CHAPTER 1

INTRODUCTION

In today's world, an estimated 7% of the world's population needs a wheelchair. All the elderly and disabled people who want to enhance their personal mobility use wheelchair. However it becomes impossible for a disabled person to loco mote without any assistance. Such people need constant care and a caretaker to look after them and fulfill their needs. Our aim in this project is to develop an efficient system using which a paralytic can carry out his mundane tasks. The system consists of a gesture controlled wheelchair which understands the gestures made by the patient. The patient is made to wear a glove fitted with an Accelerometer sensor, whenever the patient makes gestures with his hand i.e. bends his hand in any of the four directions (left, right, forward or backward) the wheelchair steers in that direction accordingly. The wheelchair stops if the patient keeps his hand parallel to the ground. We know how important it is to monitor a paralytic more than that the patient should be capable of letting us know of their needs, keeping this in mind we have integrated a safety critical system in the wheelchair. The patient is made to wear another glove which is fitted with a flex sensor, whenever the patient bends his fingers, an appropriate message is sent to the caretaker with the help of a GSM module, there are two flex sensors when one of them is bent a message is sent stating “I'm at home, I need assistance”. If the patient plans to go out and if he gets stuck anywhere, he can simply bend another flex sensor, by doing so the caretaker receives an SMS which consists of the actual GPS location of the patient, thus he can easily track down the patient and save him. The GPS coordinates are collected using a GPS module. The safety critical system is integrated by keeping in mind that the patient might be mute. He can also be blind or have partial vision for which we have integrated ultrasonic sensors onto the wheelchair; each sensor prevents the wheelchair from colliding with an obstacle present anywhere around. It also prevents the wheelchair from falling into a pit. Thus by using all these features a patient is able to carry out his day to day task and also perform locomotion without any assistance.

CHAPTER 2

LITERATURE SURVEY

Literature Survey is focused on a research question, trying to identify, appraise, select and synthesize all high-quality research and arguments relevant to that question. Literature Survey is typically a systematic review using statistical methods to effectively combine the data used on all the selected studies to produce a more reliable result.

Literature Survey of four papers is done and the contents of each are briefly written. All the papers are deeply analyzed for pros and cons and the best possible method for the project is derived.

2.1 Intelligent gesture controlled wireless wheelchair for the physically Handicapped

Robots of the future should communicate with humans in a natural way. Hence, we are especially interested in hand motion based gesture interfaces. The purpose of this study was to present a reliable means for human-computer interfacing based on hand gestures made in three dimensions, which could be interpreted and adequately used in controlling a remote robot's movement. In this paper we discuss the development of a novel architecture of an intelligent wheelchair working on wireless hand gesture control and not by the usual method of keypad for the physically handicapped people. Unlike others before it, this project also has a distress call system (GSM) to alert the concerned people or family in times of necessity for the person, by the person himself/herself from an alert switch or when there is any sudden detection of edge or staircase during backward motion, thus saving the chair from accidents. The locomotion of the wheelchair is controlled by a MCU (microcontroller). The physically handicapped people will have the option of controlling the system through hand gesture wirelessly from ranges up to several meters and will have the independence of using the wheelchair without the help of any other people.

With the development of the project it can be successfully implemented on a larger scale for the handicapped people. The low cost of the assembly makes it really a bonus for the general public. The wireless system will be a boost to the confidence and willpower of physically challenged people as it will help them to be self reliable. As a part of further development the project can be developed with addition voice recognition features through on board processing and power supply. There can also be the application of intelligent home navigation for handicapped people to go through the entire house and get help from technological interface for the navigation. The object avoiding and careful navigation principle can be improved with algorithm based image processing technology.

2.2 A Comprehensive Review of Smart Wheelchairs: Past, Present, and Future

A smart wheelchair (SW) is a power wheelchair (PW) to which computers, sensors, and assistive technology are attached. In the past decade, there has been little effort to provide a systematic review of SW research. This paper aims to provide a complete state-of-the-art overview of SW research trends. We expect that the information gathered in this study will enhance awareness of the status of contemporary PW as well as SW technology and increase the functional mobility of people who use PWs. We systematically present the international SW research effort, starting with an introduction to PWs and the communities they serve. Then, we discuss in detail the SW and associated technological innovations with an emphasis on the most researched areas, generating the most interest for future research and development. We conclude with our vision for the future of SW research and how to best serve people with all types of disabilities.

