with Kalman filter, we check the stride length and minimum foot clearance for knee joint functionality assessment. The device also measures gait speed and cadence, which are crucial factors in assessing walking performance in general. As a result, the smart wearable knee monitoring device can be used to identify falls, track a patient's mobility after surgery, and provide an early diagnosis of joint issues including osteoarthritis and osteoporosis.

Fawaz Alassery et al. [12] states that stress is common in daily life. However long term stress or the one with higher degree will affect our normal lives. The majority of studies have employed self-reporting questionnaires like the DASS 21 to calculate stress levels. Through the E4-wristband6 sensors, data is gathered. Increased Electrodermal activity is detected via perspiration, which is then used as an input. The primary function of the stress detector is to gauge the user's degree of stress.

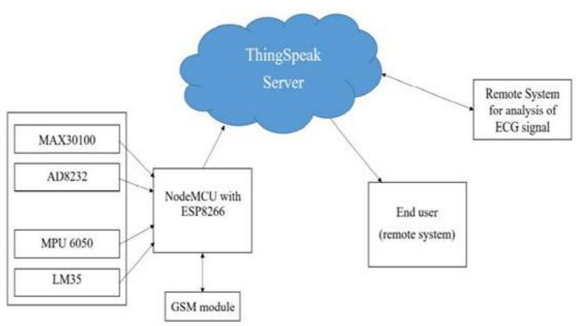


Figure 2 Diagram for Heart Attack Prediction

Priyanuj Borthakur et al. [13] proposed the architecture for heart attack prediction. The diagram for Heart Attack Prediction is shown in the figure 2. Different sensors are utilised to measure blood oxygen saturation level, body temperature, and the user's position and ECG signals for heart prediction (fig 2).

The microcontroller sends the sensor data it has gathered to the ESP8266 for WiFi cloud transmission. ThingSpeak is the cloud-based platform used for data analysis and storage. The Mathworks has linked ThingSpeak with MATLAB, a programme used for data analysis and graphical display. The end user can use an internet connection to access the ThingSpeak. The data kept in the cloud can be used for parameter analysis and ongoing monitoring.

Machine learning techniques are used with the data gathered on the server to forecast heart attacks. The required libraries are imported. The dataset is read and stored as variable which later is classified as dependent or independent. The entire data is then split into a training set and a test set. Feature scaling is done by standardization odd values in a column. The test set dependent variables are predicted from the test set independent variable. Every plot is time-related in some way. These graphs give you access to the data you require throughout the day. These charts help doctors and caregivers make proper diagnoses and care for individuals.

Utilising the ECG output signal, various machine learning approaches are used to test the model for heart attack prediction. In order to monitor and forecast the sickness, the IoT and machine learning technology are both used.

Afzaal Hussain et al. [14] The main focus of this study is the concept of a wireless, real-time, fog-centric, smart wearable, and Internet of Things-based architecture for pervasive health and fitness analysis in a smart gym environment. The proposed framework aims to support the health and fitness industry by utilising body vitals, body mobility, and health-related data. Athletes, particularly newcomers who overdo their gym workouts frequently, frequently face tiredness, mental exhaustion, and muscular fractures. Through real-time analysis of data from smart wearables, such accidents to exercisers can be avoided. The framework is intended to help athletes, trainers, and doctors assess a variety of physical indicators and raise alarms in the event of any health threat. The framework included a six-week workout schedule that includes all the muscles working on for six days, with one day of rest in between. The ECG, heart rate, heart rate variability, and breath rate were also measured, while utilising a 3D accelerometer to estimate the athlete's mobility. In order to analyse the effects of each activity on the athlete's body and develop a system of guidance that can be used by aspiring athletes, the exercise-specific data is collected. Rather than sending data to the cloud and waiting for a response, the fog computing paradigm is specifically chosen to forecast health risks in real-time on edge networks. The two modules used are the Hzone module and gym activity recognition (GAR) module. The Hzone module's amazing ability to accurately predict an athlete's physical state in five categories with a rate of accuracy above 97% is impressive. We conducted four distinct LSTM-based gym activity recognition (GAR) assessments. All experiment types had accuracy levels that were greater than 80% overall. The proposed framework serves as the basis for developing recommendations for newcomers based on their physical condition and any health conditions.

The systems engineering perspective for applications based on mobile health monitoring was the main topic of this study. Smartphone-based ECG monitoring was specifically examined in this paper because cardiovascular disorders are known to cause the greatest irreparable harm and mortality .In order to demonstrate a causal model was initially developed to show the efficacy of a customised smartphone-based ECG monitoring system, and then a novel SD model was suggested. Performance, usability, feasibility, and other aspects of the ECG gadget or app were incorporated in the model, along with social and economic aspects including patient well-being, price, and demand [15].The reported SD model is developed using Vensim Pro software. It exemplifies a portion of the general causal model that reflects its elements and variables needed to assess the impact of several changes in the variables, their effects on other variables, and the efficacy of the chosen service. Additionally, it can evaluate the dynamic effects of different choices without interfering with or changing the system itself. According to the findings, the effectiveness of the service would improve or decrease when specific circumstances changed.

Lloyd E. Emokpae et al. [16] explains the telehealth-IOT system monitor the patients using acoustic sensors whose primary work is to track respiratory related problems. Cough and breathing sounds are analyzed to detect diseases namely- pneumonia ,asthma and lung inflammation. The approach is to apply various deep learning algorithms to detect the possibility of COVID-19 based on the features extracted. The data is trained using existing cough recording and synthetically using the Generative adversarial network (GAN).Following data is used to train Convolutional neural networks (CNN) classifier. Similarly generative learning mechanism is also used for the datasets of breathing sounds. The architecture of CNN model includes two convolutional layers followed by two dense non-linear and then a linear layer. We also apply different classifiers and select the one with highest accuracy.

In the year 2020, healthcare professionals struggled to provide their patients with the appropriate care because of the coronavirus. In this COVID-19, a sizable number of people who worked in the health sector also perished. As a result of their fear of contacting an infection, many severe patients at the time skipped their scheduled checkups. Patients in both urban and rural areas struggle greatly during the pandemic. Mohammad Nuruzzaman Bhuiyan et al. [17] proposed a system space about the cloud's ability to enable security, access performance metrics and real-time data by connecting. The goal of this research is to build and develop a workable model for a ubiquitous, Internet of Things-based healthcare monitoring system for both urban and rural settings. The suggested model can follow the patient's location using various sensors, measure and display blood pressure, room temperature, body temperature, oxygen saturation, and heart rate, and communicate data both online and offline to mobile apps. It also sends a warning signal to medical professionals and other carers so they know the patient is in a serious medical state. The technology under test will notify medical professionals and carers when a patient's body temperature and pulse rate are out of the ordinary. It is technologically advanced, affordable, dependable, user-friendly, and fulfils a variety of functions. The recommended system consists of an enhanced and automated alarming procedure, an emergency alert button, and continuous, uninterrupted 24/7 monitoring of a patient's health and room condition characteristics. A physical device that the patient wears plus a mobile application that displays recent and past health records make up the system. Sensors gather body and environmental parameters and then send them to the processing unit. The processing unit provides the data to the mobile application after storing it in a patient database.

