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IoT based on secure personal healthcare using RFID technology and steganography

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ABSTRACT

Internet of things (IoT) makes it attainable for connecting different various smart objects together with the internet. The evolutionary medical model towards medicine can be boosted by IoT with involving sensors such as environmental sensors inside the internal environment of a small room with a specific purpose of monitoring of person's health with a kind of assistance which can be remotely controlled. RF identification (RFID) technology is smart enough to provide personal healthcare providing part of the IoT physical layer through low-cost sensors. Recently researchers have shown more IoT applications in the health service department using RFID technology which also increases real-time data collection. IoT platform which is used in the following research is Blynk and RFID technology for the user's better health analyses and security purposes by developing a two-level secured platform to store the acquired data in the database using RFID and Steganography. Steganography technique is used to make the user data more secure than ever. There were certain privacy concerns which are resolved using this technique. Smart healthcare medical box is designed using SolidWorks health measuring sensors that have been used in the prototype to analyze real-time data.

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1. INTRODUCTION

People's safety and critical health become a paramount concern whereas, an estimate of 421 million hospitalizations adverse each year. A lot of research has been studied and conducted related to the IoT using it to acquire data continuously and wirelessly which is distributed in the healthcare field. With the employment of IoT in the health sector, which is defined on mobile or computer, medical sensors, and researcher's communication technology for healthcare services [1-3]. Remote monitoring has become a strategic tool for social platforms over the last few years. Over the past few years, RFID has become emerged for automated and data collection identity. RFID technology is applied and manufactured by a lot of industries in terms of retail and logistics but it is not related to the medical instrument [4]. Emerging technology is related to the IoT and increment of a variety of cheap medical sensors such as wearable, environmental, and implanted, have the potential habitat of a person and the internet to manage and produce medical knowledge. In recent research goals of extraction of physical information about tags through electromagnetic signals received. RFID, therefore, provides efficient ways of interaction of a person with the surrounded environment with the last few meters of IoT concerning quantification [5]. RFID system having a battery-powered surrounding will be wearable smart IoT device supporting aid services with a network of the reader. The project focuses on the scenery of current RFID work from an IoT viewpoint. The project is launched to aim the IoT based system for personal healthcare using RFID technology. This research will cover passive devices having a UHF short range of (10-13.56 MHz) which are capable of providing enough read range to implement sensors for wellness and monitoring the local quality environment [6]. IoT is the most innovative resource in manufacturing, commercial, and residential structures every day, playing a critical role [7-12]. The use of IoT in monitoring and personal healthcare helps reduce human interaction in remote monitoring, processing, and review of RFID-powered data [13-16].

IoT based Personal healthcare RFID systems in Smart spaces have been developed being costly, In-home IoT based technology a suitable platform is still missing with user security concerns and implantation of RFID tags in the human body has also been a major issue raised by many people. According to the study in [17] found that average people questioned the idea of implanted chips. Security and safety of the user are still missing in smart health care systems using RFID which is a questionable problem till now.

There was much research that has been conducted contributing to the field of IoT technology to acquire data continuously which is processed timely and wirelessly in Personal healthcare, but the results are not satisfactory [18-20]. RFID systems can help identify patients but built systems efficacy and user's protection are still missing [21-22]. Systems that have been developing so far lack all health parameters in one system which is not convenient for the user’s experience [23-25]. The system with different sensors measuring heart rate, oxygen level, body temperature, humidity level, air quality, and sweat level of the body using GSR can be more effective and efficient for user experience and personal healthcare parameters. In general, most of the systems built based on RFID healthcare do not effectively cover the concerning parameters. RFID used in this project will act as a security shield for the user's safety in the health care system. Given all this, with all physical health parameters and data reliability, a wearable smart design or medical box would be more successful.

This research aims to design and develop IoT based Personal healthcare system using RFID technology for the user's better health analyses and security purposes by developing a two-level secured platform to store the acquired data in the database using RFID and Steganography. The current medical model towards medicine filed can be wisely boosted involving sensors such as environmental, wearable sensors. RFID smart health care system enables the remote assistance of the user's health and monitoring parameters. Making the environment smart enough through low-cost energy-autonomous and disposable sensors. For necessary evolution, IoT passed personal health care using RFID technology comes in handy. Sensors are used for air monitoring and to avoid the inhalation of anesthetic gases along with a check on other health parameters such as heart rate, oxygen level, body temperature, humidity level, air quality, and Co2. The model/design which will be used in this proposal consists of body network sensors attached to the microcontroller Arduino Mega2560 and Arduino Uno linked with Node MCU. The final testing will include IoT and the data will be displayed on a mobile android app. RFID adoption in healthcare will improve patient safety which includes monitoring, physical health, surrounding information, and body health level in all aspects.

