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# Towards Improving Patient Health Monitoring System using Machine Learning and Internet of Things

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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 because of their unhealthy habits. People are primarily affected by heart attacks and low oxygen levels because of poor medical care and late diagnosis. As a result, this work aims to combat such untimely deaths using smart health monitoring, which employs machine learning and IoT. 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 Internet of Things. Following these steps, a trained Machine Learning model is used to determine the type of disease being experienced by the patient. This system predicts Normal and two major disease namely Hypertension and Lung disease. By incorporating all 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 in a real time scenario. Furthermore, because raw medical data can be analyzed in a short period of time, the work will aid clinicians in remote monitoring during epidemic situations such as covid.**

**Keywords— biosensors, IoT, machine learning, Thingspeak, remote health-monitoring, epidemic management, covid detection**

## 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 do not 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, a cost-efficient compact system is developed using Raspberry Pi as a minicomputer. Multiple parameters of a patient were collected and processed using a single Raspberry Pi. This proposed system eliminates many of the shortcoming that exist in existing methods. The sensor in the proposed system is controlled by Raspberry pi. The data collected from sensor is then sent to the doctor's webpage via Internet of Things (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.

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 areas where people do not have adequate access to health care.

The proposed system employs electronic sensors to measure patient health parameters. On placing an electronic sensor in a patient's body, health parameters such as temperature, pulse rate, oxygen level, and blood pressure are detected and transmitted to the doctor via cloud. For disease prediction, the collected data is analysed through a trained Machine Learning (ML) model.

The significant contributions of the proposed work are:

- The primary goal of this work is to propose a robust health monitoring system by combining IoT and ML.
- The proposed system can be used as an alternative option for continuously monitoring patients.
- The system provides a low-cost method of improving the accuracy of a health monitoring system.

## 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. Stress detection [1], Cancer detection [2-4] are widely used health monitoring system using artificial intelligence techniques.

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IoT technology in conjunction with machine learning [5-19], is used to make the remote health monitoring more reliable.