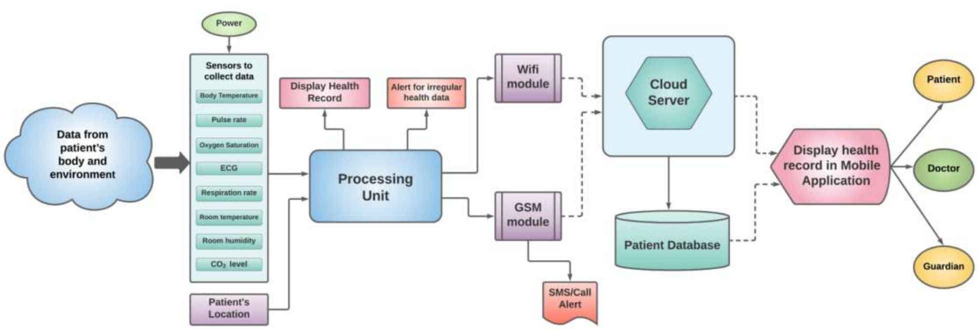


Figure 3 Block Diagram of operation of health monitoring system

Figure 3 provides a block diagram to help you understand the system's overall process. The block diagram depicts the system's basic operation, which is the information flow from the patient's body or environment to the person using it to manage the patient's medical records. The hardware components involved are Arduino UNO ,Node MCU ESP8266, GSM Module SIM900A, Body temperature sensor DS18B20, Pulse sensor MAX30100, ECG sensor AD8232, Air quality sensor MQ135. The extract, process, and error-check sensor data in the sensing and data processing module. The monitoring system checks for the internet connectivity and uses the ESP8266 Wi-Fi, GSM SIM900A, and data storage module to send health records to the cloud. Access to health records is restricted to authenticated users. One of the essential elements for making sure that remote healthcare monitoring systems are built properly is network authentication. The system has a great deal of potential for both urban and rural areas in developing nations after proper manufacturing.

This literature review highlights the key findings in the subject of health monitoring, with a focus on wearable technology, remote monitoring, and data analysis methods. The advantages of the health monitoring are emphasised, and the difficulties that must be solved for general use are also covered. This review lays the groundwork for future developments in health monitoring, which will eventually result in better healthcare outcomes and personalised treatment.

1.2 Proposed Work

This project's goal is to supply an alternative to the traditional management of patients and reducing the expenditure of patients by providing accurate health status based on certain parameters which can be entered by the user. By being able to monitor one's health status while at home, a user can avoid having to travel to the doctor's office for a check-up.

We have worked on developing a smart health monitoring system using various sensors to collect patient's records and monitor them. In the project we interfaced esp32 with AD8232 ECG sensor, DHT11 temperature sensor and WPSE340 pulse sensor. We have employed esp32 microcontroller as they have faster processor, in-built wi-fi ,bluetooth and more GPIO pins with several other features that are better than the other microcontrollers as shown in Figure 4.

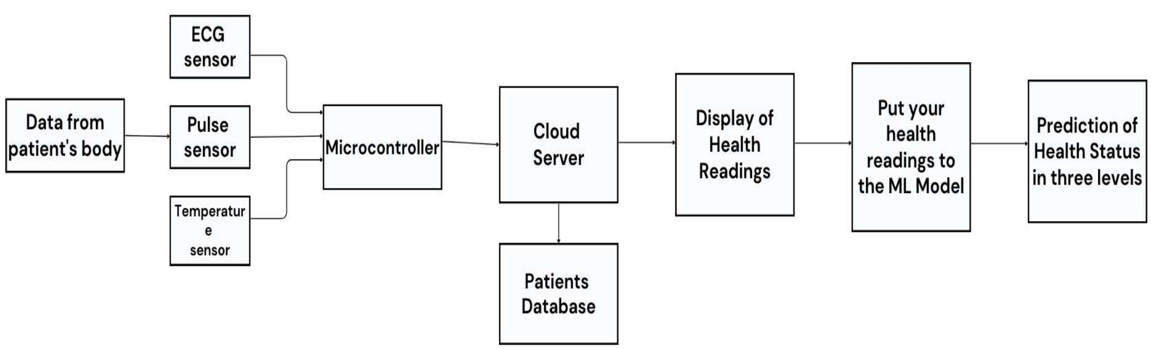


Figure 4 Flowchart of Proposed Work

After interfacing we apply the ECG electrodes on our body, before applying the sensor pads to the body, it is advised to snap them onto the leads. The measurement is more accurate the closer the pads are to the heart. The electrodes cable are placed over the left arm, right arm and right leg generally. The pulse sensor is placed gently, covered with any kind of tape and a small pressure is applied over it. Similarly the temperature sensor is also operated. Wi-Fi technology is used to obtain the sensor readings on the ubidots server. These readings can be analyzed by the caretaker or professional themselves. We also created a ML model to predict the level of health status of the individual. We applied certain algorithms such as K- nearest neighbor(KNN) , support vector machine(SVM), decision tree and random forest. Out of which we used KNN algorithm to implement the model. This ML model predicts the health status of an individual in three levels. Level 0 will indicate health status as Healthy, Level 1 will indicate a little decline while Level 2 will show the person with poor health. We also created a webpage for user interface. The images of all the above mentioned work is provided in the later section of this report.

CHAPTER 3 : METHODS & METHODOLOGY

The suggested solution is to create a remote patient health status monitoring system using machine learning and the internet of things (IoT). This system can be set-up both in one's home and in other healthcare facilities.

3.1 Internet of things

The Internet of Things is a megatrend in the future of technology that has the potential to have a significant influence on all business sectors. It may be conceptualized as the connecting of individually identifiable smart items and devices with enhanced benefits within the current internet infrastructure. Its benefits often include the improved interconnectedness of these components—which goes beyond machine-to-machine interactions systems, and services[18].One of the most alluring IoT application areas is healthcare, which focuses on patient-centric healthcare, real-time and remote monitoring, early detection of chronic diseases, medical emergencies, and cost-effective treatment. [19].

The Internet of Things represents a significant area of research has the ability to transform many other industries totally. As researchers continue to explore new applications and address the challenges associated with IoT, it's possible that we will witness even more impactful and creative use of this technology in the years to come Moreover we see the major components of IoT as described in the Figure 5.

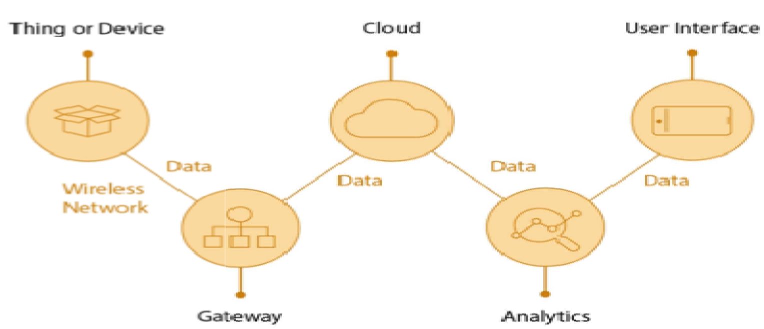


Figure 5 Components of IOT

The devices that have wearable sensors can be worn on the body to collect information which is send to the server through a medium called gateway. A gateway is a device that connects Internet of Things (IoT) devices to the cloud, translating protocols and data formats into formats that can be transmitted over the internet. Health-related data gathered by wearable sensors is stored, processed, and analyzed on cloud platforms. It employs artificial intelligence and machine learning algorithms in finding the patterns and trends in collected data and give users information about their health. Users can monitor their health status and get alerts using these user interfaces. They could be mobile apps, web-based dashboards, or other kinds of software interfaces [20].

3.2 Hardware Used

In our project we have used different sensors such as AD8232 ECG Sensor , WPSE340 Pulse Sensor and DHT11 Temperature Sensor to record the readings of the patient. Other hardware components involved are ESP32 microcontroller, jumper wires, breadboard.

Table1 shows the parameters of the respective AD8232 ECG sensor.

Table 1 ECG sensor.

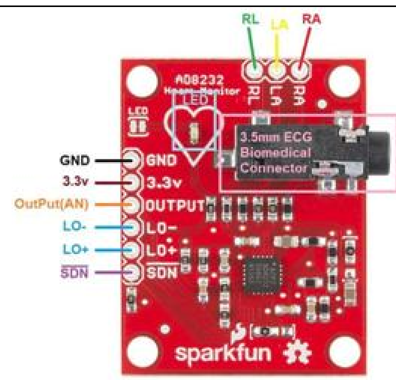
S.No.	**Parameters**	**AD8232 Sensors [18],[22],[23], [24],[26],[27]**
1.	Operating Voltage	2.0V to 3.5V
2.	Input voltage range	±300 mV
3.	Power Consumption	170µA
4.	Operating Temperature Range	-40°C to +85°C
5.	Input impedance	>2 MΩ
6.	CMRR	>80 dB
7.	Figure of ECG sensor	 Fig 6

Table2 shows the parameters of the respective DHT11 Temperature sensor.
Table 2 DHT11 Temperature sensor.

