International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-1, October, 2019

IOT based Patient Health Monitoring System using ML

Pramit Gupta, Arinjay Bisht

***Abstract:** The project focuses on the usage of sensing and analysis with the help of relevant sensor technologies in order to record the health conditions of people. The best way to understand this is with an example. A practising doctor who is not equipped with such technology can check the patients' health only when the patient pays a visit to the clinic. Now, with the application of the proposed technological measures, the doctor would have a complete record of the patient whether at home, office or on the road, and this would enable him to prescribe medication in a much more efficient and effective manner. Also, it is important to appreciate that on the basis of patient data recorded in the past, a prediction model could help the doctor see irregularities and predict if a patient suffers from commonly occurring ailments hence saving time in an initial diagnosis. This method for Healthcare Data Analytics using Support Vector Machine (SVM) Algorithm helps improve accuracy when it comes to checking for specific diseases or figuring out the right treatment. Furthermore, the doctor can give a more personalized view if he has access to a large chunk of the individual's health data along with assistance from the predictions based on modelled data. The cost of treatments can be reduced tremendously if no unnecessary tests are done. The project model first involves a tri-sensor system which takes the heartbeat, pulse-rate and oxygen saturation level of the patient. The values of all these three entities is displayed on the LCD Screen in the hardware model. The values of these sensor are able to be accessed from an Android App with the help of interfacing the App with the Hardware system using Arduino based coding. The LCD screen and Android App show the sensor data and the App data respectively which can be accessed by both the doctor and the patient's family at any point of time simply by downloading the App. The complete history of the patient's health is recorded in the IO server Adafruit. The MQTT protocol has been used for transferring information in sensor data from hardware to Adafruit and further publishing it from server to android app. MQTT uses a publish-subscribe methodology here with Adafruit as server while the hardware and Android App act as its two clients. The information is stored in Tabular form in Adafruit as well as in Graphical format. The graph form helps to see if any sudden discrepancies in values for sensor data occur and is used to warn.*

***Keyword:** Adafruit, ESP Wi-Fi, Android App, MQTT, SVM.*

Revised Manuscript Received on October 30, 2019.

* Correspondence Author

Pramit Gupta*, Pursuing Bachelors in Technology, Electronics and Communication Engineering ,Vellore Institute of Technology.

Arinjay Bisht, Pursuing Bachelors in Technology, Electronics and Communication Engineering ,Vellore Institute of Technology.

I. INTRODUCTION

A practicing doctor with no access to such technology can check the patients' health only when the patient pays a visit to the clinic. Now, with the help of this technology the doctor would have a complete record of the patient whether at home, office or on the road, this would enable him to prescribe any medication in a much more efficient and effective manner. Also, it is important to note that on the basis of past patient data, an analysis and prediction model could assist the doctor in observing irregularities and predict if a patient suffers from a commonly occurring ailment, hence saving valuable time in an initial diagnosis. The project focuses on the usage of the proposed technology to record the health conditions of people. This has been used in the past for Healthcare Data Analytics. This method helps improve accuracy when it comes to checking for specific diseases or figuring out the right treatment. It also allows for early detection of the underlying cause for a symptom. Furthermore, the doctor can give a more personalized view if he has access to a large chunk of the individual's health data along with assistance from the predictions based on modelled data. The cost of treatment will tremendously reduce as such a procedure would remove the necessity of blood and urine tests, or X-Rays. The lives of a lot of people are inconvenienced due to a delay in the prediction of any ailments they are suffering, not to mention the strain on the finances. There are cases where a wrong treatment is prescribed to the patient by the doctors due to lack of medical history and information. Also, in certain instances including the one mentioned above, people take unnecessary tests which are rather expensive and pose a financial burden on them and their family. The project has been taken up as an attempt to overcome this lack of patient medical history and records.

The Machine Learning algorithm proposed for the same can help construct a relation between the sensor data and disease analysis. The patient data can be compared with that of other patients and good analysis can be made using this information. Using available data, coupled with assistance from decision support systems that are conveniently provided access to a substantial corpus in the form of past medical records as observation data can prove very resourceful. This mechanism can enable the doctor to provide a better prognosis for the patient's health and guide him in recommending a suitable course of treatment. At the same time, it would help promote early intervention, and performance measuring indicators can be later customized to help recommend changes to the patient's life-style that would effectively improve his or her quality of life and health conditions as well. Such a radical yet effective technology could potentially impact a transformation on the functioning of healthcare systems worldwide and dramatically reduce operational costs and expenses associated with healthcare and ramp up diagnostic capabilities by improving speed and accuracy. Multiple recent designs [7] for sensors have been studied for proper tracking. This has been in the past used for healthcare analytics.