SWs represent a paradigm shift unlike the one that occurred when PWs became available on a mass scale, which was a technological advancement from the manual wheelchair. In the last decade, sensors and computers have gotten faster, cheaper, and smaller, while computer vision software has become more sophisticated and readily available than ever before. The research community has developed many prototypes, the best parts of which should be fused into a modular upgradable system that can be marketed to the millions of people who need PWs. Electric vehicle manufacturers are in a prime position to produce a stand-alone SW and capitalize on the millions of aging Baby boomers worldwide, who will want to have an SW. The best SWs will be able to accommodate people with all disability types by utilizing a multimodal interface that combines computer vision, touch, voice, and brain control. SWs will be able to build 3-D maps using mobile scanners and navigate autonomously by streaming and analyzing sensory data in real time through cloud computing applications. These solutions show much promise to significantly improve the quality of life for people who use PWs, but only if they are trusted by the people they were designed to serve. This means that human factors have be taken into account, so SWs should be customizable to the individual user’s preferences, provide verbal feedback when appropriate, and be mountable on any PW. The stage is set for humans and robots to interact in public spaces in order to give People with disabilities the best quality of life possible and the opportunity to maximize their human potential.

2.3 Hand Gesture Based Wheelchair Movement Control for Disabled Person Using MEMS

This paper is to develop a wheel chair control which is useful to the physically disabled person with his hand movement or his hand gesture recognition using Acceleration technology. Tremendous leaps have been made in the field of wheelchair technology. However, even these significant advances haven't been able to help quadriplegics navigate wheelchair unassisted. It is wheelchair which can be controlled by simple hand gestures. It employs a sensor which controls the wheelchair hand gestures made by the user and interprets the motion intended by user and moves accordingly. In Acceleration we have Acceleration sensor. When we change the direction, the sensor registers values are changed and that values are given to microcontroller. Depending on the direction of the Acceleration, microcontroller controls the wheel chair directions like LEFT, RIGHT, FRONT, and BACK. The aim of this paper is to implement wheel chair direction control with hand gesture reorganization.

Voice monitoring helps the disabled person to determine the obstacle by acknowledging with alarm signals with slight modification in power section by monitoring the battery voltage levels to enhance the speed and estimate the delay for action to be taken. To enhance the speed of the wheelchair dc motors can be replaced by servomotors. Our paper is capable to control the wheelchair motion for disabled people using hand gesture. Improvements can be made by using various body gestures such as eye gaze, leg movement or head movement accordingly.

2.4 Smart Car for the physically Challenged A unique addition to the Internet of Things

Artificial intelligence plays an integral and indispensable role in the advancing technology. In an era of expeditious human life, the demand for automated devices is increasing rapidly. The growth of smart technology has given room for many applications. Such systems analyze the situation and respond appropriately in accordance to the function they are to perform. In this paper, the mechanism of a smart car for a physically disabled is explained. The concept is based on the use of sensors for direction control and automatic sensing of the presence of any obstruction nearing it. Thus, alerting the driver in the form of a buzzer and LED. The smart car is also equipped with a separate GSM and pressure sensor based Arduino safety alert system. This alerts the caretaker as soon as the driver sits inside the car through a text message. The smart car ensures complete safety of the driver on seat and helps him to move about independently.

All the software used is extremely user friendly. The entire smart car consists of very little complex structure making it less bulky. The smart car does not have any external wire circuitry, thus preventing any danger for the user. The text message is sent instantly. This action helps alert the responsible person and facilitates him to take measures for his safety. More than one mobile number can be stored in the Arduino program which facilitates different caretakers to receive the message at the same time. As there is no emission of any kind of harmful material; smart car is eco- friendly. Most of the technology seen today is dependent on automated systems. Moreover, eco- friendly systems are in need. Scientists and researchers are working upon technologies to eliminate the vehicles and mechanisms that harm the environment in any way. The smart car is a great choice and most suitable for a pollution free environment because there no release of any toxic substance from it. The smart car for the physically challenged is also a useful replacement for wheelchairs.

CHAPTER 3

PROBLEM DEFINITION

3.1 Problem Identification

Much of advancement has been done in order to make a paralytic patient loco mote without much assistance. However few problems still remain to be addressed and solved.

- Most of the motorized wheelchairs need to be steered manually, which may not be possible by a quadriplegic patient as it becomes impossible for them to operate the joystick.
- No obstacle or a pit detecting feature is provided in a manual or a motorized wheelchair.
- No safety alert system is integrated hence a patient outside of his house can't be tracked by a caretaker.
- Recently developed wheelchairs like brain controlled wheelchairs are expensive which most of the people living in rural India or at old age homes can't afford.

3.2 Existing System

The existing system consists of manual wheelchairs, motorized wheelchairs operated through joystick, voice controlled wheelchair, brain controlled wheelchair etc. the voice controlled wheelchair is inefficient in those cases where a patient does not have a distinctive speech or are mute.

3.3 Proposed System

We propose a system which addresses all of the issues stated. Instead of a joystick we have gesture recognition technology which makes it easy to operate a wheelchair; we have integrated obstacle detection and safety alert system which successfully improves the mobility of the patient. Moreover all the components are low cost hence making it affordable for all the sections of the society.

CHAPTER 4

REQUIREMENT SPECIFICATION

A System Requirement Specification (abbreviated SRS) is a structured collection of information that embodies the requirements of a system.