This paper is organized as follows. In the following section, we discuss the issues of people's safety, critical health and IoT based Personal healthcare RFID systems. In section 2, we describe the overall block diagram and design consideration. In section 3, we explain the results occupied from the data analysis using smart healthcare medical box. Then, we evaluate the system performance in section 4 and give a conclusion in section 5.

2. PROPOSED DESIGN METHOD

2.1. Overall block diagram

The key sections of the framework as proposed are shown in Figure 1 where a type of block is connected with arrows indicating the relationships between the blocks and the contact with data stream directions. Stage 1 of the block diagram is the main controller of the system which is Arduino mega 2560. There are multiple sensors connected with the microcontroller which are taking input data from the hand as shown in stage 2 of the block diagram. For the two-step, security feature the keypad is connected with the Arduino mega which requires an input password to access the system.

Stage 3 is the IoT platform using Blynk software where all the necessary data is displayed as shown in the block diagram. NodeMCU is connected with Arduino mega using Rx pin which transmits data from Arduino once the passcode is correct and displays it on the IoT platform using Wi-Fi connection. An RFID reader is connected to NodeMCU which is operated manually and also used for two-step security features in the project. To access the data on the IoT platform, the user has to place their RFID card on the reader. If the card ID is correct, data will be transmitted or otherwise, the system will display access denied text. For security purposes, the user is required to enter a security passcode to assess. The system and get full access to all the functions within the system in such a way that each user, that is, the RFID cardholder has their password.

Stage 4 consists of an IoT database where the passcode and user ID are stored in arrays along with RFID tag ID and user data received from the sensors. The data is stored in a tabular fashion to analyze user previous data and recent data and check whether the patient needs immediate medical assistance or not. If the data falls below the threshold value, then the authorities and family members are informed using SMS technology making the system automated and completely closed.

Stage 5 shows the LCD system installed on the smart healthcare medical box for quick assistance of the user from which they can get to know their healthcare parameters and can easily access healthcare data in their surroundings e.g. (temperature, humidity, and air quality (Co2)). Each block diagram is divided into step by step procedures which best describes the best possible ways to implement the idea practically.

