PATIENT HEALTH MONITORING USING IOT AND MACHINE LEARNING

PROJECT REPORT
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BONAFIDE CERTIFICATE

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ABSTRACT

In today's world, everyone's health is a major concern and a top priority. Humans are afflicted with a plethora of diseases as a result of their unhealthy habits. People are primarily affected by heart attacks and low oxygen levels because of poor medical care. As a result, this project was created to combat such untimely deaths using smart health monitoring, which employs a wireless sensor mechanism. The proposed system includes ThingSpeak cloud to communicate with the doctor in case of any emergency. This system consists of body temperature sensor, pulse oximeter sensor (for collecting heartbeat rate and oxygen level) and blood pressure sensing module for tracking patient's health. These sensors are interfaced with the raspberry pi and Arduino Uno microcontroller. The obtained result from patients is continuously monitored and it is updated in LCD and doctor's webpage using IOT. After these process Machine learning is performed to determine the type of disease that the patient is affected. This system predicts two major disease namely Hypertension and Lung disease. By incorporating all of these features, we can ensure that people who suffer from heart attacks and lung disease will not die suddenly. The accuracy of this proposed method is 86% approximately.

K*ey words*: bio-sensors, IOT, machine learning, Thingspeak, health-monitoring

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LIST OF ABBREVIATIONS

ABBREVIATION	EXPANSION
LED	**L**ight **E**mitting **D**iode
Wi-Fi	**Wi**reless **Fi**delity
SVM	**S**upport **V**ector **M**achine
GSM	**G**lobal **S**ystem for **M**obile **C**ommunication
PC	**P**ersonal **C**omputer
IOT	**I**nternet **O**f **T**hings
IDE	**I**ntegrated **D**evelopment **E**nvironment

CHAPTER I

INTRODUCTION

Today, a variety of factors contribute to a person's unhealthy lifestyle. These factors include unhealthy eating habits, a lack of proper exercise, and poor diet plans, among others. People don't have enough time to focus on their health because of their hectic daily schedules. To keep track the health status many health monitoring systems are available. Existing methods primarily employ analogue devices, with the output displayed in CRO. This procedure necessitates the use of an ADC and a DAC to convert the output. To overcome these drawbacks, the Raspberry Pi is used as a minicomputer. Multiple patients' data were collected and processed using a single Raspberry Pi. This proposed system eliminates many of the shortcoming that exist in existing methods. The Raspberry Pi is used in this system to control the sensors and collect data remotely. The data is then sent to the doctor's webpage via IOT. Disease prediction is also included in this system using an ML model. This proposed system may be useful for people who require emergency services and coordination.

1.1 BACKGROUND AND MOTIVATION :-

Some people do not have access to medical facilities in this technological age. They lack proper medications, transportation, and there are no hospitals nearby. The primary motivation for this proposed system is to improve medical facilities in and around people who do not have adequate access to health care facilities.

1.2 OBJECTIVE:

- The proposed system employs electronic sensors to measure patient health parameters. If we place an electronic sensor in a patient's body, it will detect health parameters such as temperature, pulse rate, oxygen level, and blood pressure and send it to the doctor via the cloud. For disease prediction, the collected data was run through an ML model (SVM classifier).

- The primary goal of this project is to provide the best health monitoring system possible.
- The proposed system can be used as an alternative option for continuously monitoring patients.
- At the same time, this proposed system offers a way to improve the health monitoring system.

CHAPTER II

LITERATURE REVIEW

Many literature studies on patient monitoring systems have been conducted. Furthermore, healthcare datasets are being saved in the cloud to improve communication between doctors and patients. IoT technology in conjunction with machine learning , is used to make the remote health monitoring more reliable.

Jabeen and his crew proposed an efficient health monitoring system. It uses IOT technology. They mainly focused on cardiac disease and its diagnosis. Initially the important parameters related to cardiac disease are collected using bio-medical sensors. Then the collected information sent to the doctor through cloud server. The wireless sensor mechanism was used for diagnosis of cardiovascular disease [1]. Lakshmanaprabu and his team developed a framework called clinic support system based on cloud computing. In this paper, prediction and diagnosis of Chronic Kidney Disease (CKD) is discussed. [2]. Hussain and his team created real-time monitoring of patient using IOT technology. This system uses modern sensor technology [3].

In [4], The patient's wellbeing and chronic disease monitoring system is developed. They mainly focus on diabetes, renal disorders and heart failure. This proposed system uses wireless sensor mechanism. A student health monitoring was proposed in [5]. In this proposed system, the vital parameters of student were collected using wireless sensor mechanism. They also concentrated on student's heart wellness.

A prediction approach to identify important factors influencing student healthcare with chronic disease was proposed. They have introduced monthly analysis of chronic illness, and health status as the main factors [6]. A real-time monitoring system for students and for elder people is used to enhance the emergency services [7]. A student health monitoring system used for monitoring the student's behavior with the help of bio-sensors and digital devices is proposed [8].

Monitoring of soldier's Healthcare using IOT and tracking system is experimented in [9]. This proposed system uses bio-sensors for observe the health parameters of soldiers and GPS for tracking their location. Using IOT, these collected data sent to the control room . In [10], a cardiac prediction system is proposed through IoT. For this prediction, the cardiac data is analyzed and also many ML algorithms were used to improve the accuracy .

Raspberry pi based real-time monitoring of patient's health is developed. The patient's health parameters such as temperature and heartbeat rate were collected using bio-sensors and observed the patient using camera. After this process, the collected data is sent to the doctor webpage through IOT for faster diagnosis [11]. Health monitoring system using IOT was proposed in [12]. In this project, they were indeed concerned with developing a real-time health monitoring system that makes use of cloud services. This has a lot of advantages for chronic patients and the elderly. In this system, they have also included faster realization methods.

