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Development of Electric Wheelchair for Smart Navigation and Health Monitoring System

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ABSTRACT
This paper presents framework of smart wheelchair for differently abled people by incorporating many facilities in a single wheelchair at low cost. A prototype of smart electronic wheelchair is developed to help the individual move freely without any external assistance. The wheelchair can also be converted into a stretcher. The system will monitor the vital health parameters such as pulse rate, heart rate, temperature and ECG of the disabled person and the information is stored in cloud (Thing Speak). An alert SMS will be sent to the care taker in the abnormal health conditions. The proposed system is developed using raspberry pi single chip-computer, it is implemented using Python serial data communication, PWM and android application

Keywords: *Smart Wheelchair, Serial Communication, IoT, Health Monitoring.*

1. INTRODUCTION

In the world many people are suffering from physical disabilities and other types of disabilities. According to the World Health Organization an estimated that 1% of the world's population that is 75 million people are using wheelchair due to various disabilities. The disabilities can be classified into various types which are referred as mobility impairment. The disabilities may be orthopaedic which is related to bones and muscles or neuromuscular which is related to nerves and muscles. Some of the common types of diseases are amputation, paralysis, muscular dystrophy and spinal cord injury. These people have difficulty in moving from one place to another. So a wheelchair was developed to help these people in moving from one place to another. The wheelchair which was developed was moved by the care taker or it was manually operated by the person in the wheelchair which was stress full to the person. The dependency on others makes them helpless and depressed. Therefore electronic wheel chairs was developed.[1] The initial approach of electronic wheelchair was published by George Westinghouse in 1914 which was the first electric powered wheelchair.[2] The commercial production of this chair started in 1956.[3] From the development of electric wheelchair many researchers proposed different systems or methods to control them.[4] The most common method used to control the wheelchair was by joystick.[5] The other methods were voice controlled wheelchair where predefined word would help to control the wheelchair[6]. Another alternative is to control the wheelchair through eye movement which was proposed by Duhlari Sahu where Haar algorithm was used to recognize the face and eye and location of eye ball is detected by IR reflection.

Quadriplegics are those who can't handle extremities. There are several reasons are there for movement disabilities such as high BP, Stroke, Joints and bones degenerative diseases, arthritis, birth defects and paralysis. Due to accidents also this quadriplegia occurs. These disabilities cause inability to do the daily activities by themselves. Such people need to use medical devices based on the severity of the disability different types of medical device are available in the market [7].

Wheelchair is considered as medical devices [8]. Since patient with impairment in mobility are prescribed to use the wheelchair for assisting in their movements independently. They design a user-friendly Android based mobile application software. Android based

software is designed for easy access. This android application uses GPS to locate the destination to be travelled. Dedicated buttons are provided namely "CONNECT" and "DISCONNECT". For the navigation of wheelchair four buttons are provided with arrow keys to move forward, backward, right and left. Map is also provided to view the path. Obstacle avoidance can be done by using ultrasonic sensors. Arduino microcontroller is used to develop the wheelchair [9, 10].

Mobile robotics play a vital role in several robotic industries. The mobility of the robots helps to solve lot of challenges. These autonomous robots can be controlled remotely from any place. Microcontrollers will be used to control the robot. The controlling commands will be given in the program loaded into microcontroller. Mobile robots become very popular in both industrial and commercial applications [11].

The most important and commonly used mobility assistant are wheelchair and stretchers. Shifting patient from Wheelchair to stretcher or to medical bed or vice versa is difficult for caretakers and nurse. Today many types of wheelchair have been developing based on their requirement. So we have designed the wheelchair convertible stretcher according to the need of patient desire or caretakers, which will be the contribution to medical field. In this paper a smart navigation electronic wheelchair is developed with health monitoring System. Here Raspberry Pi 3 Model B and Arduino UNO is used to control the wheelchair and health monitoring respectively. For the movement of wheelchair from one position to another an android application called Bluedot app is used. The communication is done via Bluetooth. Live Streaming and health monitoring is also done. In health monitoring vital parameters like pulse rate, heart rate and ECG of the individual is monitored and uploaded to cloud (Thing Speak) for future use. The aim is to incorporate many facilities in single wheelchair [12-15].

The normal wheelchair needs external aid or the user has to move with their hands which had to stress on the user at the time of travelling to avoid this wheelchair is designed using technology and human intelligence. The aim of this research is to automatically move the wheelchair with the aid of solar panel and android application and obstacle detection. The wheelchair uses the solar panels that collects required energy from sun and charges the battery which intern helps in the movement of the motors. The wheelchair is controlled using android application. Bluetooth module is used as controller to command over the movement. Ultrasonic sensors are used to sense the hurdles in the path [16].