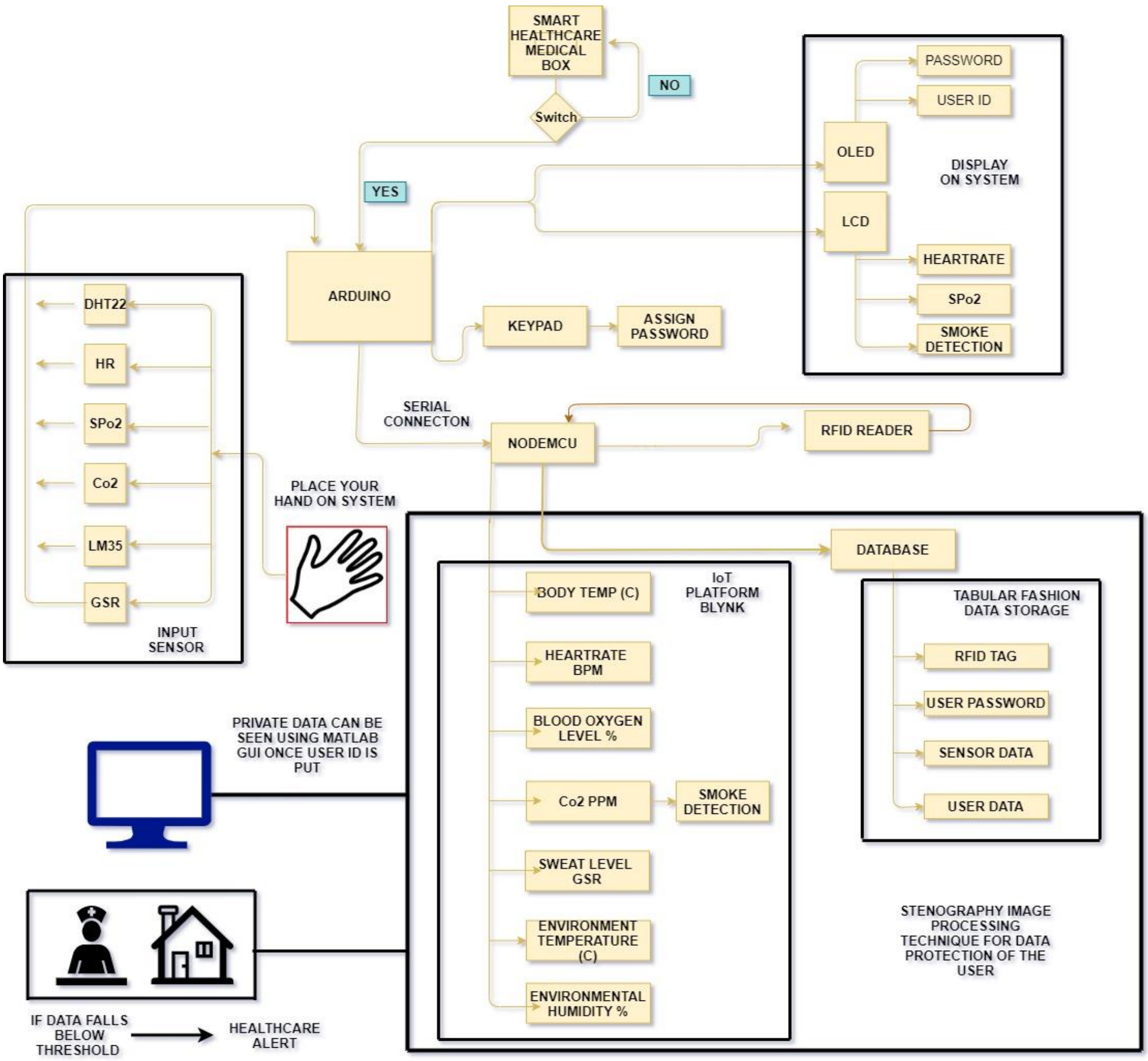

Figure 1. Overall main block diagram of a complete system

2.2. Working principle

Turn on the system by using an N.O switch as shown above in Figure 2. Once the system gets turned on, all the components attached to that system are powered on such as Arduino Mega, NodeMCU which are used for data acquisition and transmission. The sensing circuitry consists of a heart rate sensor, GSR sensor, air quality sensor, smoke detection sensor, body temperature sensor, and digital humidity and temperature sensor which are being connected to the main microcontroller, Arduino Mega. The display unit of the system consists of one OLED and one LCD screen for displaying the patient relative data. Arduino Mega, that is, the brain of the smart healthcare system is utilized within the implemented system to acquire data from all sensors excluding the RFID reader that is connected to the Nodemcu.