A health monitoring system using IOT was developed to measure important health parameters of the person such as temperature, ECG, EEG, Blood pressure rate and heartbeat rate for remote health monitoring [13]. In [14], the person's health parameters like temperature, oxygen level of blood and heartbeat rate were collected using bio-sensors and using IOT and mobile application E-Health services were implemented .

An IOT based health monitoring system for observe the wellness of the patient was proposed. They used wearable bio-sensors for collecting the important health parameters of the patient. The collected data distributed in multiple sensors and this system helps the patient to access information from many locations [15]. ICU supportive real-time tracking proposed in [16], In this system, the health parameters collected using body sensors with the help of

Arduino uno r3 and using mobile application, for better diagnosis. They also used a variety of data transmission methods to the mobile application with the help of the IOT cloud .

A healthcare monitoring system with real-time clinical feedback using IOT and raspberry pi is developed. This system uses Arduino and raspberry pi as a controllers. Arduino for collecting data from a person using various sensors and raspberry pi to take a video of a person using pi camera. They have created a hub using local servers and this is used for aged people and patients who do not visit the doctor regularly [17].

An efficient wireless monitoring system for patients using raspberry pi is proposed in [18]. This system consists of GSM module to intimate the doctor. In the developed prototype, the data is collected using various health sensors and using GSM module the gathered information directly send to a doctor's mobile number. It reduces the load in the hospitals for health monitoring. This model takes 20 seconds for sending the data to a doctor.

In[19], different parameters such as temperature, respiratory rate, heart rate and body movement were collected using various bio-medical sensors. Using raspberry pi, the collected data is processed and information is stored in cloud [19]. In [20], a IOT based health monitoring system using raspberry pi, different health values like body glucose, heart rate, blood pressure and activity monitoring was proposed. ECG (Electrocardiogram) sensor data is used for collecting heart beat rate and predicting the diseases.

A Health monitoring system using IOT was developed in [21], They attempted to resolve the issue of time waste in ambulance service. They used Bluetooth and GSM module technology to solve this problem. Through IOT, the various sensors placed in a person send the collected data to a doctor's webpage. It will notify the ambulatory service in the event of an emergency.

A low cost and a portable E-health monitoring services is proposed in [22].A mobile based application was created for both patient and doctor and then the various bio-sensors like oximeter, BP and temperature connected to the raspberry pi for collecting information from patient and transferred using mobile application [22].

An apnea med-assist was developed in [23], This is a low cost system which is used for sleep apnea monitoring. This system analyze the ECG signals and it will automatically detects the apnea. It also uses SVM classifier for apnea detection [23]. An android based body area network for faster diagnosis is designed. Various parameters from human body such as Oxygen saturation value, heart rate, heart rate variation, fall detection and ECG were collected using bio sensors. Using these collected values, an android application was developed for the diagnosis [24].

An E-health monitoring system was proposed in [25], This method uses android mobile application and wireless network for monitoring patient's health report. It uses real-time data and can be used in emergency conditions. This system employs tele-monitoring and will benefit both patients at home and those in hospitals. The collected data is saved on a server for future use. In [26], a continuous observation of patient parameters was proposed. They collected heart rate and its properties (rhythm), blood-oxygen level, blood pressure and respiratory rate using different bio-medical sensors. The data in cloud is used for continuous observation. The system shall be used to make immediate ambulatory services and faster diagnosis [26].

A psychological monitoring system based on IOT is proposed in [27]. This system continuously monitors the psychological signals. They have used bio-medical sensors for this purpose. A "Health monitoring system using cognition control wireless network for murmured speech was proposed in [28], uses raspberry pi and bio-sensors for collecting data and processing the speech data for faster rehabilitation.

A survey on health monitoring using IOT in [29] was proposed for wellness monitoring through wireless sensor mechanism and IOT. It is an efficient technique with ubiquitous monitoring. This method has a disadvantage of difficult deployment of nodes compared to wired networks [29]. In [30], various parameters from a patient using sensors were collected and processed through WBASN.

When comparing these existing methods to the proposed system, only IOT is used in the existing methods. However, in the proposed system, IOT and machine learning were used to improve response time and speed up diagnosis.

CHAPTER III

METHODOLOGY

3.1 Baseline system:

Figure 3.1 depicts the ML architecture. Initially, the workflow begins in the software section. A comparison of four machine learning algorithms was performed to select the best ML model for the provided dataset. The dataset consists of four classes. The classes are normal (class-0), fever (class-1), hypertension (class-2) and lung disease (class-3). For training the ML model, 200 data were taken. It consists of 51 normal data, 48 data for class-1, 55 data for class-2 and 47 data for class-3. Algorithms such as Decision Tree Classifier, K-Nearest Neighbor classifier, Gaussian Naïve Bayes classifier and Support Vector Machine classifier were used for classification. On comparing these four algorithms, SVM algorithm provides the best accuracy when compared to other algorithms.

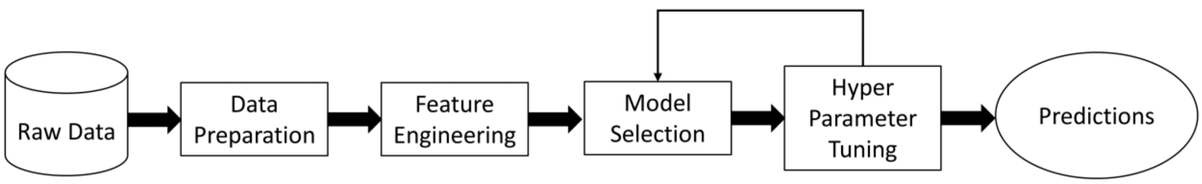


Fig 3.1 ML architecture

Following the completion of the ML algorithm, the proposed system moved on to the hardware component, which includes bio-sensors, controllers, and the cloud. Biosensors are used to collect real-time data. The biosensors are DHT11 (Temperature sensor), Blood pressure sensor and Pulse oximeter sensor (used for both heartbeat rate and oxygen level measurement). DHT11 sensor is interfaced with the raspberry pi and pulse oximeter sensor and is sensor interfaced with the Arduino microcontroller. Then an Arduino interface with the raspberry pi is established via serial communication. The connection between these controllers is implemented using I2C protocol. Here, Arduino act as a slave and raspberry pi acts as a master.

