IoT based Smart Sensing Wheelchair to Assist in Healthcare

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Abstract: *Many people are suffering of temporary or permanent disabilities due to illnesses or accidents. For cases of difficult or impossible walking, the use of a wheelchair is becoming essential. Manual or electrical wheelchairs are satisfying for most of the low and medium level disability case where patients can use the wheelchair independently. However, in severe cases, it is difficult or impossible to use wheelchairs independently. In such cases wheelchair users often lack independent mobility and rely on somebody else handle the wheelchair. Researchers involved in wheelchair are aiming at designing smart wheelchairs to solve such problems. The purpose of Smart Sensing Wheelchair is to monitor the heartbeat of the patient on a regular basis and notify the concerned person through a message. This is an IoT based project and will be user friendly.*

Keywords--* *wheelchair, internet of things, arduino, raspberry pi, sensor.

1. INTRODUCTION

Technology has dawned upon mankind in today's era and has successfully turned their lifestyle into an effortless one. From education to business to butchery, everything is available at our disposal. Technology has been the sole reason behind the evolution and modernization around the globe. The impact has been so significant that, today, nothing seems to be impossible. The trending technologies such as artificial intelligence, 3D printing, nanotechnology and robotics are responsible for moulding the future healthcare systems. Digital technology in medical field can help transforming unsustainable healthcare systems into sustainable ones, maintaining a balance between medical professionals and patients, providing inexpensive, efficient and effective solutions to combat diseases. The ratio of the ageing population is rising significantly. The rapid evolution of health monitoring systems is replacing the traditional healthcare solutions. Maintaining health records of the patients online has not only been beneficial for the doctors but also proved to be a source of relevant data for the analysts to produce meaningful information with respect to the patient. These systems are not only inefficient, but also provide the patients wishing to live independently, the ability to access the health services online. Health monitoring systems prove to be most beneficial for the patient parties residing in remote places. By accessing the services online, they can directly communicate with their doctors only in case of an emergency. Thus, the elderly individuals can avoid interactions with the nursing homes, hospitals, etc. for as long as possible, reducing the pressure on the health system. Since disabled patients cannot afford to travel, smart healthcare systems help them gain access to healthcare systems. A possible solution to monitor their health status is by developing a health monitoring system based on a smart wheelchair since it is adequate for a wider range of audiences and it does not require a lot of maintenance unlike the wearable systems. Many people are suffering of temporary or permanent disabilities due to illnesses or accidents. For cases of difficult or impossible walking, the use of a wheelchair is becoming essential[7]. Manual or electrical wheelchairs are satisfying for most of the low and medium level disability case where patients can use the wheelchair independently. However, in severe cases, it is difficult or impossible to use wheelchairs independently. In such cases wheelchair users often lack independent mobility and rely on somebody else to handle the wheelchair. Researches involved in wheelchair are aiming at designing smart wheelchairs to solve such problems. There have been devices that are constructed to make the wheelchairs "Smart" in terms of motion wherein the wheelchair movements are controlled by the patient. The purpose of the proposed Smart Sensing Wheelchair is to detect any cardiovascular abnormality of the patient on a regular basis and notify the concerned person through a message[8].

2. RELATED WORKS

The following observations have been made from a few papers related to this topic:

Materials

In [2], the choice of a wheelchair is rather complicated and depends on many criteria, such as the user's pathology, morphology, his/her rate of evolution, his/her environment (at home, in the office, etc.). Accordingly, there is not a "model" wheelchair. Thus, the wheelchair is selected according with economic and technical criteria

Methods

According to [2], the position of each force sensor is identified where one force sensor is positioned in each pressure zone except those that are less than 25 and 40mmHg for the seat and the backrest, respectively. In total, four force sensors are integrated into the seat textile cover and other four sensors are integrated into the backrest cover[2].

Temperature sensors are integrated following the same procedure of force sensors, where a temperature sensor is placed just in front of each pressure sensor. By using a miniature high-resolution acceleration sensor, it is possible to measure the heart functioning more accurately and less annoyingly than with conventional electrocardiograms, with “Ballistocardiography”. When the person is leaning against his or her chair, the backrest begins to vibrate following the movement of the blood[3].