A person who have locomotive disability need a wheelchair that work according to their desire to move all around, she/he need to push the wheelchair manually using hand which need some muscular energy but many people have weak upper limbs. The individual who suffers from mobility impairments is one of the rising problem, the independent mobility of human is one of the crucial issue across the globe. Around 8 million people who are born with disabilities or become disabled due to accidents. We don't have proper education on how to deal with disabled and this the case even in hospitals hence wheelchair plays a major role in individual who have mobility impairments. We don't have any education on how to deal with the needs of the disabled. This, unfortunately, is the case even in hospitals. Even in workplaces, the situation is not any better. Hence, wheelchairs are one of the important devices in the contemporary world since it plays a vital role in determining the quality of life for individuals with mobility impairments such as wheelchair users. The system will interrupt the commands and controls the wheelchair accordingly via Android application. This project elaborates the design and construction of smart electronic wheelchair with the help of Bluetooth module. The detection of any obstacles is successfully controlled by the microcontroller [17].

Wheelchair with stretcher is developed so that it should useful in both hospital as well as home. Cost of wheelchair cum stretcher is less and it is easy for the patient to handle. Patient health status is watched and parameters were monitored by doctors or caretakers through medical server which help in accurate and effective way of diagnosis. Patient status or data were collected through the IOT which help to know the status of patient [18, 19].

The rest of paper is organized as follows. Section II describes the methodology. Section II describes the implementation. Experimental results are shown in section IV. Finally, in section V the conclusion of our work will be discussed.

2. PROPOSED SYSTEM

The proposed system contains a Raspberry Pi that has its own Operating system, thereby reducing the circuitry on the person's body. Bluetooth application controlled robot is used for the effective movement of wheelchair in any directions. Various sensor modules are used for acquiring the data like heart pulse rate, body temperature.

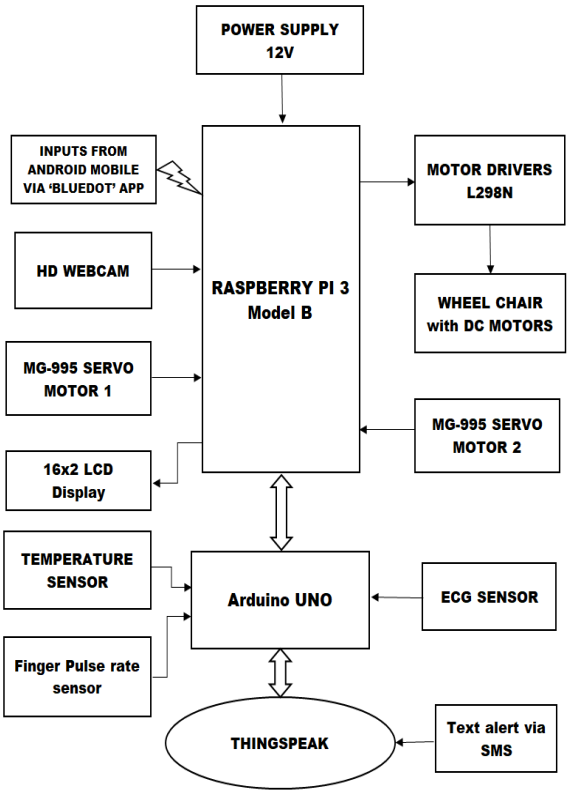

Figure 1 Block diagram of the proposed system

The block diagram of the proposed system is shown in the above figure, which consists of all blocks which are used for the implementation of smart wheelchair.

The proposed system contains a Raspberry Pi that has its own Operating system, thereby reducing the circuitry on the person's body. We have used two microcontrollers, Raspberry Pi and Arduino UNO. The main control in the proposed wheelchair system resides with a low cost minicomputer. Raspberry Pi was selected due to its low price, interaction with other electronic devices, and flexibility and performance in numerical computation. Raspberry PI is a single board computer is used for main operations like, wheelchair movement, conversion of wheelchair into stretcher and live streaming.