4.1 Functional Requirements

- The system should move Forward, Backward, Left and Right according to the gestures made by the user.
- The wheelchair should detect obstacle lying ahead of it and should reverse its direction i.e. move backward.
- The Wheelchair should detect the pit lying ahead of it and should not fall rather reverse its direction.
- The wheelchair should detect any obstacle lying behind it and should reverse its direction of movement.
- The user should be able to send the distress message to the caretaker using the safety alert system; the message should contain the correct location of the patient.

4.2 Non - Functional Requirements

Non-functional requirements, as the name suggests, are those requirements that are not directly concerned with the specific functions delivered by the system. Non-functional requirements are the constraints on the service or functions offered by the system. They include timing, development process and standards constraints. Non-functional requirements often apply to the system as a whole, not to individual system feature or service. These arise through user needs, because of budget constraint, organizational policies, need of interoperability with other software or hardware system.

- **Performance:** Should not take excessive time in conveying the message or transmitting commands from transmitter to receiver.
- **Functionality:** Detection of pits and obstacles, sending of message to the caretaker, wheelchair movement through gesture recognition is few of the functionalities.
- **Usability:** The chair should be easily movable, user should be easily tracked.
- **Reliability:** The Message should go in time when the user is lost and the chair should move in correct directions.
- **Supportability:** Contain code which is easy to understand with provisions for future enhancement.

4.3 Software Requirements

- Arduino IDE.
- External Libraries:
  - SoftwareSerial
  - VirtualWire
  - TinyGPS

The Arduino integrated development environment (IDE) is a cross-platform application that is written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It includes a code and provides simple one-click mechanisms to compile and upload programs to an Arduino board. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware. A program written with the Arduino IDE is called a sketch. Sketches are saved on the development computer as text files with the file extension .ino. A minimal Arduino C/C++ program consists of only two functions:

- setup(): This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.
- loop(): After setup() has been called, function loop() is executed repeatedly in the main program. It controls the board until the board is powered off or is reset.

The softwareSerial library is used to provide serial communication with all the other digital pins of the arduino apart from 0 and 1 which are the standard Tx and Rx pin of the arduino board.

The VirtualWire library is used to enable Radio Frequency communication between a transmitter and receiver. The library includes API's which define the digital pins on the arduino board which will send and receive the data.

TinyGPS library is used to parse the incoming NMEA sentences from a GPS module.

4.4 Hardware Requirements

- Arduino UNO
- GPS Module
- GSM Module(SIM900)
- L293D Motor Driver
- DC Motor
- RF Tx-Rx (433MHz)
- Flex Sensor
- Ultrasonic Sensor
- ADXL335 Accelerometer

System Requirements Specification gives the requirement of the system like functional requirement, non-functional requirement, and hardware and software requirement. Non-functional requirement includes performance, reliability, functionality etc. of the system. Hardware and software requirement specifies the components required and tools for programming the code.

CHAPTER 5

SYSTEM DESIGN

A design document is a primary document of agreement between a customer and a software engineer. It consists of the various functional and non-functional requirements of software in a language that is understood both by the user and the software engineer. Design documents usually have various levels of details. The high-level design document describes the abstract or the outer functionalities of the system. The low-level design documents focus on the minute and internal details of the system.

5.1 System Architecture

The following section describes the design in detail of both the transmitter and the receiver section.

5.1.1 Transmitter Section

The Transmitter section consists of two gloves which are worn by the patient. One of the gloves include gesture recognized steering feature using which the wheelchair can be controlled. The architecture is depicted as followed.