II. RELATED WORK

In [1], an IoT architecture specifically customized for applications related to healthcare has been presented. The architecture proposes to collect data and relay it to an online database with the help of cloud services where it can be easily processed and further analysis could be carried out effectively. Feedback actions on the basis of analysed data can be reverted back for the purpose of user review. A prototype of the same has been built in an effort to establish its reliability and demonstrate performance capabilities. In [2], the potential possibilities as a result of availability of data at scales and longitudinal measures which earlier were unimaginable have been explored, along with next generation intelligent processing algorithms which are capable of: (a) encouraging a development in acts involving use of medication, post facto medical analysis and administration of responsive treatment, to the deployment of a proactive system for visualization of ailments when they are in their nascent or preliminary stage, along with measures for prevention and cure, (b) empowering the personalization of treatment and advocation of treatment administration choices focused particularly on conditions specific to the needs of the concerned patient, and (c) helping in decreasing social insurance expenses, and at the same time achieving enhanced.

Despite all this, the primary issue of concern is to enable IOT to successively apply this vision to situations which are out of bounds for human services. Based on the existing strategies which have been deployed in the past, the first requirement is to attach the selected Pulse Sensor on a strategic location where it can detect the patient's pulse easily. The sensor will then accordingly measure the change in blood volume, at every instant the heart pumps blood in the body following an interval. This adjustment in volume of blood correspondingly leads to an adjustment in the Arduino readings over this change into the heart beat per minute (BPM). The LED connected will also blink to signal the occurrence of each Heart Beat. The ESP8266 will then communicate with the Arduino and will transmit the information to ThingSpeak. Following this the ESP8266 will interface the system with the switch for which a provision has been made in an effort to send the sensor information on the web. This transmitted data will be presented in a Graphical format showcasing the past readings along with the present ones and can be conveniently accessed over the internet. The heart beats per minute (BPM) is presented by the Liquid Cristal Display interfaced with the Arduino.

III. LITERATURE REVIEW

A. Hardware Requirements

Heartbeat Rate Monitor measures a man's pulse. LM35 Temperature Sensors measure the measure of warmth vitality or even coldness. SPO2: Oxygen Level. Atmega328P-PU. The High-performance Microchip 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory which is equipped with read-while-write capabilities. ESP 82661: Wi-Fi Module it can be associated with one pc utilizing Ethernet portLM1117 this is the power for the Wi-Fi module. LCD Display (LCD) is a level board show or an electronically regulated optical device that uses the light-balancing properties associated with fluid precious stones. Resistors have been used which are essentially uninvolved two-terminal electrical parts that execute electrical assurance as a circuit segment. The capacitors used are an idle two terminal electrical part that stores potential imperativeness in an electric field. The diode used is a two-terminal electronic section that practices current basically one way, i.e., it has low (ideally zero) insurance in one course, and high (ideally limitless) security in the other.

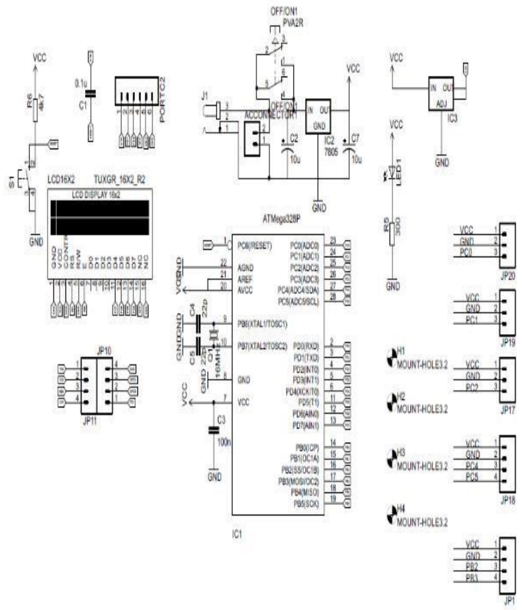


Fig 1 System Components

B. Software Requirements

The open-source Arduino Software (IDE) is used to implement the code for the functioning of the hardware sensors. MC Programming Language: is the coding language used for the embedded code. Android Studio: we have used android studio to build the app. Message Queue Telemetry Transport (MQTT) protocol has been used to send and receive changes the patient's health monitors.