Human- Machine Interface

In [1], the main target of the human – wheelchair interface is to allow the user to control the mobility of the chair in less effort and more robustness and safety. For mobility control, the joystick is the most common steering control interface for electric powered wheelchairs. Hand gesture controlled system is another method for interfacing humans and machines[4].

Smart phones and tablet computers are increasingly becoming popular. They are equipped with many useful built-in sensors. Researchers and developers are recently using these devices for powerful controlling applications. More advanced joysticks may have more add-ons technologies to facilitate other options depending on the user’s abilities and situation[5].

The Navigation Methods and Devices

- According to the survey in [1], many projects study how a smart wheelchair can be of maximum assistance to its user. Navigation methods are divided to three categories according to levels of assistance. The three main categories are: Shared control, semi-autonomous control and completely autonomous control. In semi- autonomous, wheelchairs are involved more in route planning in addition to collision prevention, obstacle avoidance and wall following. Semi-autonomous systems wait commands from users providing a short term *local* destination. The wheelchair then starts moving until an external flag from the navigation system informs that the command was executed.
- In autonomous system, the user indicates the final desired destination and the wheelchair system takes complete control of the navigation0
- from the current location to the goal destination. Autonomous systems therefore need mapping and position monitoring techniques. Consequently, they usually preferred to be operated in well-defined environments[6].

3. PROPOSED WORK

3.1 SYSTEM ANALYSIS

The system is decomposed into components and analyzed to see how well those components work and interact with each other.

3.1.1 Relevance of platform

The client side requires IOT edge device. The server side requires Arduino platform.

3.1.1.1 IOT edge devices

The IOT edge devices help in connecting the existing machines to an IOT cloud platform. They are essentially hardware components with embedded software that provide an operating environment for running custom programs for:

- Interfacing with connected machines
- Reading parameters or signals from connected machines

- Connecting to the internet
- Transmitting data to an IOT cloud
- Fetching data from an IOT cloud
- Hosting local endpoints for receiving requests from an IOT cloud
- Sending signals and controlling the connected machines

3.1.2 RELEVANCE OF PROGRAMMING LANGUAGE

3.1.2.1 Processing is a programming language which is built to help the visual design communities learn the basics of computer programming in a visual context. It also includes a basic Integrated Development Environment (IDE) which serves as a programming interface.

3.1.2.2 Sketch is the name of the arduino program that is used for programming. It is the code that is uploaded to and run on an Arduino board.

3.1.2.3 Cayenne is a programming system for the IOT. It standardizes the connection of sensors and use the collected data. To make the interactions you have to run a suitable sketch that is an arduino program that handles the communication between the sensor and the cloud.

3.1.2.4 MQTT is the most commonly used protocols in IOT projects. It stands for Message Queuing Telemetry Transport. It is a system where you can publish and receive messages as a client. MQTT is mainly used for communication purpose.

3.3 HIGH LEVEL SYSTEM ARCHITECTURE

Smart wheelchair makes use of the PPG sensor and the Oximeter to capture the bits per minutes (bpm) and the blood oxygen level. After capturing the signals we use microcontroller unit to process the signal and display the bpm on an OLED screen and sent to cloud as well. If the processed signal is found abnormal the patient's relative will be notified through email or sms which can be triggered on cloud.