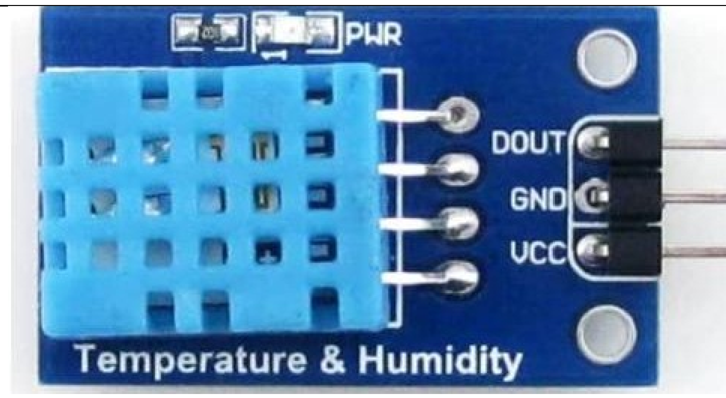
S.No.	Parameters	DHT11 Temperature Sensors [25]
1.	Power Supply Range	3.0V to 5.0V
2.	Operating Temperature Range	0° C to +50° C
3.	Temperature Measurement Accuracy	±2°C
4.	Humidity Measurement Accuracy	±5% RH
5.	Size	15.5mm x 12mm x 5.5mm
6.	Figure of Temperature sensor	 Fig 7

Table3 shows the parameters of the respective WPSE340 Pulse sensor.
Table 3 WPSE340 Pulse sensor.

S.No.	Parameters	WPSE340 Pulse Sensors
1.	Description	The module can be used to include live heart rate data
1.	Power Supply Range	3.0V to 5.0V
2.	Working current Range	4 mA at 5 V

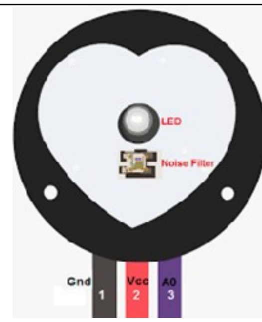
3.	Connections	GND, VCC, analog signal out
4.	Figure of pulse sensor	 Fig 8

Figure of the Project

Following is the image of the circuit diagram of the project. Esp32 is interfaced with AD8232 ecg sensor, DHT11 temperature sensor and WPSE340 pulse sensor.

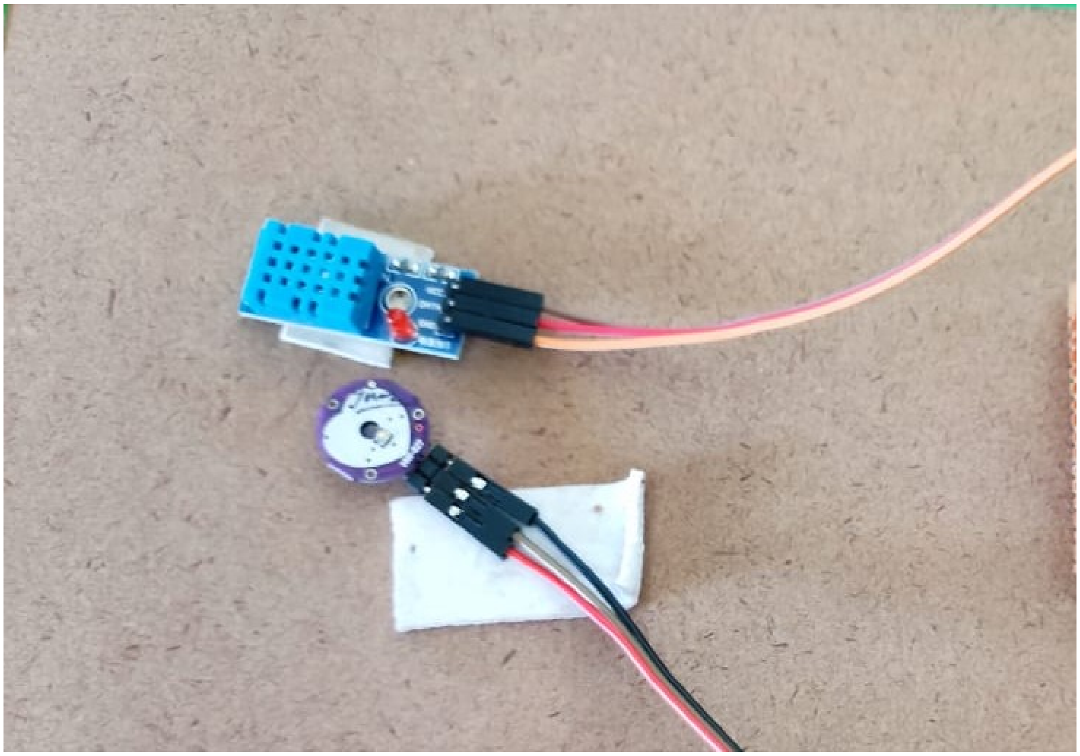


Figure 9 Top view of the Health Monitoring system

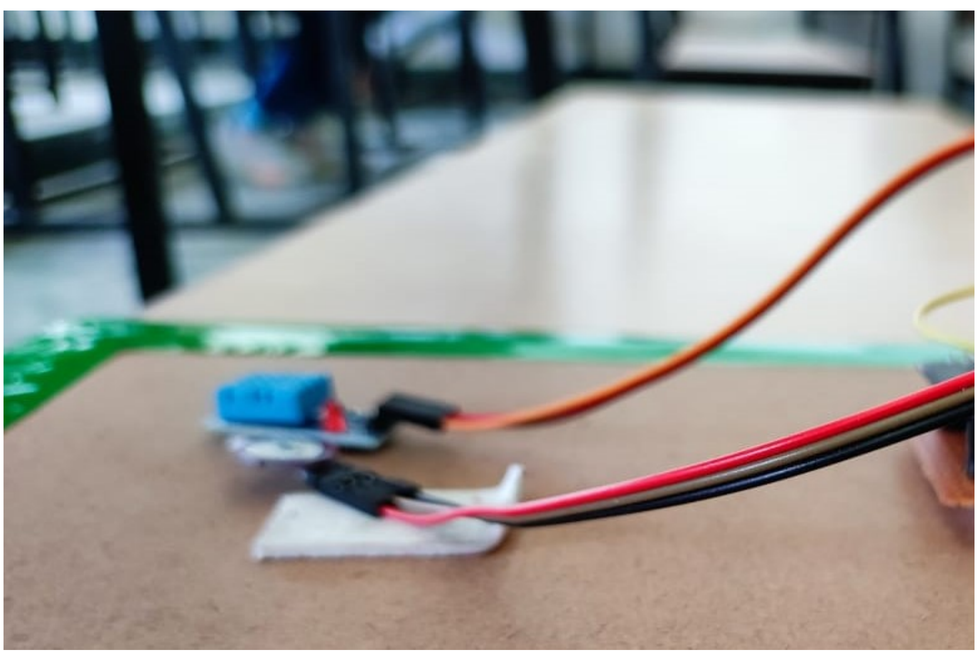


Figure 10 Side view of the health Monitoring System

3.4 Machine Learning and its Implementation

Machine learning (ML) has the potential to bring reform in health monitoring by identifying patterns in vast quantities of patient data to forecast outcomes and suggest personalised interventions. ML algorithms can be trained with data from a variety of sources, including electronic health records, medical images, wearables, and sensors, to develop models that help diagnose, treat, and prevent disease. The combination of IoT devices, which can collect vast amounts of data on patient health, and that data can be analysed by machine learning algorithms to find patterns and forecast outcomes, has the potential to revolutionize healthcare. It has the potential to bring improvement in healthcare outcomes, reduces the healthcare costs, and increase the patient satisfaction.

