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STABILITY SPOON AND PATIENT HEALTH ANALYSIS FOR PARKINSON'S DISEASE

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Abstract*—Parkinson's disease (PD) is a progressive, neurodegenerative disorder of aging that affects both motor and cognitive function. Its underlying cause is unknown, but complex interactions between aging, genetic, and environmental factors contribute. There is no cure for PD, but symptomatic treatments are available and research efforts focus on neuroprotection. Parkinson's disease is the second most prevalent neurodegenerative illness, affecting primarily the elderly. It is caused by extensive nerve cell degeneration, which impairs mobility and daily activities. The patient's early symptoms may include unintentional shivering and tremors in the hand, making it impossible for them to perform daily duties such as eating out of a bowl. Patient remote monitoring is especially challenging for the attendant. Our project intends to produce a stabilizing spoon for Parkinson's disease sufferers as well as a health monitoring system using IOT and sensor network principles along with ML for prediction of the presence of Parkinson's disease. The stabilizing spoon adjusts for unintentional tremors or shivers from the user by calibrating its head against these forces, ensuring that the spoon bowl remains steady at all times. To aid patients' eating processes, a prototype of the gadget was constructed utilizing an accelerometer to measure the speed of these motions. Another aspect of the project entails monitoring the patient's heartbeat, SpO2 levels, and temperature and transferring the information to a mobile application for monitoring the patient's status.

***Keywords*— KNN; Logistic Regression; Decision tree; PD; Accelerometer; Servomotor; Machine Learning; IOT**

I. INTRODUCTION

In these recent years IoT has taken over most of the industrial area specially automation and control. Biomedical is one of recent trend to provide better health care. Not only in hospitals but also the personal health caring facilities are opened by the IoT technology. So by having a smart system various parameters are observed that consumes less power, cost and increase efficiency. In traditional method, doctors play an important role in health checkup. For this process requires a lot of time for registration, appointment and then checkup. Also reports are generated later. Due to this lengthy process working people tend to ignore the checkups or postpone it. This modern approach reduces time consumption in the process. In the recent years use of wireless technology is increasing for the need of upholding various sectors. Body sensor network systems can help people by providing healthcare services such as medical monitoring, memory enhancement, medical data access, and communication with the healthcare provider in emergency situations through Internet. Continuous health monitoring with wearable or clothing-embedded transducers and implantable body sensor networks will increase detection of emergency conditions in at risk patients. Not only the patient, but also their families will benefit from these. Also, these systems provide useful methods to remotely acquire and monitor the physiological signals without the need of interruption of the patient's normal life, thus improving life quality. Medical scientists are trying in the field of innovation and research since many decades to get better health services and happiness in human lives. Their contribution in medical area is very important to us and cannot be neglected.

The prevalence of PD is 200–300 cases per 100 000 people, and in the United States about 1 million persons are affected. The annual incidence is approximately 20 new cases per 100 000 people, and about 60 000 Americans are diagnosed with PD each year. The likelihood of developing PD increases with age. PD typically develops in the 60s, but can occur at younger ages. Approximately 10% of all patients develop symptoms before age 40. PD is usually a sporadic disease but is hereditary in 10% of the patients. Men are slightly more frequently affected than women.

Symptoms start slowly. The first symptom may be a barely noticeable tremor in just one hand. Tremors are common, but the disorder may also cause stiffness or slowing of movement or even impaired balance and coordination affecting activities like eating and sometimes leads to falls. In the early stages of Parkinson's disease, your face may show little or no expression. Your arms may not swing when you walk. Your speech may become soft or slurred and speech is frequently significantly affected, leading to dysarthria (difficulty articulating sounds), hypophonia (lowered volume), and monotone (reduced pitch range). Parkinson's disease symptoms worsen as your condition progresses over time. They may also have mental and behavioral

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changes, sleep problems, depression, memory difficulties, and fatigue.

In this project, we have also used Machine Learning algorithms to detect the disease in the early stages by the doctors and hence increase the lifespan of the elderly people.

II. LITERATURE REVIEW

A. IOT based patient health monitoring system, 2018.[1]

The system is developed for home use by patients that are not in a critical condition but need to be timely monitored by doctor or family. In any critical condition the SMS is send to the doctor or any family member. So that we can easily save many lives by providing them quick service.