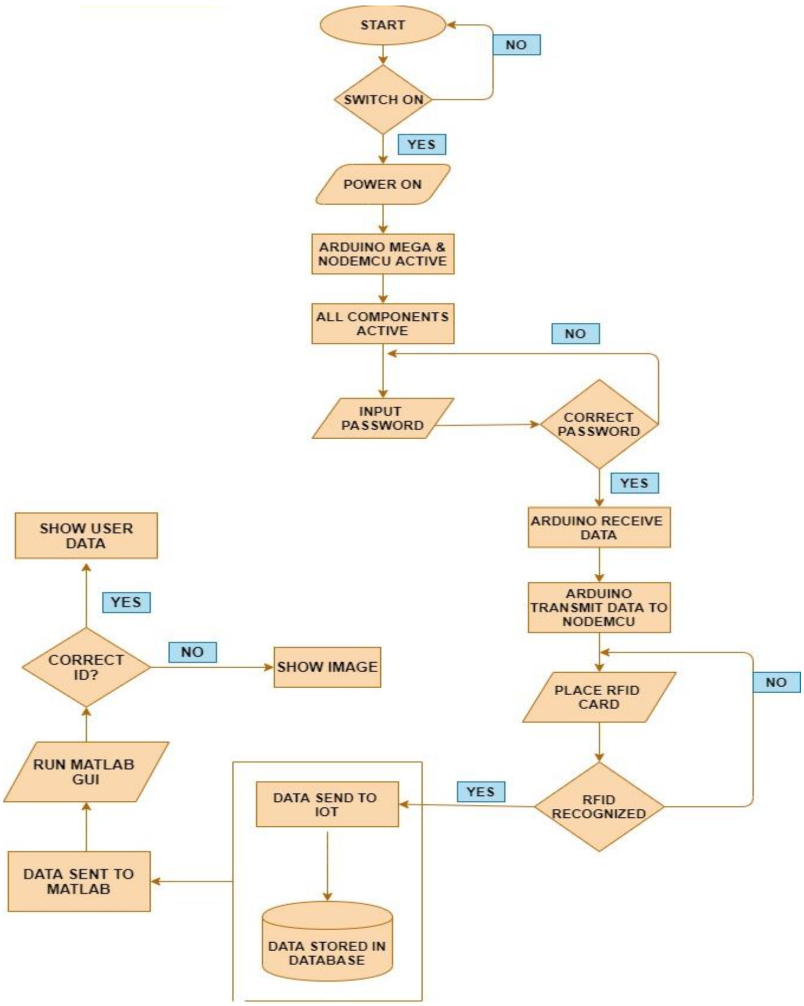

Figure 2. Complete flowchart of the system

The main reason behind connecting the RFID reader to the Nodemcu instead of connecting it to the main Microcontroller is that the Arduino Mega SCL and SDL pins are occupied by the display unit represented by the OLED and LCD screens. In terms of user security, the developed medical healthcare system incorporates a reliable security system for securing patent data. For security purposes, the user is required to enter a security code to access the system and get full access to all the functions within the system in such a way that each user is provided with a personal RFID card and passcode. Once the RFID is placed and the corresponding password is entered, the system will send the data to the IoT cloud using the data received by the NODEMCU from the Arduino Mega. To get easy access to the data, the user is required to place their hand on the machine and place their RFID card on to the system. Once the system recognizes the user card, data will be shown on the IoT platform. The transmitted data will be sent to a DATABASE so that each user data can be stored safely which can be later reviewed for better medical health analysis. This database file is called out in the MATLAB program. Run the MATLAB program and GUI will appear. Click on the user button to enter. Each user is asked to put in their passcode assigned personally to them only. Once the user enters the password, on the left side an image will appear, and on the right-side data will be appeared which has been stored in the database. The image on right can only be seen by others and the data can be seen by the user himself only. This technique is call steganography which is used to keep the user data secure.

3. SOFTWARE RESULTS (GUI)

Figure 3 shows the results occupied from the data analysis using smart healthcare medical box. The galvanic skin response is measured using GSR sensors on the fingers and the working principle of it is very simple. As the user moves his fingers, there is sweat on the fingers from which the sensor detects the emotional change of the user. For example, as seen in Figure 4, there is a galvanic skin response graph with two-line indicating the normal emotion was the user and the change in emotion by just moving his finger. Redline shows the normal emotion and the white line shows a change in emotion as the user moves his fingers. If the sweating threshold moves above the pre-defined value which is 60 then the white line starts to move above of red line for a specified time as shown in the graph. The live graph which is used to display the emotional change of the user has the ability to shown live data for up to 3 months. The smoke detection alarm is used for two different conditions, such as the "Normal" condition and "Alert" condition. As the threshold passes 102 then the smoke detection sensors (MQ-135) sends the data to the app as “Alert” and the value is showed to see how much smoke is present in that particular area. Max 30102 sensor is used to measure heart rate and Spo2 level of the body. The body temperature is sensed by the LM 35 sensor module which shows an accurate body temperature which is 36. Air quality, which is shown in Figure 5, the GUI is CO2 gas present in the air which is also measured by MQ 135 air quality sensor. User is required to place their hands on the device. Place RFID card on the reader to send the data on IoT platform and the data is stored locally on txt. file. Run MATLAB and call text. file there in the code and run. The text. file in which the data is being stored is called out in the steganography program where the whole data is being hidden in a random image.