Akhil et al. [28] tells that It is a type of artificial intelligence that enables programmes to predict events better without having been expressly trained to do so. It seeks to identify patterns in the data and use those patterns to draw conclusions that are beneficial. Kh. Jitenkumar Singh et al. [29] explains the basic two approaches in ML i.e. Supervised learning and Unsupervised learning. Type of algorithm implemented on the datasets depends on what type of data they want to predict. ML offers with the records, the use of diverse algorithms which includes logistic regression, linear discriminant analysis, random forest, support vector machine, k-nearest neighbor classifiers, cluster analysis, and modern deep learning, reinforcement learning, decision tree, etc [28]. Two main algorithms that come under unsupervised learning is clustering and principal component analysis.

Unsupervised learning differs from supervised learning as that the former involves learning from unlabeled data, while the latter involves learning from labelled data. Machine learning has wide application that includes mail filtering, face and speech and image recognition, site visitors prediction, self riding cars, inventory marketplace buying and selling and medical diagnosis etc. ML needs prior data handling before its implementation healthcare so it could differentiate records. ML can be applied in smart health monitoring for disease diagnosis which helps doctors to make accurate diagnoses, leading to better outcomes for the patients, early warning systems which helps doctors intervene early and prevent the disease from progressing, treatment recommendations using ML algorithms, we can evaluate patient data to identify the most effective treatments for specific diseases. Neural network-based machine learning is introduced, producing more precise and trustworthy outcomes as proposed in [30], [31].

Overall, ML has great potential to improve health surveillance and transform how we approach disease diagnosis, treatment, and prevention. However to preserve patient privacy and safety, it is essential to make sure that these technologies are developed and used in an ethical and responsible manner.

ML Implementation

After the readings of the patient are obtained we can apply ML algorithms to the dataset for training purpose. We find out the accuracy of different algorithms and plot them as bar-plot. The dataset is taken from the kaggle.

	Models	ACC
0	KNN	96.666667
1	SVM	90.000000
2	DT	96.666667
3	RF	96.666667

Figure 11 Level of accuracy of various models

The accuracy of different models such as K-nearest neighbor(KNN), Support Vector Machine(SVM), Decision Tree(DT) and Random Forest are shown in the figure 11.

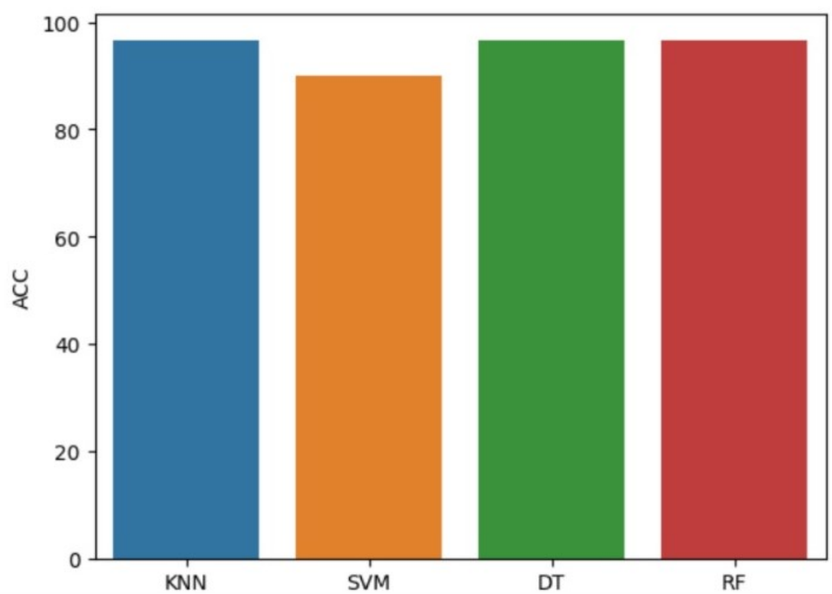


Figure 12 Bar-plot representation of accuracy of various models

Figure 12 is the bar-plot representation of the accuracy of the models.

Chapter 4 : RESULTS & DISCUSSION

Integration of Iot and ML is successfully achieved that can predict the level of ill health of a person. The application can be used by either patient or doctor to get a second opinion. If the trained dataset given to the model is accurate then the accuracy of the model is increased and this application can be used as the main determinant to check the illness of a person.

Machine learning-based IoT-assisted health monitoring has produced encouraging results in a number of applications. It offers the ability to enhance healthcare outcomes and enable pro-active healthcare management by utilising the power of linked devices and sophisticated machine learning algorithms.

The readings from the sensors are recorded and uploaded on ubidots sensor which are refreshed from time to time.

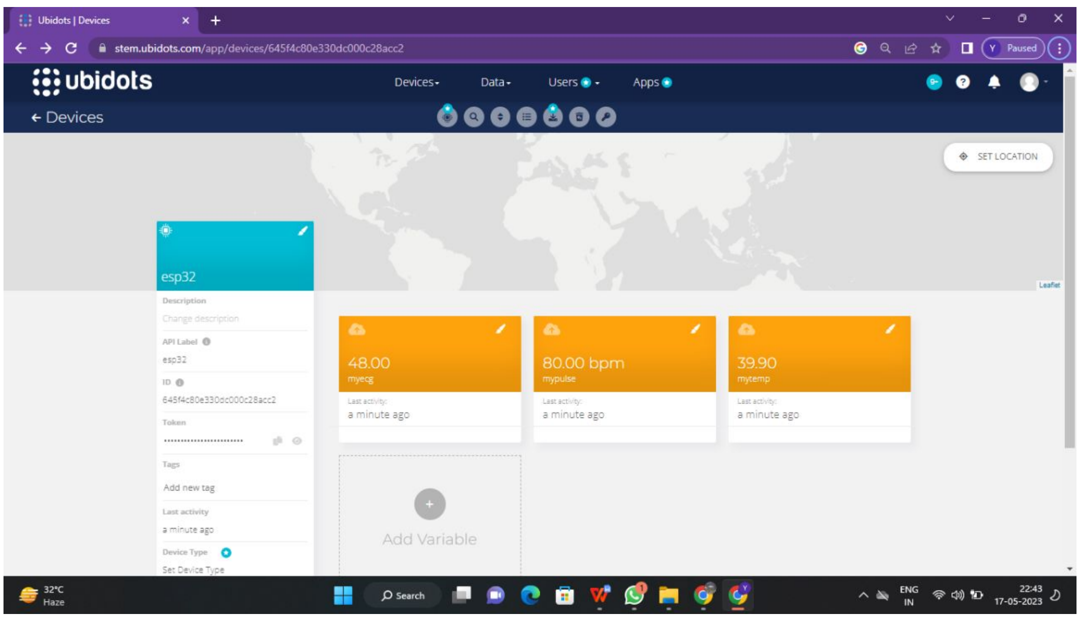


Figure 13 Readings of ECG ,pulse and temperature sensor

Figure 13 shows the readings of all the sensors together. It shows the real-time readings of the ECG sensor, pulse sensor and the temperature sensor. It refreshes each and every readings after a certain interval of time.

Figure 14,15,16 represents the individual plot readings for ECG, pulse and temperature sensor respectively.