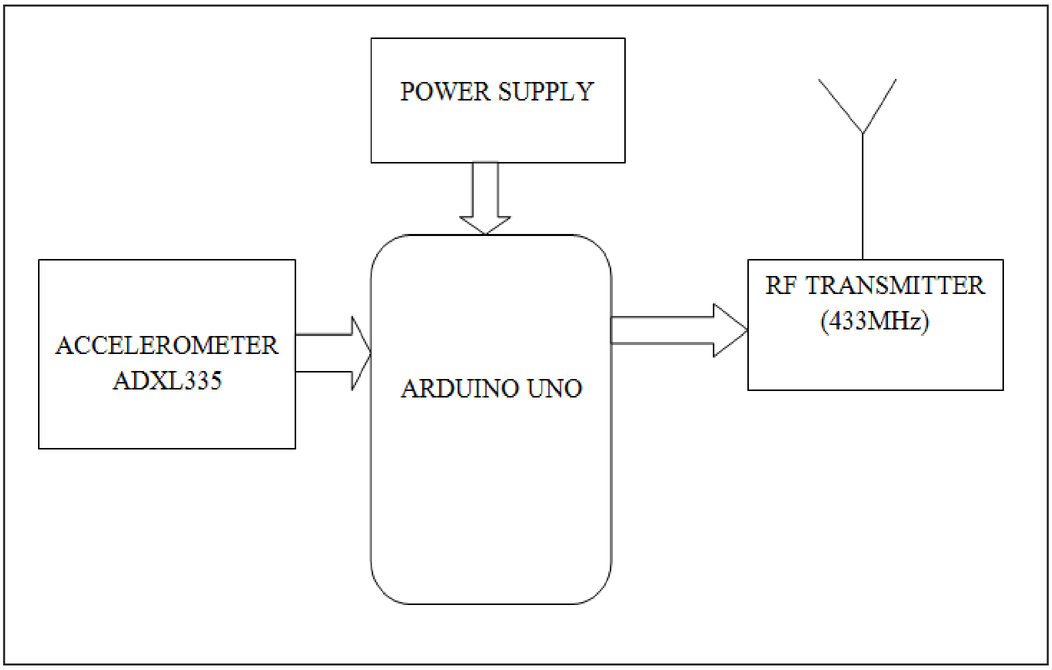


Fig. 5.1 Right Glove Transmitter Section

The other glove consists of Safety Critical System, which the patient can make use of whenever he needs assistance or whenever he is outside and stuck somewhere. Whenever the input from flex sensor is above

Threshold value then the GSM module gets triggered and an appropriate message is sent to the caretaker.

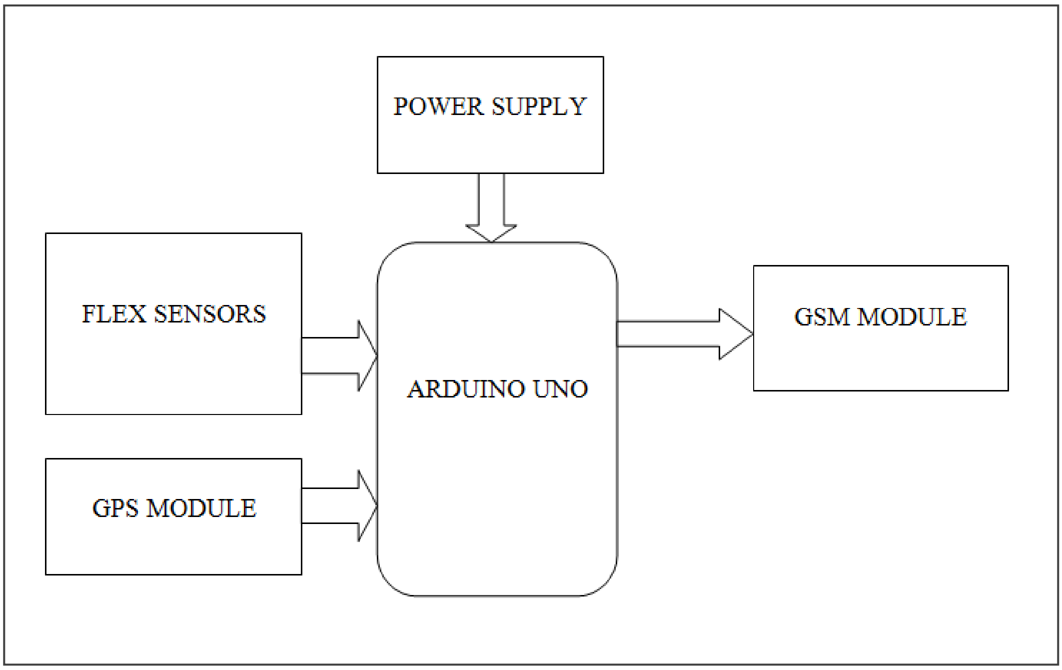


Fig. 5.2 Left Glove Transmitter Section

5.1.2 Receiver Section

The receiver section is the wheelchair which senses gestures and moves forward, backward, left or right. The chair is integrated with ultrasonic sensors which serve to prevent colliding with any obstacle or falling into any pit. The architecture is depicted as followed.