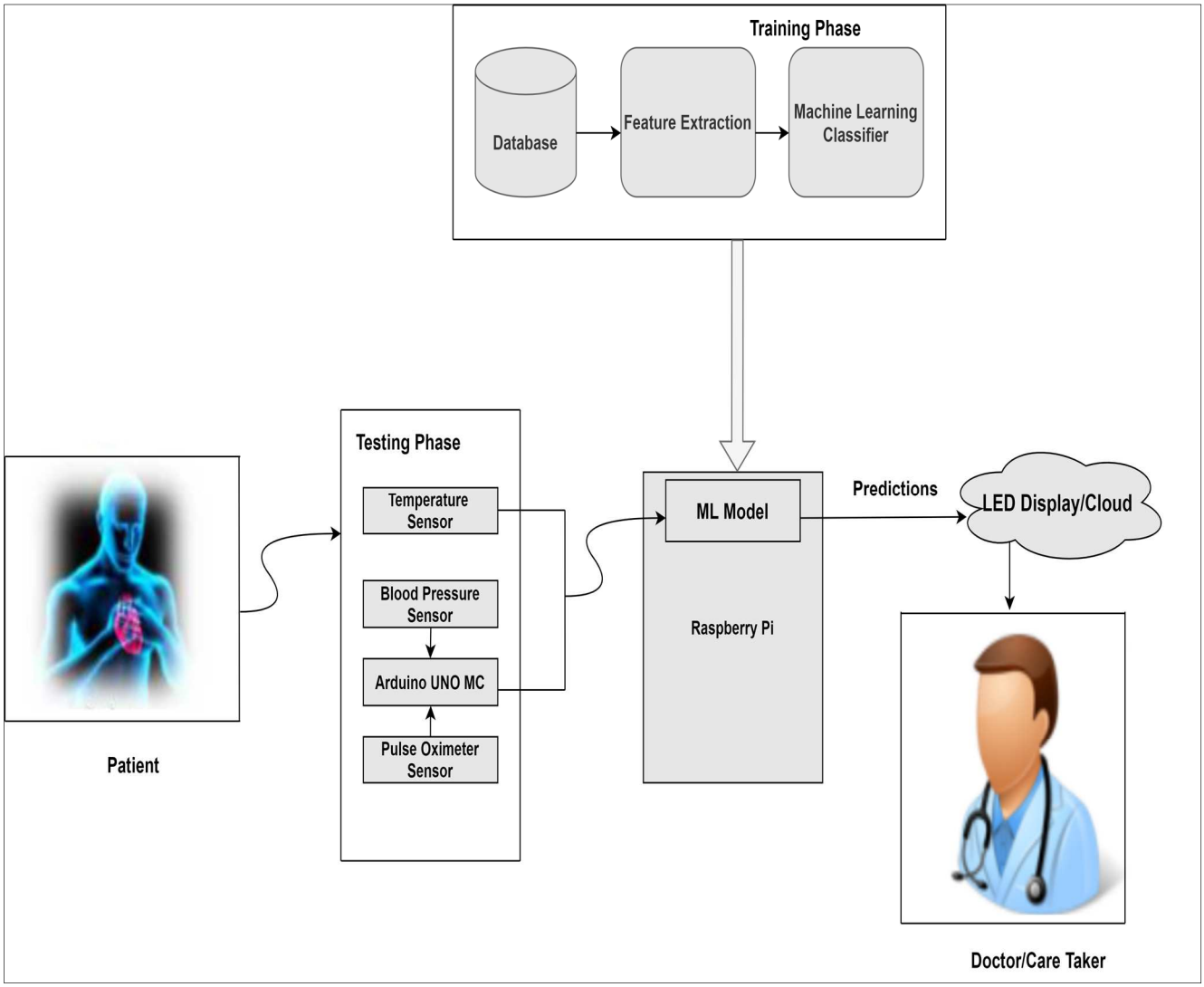


Fig. 1. System Architecture

In [5], an efficient health monitoring system is proposed. It uses IoT technology. The focus is on cardiac disease and its diagnosis. Initially, the important parameters related to cardiac disease are collected using bio-medical sensors and sent to the clinician through cloud. The wireless sensor mechanism was used for data collection and further diagnosis of cardiovascular disease.

An IoT based clinic support system embedded with ML and cloud computing is proposed. Deep neural network as classifier and Particle Swarm Optimization was used for feature selection for prediction and diagnosis of chronic kidney disease [6].

In [7], a real-time health monitoring of patient using IoT technology and bio, and environment sensors is experimented. A patient centric model for accurate health diagnosis is proposed. Further, Fuzzy logic is used for data analysis.

A Raspberry Pi and Arduino-based IoT-based remote patient health monitoring system prototype is proposed. The data is sent to the cloud server from Raspberry pi. An Android app was developed to represent the health parameters [8].

Authors in [9], proposed a IoT and sensor-based approach for behavioural monitoring system. The system identifies the frailty and mild cognitive impairment of elderly. The system could be used as initial screening system for detecting cognitive impairments at early stage.

A health monitoring system for students is proposed in [10] to assess the vital parameters and behavioural changes of students. Data collected from biosensors are analysed and classified using Machine Learning classifier. SVM classifier outperformed other classifiers in evaluating the student condition.

In [11], The patient's wellbeing and chronic disease monitoring system is developed. They mainly focus on diabetes, renal disorders, and heart failure in addition to vital parameters. This proposed system uses wireless sensor mechanism.

Monitoring of soldier's Healthcare using IoT, and tracking system is experimented in [12]. This proposed system uses biosensors for observe the health parameters of soldiers and GPS for tracking their location. Using IoT, these collected data sent to the control room.

In [13], a cardiac prediction system is proposed through IoT. For this prediction, the cardiac data is analysed, and many ML algorithms were used to improve the accuracy.

An E-health monitoring system was proposed in [14], 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.

A survey in [15] 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.