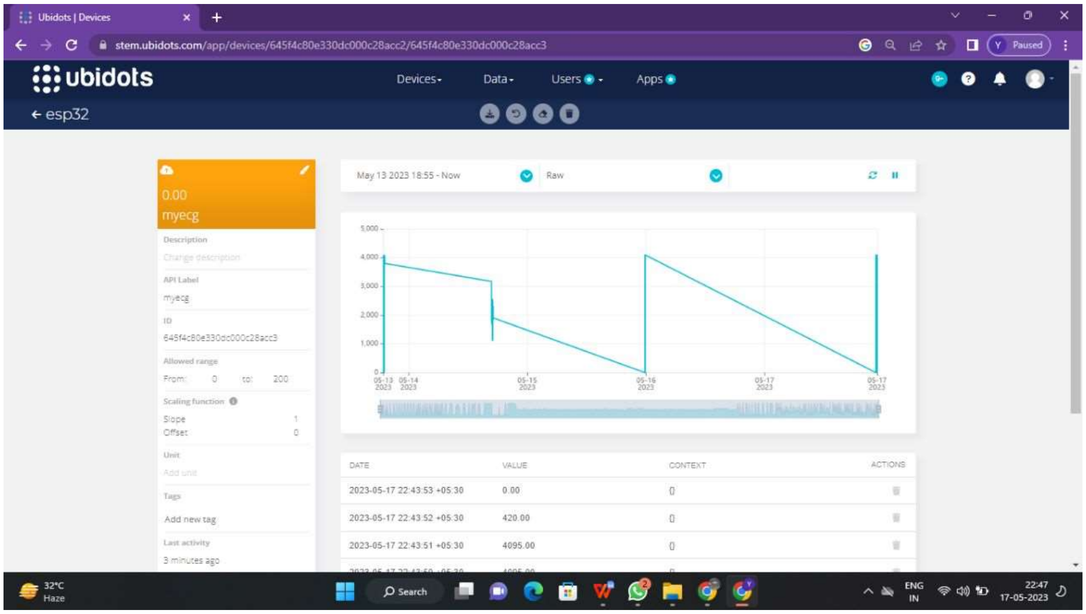


Figure 14 Plot of ECG graph

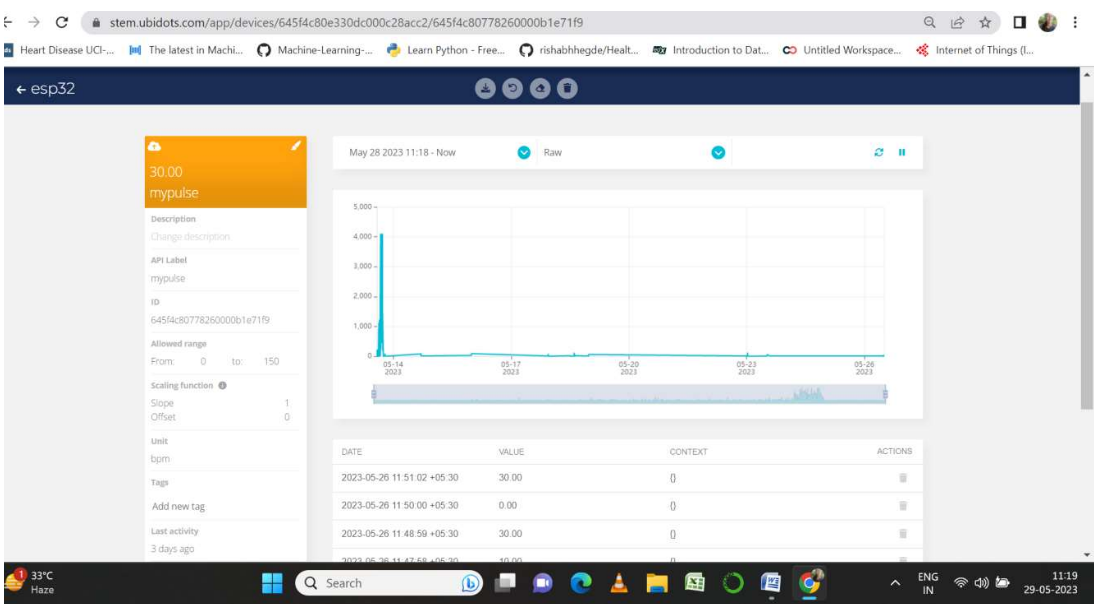


Figure 15 Plot of Pulse values

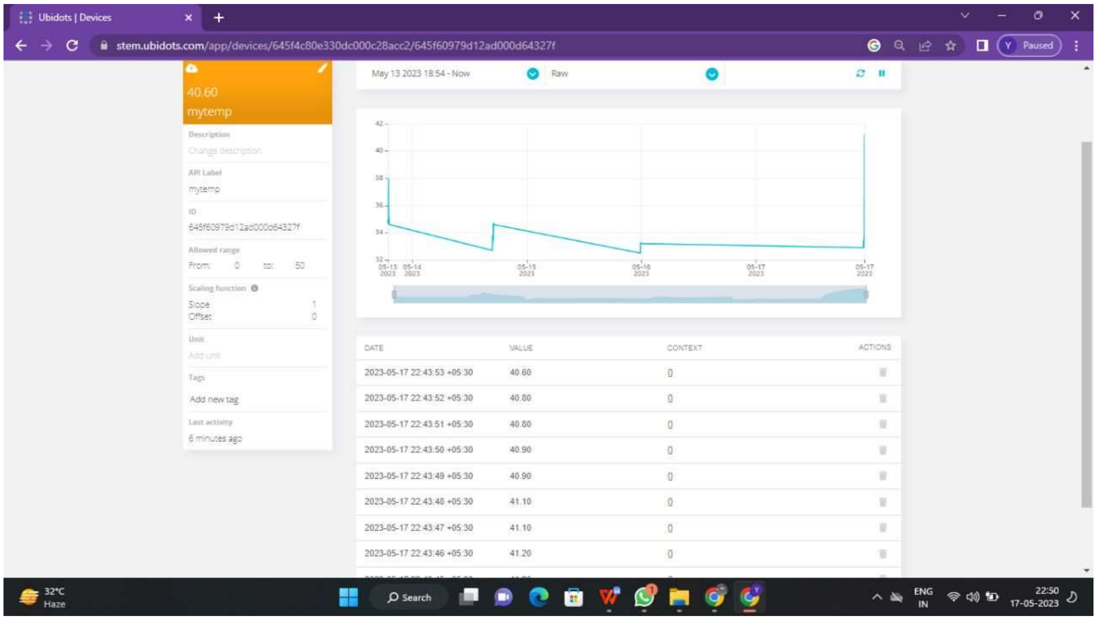


Figure 16 Plot of Temperature values

After these readings we implemented an ML model which checks the health on three levels. Level 0 will indicate health status as Healthy, Level 1 will indicate a little decline while Level 2 will show the person with poor health.

Following Figures are the representation of the web page predicting the Health status of patient using ML model.

Figure 17 shows the web-page where one can checkup the health status of individual.

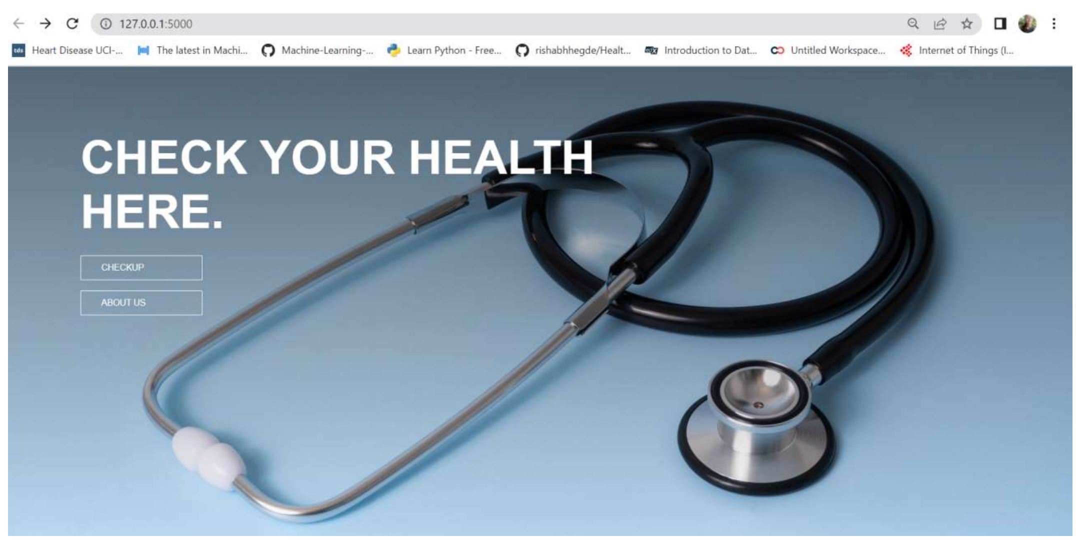


Figure 17 Index page of the web page

Figure 18 displays the about us page demonstrating about the Project.