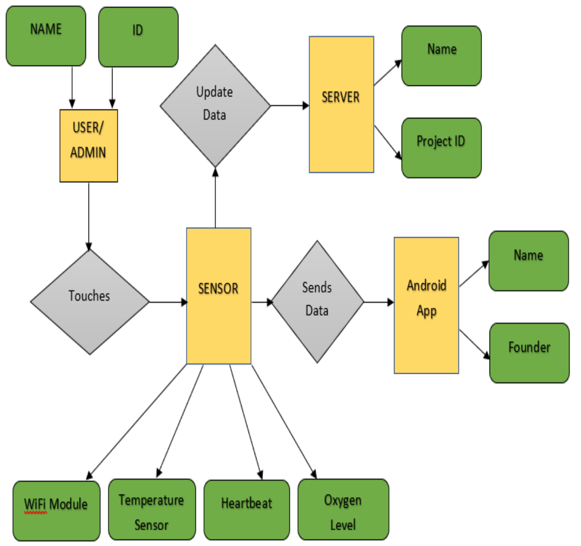


Fig.2 ER Diagram for the Project

C. Support Vector Machine

Support Vector Machine (SVM) takes the case of separation of patterns whose origin could take place while performing classification of patterns. The main idea behind the working of Support Vector Machine is the construction of a hyperplane as the decision surface in a manner that the margin of separation between positive and negative examples is maximized. This method is the preferred strategy for the analysis of data pertaining to the healthcare of the concerned patient, since it follows a principled approach which is firmly rooted in the theory of statistical learning involving the employment of a method to minimize structural risk. With the help of this, the support vector machine manages to achieve a good generalization performance when dealing with problems involving pattern classification, even though it does not incorporate any knowledge pertaining to the domain of the problem which it is dealing with.

Despite the outstanding performance of this algorithm and its powerful performance when dealing with data classification, it doesn't necessarily leave behind its few flaws. One major flaw that is of concern to us is that Support Vector Machine is unit sensitive and therefore we need to come up with a data pre-processing method in order to eliminate this flaw, and at the same time improve the generalization performance and precision of SVM. The main idea behind this scheme is to use decision trees to initially train the data, and then perform scaling it based on the outcome decision tree. Finally, the SVM gets adapted on this newly pre-processed data and is further trained and used for prediction.

D. MQTT

MQTT is a light weight protocol that deals with the approach called as publish and subscribe. It is dissimilar to the Hyper Text Transfer Protocol which deals with the request and response instrument. The Broker performs the role of the middleman of the client while the server performs regular checks and obediently transmit sustains and changes between the right client and servers. The subject for the message by any client like Android App in this task must be obviously indicated in the membership request. The clients need to fundamentally subscribe for the subjects they need reports on like change in sensor esteems in the case. The publish technique from the equipment to Adafruit server is utilized to show the changed esteems in server. The clients are not associated.

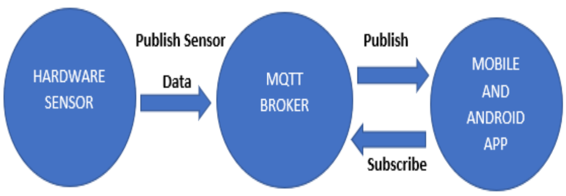


Fig.3 MQTT Broker

E. Android App

The Android App is basically written with the code so as to use MQTT and Adafruit. The Android App displays the real time sensor data and has an access subscription to the health monitor so as to receive the data. The **TOAST** has been used here so as to display the message "Connected to IOT server". Toast is a small information shown to the user for a short time duration. This is defined in MainActivity.java:

```
Toast.makeText(getApplicationContext(), "Connected to
   IOT Server", Toast.LENGTH_LONG).show();
```

To set the apps layout we use <Relative layout> in the Activity_main.xml code. 0 degrees, 66 BPM and 96% are the default values specified in this code. The intent-filter in Manifest.xml defines the activity page to start with.