The collected data using these bio-medical sensors, sent to the cloud. In this system, thingspeak platform is used as a cloud storage. For upload the data in thingspeak webpage, account facilities are needed. The webpage link is shared with the doctor for consulting and taking medications. Then the collected data is used for real-time prediction. These values sent to the ML model as testing data. The initially created ML model, process the given test data and provide the results.

The SVM classifier is used for creating ML model. If the data has normal values as per medically defined values, then the system gives the output as normal. The normal values for any human being as per medically defined values are temperature 36 deg Celsius, Heartbeat rate is 70-90 beats per minute, Blood pressure is 120/80 mmHg and oxygen level of blood is 80-100mmHg. Based on the trained data, this proposed system also predicts diseases such as fever, hypertension and lung disease.

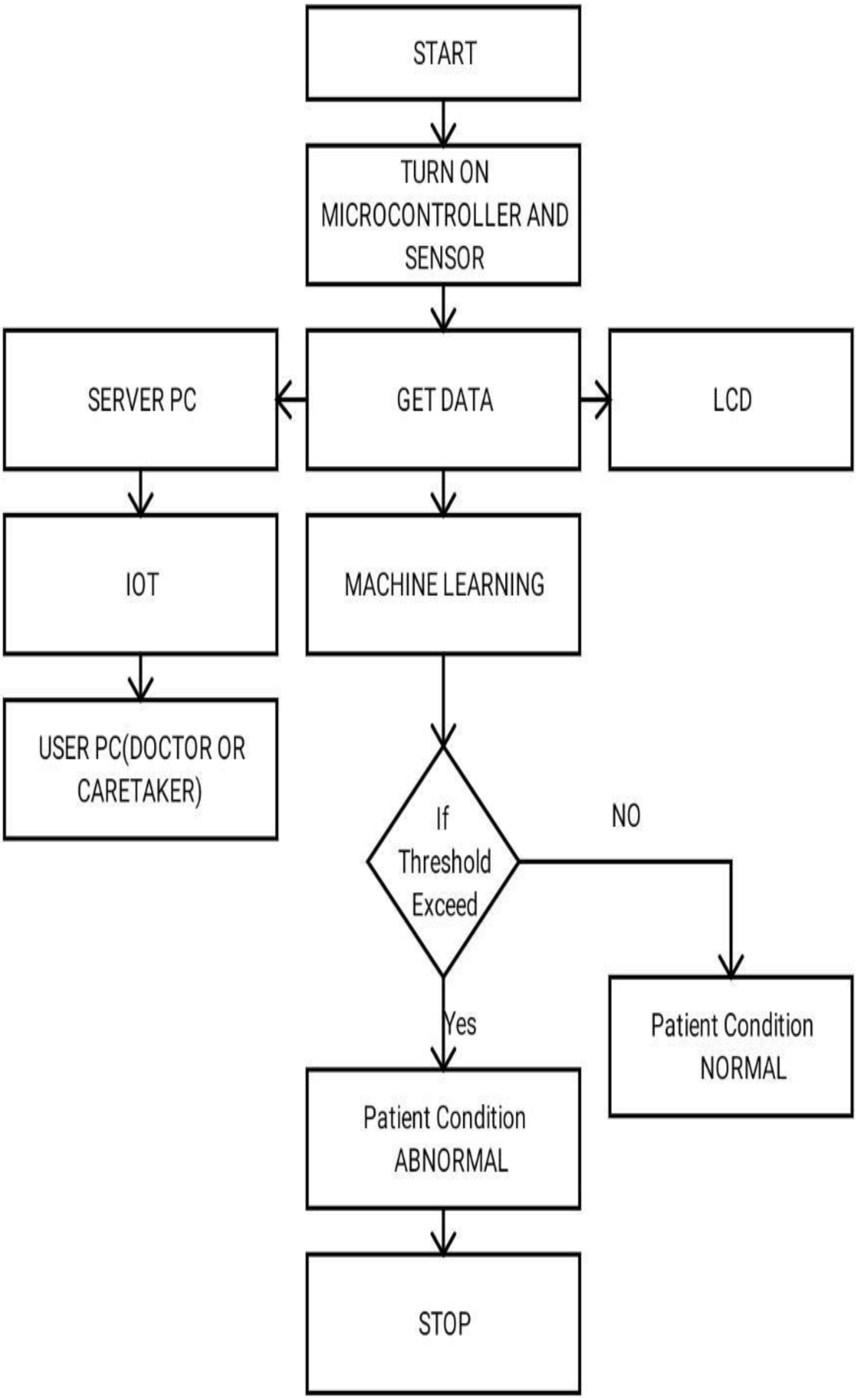


Fig 3.2 Methodology Flowchart

3.2 Flowchart Explanation:

In figure 3.2, the methodology flowchart is presented. The steps are explained as follows:

- First, power up the raspberry pi and Arduino using USB cable and make sure provide appropriate supply to the sensors.
- Place the sensors on the patient’s body surface.
- If the sensor is not correctly placed, the system shows “PLACE THE SENSORS PROPERLY” on the serial monitor.
- After correct sensor placement, the vital parameters (body temperature, oxygen level of blood, heartbeat rate and blood pressure) of the patient are collected using those bio-medical sensors.
- The collected information will be displyed in LCD display as well as in serial monitor.
- Collected parameters will be shared to the doctor through IOT using thingspeak cloud.
- The collected data applied to the support vector machine classifier as a testing data.
- Here the real-time data used is taken from the patient. The SVM model created with the use of heart disease dataset is taken from Kaggle. This dataset is a four-class dataset with values of the temperature, blood pressure rate, oxygen level and heartbeat rate.
- If the person is having normal medically defined values, this system shows the status as “NORMAL”. Otherwise, it moves to the next class.
- If the patient’s body temperature is high and the system shows “FEVER” as an output.
- In the next class, if the heartbeat rate and blood pressure is high as per medically defined values, the system will display that the particular patient’s status is in “HYPERTENSION”.

- Sometimes hypertension related to only blood pressure value. If oxygen level of blood is low, then the system provides the status of the patient as "LUNG DISEASE".
- The model is created as per the given values in the dataset. If the collected values are not suited for the model, then the system shows "CONSULT YOUR DOCTOR" in a LCD display.

CHAPTER IV

SYSTEM ARCHITECTURE AND COMPONENTS

4.1 System architecture:

The system architecture is illustrated in figure 4.1. In this proposed system, the temperature sensor is directly interfaced with the raspberry pi controller and then the blood pressure sensor and pulse oximeter sensor (it gives both heartbeat rate and oxygen level values) are interfaced with the Arduino Uno r3 microcontroller. Arduino controller is connected to the raspberry pi via serial communication using I2C protocol. Here Arduino works as a slave for raspberry pi. As, the pulse oximeter sensor cannot be directly interfaced with raspberry pi. The actual reason is, after interfacing pulse oximeter sensor with raspberry pi that provides less accurate results. After getting values from the biosensors, the values are send to the doctor’s webpage. The obtained values are used for predicting diseases such as fever, hypertension and lung disease with the help of ML model.

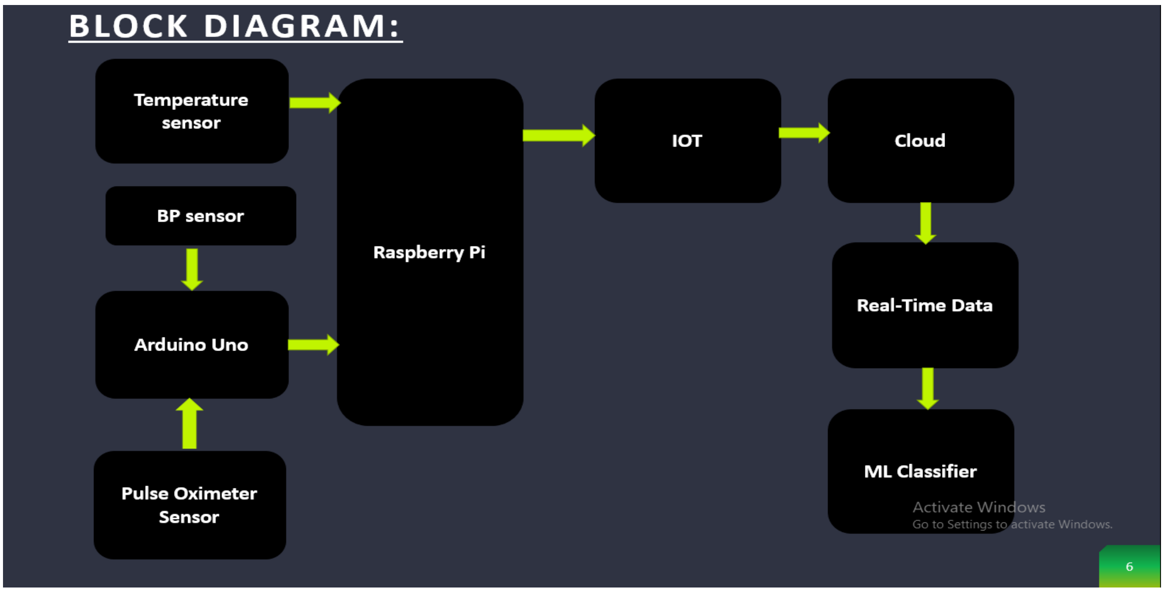


Fig 4.1 System Architecture

4.2 Raspberry pi:

Fig 4.2 Raspberry PI

In figure 4.2, the raspberry pi is shown. The initial model in raspberry pi 3is model B. It is named as raspberry pi model B in February 2016.

Features:

- It has quad core processor and 1GB RAM
- 40 GPIO pins are there in this controller
- BCM43438 wireless LAN and Bluetooth Low Energy (BLE) on board
- It has 64-bit CPU

4.3 Arduino:

In figure 4.3, the Arduino is shown. The Arduino Uno is an open-supply microcontroller board primarily based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. This board have totally 28 pins (6 analog input/ouput pins, 12 digital input/output pin, serial input and serial output pins)

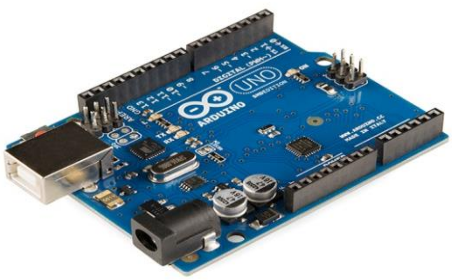


Fig 4.3 Arduino

Features:

- Microcontroller: Microchip ATmega328P
- The operating voltage of this is 5V.
- The input for this board is 7-20 V.