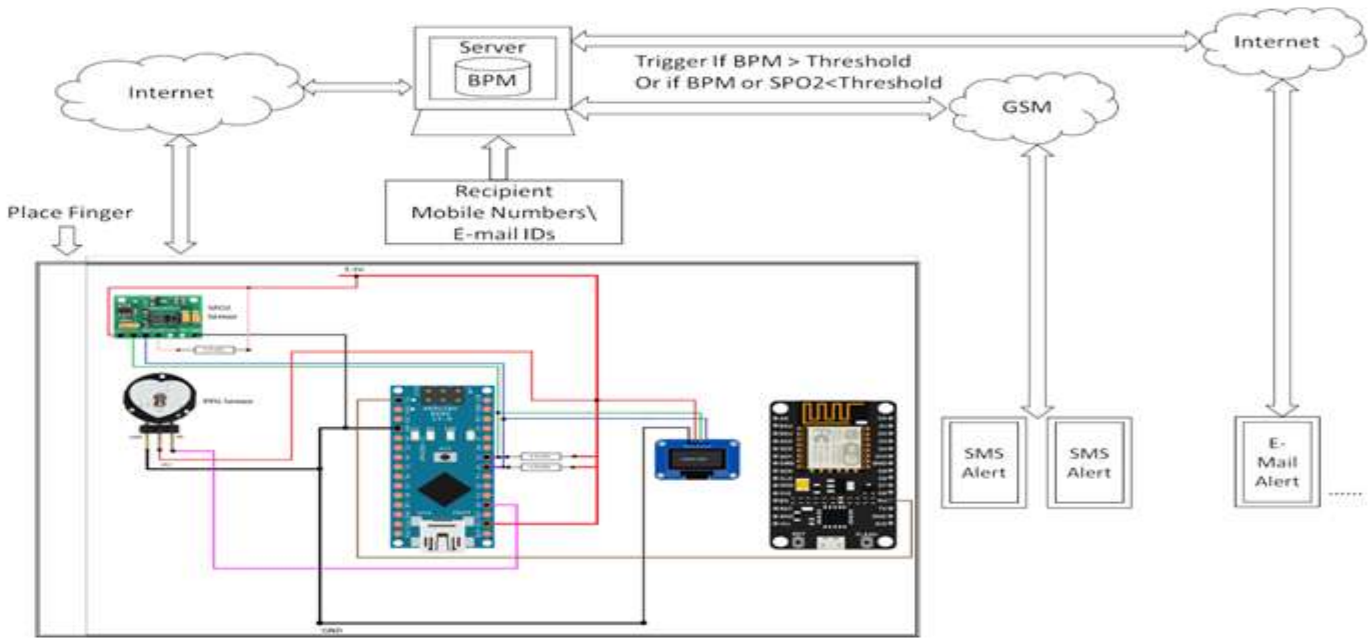


Fig 3.1 High Level System Architecture

3.4 LOW LEVEL SYSTEM DESIGN

We identify the scope of the application – the boundary of the system and the external objects that interact directly with the system called actors. Here the actor is user. We list the fundamentally different ways in which the actor uses the system. Each of these ways is a use case. These use cases partition the functionality of a system into a small number of discrete units.

Use case descriptions

Login: User supplies username and password. If the username is known and password is valid, user is logged in on cayenne.

Register: User creates his/her account on cayenne by supplying valid details.

Measure Bpm: The user will be able to measure his/her beats per minute using PPG sensor.

Trace PPG Signal: The user can trace the PPG signal on the OLED screen.

Trigger the Notification: User can add or delete mail id or phone numbers to which the uncertainty will be notified.

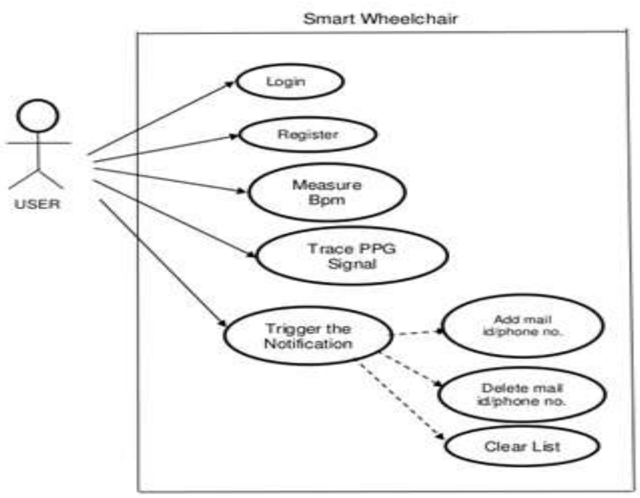


Fig 3.2 Low Level System Design

Use case diagram only shows the actors that are involved with each piece, but they do not show the behaviour clearly. To understand behaviour, we must understand the execution sequences that cover these use case. A sequence diagram shows object interactions arranged in time sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. The following sequence diagram illustrate various scenarios.