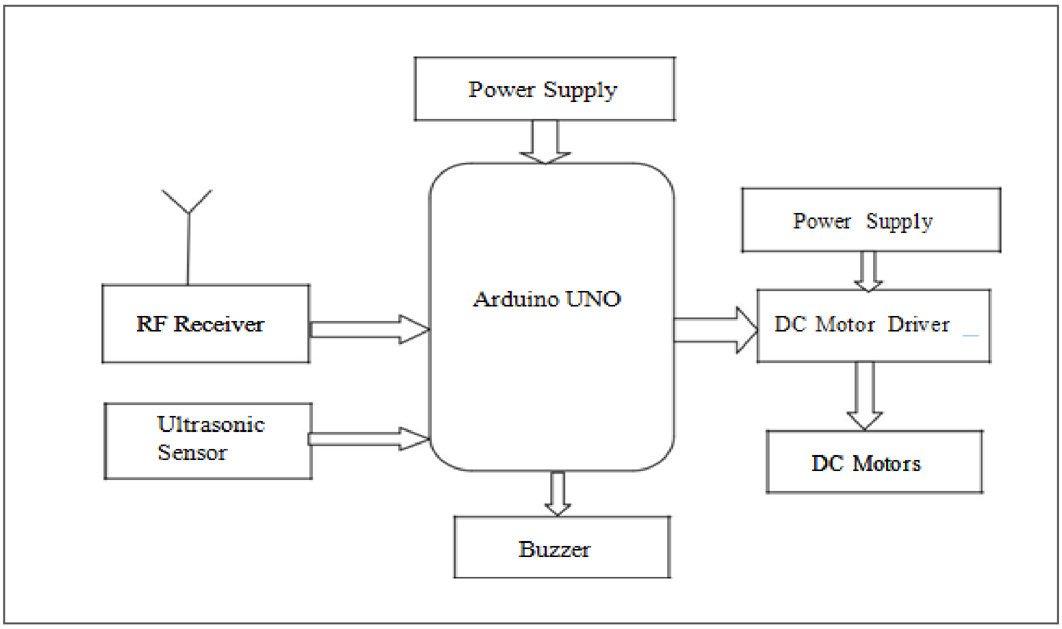


Fig. 5.3 Receiver Section

5.2 High Level Design

The purpose of the design phase is to plan a solution of the problem by the requirement document. This phase is the first step in moving from the problem domain to the solution domain. Here we build the system block diagram that will be helpful to understand the behavior of the system. Here we divide the problem into modules.

This section represents the following:

- Design Considerations: This section describes many issues, which need to be addressed or resolved before attempting to device a complete design solution.
- Development methods

5.2.1 Design Considerations

The design of the system is perhaps the most critical factor affecting the quality of the software and has a major impact in the later phases, particularly testing and maintenance. System design aims to identify modules that should be in the system, the specifications of these modules and to interact with each other to produce the desired results. At the end of the system design all the major data structures, file formats, output formats as well as major modules in the system and their specifications are decided.

5.2.2 Development Methods

The research work is using the waterfall lifecycle model for the development of the project. The waterfall model is an activity centered lifecycle model developed by Royce.

The approach of the waterfall model is in a step-by-step way where all the requirements of one activity are completed before the design of the activity is started. The entire project design is broken down into several small tasks in order of precedence and these tasks are designed one by one making sure they work perfectly. Once one of these small tasks is completed another task, which is dependent on the completed task, can be started. Each step after being completed is verified to ensure the task is working, error-free and meeting all the requirements.

The research work chose this lifecycle model for the project primarily for two reasons. First reason being simplicity, by using waterfall model the entire project can be broken down into smaller activities which can be converted relatively easily into code and once the entire thing is combined the code for the project can be derived. The second reason is because of the verification step required by the waterfall model it would be ensured that a task is free before other tasks that are dependent on it are developed. Thus chances of an error remaining somewhere high up in the task hierarchy are relatively low.

Some of the unique features of waterfall model are:

- It can be implemented for all size projects.
- It leads to a concrete and clear approach to software development.
- In this model testing is inherent in every phase.

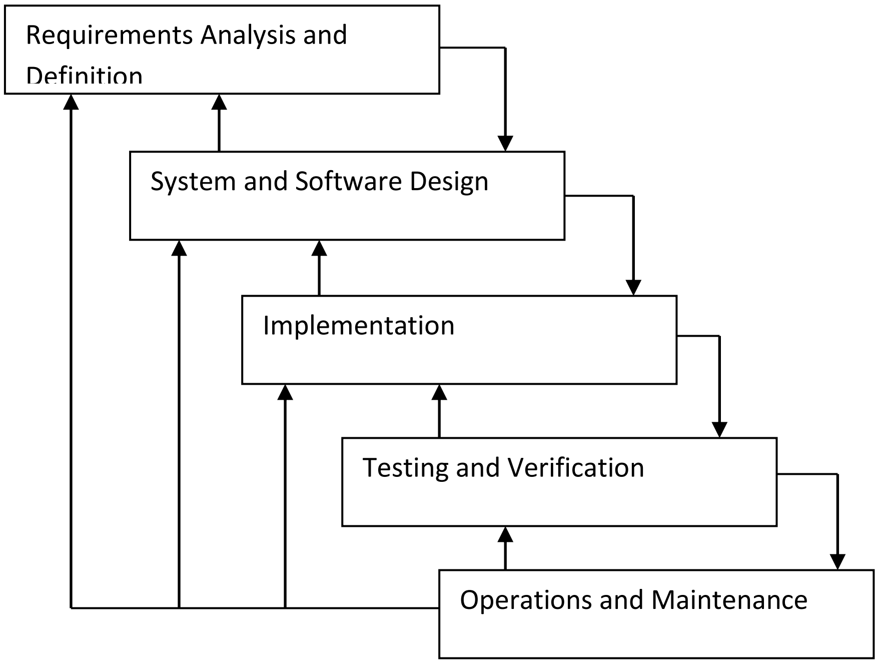


Fig 5.4 Waterfall model

The waterfall model consists of the following stages, namely:

- **Requirement Analysis and Definition:** In this stage, the problem is specified along the desired objectives and the constraints are identified.
- **System and Software Design:** In this stage, the system specifications are translated into a software representation. The software engineer at this stage is concerned with the data structure, software architecture, algorithm details and interface representations.
- **Implementation:** In this stage, the designs are translated into software domain.
- **Unit, Integration and System Testing:** Testing at this stage focuses on making sure errors are identified and that the software meets its required specification. After this stage the software is delivered to the customer.
- **Operations and Maintenance:** In this phase, the software is updated to meet the changing needs, adapted to accommodate changes in the external environment, correct errors and oversights previously undetected in the testing phases, enhancing the efficiency of the software.

The various diagrams that illustrate the high-level design of the product are shown using use case diagram, class diagrams and sequence diagrams.

5.2.3 Use Case Diagram

A use case diagram at its simplest is a representation of a user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved. A use case diagram can identify the different types of users of a system and the different use cases and will often be accompanied by other types of diagrams.

The Figure 5.4 shows the Use Case diagram of the proposed system. Various actors involved in the product are User, Care taker. The various use cases are left glove, right glove, and wheelchair, cell phone.

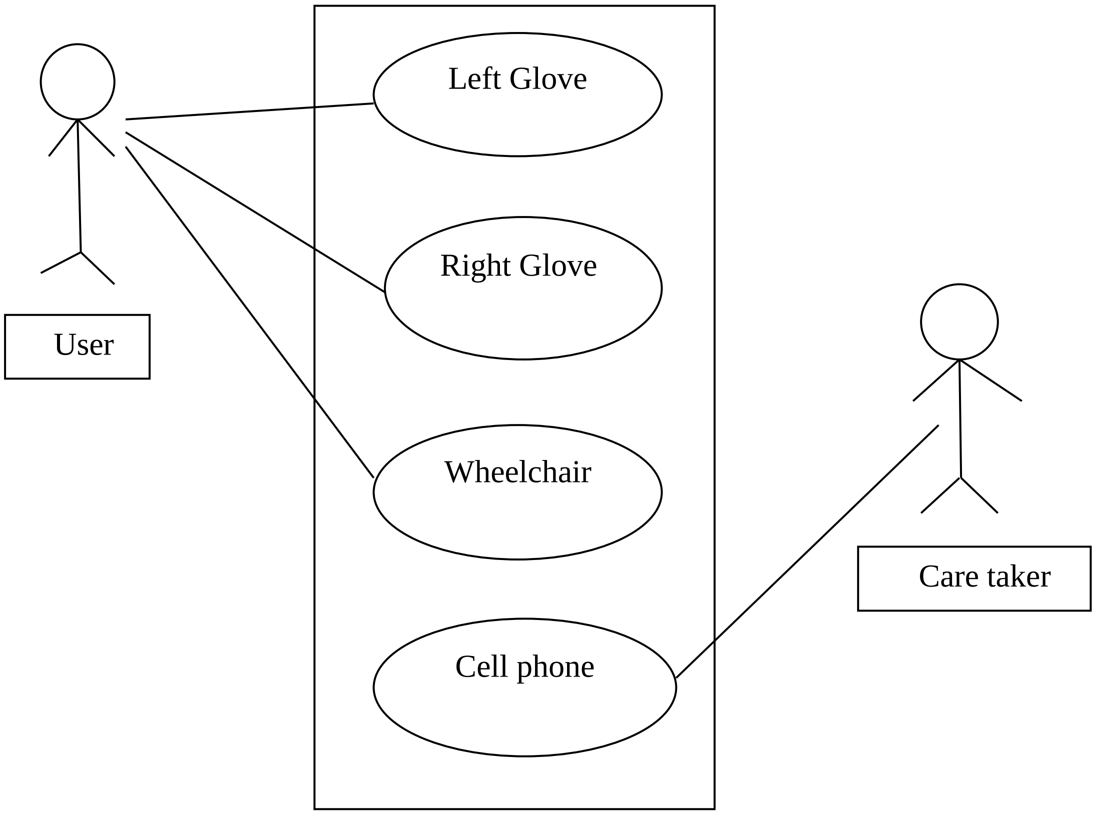


Fig. 5.5 Use Case Diagram

5.2.4 Class Diagram

A class diagram in the Unified Modelling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among objects. The Figure 5.6 shows the important classes and their associations with each other.

The most important classes in this project are the user, chair, right_glove, left_glove, obstacle_detection, pit_detection.

The user class makes gestures and triggers the safety alert system.

The right_glove class record accelerometer_value and sends it to chair class.

The left glove class collects flex_value and gps_value and sends sms using gsm module.

The obstacle_detection and the pit_detection class detect obstacles and reverse the chair direction.

The chair class moves according to the gestures.