B. Disease Prediction using Machine Learning.[2]

Supervised machine learning (ML) algorithms have showcased significant potential in surpassing standard systems for disease diagnosis and aiding medical experts in the early detection of high-risk diseases. In this literature, the aim is to recognize trends across various types of supervised ML models in disease detection through the examination of performance metrics. The most prominently discussed supervised ML algorithms were Naive Bayes (NB), Decision Trees (DT), K-Nearest Neighbor (KNN). As per findings, Support Vector Machine (SVM) is the most adequate at detecting kidney diseases and Parkinson's disease. The Logistic Regression (LR) performed highly at the prediction of heart diseases. Finally, Random Forest (RF), and Convolutional Neural Networks (CNN) predicted in precision breast diseases and common diseases, respectively.

III. SYSTEM ARCHITECTURE

The system consists of two modules

1. Stability spoon and patient health monitoring module

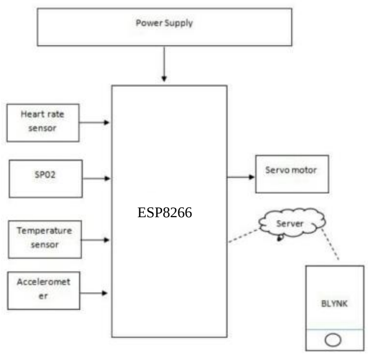

Fig.1 Stability spoon and patient health monitoring module

The prototype consists of heart beat sensor, SP02 sensor, temperature sensor that monitors the health stability of the individual. ESP8266 is a cost-effective and highly integrated Wi-Fi MCU. Pulse oximeter sensor (MAX30100) is used to measure the frequency of beats in a human heart and also the SPO2 or the oxygen levels in the human body. Temperature and humidity of the body is monitored using temperature sensor (DHT11) and the alert system (buzzer) is switched on when the temperature is high or when the help button is pressed. Accelerometer (ADXL345) is used to detect the tremors in the patients hand movement while having food by measuring the inertial acceleration. Two Servo motors (SG90) which are placed perpendicular to one another are used to stabilize the spoon according to the readings taken in by the sensors. The prototype is combined with mobile application called blynk which is an IOT platform for iOS or android that is used to control any micro- controller via the internet for remote monitoring of the patient's health. Blynk server is responsible for all the communication between smartphone and the hardware. If any abnormality is observed a notification is sent to the registered contact using the Blynk app.

2. It also contains a module for prediction of Parkinson disease.

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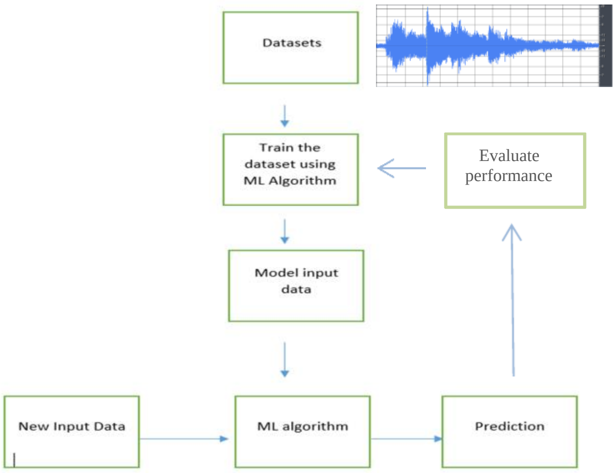

Fig.2 A general machine learning pipeline for prediction

1) Dataset used – We have considered a range of biomedical voice measurements from 31 people and 24 various voice measures are taken as attributes. The healthy people and those with PD are discriminated according to the "status" column which is set to 0 for healthy and 1 for PD patients.
2) Attribute Information: Matrix column entries (attributes):
name - ASCII subject name and recording number
MDVP:Fo(Hz) - Average vocal fundamental frequency
MDVP:Fhi(Hz) - Maximum vocal fundamental frequency
MDVP:Flo(Hz) - Minimum vocal fundamental frequency
MDVP:Jitter(%), MDVP:Jitter(Abs), MDVP:RAP, MDVP:PPQ, Jitter:DDP – Several measures of variation in fundamental frequency
MDVP:Shimmer,MDVP:Shimmer(dB),Shimmer:APQ3,Shimmer:APQ5,MDVP:APQ,Shimmer:DDA - Several measures of variation in amplitude
NHR,HNR - Two measures of ratio of noise to tonal components in the voice
Status - Health status of the subject (one) - Parkinson's, (zero) - healthy
RPDE,D2 - Two nonlinear dynamical complexity measures
DFA - Signal fractal scaling exponent
spread1,spread2,PPE - Three nonlinear measures of fundamental frequency variation