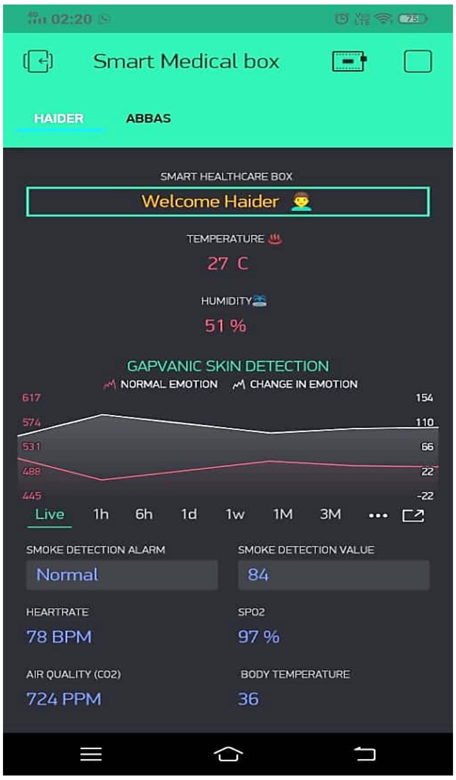

Figure 3. Software results

Run MATLAB code and a GUI will be displayed. Select user login and out in the unique password for each user to view the data. Data can be only viewed by the user who has entered the unique password and others will only see an image where the text is being stored and hence data is not visible to the unknown. Users can compare the data with the IoT platform which is Blynk in this case where data is transmitted using NodeMCU. Following are the steps that how the steganography technique is applied to keep the data secure and private for the users and family members so that their data is not in the wrong hands. This technique is very useful in the healthcare field as many of the users had a concern that their data is being stolen and used against them but now that will not be so easy again.

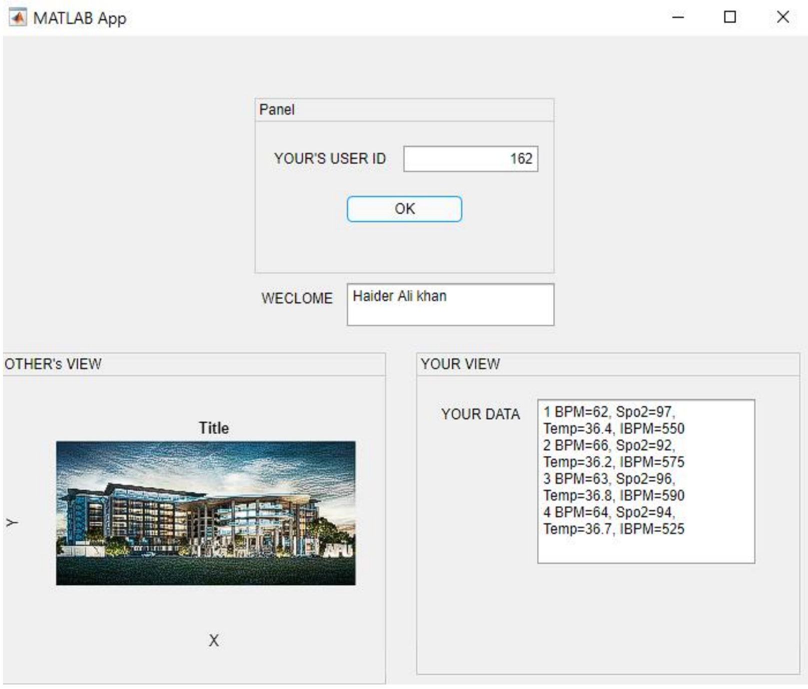

Figure 4. MATLAB GUI (steganography)

4. TESTING OF THE PROPOSED DESIGN

4.1. Air quality and smoke detection

The sensor output was connected to Arduino mega. Sensor MQ 135 was used to measure Co2 in the surroundings for patients' better health analysis and monitor breathing conditions. The gases were also identified by assigning the threshold using the same sensor. The voltage output of the sensor was connected to 5v of Arduino mega and the Gnd was connected with the ground of Arduino mega using wires. The software used to program the sensor was Arduino IDE and the programming language used for conduction the data was C+. The data was analyzed using the serial monitor in the Arduino software by Serial. print function. Co2 is shown in PPM and smoke detection is shown in percentage with a threshold of 102 which means once the percentage crosses the threshold of 102 the Alert sign will be indicated on a mobile app using Blynk. The average of samples is not taken for this experiment as Co2 in the air is not constant and changes rapidly. There were in total of 10 samples taken for the following experiment.