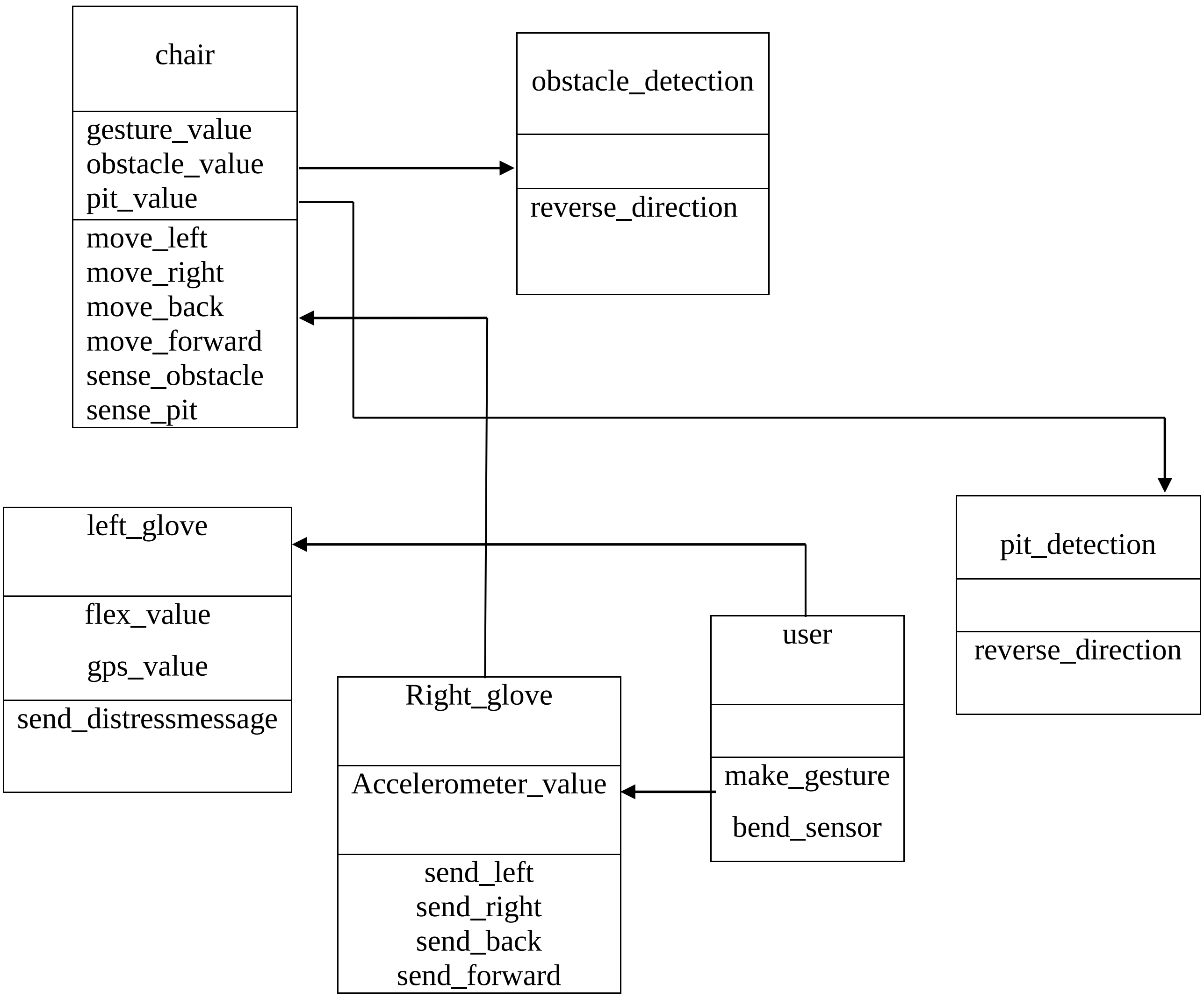


Fig. 5.6 Class Diagram of the system

5.3 Low Level Design

The various diagrams that illustrate the high-level design of the product are shown using sequence diagrams and data flow diagram. First the module overview is shown followed by the sequence diagram and data flow diagram.

5.3.1 Module Overview

The entire project is divided into two parts the Transmitter and the Receiver section. The development phase of the project was divided into three modules. Each of the modules is further divided into sub modules. The main three modules and their sub-modules are depicted in the figure 5.5.