An android application called 'Blue Dot' is used for controlling the wheelchair, Bluedot is python library and also used as joystick. The Forward, backward, left and right movements of the wheelchair are accomplished through the use of four DC motors with speed reducers. The Bluedot consists of four buttons, Top, Bottom, Left and Right. These buttons are used for movement of wheelchair in all directions. Raspberry is connected to two L298N motor drivers which will control four DC motors which are used to move the wheelchair. Two MG-995 metal geared servo motors are used for converting the wheelchair into stretcher and vice-versa. HD-webcam is used for live streaming between patient and doctor/care taker. Raspberry pi camera is used for live face tracking of the person sitting on the wheelchair, so that the care taker of the patient can see the person from remote place and know the condition of the patient during emergency situations. OpenCV software will be used for this process. GPS NEO-06 module is used to obtain the location details of the wheelchair. The GPS module aid in obtaining the coordinates (longitude and latitude). These coordinates are then gathered utilizing the Raspberry Pi module. 12volt power supply will be given to power up the raspberry pi.

Patients with disabilities make use of mobility aids such as wheelchair stretcher for movement. Wheelchairs are one of the important devices in the contemporary world since it plays a vital role in determining the quality of life for individuals with mobility impairments such as wheelchair users. The system will interrupt the commands and controls the wheelchair accordingly via Android application. It is difficult for nurse or care taker to shift the patient from wheelchair to medical bed or stretcher or vice-versa. We have designed and developed wheelchair is fixed on the four wheeled robot, this wheelchair is developed using metal sheets. The designed wheelchair can be easily converted into stretcher. So that the patient can operate it easily according to their comfort. It can also be maintained and operated by attendant/caretaker.

Wheelchair is fitted with health monitoring sensors to read health parameters like temperature, heart rate and ECG. Raspberry is not able to read analog signals and hence we have used an Arduino UNO for reading the analog values of health monitoring data. We have used different sensors like Temperature, heart rate and ECG sensors. We have used DS18B20 digital temperature sensor, it is a waterproof sensor which measures temperature in wet conditions also. We have used thumb heart beat sensor, finger is inserted to this sensor to measure the heart beat at fingertip. The received sensor data will be displayed on 16x2 LCD display and also python shell. The data values acquired from different sensors will be uploaded to cloud i.e., ThingSpeak, if the values of the temperature and heart rate exceeds the predefined threshold values, then an alert SMS will be sent to the care taker, so ThingSpeak can also be used as an API to send alert messages.

3. SYSTEM IMPLEMENTATION

A The hardware design implementation of the wheelchair system is as shown in the Figure 2.

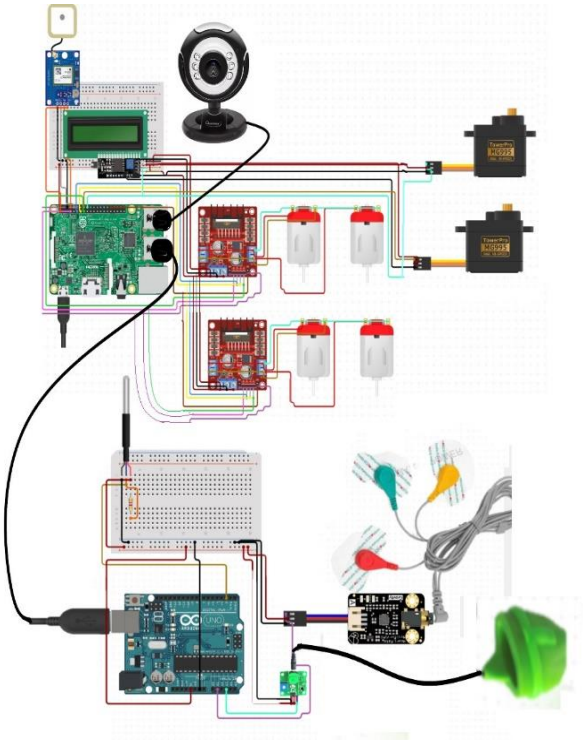

Figure 2 Circuit diagram of the Wheelchair system

The figure 2 shows design of the Raspberry Pi & L298N Motor Driver Interface Circuit. First it is required to connect 12V Power Supply to L298N Motor Driver Module. Then, make the GND terminals of Raspberry Pi and L298N Motor Driver Module common (connect them together).

To control the movement of wheelchair, four 12V DC motors are used which are controlled by a pair of L298N H-Bridges. Therefore, the enable pins of the L298N motor drivers are connected to GPIO pins of raspberry pi. The wheelchair to stretcher operation is done by using two servo motors, the data pin of servo motor 1 which controls the backrest of the wheelchair is connected to GPIO 2 of the raspberry pi and servo motor 2 is connected to GPIO 3 of raspberry Pi. Both servo motors are connected to external 5V DC power supply. The HD-webcam which is used for live streaming is connected to USB port of the Raspberry Pi.