IV. METHODOLOGIES

1. Electronic connections

The accelerometer checks the orientation of the stability spoon in the X, Y and Z axis and the values are sent to the servomotor. The spoon is required to maintain a horizontal position, with respect to two axes. Two servo motors will be

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placed orthogonally to each other to establish a system of two degrees of freedom. With this setup in place, the spoon is intended to maintain its spoon bowl in a horizontal position.

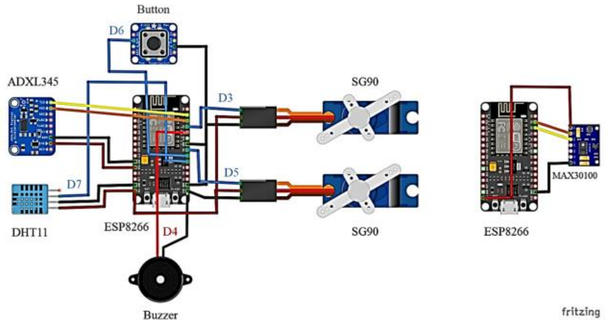

Fig.3 PCB Schematic circuit diagram

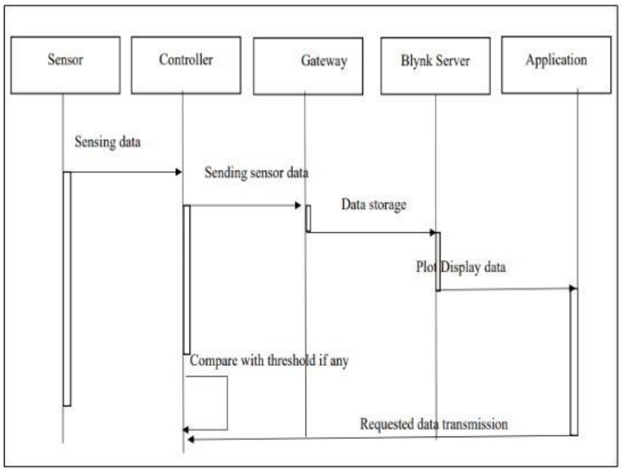

Fig.4 Sequence diagram

2. Data preprocessing – feature selection

The goal of feature selection techniques in machine learning is to find the best set of features that allows one to bui optimized models of studied phenomena. Correlation is measure of the linear relationship between 2 or more variabl Through correlation, we can predict one variable from the oth The logic behind using correlation for feature selection is t good variables correlate highly with the target. Furthermo variables should be correlated with the target but uncorrelat among themselves. Therefore, if two features are correlated, t model only needs one, as the second does not add additior information. We need to set an absolute value (correlati coefficient), say 0.8, as the threshold for selecting the variabl If we find that the predictor variables are correlated, we can dr the variable with a lower correlation coefficient value than the target variable.

```
{'MDVP:Shimmer(dB)', 'Shimmer:APQ3', 'MDVP:RAP', 'NHR', 'Jitter:DDP', 'MDVP:APQ',
A', 'PPE', 'Shimmer:APQ5'}
MDVP:Fo(Hz)
 MDVP:Fhi(Hz)
 MDVP:Flo(Hz)
 MDVP:Jitter(%)
 RPDE
 DFA
 spread1
 spread2
 D2
```

Fig. 4 The nine attributes selected after feature selection

3. Logistic regression

Logistic regression is one of the most popular Machine Learning algorithms, which comes under the Supervised Learning technique. It is used for predicting the categorical dependent variable using a given set of independent variables. Logistic regression predicts the output of a categorical dependent variable. Therefore the outcome must be a categorical or discrete value. It can be either Yes or No, 0 or 1, true or False, etc. but instead of giving the exact value as 0 and 1, it gives the probabilistic values which lie between 0 and 1.