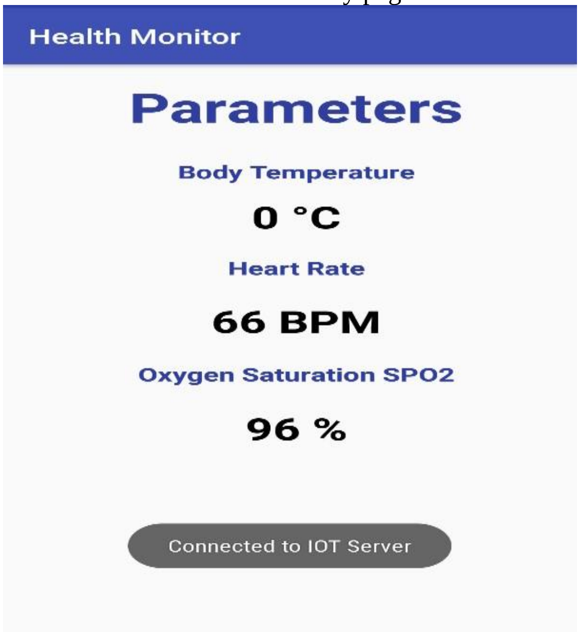


Fig.4 Android App

F. ADAFRUIT

Adafruit server provides space so as to store the data received on the sensor. The MQTT protocol has been used by us for data subscription and publication. The MQTT works in Client-Server code. MQTT provides us with a publish and subscribe mechanism. The publish mechanism is used by hardware sensors to send their data to Adafruit server for storage.

Retrieval Number: A2148109119/2019©BEIESP
DOI: 10.35940/ijeat.A2148.109119
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

The Android App subscribes to the Topic "Health Monitor" so as to receive any changes in the values. However, the data values for sensor received in Android App are real time values. MQTT is low level and not suitable for a high storage level. We create an Account in Adafruit and get our key in that account. For establishing connectivity, we need values like:

USER_ID "EM_Home_Wifi" SERVER "io.adafruit.com" USERNAME "wxyz" KEY "5e1604xxxxxxxxxxxxxxxxxxxxx"
PUBLICATIONPATH "wxyz/feeds/health-monitoring"
SUBSCRIPTIONPATH "wxyz/feeds/health-

MONITORING"

The android app code is modified and so is the Wi-Fi code in order to facilitate the development of this functionality. Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable. Activity_main.xml is used for creating the apps layout. MainActivity.java is used to connect to adafruit server and all data on this goes to the android app. The Manifest.xml file gives an idea of the file to be executed. We use toast to display connection to server in android app.

IV. METHODOLOGY

1. The Arduino board has the LED, LCD, Wi-Fi, Heartbeat sensor, temperature sensor, capacitors, switch attached to it. On connecting it to a power the board starts to work.
2. The LED light displays a characteristic color which means that the system is working. Then the LCD starts with values of room temperature and a random value for BPM.
3. On holding the heartbeat sensor and the temperature sensor in between our hands we get the value of the heartbeat and temperature of our own body. These values are then displayed on the LCD screen. Here we have configured the LCD to display the heartbeat, temperature and oxygen saturation level values.
4. The PCP is prepared using Eagle which is a Computer Aided Design Software. There is also a Wi-Fi module in place which is connected to the system.
5. This Wi-Fi module is used to send the details of the Temperature, Heartbeat and Oxygen level to an android app where the users, friends, family or the attending doctor are able to monitor it or detect any case of discrepancies.
6. The development of the code takes place in the Arduino Integrated Development Environment (IDE) and uploaded to all the sensors and also the Wi-Fi module. The system that we have currently built is used for getting the sensor values for the temperature and heartbeat for any person. The system has a Wi-Fi module connected to it. This module sends the data from LCD screen to the android app.
7. The Hardware has sensors for heartbeat detection and temperature detection. The hardware uses Wi-Fi ESP8266 for internet connection and transferring the sensor data to the server Adafruit. The MQTT protocol is a light weight protocol that the project uses for transferring the sensor data. MQTT has subscribe and publish methodologies. MQTT here has two clients: the hardware and android app. The android app code is modified for working of MQTT protocol and attaching to the server. For connection we need Adafruit login id, key, topic, server name, port.
8. The publish methodology is used for transferring the data from hardware sensor to server Adafruit where the values are stored. Android App uses the subscribe method. It subscribes for feeds of the topic "Health Monitor" and it gets the real time values for the person using the hardware sensor from the app. The app does not store values.
9. The code for the Wi-Fi module is configured so as to transmit the necessary data to the Adafruit server where it is stored and displayed in both tabular and graphical form. This data can then be conveniently and effortlessly viewed and analysed by the user for help with prognosis.