IN1, IN2, IN3, IN4 of L298N of back wheels are connected to GPIO5, GPIO6, GPIO 25 and GPIO 8, IN1, IN2, IN3, IN4 of L298N of front wheels are connected to GPIO17, GPIO18, GPIO 22 and GPIO 23. GPS NEO-6M module is used for fetching location details, VCC of Neo 6M to be connected with 5v of Raspberry pi, GND of Neo 6M with GND of Raspberry pi and TX of Neo 6M with RX of Raspberry Pi so that the GPS module can send data to raspberry pi through the serial connection.

For health monitoring of the person uses wheelchair, temperature, pulse rate and ECG sensors used. The temperature sensor is connected to PIN 4 of Arduino UNO. ECG module is connected to PIN 10 and PIN 11. The finger pulse sensor is connected to analog pin A0. Arduino UNO is interfaced with raspberry pi using USB port.

The working of the proposed system and sequential steps involved in the process is as depicted in the above flowchart.

The workflow of the proposed system starts with pairing the Bluetooth in Raspberry Pi and Smartphone. Establish the Bluetooth connection for communication between Raspberry Pi and Smartphone. Smartphone is pre-installed with an Android application called “Blue Dot” which is used for movement of wheelchair. The “Blue Dot” is used as joystick to move the wheelchair by pressing the blue dot when the top, bottom, left and right positions of the dot in android application. “Blue Dot” is both python library and android application. Based on the Positions touched the wheelchair will be moved in forward, backward, left and right respectively. We can also control the speed of the wheelchair by using blue dot. If we press at the extreme ends of blue dot the wheelchair will be moved with more speed, if we touch at inwards region of blue dot then wheel chair will be moved with low speed. Wheelchair will be stopped when the Blue Dot is released. Four DC motors are used for the movement of wheelchair which are controlled by a pair of H-bridges (L-298N motor drivers).

Person who use wheelchair may require health monitoring, all the time it is not possible to consult Doctor each time by visiting hospital. So using live streaming we can make person to communicate with doctor for health check-up. HD Webcam is used to establish the live streaming using raspberry pi. Several python commands are used to establish live streaming. When live streaming is running in both server and client ends, doctor can communicate with patient and suggest the medication effectively.

The problem of moving the patients with disabilities from one place to another is there from ancient times. People who got injured or ill were carried by others by means of wooden stretcher with cloth tied to it. Afterwards as technology evolved they were carried on wheels which reduced the effort of the people carrying the patients. Although medical field is evolved in the field of healthcare and technology we are not yet able to address this problem efficiently. Wheelchair will be used by elders and especially abled people, most of the elders or sick people needs medical care. It’s difficult to shift the person sitting from wheelchair to medical stretcher, so it will be useful if we convert the wheelchair into stretcher.

We have used two high torque servo motors which will convert the wheelchair into stretcher by rotating the back support and leg support metal sheets by 90 degrees clockwise and counter clockwise directions. The

wheelchair is fitted with different health monitoring sensors like temperature, pulse rate, ECG etc., the sensor readings will be obtained from sensors which will be displayed on raspberry pi. Raspberry pi consists only digital GPIO pins, so in order to obtain the readings from health monitoring sensors we use Arduino board as analog to digital converter.