4.4 Pulse oximeter sensor:

In figure 4.4, the pulse oximeter sensor is shown. MAX30100 is used to measure the oxygen level and heartbeat rate of a human being. It has RED and INFRARED LED's for measuring these parameters. It has an operating voltage of 3.3V.

Fig 4.4 Pulse oximeter sensor

4.5 Temperature Sensor:

In figure 4.5, the temperature sensor is shown. This DHT11 sensor (temperature sensor) have three pins (vcc, gnd and analog output pins). This is used for measuring both body temperature and room temperature. This sensor measures the temperature that where it placed.

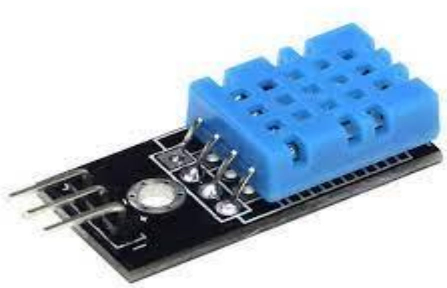


Fig 4.5 Temperature sensor

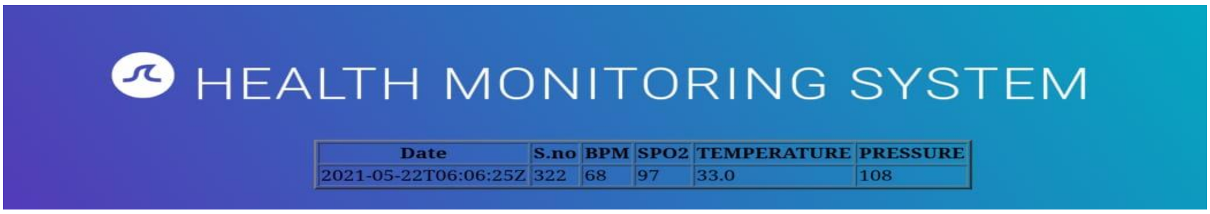
4.6 Blood Pressure Sensor:

In figure 4.6, the blood pressure module is illustrated. On the display of this blood pressure module, the systolic, diastolic blood pressure and heartbeat rate are displayed. After measuring these values, via serial communication, the data is sent to Arduino microcontroller. This module is compatible to wear in wrist.

Fig 4.6 BP sensor

4.7 IOT (Thingspeak):

In figure 4.7, the message displayed in thingspeak cloud is shown. IOT is described as many embedded systems (things) are connected through internet. These systems connected with sensors for collecting information remotely. The collected data using sensors were processed by these embedded systems and stored these data in cloud storage through IOT. The data is used for future reference. The cloud link is shared with doctor for consulting. Patient monitoring, environmental monitoring are the main applications of IOT. Here we have used thingspeak to store and display collected patient's data in cloud.



Date	S.no	BPM	SPO2	TEMPERATURE	PRESSURE
2021-05-22T06:06:25Z	322	68	97	33.0	108

Fig 4.7 Thingspeak cloud storage

4.8 Support Vector Machine Classifier:

In figure 4.8, the SVM hyperplanes is illustrated. The fundamental objective of the SVM ML algorithm is to perceive a hyperplane in an N-dimensional space (N - the number of features) that clearly classifies the data points.

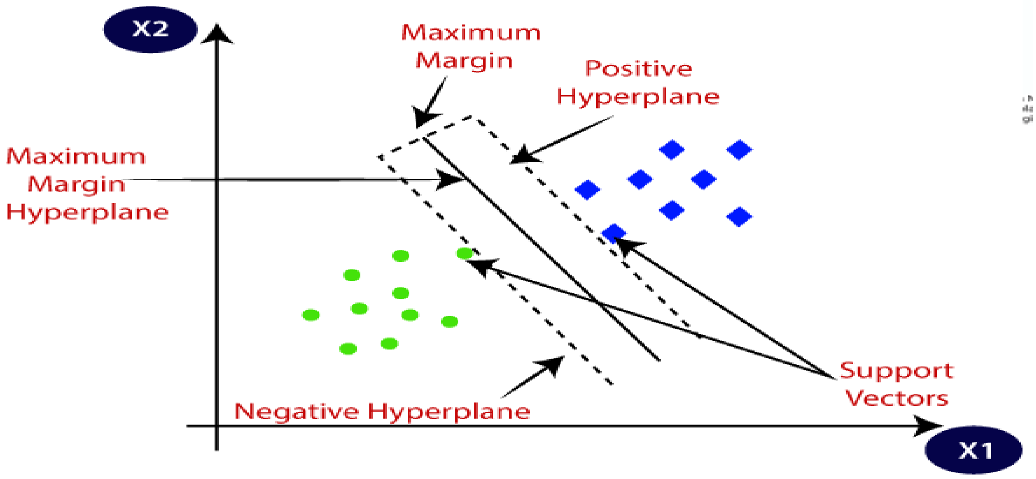


Fig 4.8 SVM hyperplanes

CHAPTER V

RESULTS AND DISCUSSIONS

5.1 Hardware Design:

In figure 5.1, the hardware design is illustrated. The system shown here is patient health care monitoring system to monitor the vital signs of patient like blood pressure, heart rate, SPo2 level and temperature. The success rate between the actual data and observed data is approximately 85 percentage for diseases like hypertension, lung disease. This project will help the doctors to easily access the data of patient .This project can help doctors and nurses in situations of epidemics or crises as raw medical data that can be analyzed in very short time.