In normal conditions, the Co2 present in the air is around 450-550 PPM and smoke present in room condition is about 60-80 percent. Once the sensor was exposed to the smoke of cigarette the smoke threshold crossed 120 and gave an alert on the mobile app and the value of Co2 was shoot to 755 PPM indicating the danger in the user's surroundings. The C02 detection test is shown in Figure 5. The data were also analyzed in the Arduino graph plotter where the data can be seen in form of a graph and the amount of change happening at a particular time which is shown in Figure 6 which is smoke detection. Air quality rises from the normal threshold which is about 450-580 PPM once the smoke is detected by the sensor. The more smoke is present in the air determines the more PPM which can be dangerous for the user in terms of personal healthcare.

4.2. Latency test

NodeMCU is connected with Arduino mega and transmits data once it is connected with Wi-Fi. Latency test helps to determine how much latency is there in the system which is a system delay while processing the data. As a result, it can be predicted whether the device will meet the criteria of low latency and hence take steps to minimize it before losing vital data. Figure 7 shows the latency test of the hardware and the expected time data is from 0 seconds to 1 second. Values of both real-time data are not constant whereas, expected data is constant along with average data, and hence it can be analyzed that there is a delay in the system of 1.18 s. Figure 8 shows the latency test of the software and its results. The range of software is from 0 seconds to 1.4 seconds which is also real-time data and the expected time data is from 0 seconds to 0.8 seconds. Values of both real-time data are not constant and expected data is constant along with average data and hence it can be analyzed that there is a delay in the system of about 1.7 s.