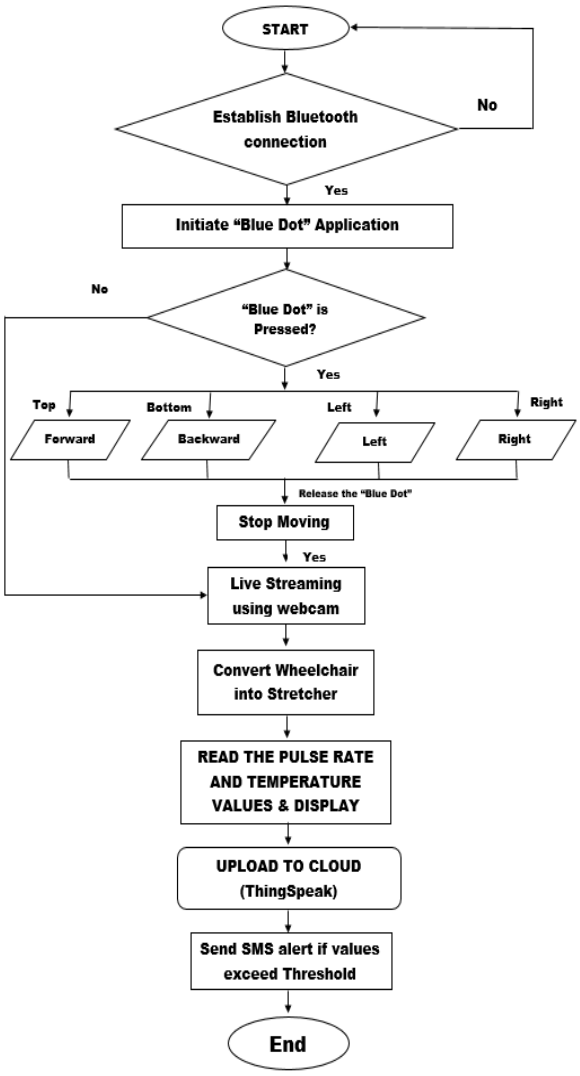

Figure 3 Flowchart of the proposed system

The Arduino acts as slave to raspberry pi will sends the sensor data to raspberry pi using USB serial communication. The received sensors data is analyzed and compared with threshold values for each parameter. If any values of any sensors exceeds the threshold value, then the alert SMS will be sent to the registered mobile number. Important part of the project is to create a database of the measured health parameters for further analysis of the respective person. So in order to create and maintain the health database, we have used ThingSpeak platform for storing and maintaining the health monitoring data.

ThingSpeak is an IOT platform which allows us to visualize and analyze the live streaming of live data received from different sensors. So the health monitoring of any person who uses this wheelchair can be maintained in efficient manner which will be helpful to large community of differently abled people.

4. EXPERIMENTAL RESULTS

The smart wheelchair which is designed for the physically disabled people is as shown in the figure. It is designed using three metal plates connected by two metal gear servo motors. The rotation of these servomotors helps this wheelchair to be converted as stretcher. Four 100RPM 12 V DC motors are used for the move this robot.

The wheelchair is converted into stretcher using two metal geared servo motors called MG-995, the rotation of the motors in clockwise and counter clockwise using PWM signals.

The movement of the wheelchair is controlled using "Bluedot" android application, Bluetooth will be enabled in both raspberry Pi and Android phone, after establishing the connection between android and raspberry Pi, a blue coloured circle will be displayed on android phone. The movement of the robot is based on the region which is pressed. If the top region of the circle is touched then it will move in forward direction, similarly if left, right and bottom regions are pressed, the robot will move that direction. The speed of the robot can be controlled by pressing inward regions and speed can be increased by pressing at the edges of the circle.

Figure 4 Developed wheelchair.

One of the main features of this project is live streaming, the implementation of live streaming uses raspberry Pi as Webcam server that can stream live video over the internet (local network). Live streaming is implemented using the python library called "Motion".

After completion of initial setup of Motion software, the IP address of the raspberry pi along with port number i.e., 8081 is entered in the internet browser. The live streaming output is as shown in the above figure 7