In Logistic regression, instead of fitting a regression line, we fit an "S" shaped logistic function, which predicts two maximum values (0 or 1). The curve from the logistic function indicates the likelihood of something such as whether the cells are cancerous or not, a mouse is obese or not based on its weight, etc, here, whether the person has parkinson's or not. Logistic Regression can be used to classify the observations using different types of data and can easily determine the most effective variables used for the classification.

Steps:

- o 1. Data Pre-processing step
- o 2. Fitting Logistic Regression to the Training set
- o 3. Predicting the test result
- o 4. Test accuracy of the result(Creation of Confusion matrix)
- o 5. Visualizing the test set result.

4. K-Nearest Neighbor

K-Nearest Neighbor is one of the simplest Machine Learning algorithms based on Supervised Learning technique. KNN algorithm assumes the similarity between the new instance and available instance and put the new instance into the category that is most similar to the available categories. KNN algorithm stores all the available data and classifies a new data point usually based on the distance parameter. This means when new data appears then it can be easily classified into a well suited category by using K- NN algorithm. KNN algorithm can be used for Regression as well as for Classification but mostly it is used for the Classification problems. It is also called a lazy learner algorithm because it does not learn from the training set immediately instead it stores the dataset and at the time of classification, it performs an action on the dataset.

5. Steps: The K-NN working can be explained on the basis of the below algorithm:

6. 1. Select the number K of the neighbors

7. 2. Calculate the Euclidean distance of K number of neighbors

8. 3. Take the K nearest neighbors as per the calculated Euclidean distance.

9. 4. Among these k neighbors, count the number of the data points in each category.

10. 5. Assign the new data points to that category for which the number of the neighbors is maximum. Our model is ready.

5. Decision Tree

Decision Tree is a Supervised learning technique that can be used for both classification and Regression problems, but mostly it is preferred for solving Classification problems. It is a tree-structured classifier, where internal nodes represent the features of a dataset, branches represent the decision rules and each leaf node represents the outcome. In a Decision tree, there are two nodes, which are the Decision Node and Leaf Node**.** Decision nodes are used to make any decision and have multiple branches, whereas Leaf nodes are the output of those decisions and do not contain any further branches. The decisions or the test are performed on the basis of features of the given dataset. It is a graphical representation for getting all the possible solutions to a problem/decision based on given conditions**.** It is called a decision tree because, similar to a tree, it starts with the root

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node, which expands on further branches and constructs a tree-like structure.

Steps:

1. Begin the tree with the root node, says S, which contains the complete dataset.
2. Find the best attribute in the dataset using Attribute Selection Measure (ASM).
3. Divide the S into subsets that contains possible values for the best attributes.
4. Generate the decision tree node, which contains the best attribute.

V. PERFORMANCE EVALUATION

When the output can be divided into two or more categories, the easiest way for solving a classification problem is to use performance measures. An confusion matrix is a table that has two dimensions: real and predicted, as well as True Positives (TP), True Negatives (TN), False Positives (FP), and False Negatives (FN) on both dimensions.

A. Accuracy

For classification algorithms, it is the most commonly used performance statistic. The share of correctly classified data instances among all predictions made. Using the confusion matrix and the formula below, we can compute it.

$$Accuracy = \frac{TP + TN}{TP + FP + FN + TN}$$

To calculate the accuracy of our classification model, we can use the accuracy_score function in sklearn.metrics.

B. Precision

Precision in document retrievals may be defined as the fraction of relevant instances that are in the retrieved set. It determines the relevance of the results. We can simply quantify it using a confusion matrix using the following formula i.e. the ratio of true positives to the sum of true and false positives

$$Precision = \frac{TP}{TP + FP}$$

C. Recall

The fraction of relevant instances that were retrieved from the whole collection by our ML model is known as recall. With the aid of the following formula, we can easily measure it using a confusion matrix.

$$Recall = \frac{TP}{TP + FN}$$

VI. RESULTS

In this UI created using streamlit, we can select any one of the three models (Logistic regression, Decision tree, KNN classifier) to predict the output. We enter the parameters for the attributes derived after feature selection, and then on clicking submit the model is able to predict if the person is suffering from Parkinson's or not. Here, as the prediction is Parkinson's detected means the person is suffering from Parkinson's disease.