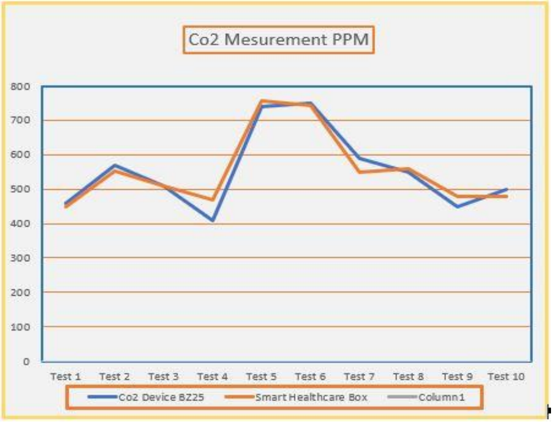

Figure 5. Co2 Graphical testing

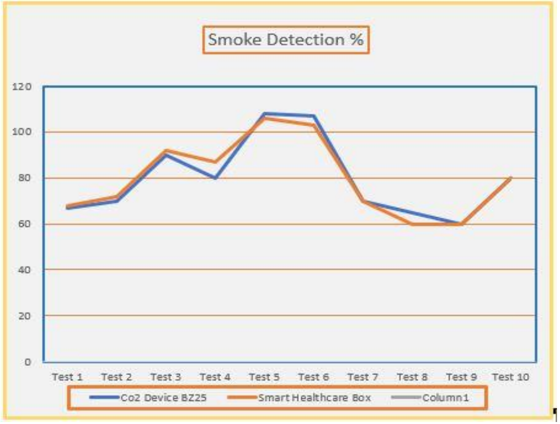

Figure 6. Smoke detection graphical testing

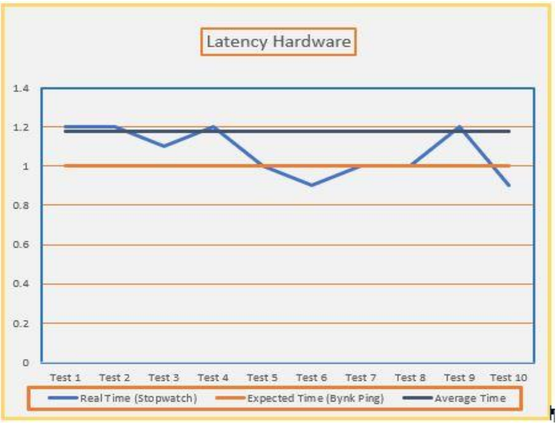

Figure 7. Latency test hardware

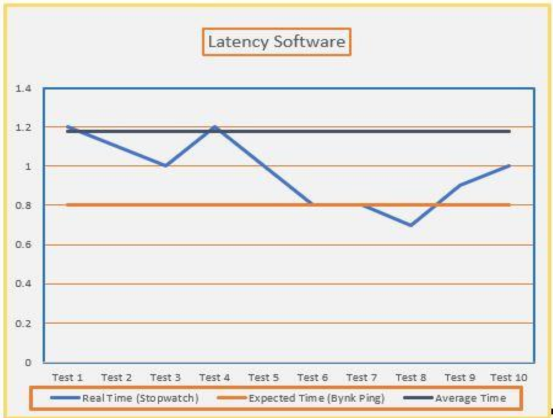

Figure 8. Latency test software

4.3. Heartrate testing

This section well illustrates the use of the max 30102 sensor for measurement of heart rate and Spo2 level in the body. The sensor is used for measuring the heart rate and Spo2 level of the user. The sensor was programmed using Arduino software and C+ programming language. The microcontroller used to program the sensor was NodeMCU and data was analyzed and send to the Blynk app using Wi-Fi. There was serval testing done for measuring the accuracy and precision of the sensors used in the smart healthcare medical box and it was compared by Samsung S10 mobile phone which is much more accurate. The values of the obtained heart rate are shown in Figure 9. The average value of heartrate measured from Samsung s10 was taken as the values shown by the device are not precise and accurate enough as per their information on the Samsung website. The average value which was calculated was 83.5 BPM and the average value of smart healthcare box was 98 BPM at the same interval giving an error of 15.5%. Data measured by smart medical box is not accurate as the sensor used to measure the data was not industrially manufactured and it can be improved. SPo2 is blood oxygen level measured by two different devices having 12 sample data each as shown in Figure 10. Sample data were fluctuating for both of the devices because with average was calculated and the final sample data was analyzed in the IoT platform. The average data of Samsung s10 was accurate enough rather than that of smart healthcare medical box because the sensor used in getting the data was not industrial accurate enough.

4.4. Interbeat analysis

The pulse sensor which is used to measure heart rate is maxed 30102 and the user can get the data only by placing one finger on the sensor. From the pulse sensor, interbeat time can be calculated which is the time required for one heartbeat. The test is done for various patients with a change in activities. Interbeat time is calculated for two activities one is when the patient is at rest and the other one is when the patient is exercising. The data which was collected is for 5 different people to know the accuracy of the tests and the error difference between interbeat actual time and detected time. The data is shown in tabulated form in Tables 1 and 2. Interbeat is measured in milliseconds.