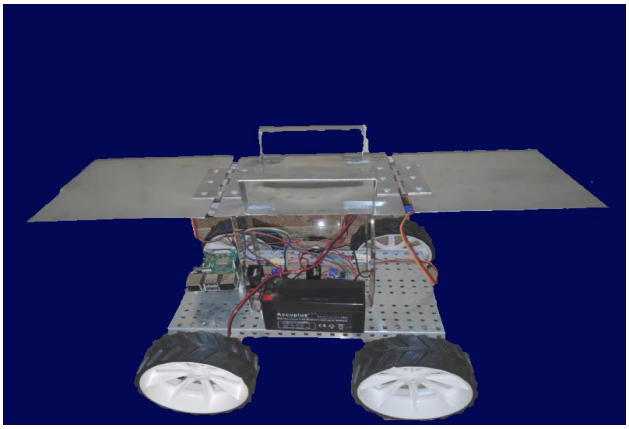

Figure 5 Wheelchair convertible Stretcher

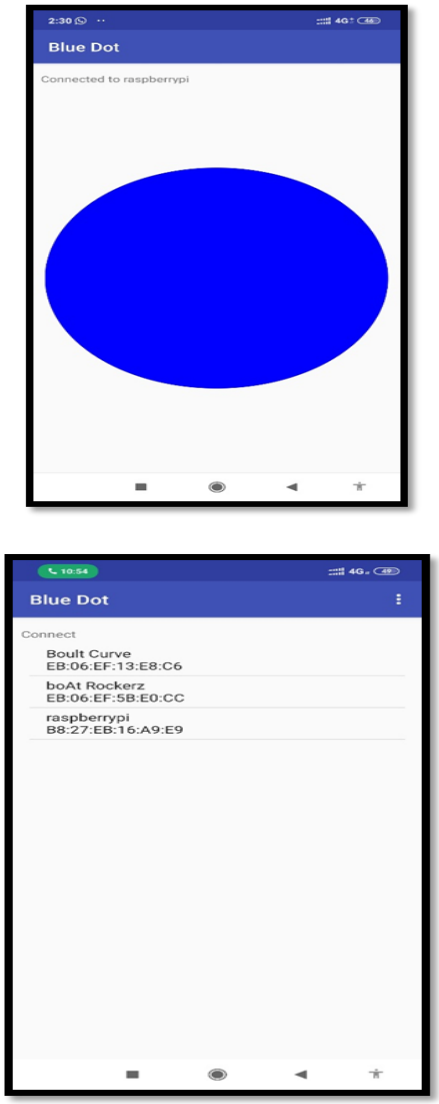

Figure 6 Bluedot connection between android and Raspberry Pi

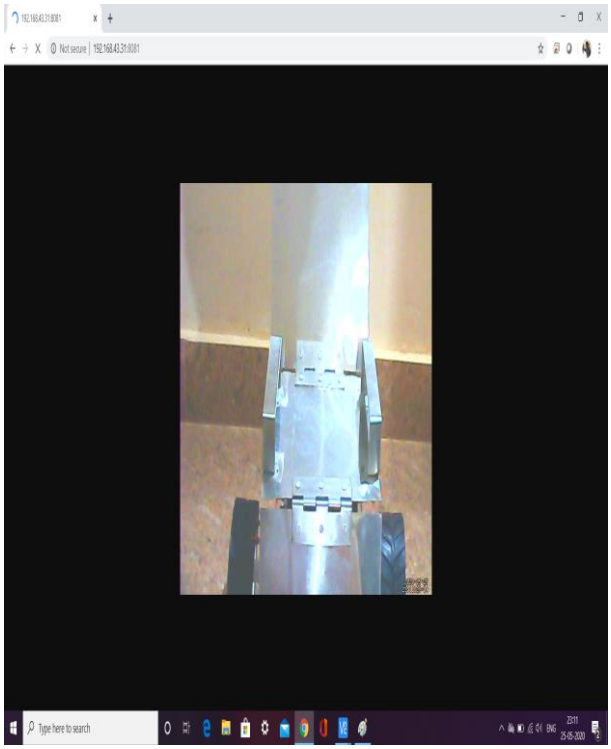

Figure 7 Live streaming

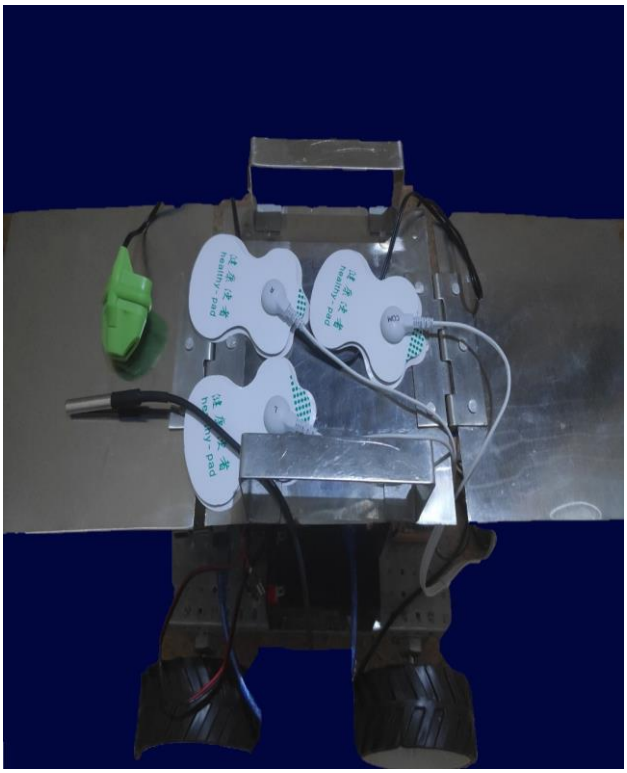

Figure 8 Health monitoring

The smart wheelchair is capable of measuring person health parameters like Temperature, Pulse rate and ECG. The health measuring sensors are fitted to the wheelchair, when the wheelchair is converted into stretcher, these health monitoring sensors like temperature, thumb pulse rate and ECG module will be applied on person's body. To read the analog readings from these sensors using

raspberry Pi, we need analog to digital converter. Therefore, we have used Arduino as analog to digital converter. These measure parameters will be uploaded to cloud IOT platform called 'ThingSpeak'.