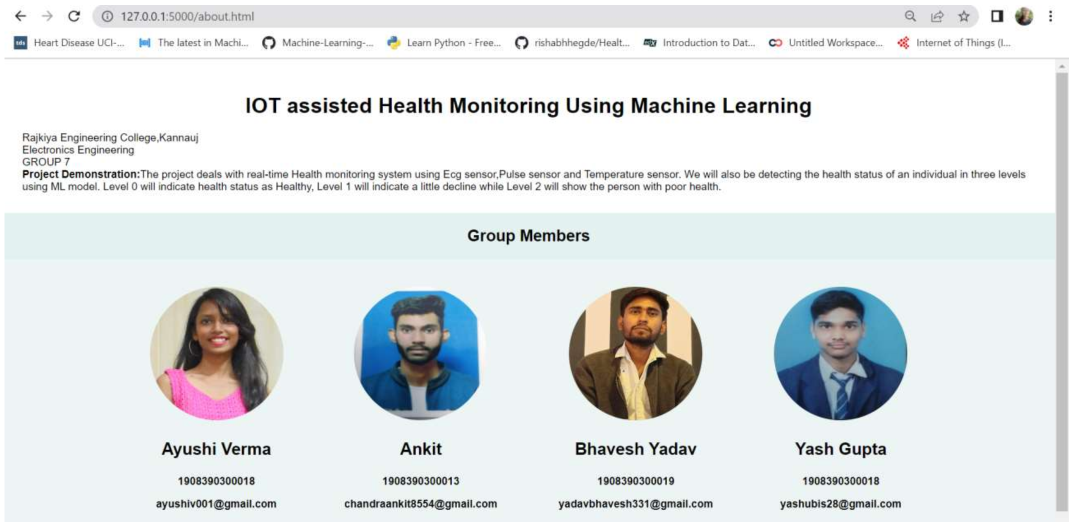


Figure 18 About section

Figure 19,20,21 shows the three levels of health status of the patient predicting using ML model using KNN algorithm. The K-NN algorithm makes the assumption that the new case and the existing cases are comparable, and it places the new instance in the category that is most like the existing categories.

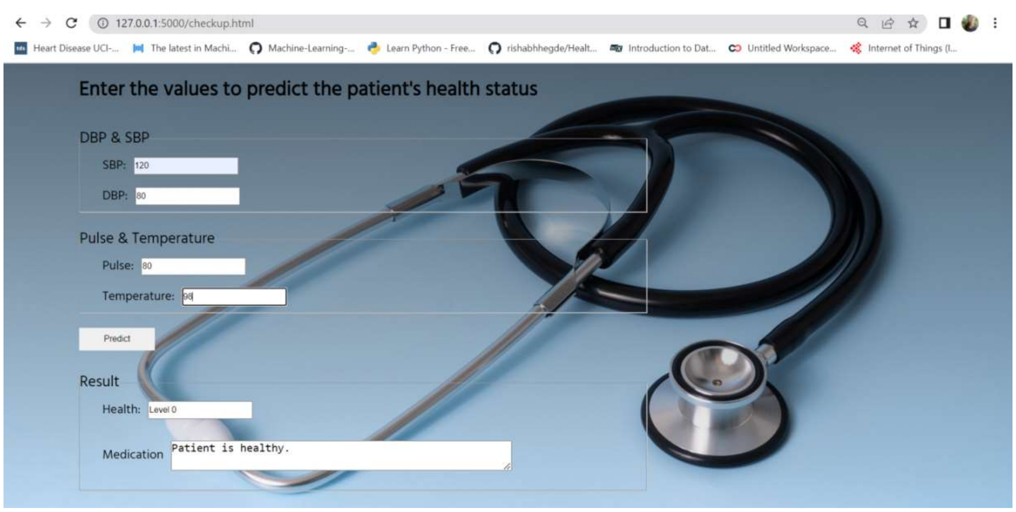


Figure 19 Prediction of Health status as Level 0

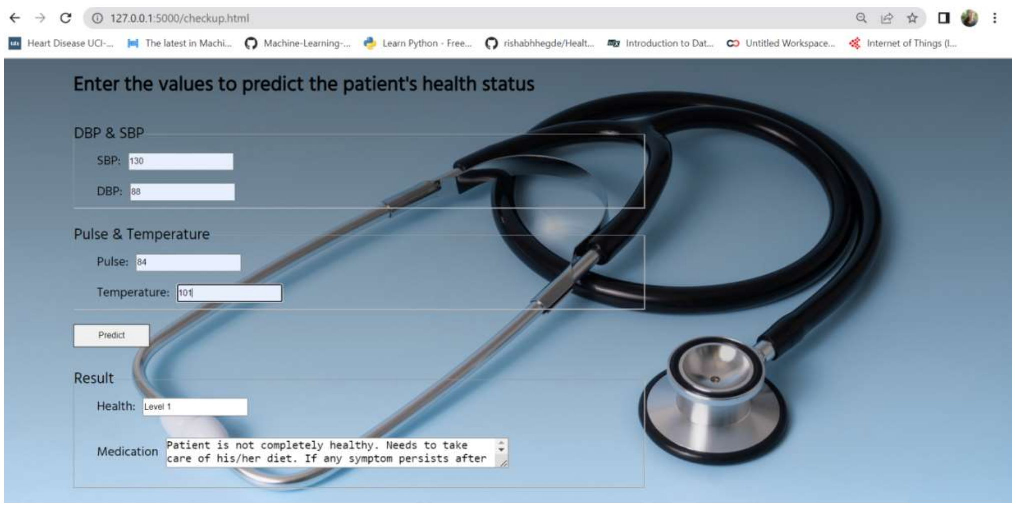


Figure 20 Prediction of Health status as Level 1

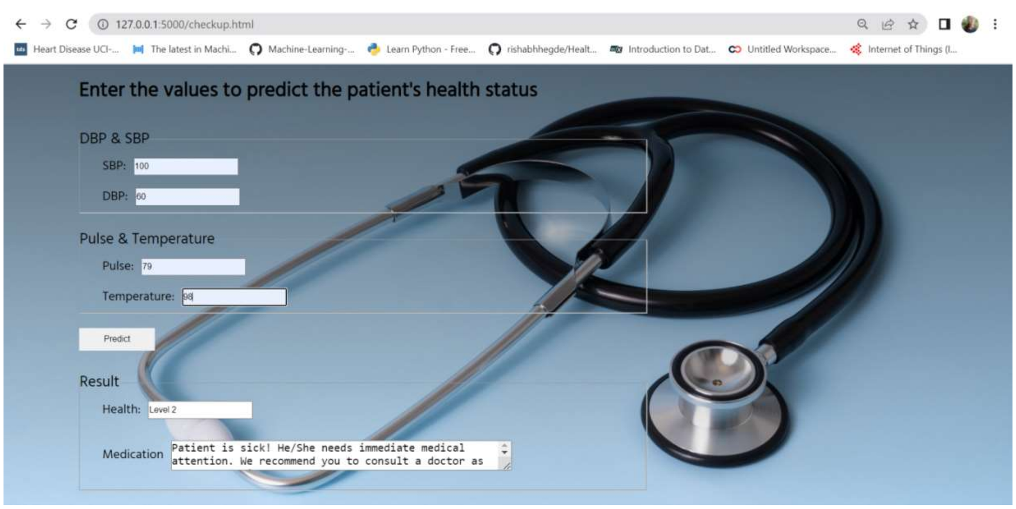


Figure 21 Prediction of Health status as Level 2

CHAPTER 5 : CONCLUSION & FUTURE WORK

In conclusion, the healthcare sector has greatly benefited from the application of Internet of Things and machine learning, particularly in the creation of health monitoring systems. Our survey took into account the rapidly developing applications that are highly relevant to daily health routines.