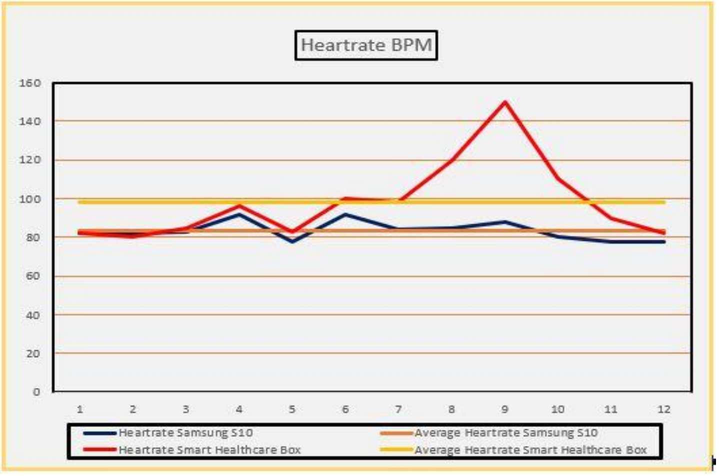

Figure 9. Heartrate testing plotter

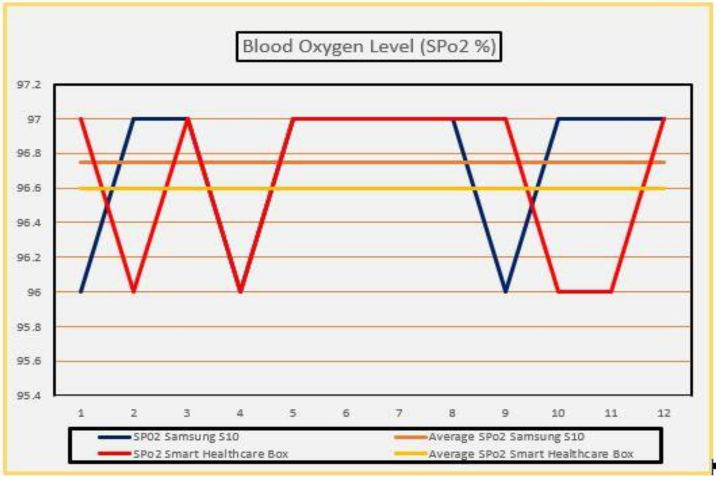

Figure 10. Spo2 testing plotter

Table 1. Interbeat time at rest

No of People	Interbeat Time Actual (ms)	Interbeat Time Detected (ms)	Error Difference	Accuracy %
1	731.7	731.7	0.00	100
2	731.7	750	-18.3	97.4
3	652.1	625	27.1	95.8
4	833.3	882.35	49.05	94.1
5	769.2	750	19.2	97.5

Table 2. Interbeat time at rest

No of People	Interbeat Time Actual (ms)	Interbeat Time Detected (ms)	Error Difference	Accuracy %
1	468.7	483.8	-15.1	98.9
2	444.4	428.5	15.9	96.4
3	394.7	379.7	15	96.1
4	454.5	468.7	-14.2	96.8
5	434.7	491.8	-57.1	86.86

4.5. GUI & GSR testing

The galvanic skin response is calculated by GSR finger sensors and is very easy to use. As the user moves his finger, the sensor detects emotional change for the user by sweating his finger. The line displays natural emotion and the white line indicates emotional change when the user's fingers pass. The white line travels above a red line for a specified time, as seen in the graph, when it is above a given value of 60. The Arduino-Software was used to program the NodeMCU ESP8266 microcontroller with the Arduino super RFID reader that handles all sensors and displays. The heart rate is determined by max 30102 and Spo2 is also calculated by the same oxygen level of the blood of the body. The sensor module of LM 35 sensors is used to sensor the body temperature, which is precisely 36. Air quality which is shown in the GUI is CO2 gas present in the air which is also measured by MQ 135 air quality sensor. The line displays natural emotion and the white line indicates emotional change when the user's fingers pass. Figure 11 shows the testing of the complete GUI. The white line stays above the red line for the defined time, as seen in the graph if the sweat level moved above the value 60. There was a total so 10 samples taken while doing the final testing of the prototype and these testing were taken as an average of the complete system.

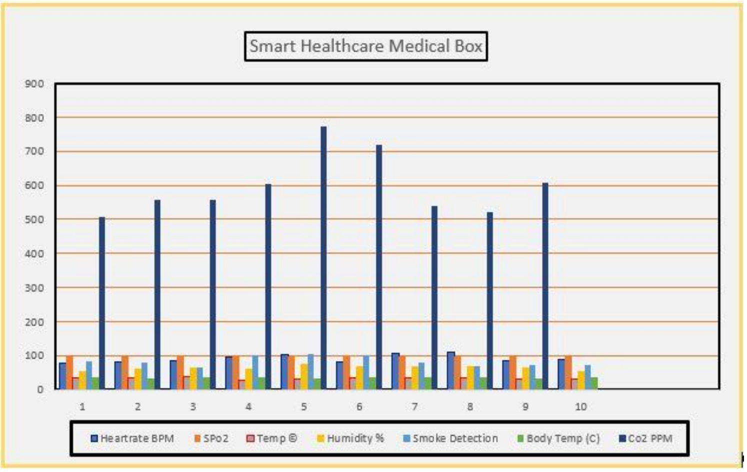

Figure 11. Testing of complete GUI

5. CONCLUSION

This research aims to design and develop IoT based secure personal healthcare system using RFID technology and steganography for user's better health analyses and security purposes. The proposed design has been programmed successfully on Wi-Fi-based Arduino Mega integrated with MATLAB using two different GUI. One GUI is used for the IoT platform which is Blynk and the data is smartly transmitted there. Another GUI is for securing data behind an image using Steganography Technique. 1st GUI was built on Blynk and 2nd GUI was built on MATLAB app designer. The consumer had a separate database with RFID technology to make health assessments safer and more reliable and open only to doctors and consumer relatives. objectives were achieved by the integration of sensors using Arduino mega and the implementation of two-step security. The RFID was used in such a way that the user is only capable of getting the data once they have placed their card on the reader where the data is stored in a database and IoT.

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