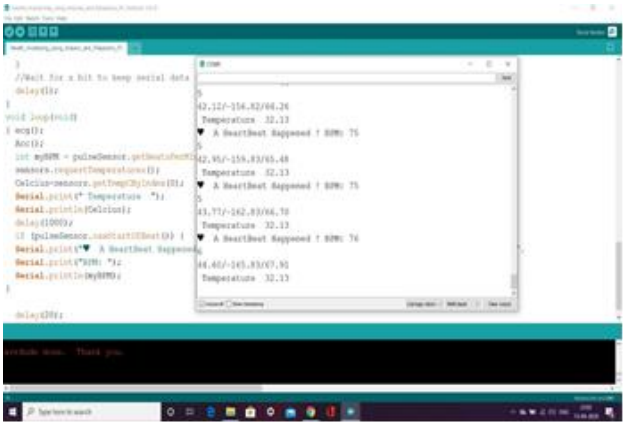

Figure 9 Health monitoring readings from Arduino

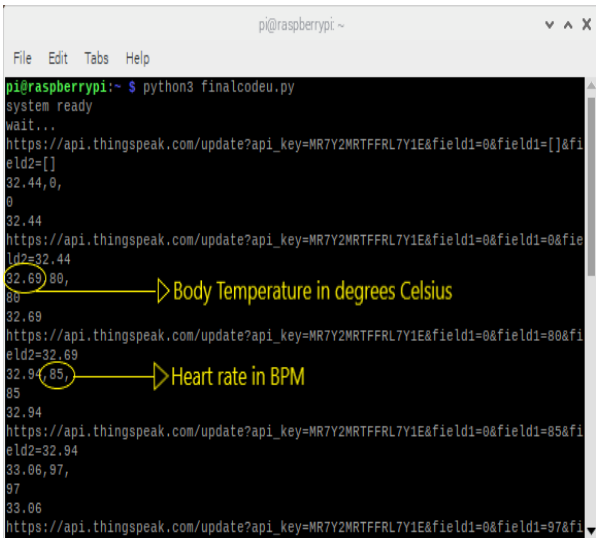

Figure 10 Raspberry Pi receiving data from Arduino and uploading them to ThingSpeak

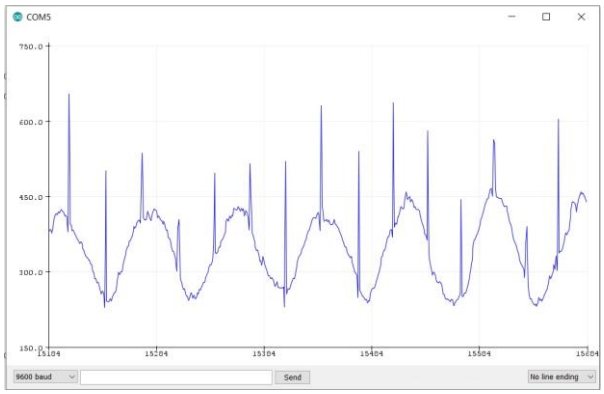

Figure 11 ECG output generated in Arduino

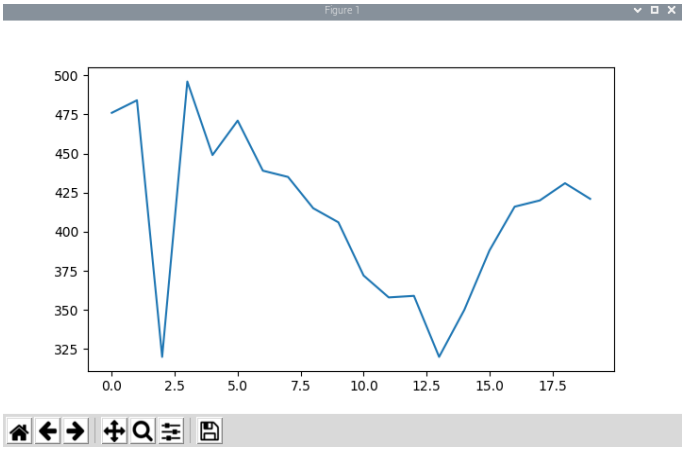

Figure 12 ECG output on Raspberry Pi

These health parameters can be stored in ThingSpeak for future reference of health data. The uploaded parameters to ThingSpeak is as shown in the figure 12 below.