In [16], a real-time health monitoring system that makes use of cloud services and IoT is proposed. This has numerous benefits for chronic patients and the elderly. Further, faster realisation methods to implement the system is also analysed.

In [17], 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. Raspberry pi based real-time monitoring of patient's health is developed in [18]. The patient's health parameters were collected using biosensors and observed the patient using camera. After data collection, it is sent to the doctor webpage through IoT for faster diagnosis.

A low cost and a portable E-health monitoring services is proposed in [19]. A mobile based application was created for both patient and doctor and then the various biosensors like oximeter, pressure and temperature connected to the raspberry pi for collecting information from patient and transferred using mobile application.

When comparing existing methods, it is observed that combining IoT and machine learning improves response time and accelerates diagnosis.

## III. Materials and Methods

System architecture, workflow and the steps involved in proposed health monitoring system are discussed in this section.

### *A. System Architecture*

In the system architecture illustrated in Fig. 1, temperature sensor is directly interfaced with the raspberry pi controller and then the blood pressure sensor and pulse oximeter sensor (provides 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. The real reason is that after interfacing a pulse oximeter sensor with a raspberry pi, the results are less accurate. Hence, Arduino is connected as slave for raspberry pi for interfacing pulse oximeter sensor. The values obtained from the biosensors are sent to the doctor's website. The obtained values are used for predicting fever, hypertension and lung disease with the help of ML model.

### *B. Methodology*

Initially, the workflow begins in training the ML model. A comparison of four ML algorithms was performed to select the best model for a Publicly available 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 samples 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 Naive Bayes classifier and Support Vector Machine were used for classification. On comparing these four algorithms, SVM algorithm provides the best accuracy when compared to other algorithms. Table I summarizes the findings.

TABLE I. Performance Evaluation

| S.No | Classifier | Test size | Accuracy (%) |
|---|---|---|---|
| 1. | Decision Tree Classifier | 0.2 | 90.54 |
| 2. | KNN Classifier | 0.2 | 91.11 |
| 3. | Gaussian Naïve Bayes | 0.2 | 94.77 |
| 4. | SVM Classifier | 0.2 | 96.11 |

After the ML algorithm has been completed, the proposed system control is transferred to the hardware component, which includes biosensors, controllers, and the cloud. Biosensors are used to collect data in real time. 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, are sent to the cloud. In this system, ThingSpeak platform is used as a cloud storage. Account access is required to upload data to the ThingSpeak website. The webpage link is shared with the doctor for consultation and providing medication . The collected data is then used to make real-time predictions. As testing data, these real time measurements are sent to the ML model. The trained ML model is used to validate the samples in real time and provide appropriate results.

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

### *C. Workflow*

In Fig. 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 appropriate supply is provided 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 displayed in Liquid Crystal Display (LCD) 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 is trained with the use of heart disease dataset taken from Kaggle.
- If the person is having normal 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, 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 values in the dataset. If the collected values deviates much, then the system shows "CONSULT YOUR DOCTOR" in a LCD display.

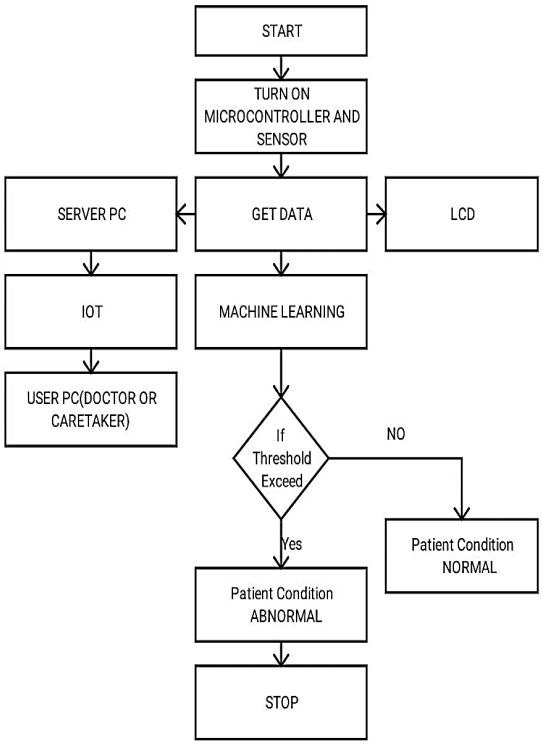


Fig. 2. Workflow of the system

## IV. Results and Discussions

In Fig 3, the hardware design is illustrated. The system depicted here is a patient health care monitoring system that measures vital signs such as 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.