V. RESULTS

The values are displayed as real time values on the android app. They are the instantaneous values as can be observed in the figures which have been displayed for this very purpose.

Fig.5 Hardware

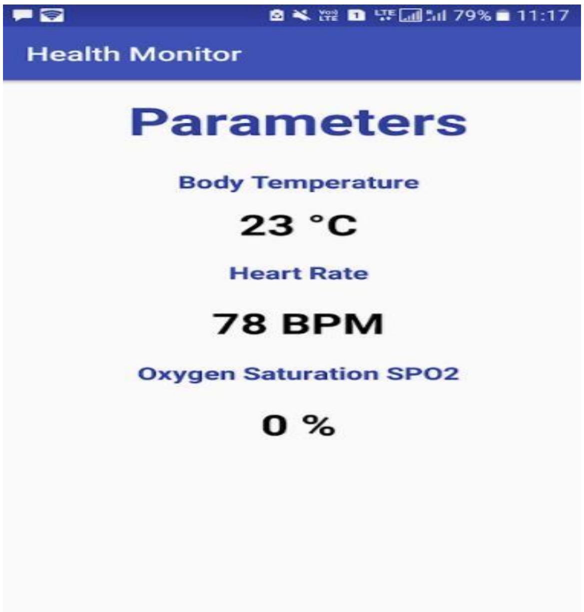


Fig.6 Android App

The results observed are first the display of the sensor data for heart rate, temperature and oxygen level on the LCD screen. The received values are then displayed on the android app. Post this the values are then stored in the Adafruit server.

International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-1, October, 2019

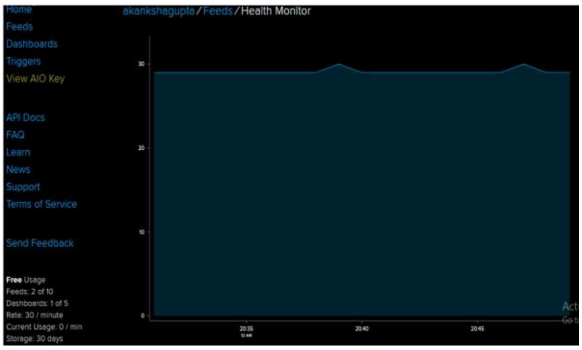


Fig.7 Graphical Representation of Patient Data on Server

The values are also displayed in a tabular form in the server and can be used for they also provide a graphical representation of the acquired information. The data can further be used for predictive analytics based on which feedback actions can be recommended for treating the patient's condition which essentially advocates the personalization of administration choices which are focused primarily on conditions specific to the needs of the concerned patient.

VALUE	CREATED		LOCATION
29,108,0,	4 minutes ago	2018-03-26 12:20:49 am	
29,108,0,	4 minutes ago	2018-03-26 12:20:48 am	
30,108,0,	4 minutes ago	2018-03-26 12:20:47 am	
29,108,0,	4 minutes ago	2018-03-26 12:20:46 am	
29,108,0,	4 minutes ago	2018-03-26 12:20:45 am	
29,108,0,	4 minutes ago	2018-03-26 12:20:43 am	
29,108,0,	4 minutes ago	2018-03-26 12:20:42 am	
29,108,0,	4 minutes ago	2018-03-26 12:20:41 am	
29,108,0,	4 minutes ago	2018-03-26 12:20:40 am	
30,108,0,	4 minutes ago	2018-03-26 12:20:39 am	
29,108,0,	4 minutes ago	2018-03-26 12:20:38 am	
29,108,0,	4 minutes ago	2018-03-26 12:20:37 am	

Fig.8 Complete sensor data values on Server

We can have 3 independent variables namely O2 Sat. Levels, Heartbeat and Temperature. The dependent variable that we can take into consideration and we can decide whether the patient is free to leave the hospital premises or needs further care. In [4], the health care analytics for chronic patients have been discussed. In [5], the discussion entails the monitoring of patients with heart disease which is something that can be accomplished with the help of this project. Other monitors like glucose level monitor can be added as seen in [6], to improve quality of the model. The system can be used to alert both doctor and the family of the patient instantly in case of any urgent issue. The system can be used for both descriptive analytics in terms of understanding current trends and also predict future case of illness when used for predictive analytics. This data analytics can also be used for detecting health fraud as seen in [8]. Health care analytics using SVM with IOT has a wide range of applications for daily processes and interactions as referred in [9].