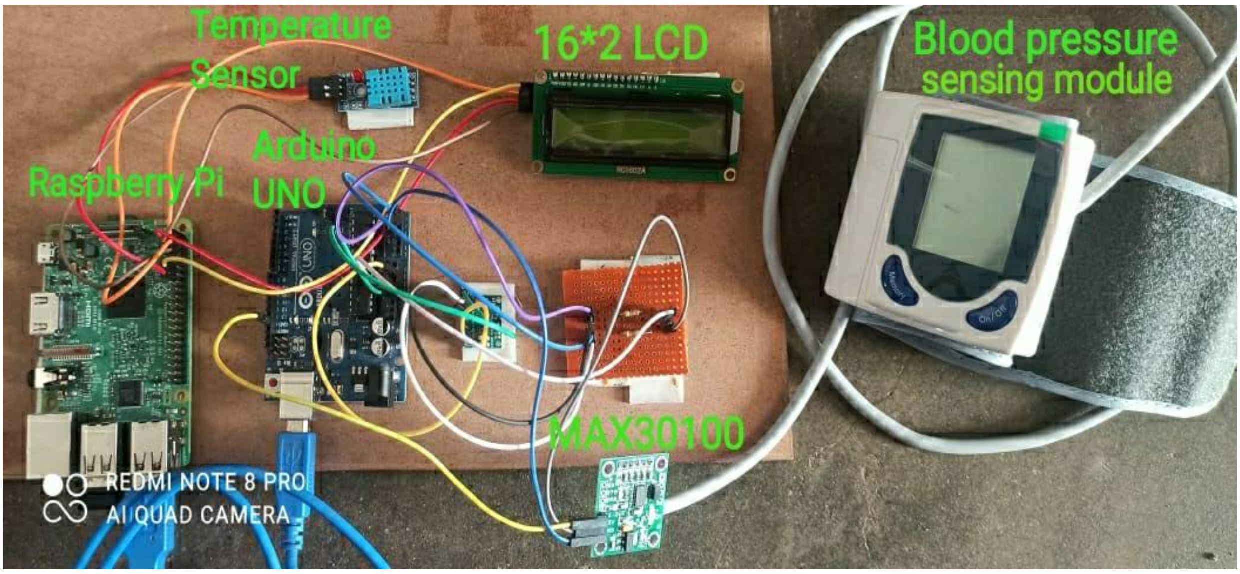


Fig 5.1 Hardware Design

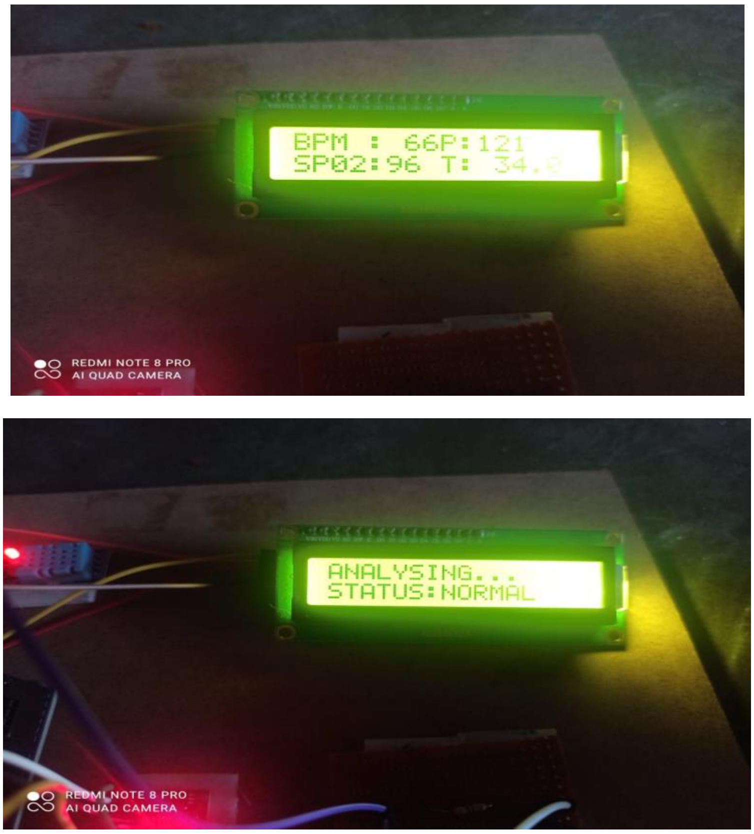


Fig 5.2 Normal person’s result

The normal person result is shown, in figure 5.2. The results of normal and abnormal persons are presented in table 5.1 and 5.2 respectively.

Parameters	Obtained results
Heartbeat rate	66 beats per minute
Temperature	34 deg Celsius
Blood Pressure	121 mmHg
Oxygen level of blood	96 mmHg
Status	NORMAL

Table 5.1 Normal person result

Fig 5.3 Abnormal person's result

Parameters	Obtained results
Heartbeat rate	75 beats per minute
Temperature	34 deg Celsius
Blood Pressure	175 mmHg
Oxygen level of blood	93 mmHg
Status	HYPERTENSION

Table 5.2 Abnormal person result

5.4 Serial communication protocol:

In figure 5.4, the serial communication is illustrated. This protocol enables the serial communication between raspberry pi and Arduino microcontroller. Then the data collected by the Arduino, is send to the raspberry pi. Here I2C protocol is used for serial communication and it is also known as bus protocol. It has a very important advantage of one master, many slave concept that using this protocol, the master controller can connect with many slave controllers. It is mainly used in real-time data processing.