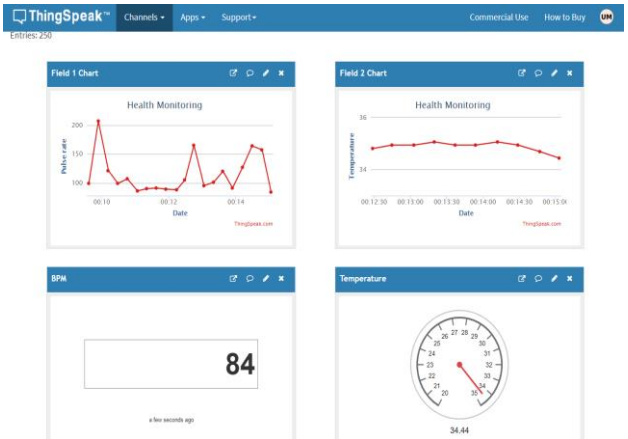

Figure 13 Health monitoring data uploaded to ThingSpeak.

The body temperature and heart rate/pulse rate data is uploaded to ThingSpeak. Two separate fields are created for both temperature and Pulse rate. The accurate readings of temperature and pulse rate are displayed using the digital meters shown below the fields. These data can be accessed anytime for analysis of person's health data. If the temperature or pulse rate exceeds the normal readings, then an alert SMS will be sent to the care taker. An API service called "Textlocal" is used for sending alert SMS.

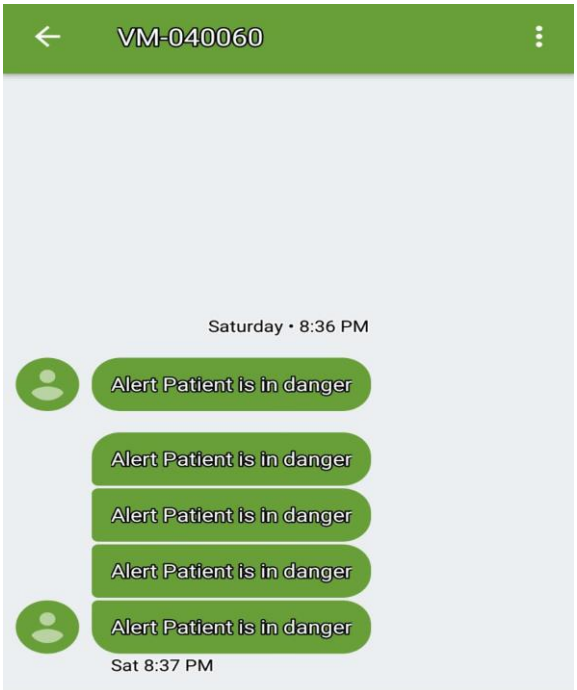

Figure 14 SMS Alert when Threshold values exceeded.

5. CONCLUSION AND FUTURE WORK

Human intervention can be minimized by advancements in smart wheelchairs using intelligent control algorithms. An android application is used to drive the smart wheelchair which is equipped with sensors. We have developed an easily accessible smart wheelchair for especially abled people. So that the person can move to desired place without anyone's support. He can also able to check his health using health sensors fitted to the wheelchair. There are several challenges which has to be overcome before it is widely used. Existing smart wheelchairs requires require specific training to understand the operation of the wheelchair which impacted on less stockholders. Our proposed system is designed to make user friendly vehicle. Autonomous wheelchair is very useful for one who can't move from one place to another place independently. The operation of the robot is very simple and easier. Just by tapping on the touchscreen phone, one can able to move in any direction which helps to reduce the dependency on others. This device is developed by providing more attention to health monitoring using visual interaction with doctor using live streaming. The smart wheelchair is based on raspberry pi and python applications. From the results it is observed that, the smart wheelchair will help the society and impact on physically disabled people in a huge way. Variable speed mobility is achieved used 'Bluedot' application. The accurate health data is read by using Arduino and it is sent to raspberry Pi. The raspberry pi is used as webserver for live streaming. The health monitoring data is uploaded to ThingSpeak continuously. Finally, if any variations occurred in health readings of the person will be sent to the care Taker immediately for immediate medication, so that the on-time treatment will save the lives.

For future work, there are several issues faced by the manufacturers and researchers which needs to be addressed so that, smart wheelchair becomes a commercial success and be widely used. One common main issue is cost versus accuracy. Inexpensive and advanced sensors can help to overcome this problem. Smart wheelchairs which can be used generally for all types of disability are still not available. Smart wheelchairs should also contain the ability to monitor the patient conditions and react accordingly. Also, smart wheelchair for independent use by mentally challenged people should be researched. Smart wheelchair has great scope in future and technological advancement in the field of robotics and sensors will lead to commercial success as well.

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