1. ML Prediction module

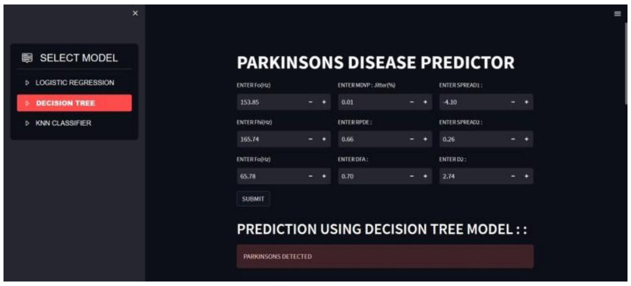

Fig.5 GUI Output for person with Parkinson

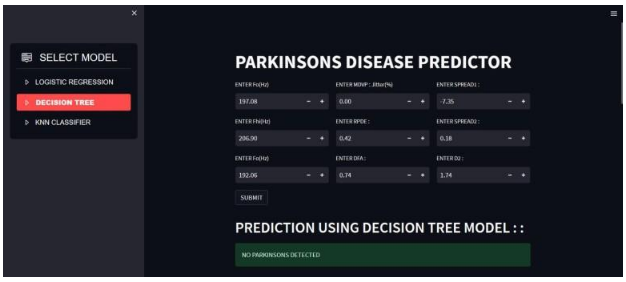

Fig.6 GUI Output for person without Parkinson

Fig.7 Performance parameters for prediction

Here, are the model parameters that are calculated for the prediction Parkinson's detected. The accuracy of this model is 92.0%, precision is 96.0% and recall i.e., the ratio of true positive to the sum of true positive and false negative is 93.0%. In the report, negative means the person is healthy and positive means the person is suffering from Parkinson's disease. F1 score is the weighted harmonic mean of precision and recall. Support is the number of actual occurrences of the class in the dataset. Macro avg is the arithmetic mean of all per-class F1 score. Weighted avg is the mean of all per-class F1 score while considering the class support.

We examine the experimental data acquired through the GUI to verify the efficacy of the suggested method. We used 3 different algorithms (Logistic regression, decision tree, KNN classifier). The quantitative measures (accuracy, precision, and recall) for these have been derived and are listed in a table.

TABLE I: The quantitative comparison of the proposed models obtained from the testing phase.

Algorithm	Accuracy	Precision
Logistic Regression	90%	90%
Decision Tree	92%	96%
KNN classifier	87%	88%

We can observe that decision tree has the highest accuracy (92%) and precision (96%).

2. **IOT Health monitoring module and stability spoon**

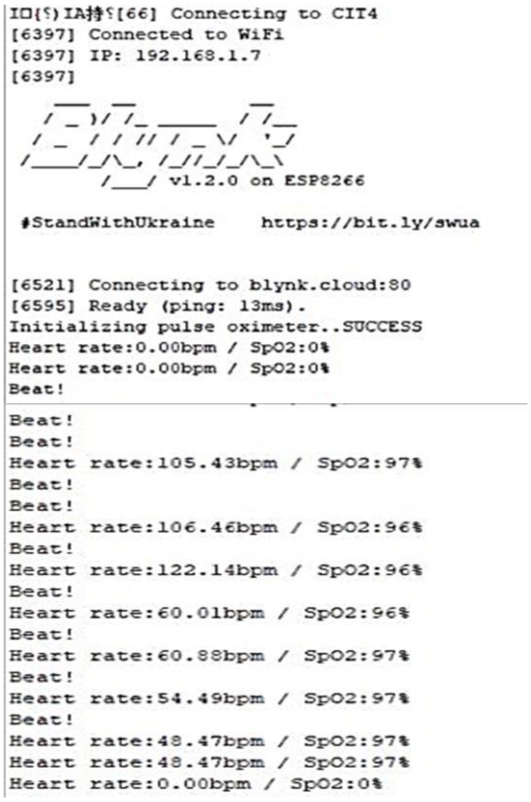

Fig. 8-9 Output of Heart Rate and SpO_2 in Serial Monitor at Port COM3 - zero values when the finger is not placed on the sensor, otherwise it shows the varying values of heart parameters.