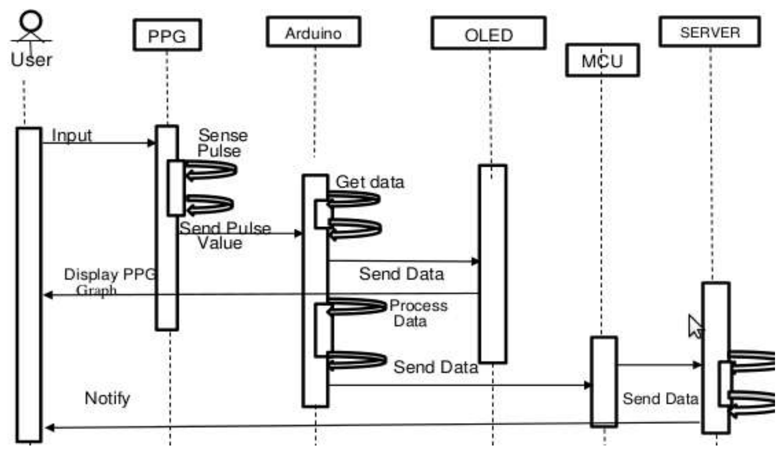


Fig 3.3 Sequence Flow

3.5 IMPLEMENTATION

We formulate an algorithm for each operation. The analysis specification tells what the operation does for the user, but the algorithm shows how it is done. We choose algorithms that minimize the cost of implementing operations and select data structures appropriate to the algorithm.

Algorithm for Data Acquisition System

step :1 Initialize Data Acquisition System
step :2 Start of Data Acquisition Setup:
step :3 Set OLED to 128x64 resolution
step :4 Initialize Serial Communication
step :5 Initialize Pulse oximeter Instance & check for failure.
step :6 Start of Data Acquisition Loop:
step :7 Update oximeter instance
step :8 Asynchronously get SPO2 level
step :9 Read PPG Signal from Analog Pin
step :10 Display PPG Signal Graphically on OLED Screen
step :11 Asynchronously get BPM
step :12 Print BPM and SPO2 on OLED Display
step :13 Encapsulate BPM and SPO2 with separate Delimiters
step :14 Write the data on to Serial Communication Transmit Line of Data Acquisition System
step :15 End of Data Acquisition Loop:

Algorithm for IOT Edge Device

step :1 Initialize IOT Edge Device:
step :2 Define the Cayenne Account Credentials
step :3 Define WIFI Router Credentials
step :4 Initialize Serial Communication
step :5 Connect To IOT Cloud Platform
step :6 Check for connection Failure
step :7 Start of Data Transmission Loop:
step :8 If Serial Data is available
step :9 Extract the BPM and SPO2 by identifying the Delimiters
step :10 Check if it is time to update the data onto the IOT cloud platform
step :11 If it is time then update it
step :12 Else wait till its time.
step :13 End of Data Transmission Loop

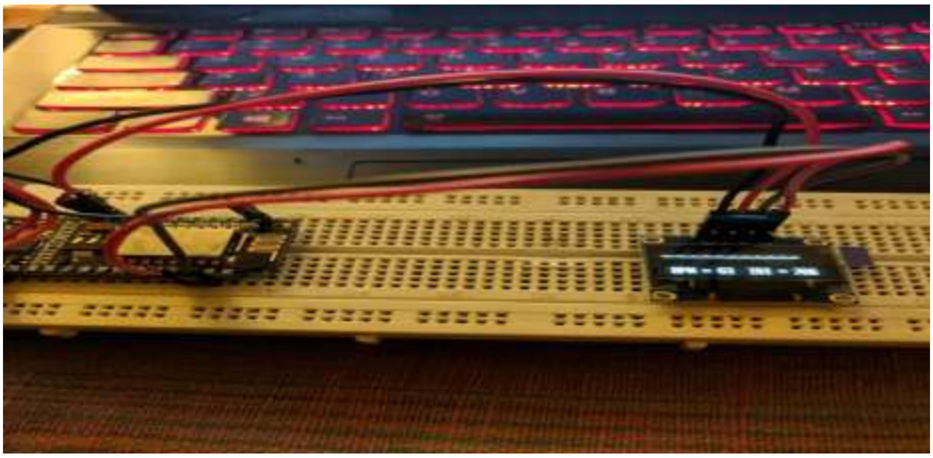
Algorithm for IOT Cloud Platform(Cayenne)