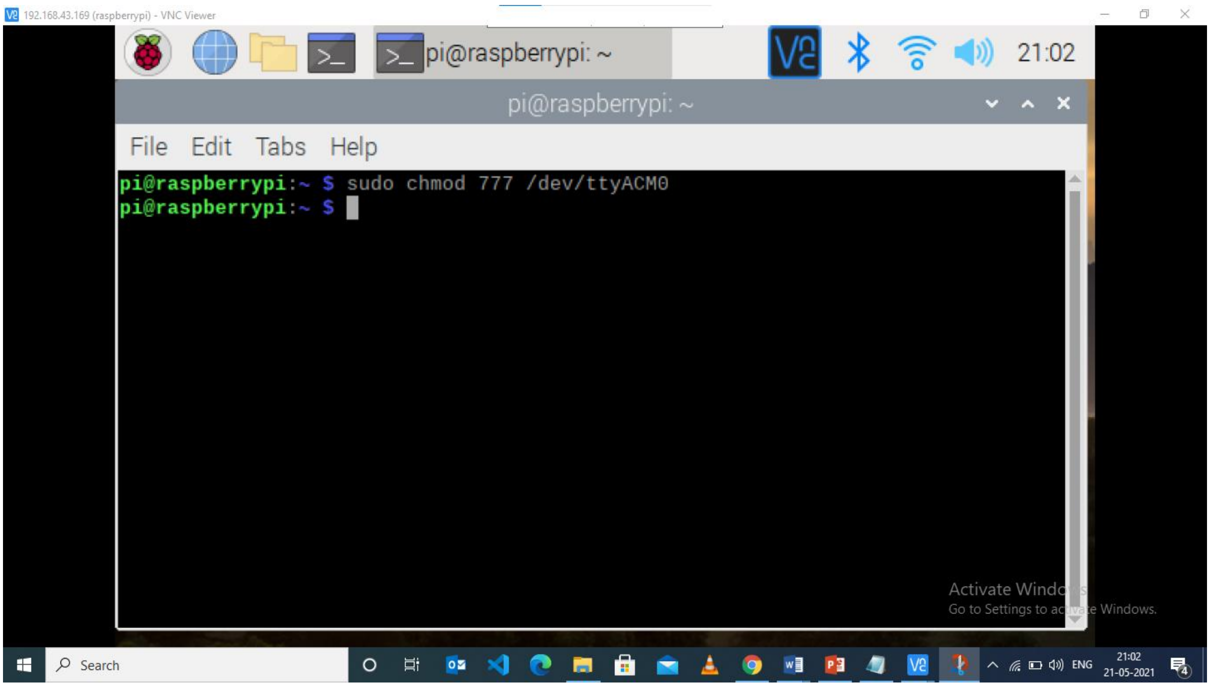


Fig 5.4 Serial communication protocol

5.5 Snippet of Arduino IDE:

In figure 5.5, the Arduino IDE is presented. The picture shows the Arduino programming for both pulse oximeter sensor and blood pressure sensor. Arduino IDE is an open-source platform that makes writing code easily.

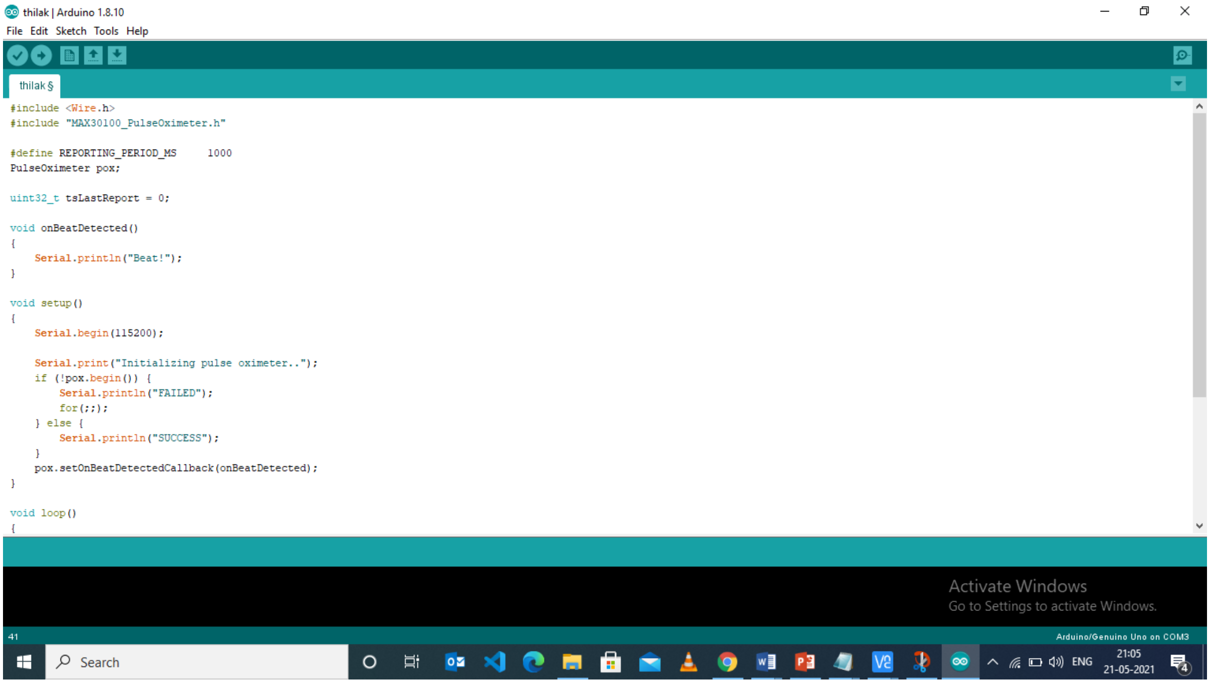


Fig 5.5 Arduino IDE

5.6 Snippet of VNC viewer IDE:

In figure 5.6, the VNC viewer IDE is shown. VNC viewer is an open-source IDE platform that controls a computer remotely. VNC is abbreviated as “Virtual Network Computing”. It uses RFB protocol that is used for transfer screen pixel data from on PC to another over network. The raspberry pi and the desktop must connected to the same Wi-Fi network. The only the raspberry pi should be accessed. Using the IP address of the Wi-Fi network, the VNC viewer and the PI is connected. On the above picture, the coding (for raspberry pi in python) and the serial monitor output has shown. The serial monitor shows the output as “NORMAL”. So, the tested person is in normal state.