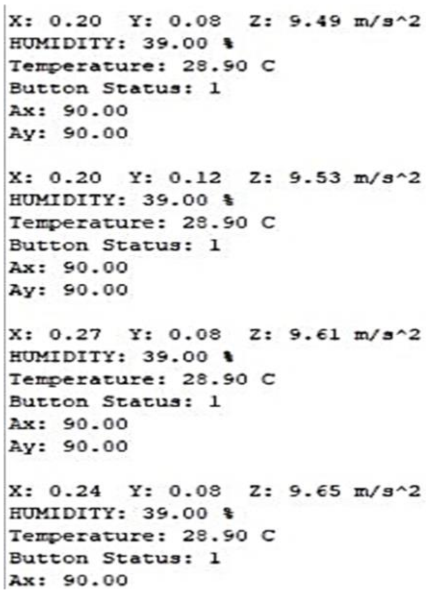

Fig.10-11 Output of the Health Parameters i.e. humidity, body temperature, Button Status determines whether the patient needs any help. If the button is not pressed, then the button status will be 1, otherwise 0 and Spoon Axis i.e. the X, Y & Z axis at Port COM3

The stabilizing spoon was built on a cardboard and on stimulating tremors, the device could calibrate against the tremors. Along with stabilization it can also sense the various health parameters and push it to the Blynk app. Emergency help can be indicated by pressing the help button.

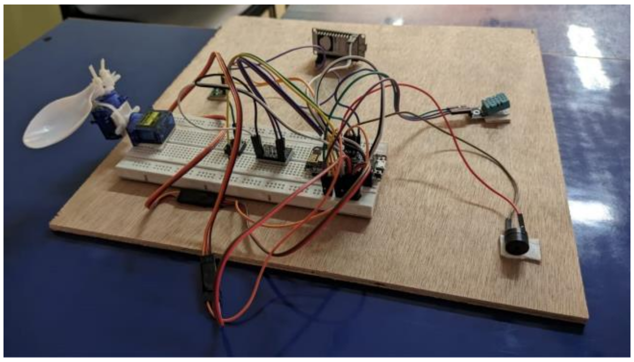

Fig.12 Stabilizing spoon – 2 ESP8266 MCU (middle on the breadboard), 2 servomotor (far left), DHT11 and buzzer (far right), Help Button (on the middle of the breadboard), MAX30100 (Behind the breadboard), ADXL345 (next to the help button).

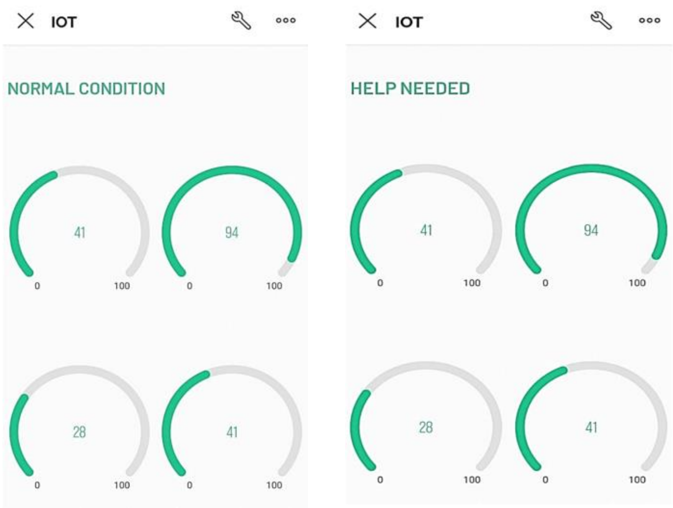

Fig. 12 Blynk Application Output: normal condition (left) help button pressed or abnormality in health parameters (right)

VII. CONCLUSIONS

Modern technologies have developed that promotes comfortable and better life which is disease/ health problem free. Our Project provides the low-cost solution to enhance the remote monitoring capability of existing health care system by using ESP32 and Wi-Fi modem. It uses Several sensors such as pulse rate body temperature and many more. The sensors are operated and vital information is transmitted to the microcontroller. By using this prototype circuit, the hardware's circuit the messages can be transmitted to mobile application used by the caretaker in case the value of any parameter falls below a predetermined value so that the corresponding medical expert can provide necessary medications to the patient.

VIII. FUTURE SCOPE

In the future, work can be done to integrate both the ML prediction module with the stability spoon and health monitoring system into a single combined system to improve the efficiency and usage of the system in the market.

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