SAMPLE USAGE OF THE SERVER STORED DATA

Taking reference from [3], we see that doctors also can prescribe well the medications for the patient by analyzing the patient data over a long period of time rather than an instantaneous analysis. This project can also be used to see if a patient is fit enough to be sent home, kept in the Intensive Care Unit (ICU) or scheduled to be paid a visit by the attending doctor in case of any mild fluctuations. The data can be used for predictive analytics. We can have three independent variables namely O2 Sat. Levels, Heartbeat and Temperature. The dependent variable that we can take into consideration and we can decide whether the patient is free to leave the hospital premises or needs further care. We can take R code and modify data such that for Blood Pressure:
High: >130, Medium: 90 to 130, Low: Less than 90

Oxygen Levels:

Excellent: >= 98, Good: >= 90 and < 98, Fair: >=

80 and < 90, Poor: < 80 Temperature:
High: > 37, mid: >= 36 and <= 37, low :< 36 Then the usage of SVM can be done for the prediction of the health status of a given patient.
The data can be first read: *data1<-read.csv("dataset.csv").*

	Ext.Body.Temp.in.C	Oxygen.Saturation	BP	Condition_A_Admit_I_ICU_S_Home
1	low	excellent	mid	S
2	high	excellent	high	I
3	low	excellent	high	S
4	low	good	high	S
5	mid	excellent	high	A
6	low	good	mid	S
7	low	excellent	high	S
8	mid	excellent	mid	A

Table.1 Sample Data Table Created

Then we split the testing and training data:
set.seed(100) Indices = sample.split(data1$X0.1.ill.or.not, SplitRatio = 0.7) Train = data1[indices,]

Test = data1[!(indices),] Then we can build the SVM Model:
model_1<- ksvm(X0.1.ill.or.not ~ ., data = train,scale = FALSE,C=1)

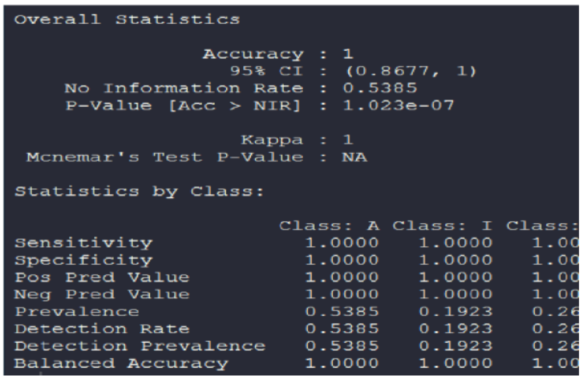
Result Prediction for test data based on Training Data:
evaluate_1<- predict (model_1, test) confusionMatrix (evaluate_1,X0.1.ill.or.not)

```
Confusion Matrix and Statistics

          Reference
Prediction  A  I  S
         A 14  0  0
         I  0  5  0
         S  0  0  7
```

Table.2 Confusion Matrix

The confusion matrix gives the degree of correct prediction using training data for the testing data here.
Here the cases mean:
S= Home, A= Consult Doctor and I= ICU Admit



```
Overall Statistics

               Accuracy : 1
                 95% CI : (0.8677, 1)
    No Information Rate : 0.5385
    P-Value [Acc > NIR] : 1.023e-07

                  Kappa : 1
 Mcnemar's Test P-Value : NA

Statistics by Class:

                     Class: A Class: I Class:
Sensitivity            1.0000   1.0000   1.00
Specificity            1.0000   1.0000   1.00
Pos Pred Value         1.0000   1.0000   1.00
Neg Pred Value         1.0000   1.0000   1.00
Prevalence             0.5385   0.1923   0.26
Detection Rate         0.5385   0.1923   0.26
Detection Prevalence   0.5385   0.1923   0.26
Balanced Accuracy      1.0000   1.0000   1.00
```

Fig.9 Complete statistics from Confusion Matrix

VI. CONCLUSION

The model has been built such that it takes the sensor values and prints the results on the LCD screen. These sensor data values are then displayed on the Android App as well. Then the values are transferred to the server and are displayed and stored there in both tabular and graphical format. The App can be used to keep a consistent check on the patients' health parameters. The app has been designed for instant values achieved. The server has information about the values over the period of time. It represents the information in a graphical form as well and hence any discrepancies can be easily detected and studied. The stored data here can be used for subsequent prediction and analysis of any underlying cause for symptoms or current health status. The project covers essentially meets it initial requirements and much can be potentially improved with the incorporation of more sensors, characteristic features pertaining to the patient's current health status and the corresponding data which will substantially improve the performance of the Machine Learning Algorithm based Disease Prediction Model.