step :1 Initialize IOT Cloud Platform(Cayenne)
step :2 Enter Credentials and Login
step :3 Enter All Parameter
step :4 Setup Channel to receive Data
step :5 Setup Triggers for channels
step :6 Setup email and Cell Phone Recipients
step :7 Start Data Reception Loop:
step :8 If data is available on the channel receive it
step :9 Check if it is beyond the upper or lower thresholds
step :10 If received values are beyond the threshold trigger is activated and message is sent to recipients email or cell phone
step :11 End of Data Reception Loop

4. RESULTS

This project aims at developing an inexpensive and easy health monitoring wheelchair. This smart sensing wheelchair which enables patients with disabilities to be in contact with the concerned person. The pulse rate of the patient is sensed and it is sent to the microcontroller. The sent data is getting processed and if in case any abnormality is seen in the pulse rate then a notification is sent to the concerned person. The pulse rate is shown as beats per minute in the SSD 1306 OLED display.

The pulse oximetry sensor is used which gives the blood oxygen level.



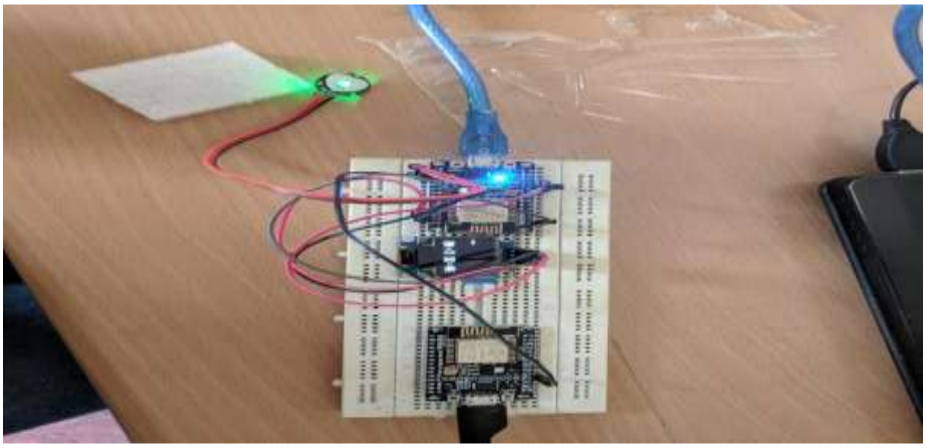


Fig 4.1 Snapshot of the OLED screen

5. CONCLUSION

In this paper we mainly aimed at monitoring the health of the patient who is sitting on the wheelchair. We made use of different sensors such as PPG sensors and SPO 2 sensors and we have also used different microcontrollers such Node mcu and Arduino. The collected data is sent to cloud. Cayenne software is used for generating trigger if in case of any abnormality and then it sends a notification via email/sms. Unfortunately, there are very few wheelchairs with the smart technology available. The reasons may be robustness and safety of the technology is not 100% guaranteed in many researches. However the main reason may be related to feasibility and marketing issues. Moreover the smart wheelchairs that are designed may be complicated for many users' therefore proper training and familiarization are needs after sales services. Future work should be focused more on the add on approach which gives flexibility in configurations of the sensors, input devices and the interface based on each individual user's needs with a reasonable budget. The other options for making the wheelchair more user friendly can be added in future. For example social communication facility and entertainment might be added to the wheelchair. Muscle relaxing, health monitoring, first aid and rehabilitation tools might be considered as useful add-ons too.

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