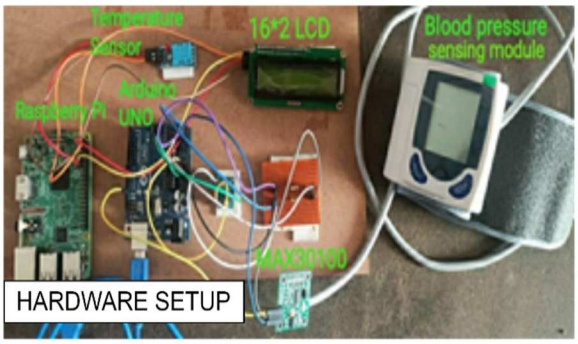


Fig. 3. Hardware setup of the system

### A. Hardware Setup and Parameter measurement

The normal and abnormal person result are shown, in Fig 4 and 5, respectively. The Parameters measurement of normal and abnormal persons are presented in Table II and III, respectively. The data displayed in cloud is shown in Fig 6.

TABLE II. Results of Normal Patients

| **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** | |

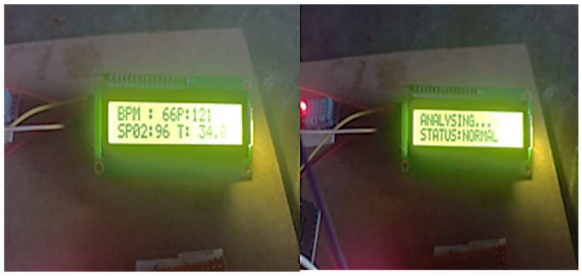


Fig. 4. LCD Display of Normal Person


Fig. 5. LCD Display of abnormal person

TABLE III. Results of Abnormal Patients

| **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** | |

### B. Serial Communication Protocol

I2C protocol enables the serial communication between raspberry pi and Arduino microcontroller. The Arduino collects data, which is then sent to the Raspberry Pi. I2C protocol has the significant advantage of the one master, many slave concept in which the master controller can connect with many slave controllers using this protocol. It is primarily employed in real-time data processing.

### C. Validation on real time data

From Table IV, validating the proposed system on real time data an accuracy of 86% is obtained. The data collected from the patients in real time, is passed as input in the test phase of SVM classifier. 38 samples are used as input in the testing phase. 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.

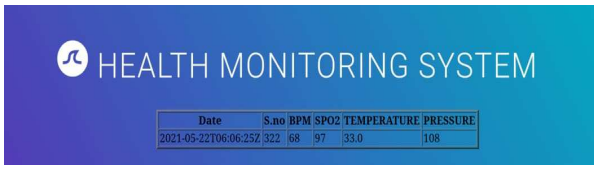


Fig. 6. Patient health parameters displayed in Cloud

TABLE IV. REAL TIME VALIDATION ACCURACY

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

## V. CONCLUSION

The proposed work provides a better way of monitoring the patient's health system. It mainly focuses on patient monitoring using ML, IoT and cloud services. ML is used to improve the decision accuracy. Further, the system can be used as smart real-time patient monitoring system enabled with IOT to monitor the patient's important vital 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. Furthermore, the work will assist doctors in easily accessing patient data and can assist doctors and nurses in epidemic situations such as covid, as raw medical data can be analysed in a very short time. In the future, wearable sensor technology based combined with tele medicine may be employed for remote health monitoring.

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