In the not-too-distant future, a large portion of medical contacts will be conducted "virtually" utilizing Iot and machine learning, leading to a situation in which this mode is the norm rather than the exception. Technology like machine learning is fascinating and continues to hold out the possibility of being genuinely transformative for everyone. Although with the use machine learning algorithms we have worked on increasing the accuracy of the results but still healthcare domain cannot afford false negatives and thus higher level of accuracy is needed. Work can be done on increasing the accuracy by trying various other algorithms and train the model with increased dataset. We managed to built a smart health monitoring system using AD8232 ECG sensor, DHT11 Temperature sensor and WPSE340 Pulse sensor by interfacing it with esp32 and showing the readings of the patients on the ubidots server. We also created a ML model for predicting the health status of patient using KNN algorithm.

Overall, IoT and machine learning play a significant role in health monitoring systems that advance the healthcare sector and raise the standard of patient care. Despite its potential benefits, the Internet of Things also has significant challenges. One of the main challenges is security, as IoT devices are often vulnerable to cyber attacks and other malicious activities. We are also concerned with data protection and the ethical implications of gathering and studying a lot of personal information.

Some of the major issues and challenges are:

1- Data privacy and security: Medical data is highly sensitive and personal, and compromise of that data can have serious consequences. As IoT devices and ML algorithms generate and analyze vast amounts of medical data, ensuring privacy and security is critical.

2- Regulatory compliance: Healthcare is a highly regulated industry, with many laws and regulations governing the use of IoT and ML technologies in healthcare. It is important to ensure that these technologies obey with all relevant regulations and standards.

3- Integration with existing systems: Healthcare systems are often complex, involving multiple stakeholders and systems. Integrating IoT and ML technologies into existing systems can be challenging and requires careful devising and coordination.

4- Cost: The cost of implementing and maintaining IoT and ML technologies can be substantial. It is important to ensure that the benefits of these technologies don’t exceed the costs.

5- Ethical considerations: As with any new technology, ethical considerations must be considered. For example, the use of these technologies should not lead to discrimination or bias in healthcare decision-making.

Researchers are looking into several strategies to strengthen the security and privacy of IoT systems to address these issues. This includes developing new encryption and authentication protocols and implementing stronger physical security measures for IoT devices. In addition, researchers are looking for new methods to analyze and process data to ensure that it is treated safely and ethically.

Overall, IoT and ML technologies collectively offer great potential benefits to healthcare, but addressing these issues and challenges is critical to realizing their full potential.

REFERENCES

[1]. Seshadri, D. R., Li, R. T., Voos, J. E., Rowbottom, J. R., Alfes, C. M., Zorman, C. A., & Drummond, C. K. (2019). Wearable sensors for monitoring the physiological and biochemical profile of the athlete. *NPJ digital medicine*, *2*(1), 72.

[2]. Aliverti, A. (2017). Wearable technology: role in respiratory health and disease. *Breathe*, *13*(2), e27-e36.

[**3].** Rahman, J. R., Sanshi, S., & Ahamed, N. N. (2021, March). Health monitoring and predicting system using internet of things & machine learning. In *2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS)* (Vol. 1, pp. 223-226). IEEE.

[4]. Guo, M., Wang, Z., Yang, N., Li, Z., & An, T. (2018). A multisensor multiclassifier hierarchical fusion model based on entropy weight for human activity recognition using wearable inertial sensors. *IEEE Transactions on Human-Machine Systems*, *49*(1), 105-111.

[5]. Boursalie, O., Samavi, R., & Doyle, T. E. (2018). Machine learning and mobile health monitoring platforms: a case study on research and implementation challenges. *Journal of Healthcare Informatics Research*, *2*, 179-203.

[6]. Hassan, M. K., El Desouky, A. I., Badawy, M. M., Sarhan, A. M., Elhoseny, M., & Gunasekaran, M. (2019). EoT-driven hybrid ambient assisted living framework with naïve Bayes–firefly algorithm. *Neural Computing and Applications*, *31*, 1275-1300.

[7]. Yang, Y., Wang, H., Jiang, R., Guo, X., Cheng, J., & Chen, Y. (2022). A review of IoT-enabled mobile healthcare: technologies, challenges, and future trends. *IEEE Internet of Things Journal*, *9*(12), 9478-9502.

[8]. Patil, D., Wadhai, D., Vijay, M., Gund, M., Biyani, R., Andhalkar, S. and Agrawal, B., 2012. An Adaptive parameter free data mining approach for healthcare application. *arXiv preprint arXiv:1211.1788*.

[9]. Zaman, M.I.U., Tabassum, S., Ullah, M.S., Rahaman, A., Nahar, S. and Islam, A.M., 2019, May. Towards IoT and ML driven cardiac status prediction system. In 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT) (pp. 1-6). IEEE.

[10]. Mitushi, Soni, and Varma Sunita. "Diabetes prediction using machine learning techniques." *International Journal of Engineering Research & Technology (IJERT)* (2020).

[11]. Faisal, Abu Ilius, et al. "A simple, low-cost multi-sensor-based smart wearable knee monitoring system." *IEEE Sensors Journal* 21.6 (2020): 8253-8266.

[12]. Alazzam, Malik Bader, Fawaz Alassery, and Ahmed Almulihi. "A novel smart healthcare monitoring system using machine learning and the internet of things." Wireless Communications and Mobile Computing 2021 (2021).

[13]. Sahoo, Sudarsan, et al. "IoT and machine learning based health monitoring and heart attack prediction system." Journal of Physics: Conference Series. Vol. 1950. No. 1. IOP Publishing, 2021.

[14]. Hussain, Afzaal, Kashif Zafar, and Abdul Rauf Baig. "Fog-centric IoT based framework for healthcare monitoring, management and early warning system." *IEEE Access* 9 (2021): 74168-74179.

[15]. Faezipour, Misagh, and Miad Faezipour. "System dynamics modeling for smartphone-based healthcare tools: case study on ECG monitoring." *IEEE Systems Journal* 15.2 (2020): 3036-3045.

[16]. Emokpae, L.E., Emokpae, R.N., Lalouani, W. and Younis, M., 2021. Smart multimodal telehealth-IoT system for COVID-19 patients IEEE Pervasive Computing, 20(2), pp.73-80..

[17]. Bhuiyan, M.N., Billah, M.M., Bhuiyan, F., Bhuiyan, M.A.R., Hasan, N., Rahman, M.M., Miah, M.S., Alibakhshikenari, M., Arpanaei, F., Falcone, F. and Niu, M., 2022. Design and Implementation of a Feasible Model for the IoT Based Ubiquitous Healthcare Monitoring System for Rural and Urban Areas. *IEEE Access*, *10*, pp.91984-91997.

[18]. Yadav, S. S., & Jadhav, S. M. (2019). Machine learning algorithms for disease prediction using iot environment. *International Journal of Engineering and Advanced Technology*, *8*(6), 4303-4307.

[19]. Holler, J., Tsiatsis, V., Mulligan, C., Karnouskos, S., Avesand, S., & Boyle, D. (2014). From machine-to-machine to the Internet of Things: introduction to a new age of. *intelligence*.