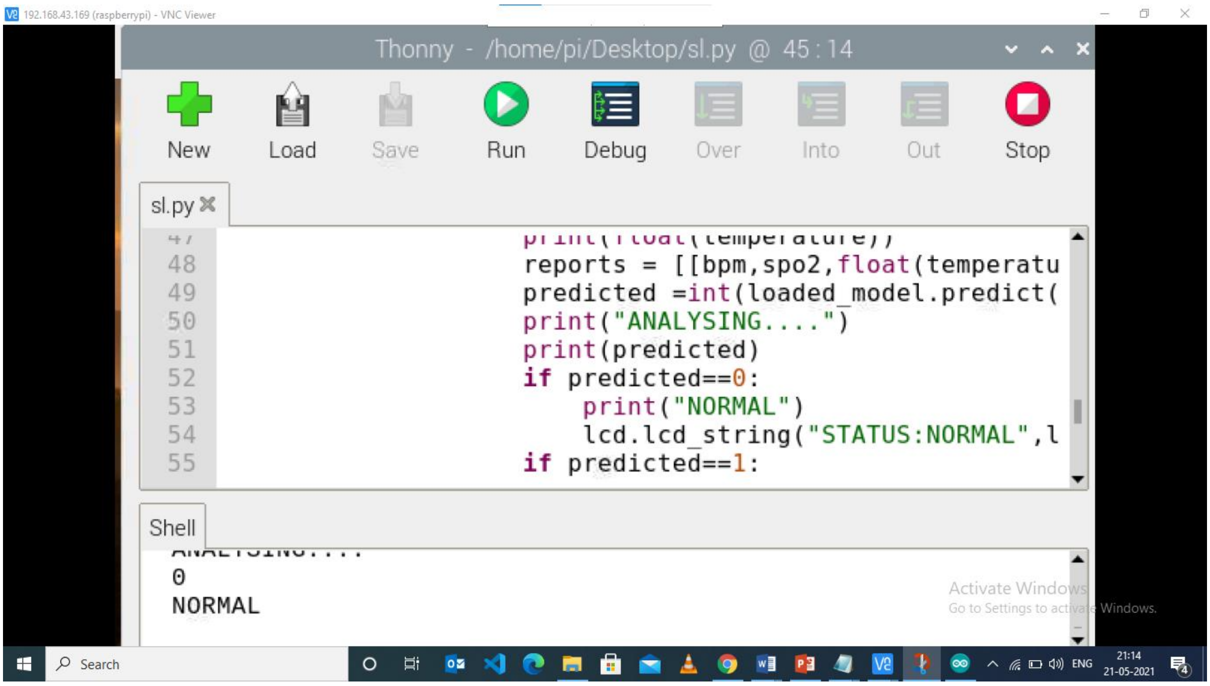


Fig 5.6 VNC viewer IDE

5.7 Comparison Table:

In figure 5.7, the comparison table is shown. The comparison between four machine learning algorithms has done to pick a best ML model for the provided dataset. Compared algorithms are Decision Tree Classifier, K-Nearest Neighbor classifier, Gaussian Naïve Bayes classifier and Support Vector Machine classifier. On comparing these four algorithms, SVM algorithm provides the best accuracy when compared to other algorithms. The results are presented in table 5.3.

Classifier	Test size	Accuracy (%)
Decision Tree Classifier	0.2	90.54
KNN Classifier	0.2	91.11
Gaussian Naïve Bayes	0.2	94.77
SVM Classifier	0.2	96.11

Table 5.3 Comparison table

5.8 Final result:

The proposed system gives an accuracy of 86%. 38 samples taken as an input for the system. Out of this 38 samples, 33 samples are correctly detected by the system. This proposed method provides a better accuracy on comparing with the existing health monitoring systems. The results are presented in table 5.4.

No. of samples obtained	**No. of sampled correctly predicted**	**System Accuracy (%)**
38	33	86

Table 5.4 System Accuracy

CHAPTER VI

CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSION

The proposed project provides a better way of monitoring the patient's health system. It mainly focuses on real-time monitoring using IoT and cloud services. This system proposes a smart real-time patient monitoring system that used to monitor the patient's important parameters such as body temperature, blood pressure, heartbeat rate and Oxygen level. Appropriate medications are suggested based on the provided results.

This system sends the collected data to the doctor for consulting, in case of any abnormality, through Cloud. It minimizes the costs in health monitoring and it enables the patient's to make use of available medical facilities. In the future, focus on improving wearing sensor experience by using low cost materials and enabling controlled sharing of information among the doctors through cloud services. This proposed system provides accurate and fast user authentication.

6.2 FUTURE SCOPE

Even though the healthcare industry was slower than other industries in adopting internet of things technology in the beginning. The new sensation internet of scientific things, on the other hand, is a game changer. It is well on its way to transforming the way humans are kept safe and healthy while also being cost-effective. All of this demonstrates the general future scope of IoT in the Healthcare sector. The IoMT market is brimming with clever devices such as wearables, scientific/vital monitors for fitness care use on the body, at home, and in network settings, as well as associating real-time location, telehealth, and other offerings. Moreover, on-body section is split into segments- consumer fitness wearables and medical/medical-grade wearables.

- **Consumer Health Wearables** are consumer-grade devices for personal well-being or fitness, such as internet trackers, bands, wristbands, sports activities watches, and smart clothing.
- **Clinical-Grade Wearables** are regulated gadgets and assisting systems that have been generally certified/approved for use by one or more regulatory or fitness authorities, including the United States Food and Drug Administration.

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