REFERENCES

1. "IoT-Based Health Monitoring System for Active and Assisted Living", Ahmed Abdelgawad, Kumar Yelamarthi and Ahmed Khattab.
2. "Health Monitoring and Management Using Internet-ofThings (IoT) Sensing with Cloud-based Processing: Opportunities and Challenges", Moeen Hassanalieragh, Alex Page, Tolga Soyata, Gaurav Sharma, Mehmet Aktas, Gonzalo Mateos Burak Kantarci, Silvana Andreescu, IEEE international Conference on Services Computing.
3. Chirs Otto, Aleksandar Milenkovic, Corey Sanders, Emil Jovanov, "System architecture of a wireless body area sensor network for ubiquitous health monitoring" International Journal of Mobile Multimedia,Vol.01, PP.307-326,2006.
4. Darkins, A., Ryan, P., Kobb, R., Foster, L, Edmonson, E., Wakefield, B., & Lancaster, "The systematic implementation of health informatics, home Telehealth, and disease management to support the care of Veteran patients with chronic conditions" International Journal of Telemedicine J E-health,Vol.14,No.10, PP.1118-1126,2009.
5. Chaudhry, S.I., Mattera, J.A. Curtis, J.P., Spertus, J.A., Herrin, J., Lin, Z., Phillips, C.O., Hodshon, B.V., Coopers, L.S., and Krumholz, H.M. "Telemonitoring in patients with heart failure", International Journal of Mass Medicals,vol.363,PP. 2301-2309,2010.
6. Chase, H.P., Pearson,J.A., Wightman, C., Roberts, M.D., Oderberg, A.D., &Garg, "Modem transmission of glucose values reduces the costs and need for clinic visits", International Journal of Diabetes Care,vol. 26,No.5,PP.14751470,2010.
7. D. Son, J. Lee, S. Qiao, R. Ghaffari, J. Kim, J. E. Lee, C. Song, S. J. Kim, D. J. Lee, S. W. Jun, S. Yang, M. Park, J. Shin, K. Do, M. Lee, K. Kang, C. S. Hwang, N. Lu, T. Hyeon, and D.-H. Kim, "Multifunctional wearable devices for diagnosis and therapy of movement disorders," Nature Nanotechnology.
8. B. Rao, "The role of medical data analytics in reducing health fraud and improving clinical and financial outcomes," in Computer-Based Medical Systems (CBMS), 2013 IEEE 26th International Symposium on, June 2013.
9. N. Bui and M. Zorzi, "Health care applications: A solution based on the internet of things," in Proc. of the 4th Int. Symposium on Applied Sciences in Biomed. and Com. Tech., ser. ISABEL '11. New York, NY, USA: ACM, 2011.

AUTHORS PROFILE

Pramit Gupta is in his third year of undergraduate studies in Electronics and Communication Engineering. He is currently pursuing his Bachelors in Technology from Vellore Institute of Technology and is expected to graduate in Fall 2021. He has worked on a variety of projects in domains ranging from Medical Sensor Technologies to Image Recognition using Convolutional Neural Networks and has been an active participant in initiatives to study and research on latest trends and innovations in the field of Sensors and Instrumentation and Internet of Things. He has worked on Embedded Technologies while interning under American Axle Manufacturing. His research interests include Embedded Systems and Integrated Circuits.

Arinjay Bisht is involved with undergraduate studies in Electronics and Communication Engineering. He is currently in his penultimate year of study while pursuing his Bachelors in Technology from Vellore Institute of Technology and is expected to graduate in Fall 2021. He has represented VIT in technical competitions such as the prestigious Smart India Hackathon 2019, held in Punjab, India and the International CANSAT 2019 Competition, held in Texas USA. He has worked on a variety of projects in domains ranging from Active Noise Cancellation to RF Based Home Automation and has worked on Network Planning for Wireless Telecommunications while interning under Nokia Networks, India. His research interests include Optical and Wireless Communications and Networks, Signal Processing and Machine Learning.