[20]. Islam, S. R., Kwak, D., Kabir, M. H., Hossain, M., & Kwak, K. S. (2015). The internet of things for health care: a comprehensive survey. *IEEE access*, *3*, 678-708.

[21]. Trivedi, A. (2022, March 11). *What is IoT? | Components of IoT - Scaler Topics*. Scaler Topics. https://www.scaler.com/topics/components-of-iot/

[22]. Patil, D., Wadhai, D., Vijay, M., Gund, M., Biyani, R., Andhalkar, S., & Agrawal, B. (2012). An Adaptive parameter free data mining approach for healthcare application. *arXiv preprint arXiv:1211.1788*.

[23]. Alazzam, M. B., Alassery, F., & Almulihi, A. (2021). A novel smart healthcare monitoring system using machine learning and the Internet of Things. *Wireless Communications and Mobile Computing*, *2021*, 1-7.

[24]. Emokpae, L. E., Emokpae, R. N., Lalouani, W., & Younis, M. (2021). Smart multimodal telehealth-IoT system for COVID-19 patients. *IEEE Pervasive Computing*, *20*(2), 73-80.

[25]. Bhardwaj, H., Bhatia, K., Jain, A., & Verma, N. (2021, July). IOT Based Health Monitoring System. In *2021 6th International Conference on Communication and Electronics Systems (ICCES)* (pp. 1-6). IEEE.

[26]. Turner, J., Zellner, C., Khan, T., & Yelamarthi, K. (2017, May). Continuous heart rate monitoring using smartphone. In *2017 IEEE International Conference on Electro Information Technology (EIT)* (pp. 324-326). IEEE.

[27]. Kumar, S. P., Samson, V. R. R., Sai, U. B., Rao, P. M., & Eswar, K. K. (2017, February). Smart health monitoring system of patient through IoT. In *2017 international* *conference on I-SMAC (IoT in social, mobile, analytics and cloud)(I-SMAC)* (pp. 551-556). IEEE.

[28]. Jabbar, M. A., Samreen, S., & Aluvalu, R. (2018). The future of health care: Machine learning. *International Journal of Engineering & Technology*, *7*(4.6), 23-25.

[29]. Saini, A., Meitei, A. J., & Singh, J. (2021, April). Machine Learning in Healthcare: A Review. In *Proceedings of the International Conference on Innovative Computing & Communication (ICICC)*.

[30]. Sahithi, G., Vinayasree, P., & Narsimhulu, P. REAL TIME HEALTH MONITORING USING IOT WITH INTEGRATION OF MACHINE LEARNING APPROACH.

[31]. Gandhi, M., & Singh, S. N. (2015, February). Predictions in heart disease using techniques of data mining. In *2015 International conference on futuristic trends on computational analysis and knowledge management (ABLAZE)* (pp. 520-525). IEEE.

APPENDIX

IOT Code

```
#include <WiFi.h>
#include <PubSubClient.h>
#include <DHT.h>

#define WIFISSID "homeiot"
#define PASSWORD "homeiot123"
#define TOKEN "BBFF-f3KGhv8nAjMcaDiCYLAfuWEZSq8C10"
#define MQTT_CLIENT_NAME "myecgsensor2"

#define ECG_VARIABLE_LABEL "myecg"
#define DHT_TEMPERATURE_VARIABLE_LABEL "mytemp"
#define PULSE_SENSOR_VARIABLE_LABEL "mypulse"
#define DEVICE_LABEL "esp32"

#define ECG_SENSOR 34 // Connect ECG sensor to GPIO 34 (Analog pin)
#define DHT_PIN 4 // Connect DHT11 data pin to GPIO 4
#define PULSE_SENSOR_PIN 36 // Connect Pulse sensor to GPIO 36 (Analog pin)

char mqttBroker[]  = "industrial.api.ubidots.com";
char payload[300];
char topic[150];
char str_sensor[10];

WiFiClient ubidots;
PubSubClient client(ubidots);

DHT dht(DHT_PIN, DHT11);

void callback(char* topic, byte* payload, unsigned int length) {
```

```
  char p[length + 1];
  memcpy(p, payload, length);
  p[length] = NULL;
  Serial.write(payload, length);
  Serial.println(topic);
}

void reconnect() {
  while (!client.connected()) {
    Serial.println("Attempting MQTT connection...");
    if (client.connect(MQTT_CLIENT_NAME, TOKEN, "")) {
      Serial.println("Connected");
    } else {
      Serial.print("Failed, rc=");
      Serial.print(client.state());
      Serial.println(" try again in 2 seconds");
      delay(2000);
    }
  }
}

void setup() {
  Serial.begin(115200);
  WiFi.begin(WIFISSID, PASSWORD);
  pinMode(ECG_SENSOR, INPUT);
  pinMode(PULSE_SENSOR_PIN, INPUT);
  dht.begin();

  Serial.println();
  Serial.print("Waiting for WiFi...");
```

```
  while (WiFi.status() != WL_CONNECTED) {
    Serial.print(".");
    delay(500);
  }

  Serial.println("");
  Serial.println("WiFi Connected");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());
  client.setServer(mqttBroker, 1883);
  client.setCallback(callback);
}

void loop() {
  if (!client.connected()) {
    reconnect();
  }

  // Publish ECG value
  sprintf(topic, "%s%s", "/v1.6/devices/", DEVICE_LABEL);
  sprintf(payload, "%s", "");
  sprintf(payload, "{\"%s\":", ECG_VARIABLE_LABEL);
  float ecg_value = analogRead(ECG_SENSOR);
  dtostrf(ecg_value, 4, 2, str_sensor);
  sprintf(payload, "%s {\"value\": %s}}", payload, str_sensor);
  Serial.println("Publishing ECG data to Ubidots Cloud");
  client.publish(topic, payload);

  // Publish temperature value
  sprintf(topic, "%s%s", "/v1.6/devices/", DEVICE_LABEL);
  sprintf(payload, "%s", "");
```

```
  sprintf(payload, "{\"%s\":", DHT_TEMPERATURE_VARIABLE_LABEL);
  float temperature = dht.readTemperature();
  dtostrf(temperature, 4, 2, str_sensor);
  sprintf(payload, "%s {\"value\": %s}}", payload, str_sensor);
  Serial.println("Publishing temperature data to Ubidots Cloud");
  client.publish(topic, payload);

   // Publish Pulse value
  sprintf(topic, "%s%s", "/v1.6/devices/", DEVICE_LABEL);
  sprintf(payload, "%s", "");
  sprintf(payload, "{\"%s\":", PULSE_SENSOR_VARIABLE_LABEL);
  float pulse_value = (analogRead(PULSE_SENSOR_PIN)/27);
  dtostrf(pulse_value, 4, 2, str_sensor);
  sprintf(payload, "%s {\"value\": %s}}", payload, str_sensor);
  Serial.println("Publishing Pulse data to Ubidots Cloud");
```

ML Code

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
dataset=pd.read_csv('Health monitoring.csv')
dataset
import seaborn as sns
sns.boxplot(dataset['SBP'])
import seaborn as sns
sns.boxplot(dataset['DBP'])
import seaborn as sns
sns.boxplot(dataset['Pulse'])
import seaborn as sns
sns.boxplot(dataset['Temperature'])
dataset.isnull().any()
```

```
x=dataset.iloc[:,0:4].values
y=dataset.iloc[:,4].values
x
y
X_train
X_test
y_train
y_test
from sklearn.preprocessing import StandardScaler
sc1=StandardScaler()
X_train = sc1.fit_transform(X_train)
X_test = sc1.transform(X_test)
X_train
X_test
from sklearn.neighbors import KNeighborsClassifier
knn = KNeighborsClassifier(n_neighbors=5,metric='minkowski',p=2)
knn.fit(X_train,y_train)
from joblib import dump
dump(knn,'hms.save')
y_pred=knn.predict(X_test)
y_pred
from sklearn.metrics import accuracy_score
accuracy_score(y_test,y_pred)
```

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