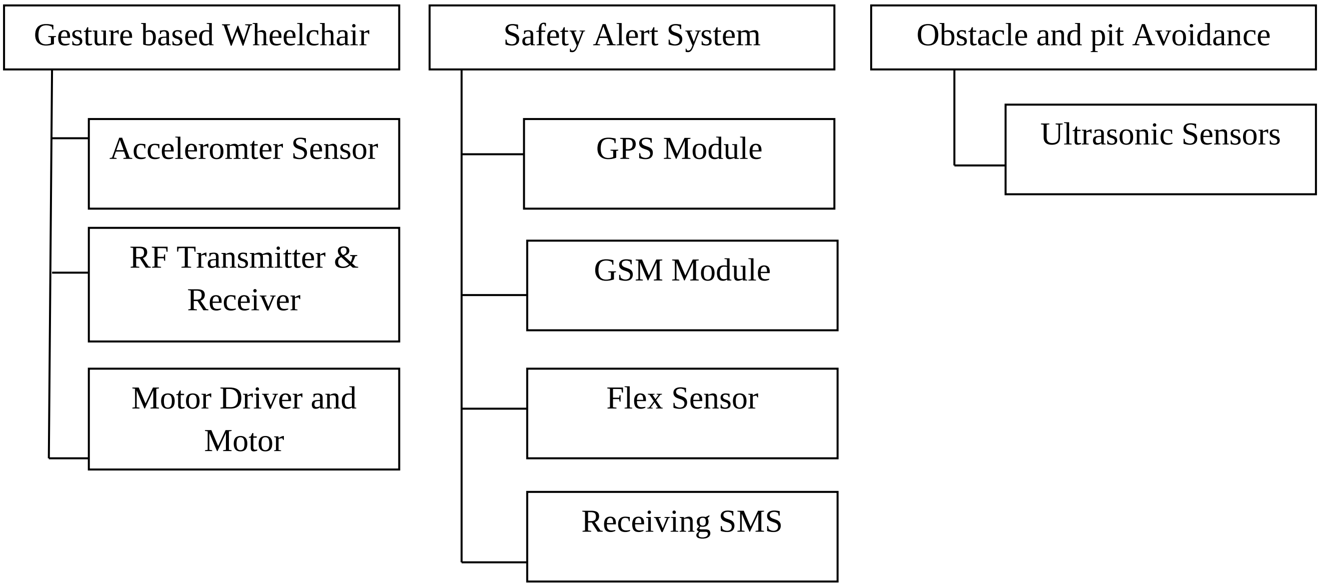


Fig. 5.7 Modules Hierarchy

- Gesture based Wheelchair-consists of both the Transmitting and the Receiving section, with accelerometer sensor at the transmitting end and motor driver and motors at the receiving end along with the RF Tx-Rx. All the components are operated by the Arduino UNO.
- The Safety Alert System consists of the triggering mechanism i.e. flex sensor and GPS module for gathering coordinates along with GSM module for wireless communication.
- The obstacle and pit avoidance module consists of all the distance measuring sensors.

5.3.2 Data Flow Diagrams

A Data Flow Diagram (DFD) is a graphical representation of the "flow" of data through an information system, modeling its process aspects. A DFD is often used as a preliminary step to create an overview of the system, which can later be elaborated. DFDs can also be used for the visualization of data processing (structured design).

A DFD shows what kind of information will be input to and output from the system, where the data will come from and go to, and where the data will be stored. It does not show information about the timing of process or information about whether processes will operate in sequence or in parallel.

Obstacle and Pit Avoidance Module

The Figure 5.6 shows the detection of obstacle. There is ultrasonic Sensor at the front and the back of the smart wheelchair. It has two pins trigger and echo. The ultrasonic waves are sent by trigger are hit to the obstacle and a wave in turn is received by echo when the obstacle is detected. It is notified using motor driver which reverses the direction of motion.

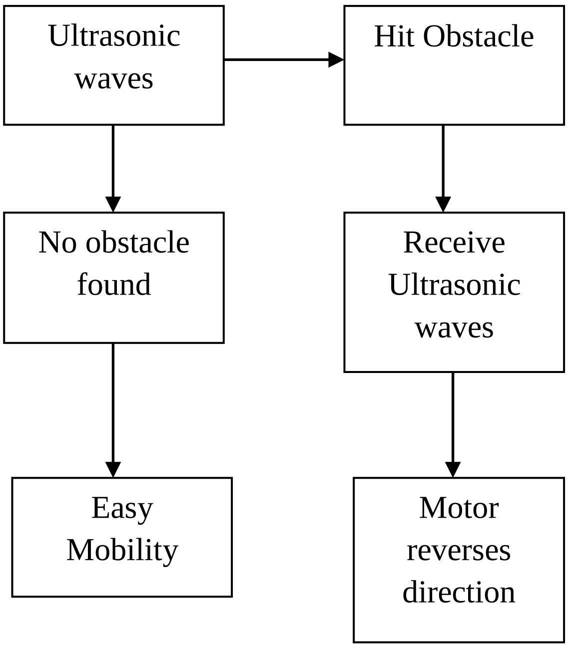


Fig. 5.8 DFD for obstacle and pit avoidance

Safety Alert System

The safety alert system starts with flex sensor as the triggering mechanism, data from GPS is continuously collected if flex value is found to be greater than threshold value then the GSM module gets triggered and the SMS is sent which can be viewed by the caretaker. Figure 5.7 shows the Data Flow Diagram.

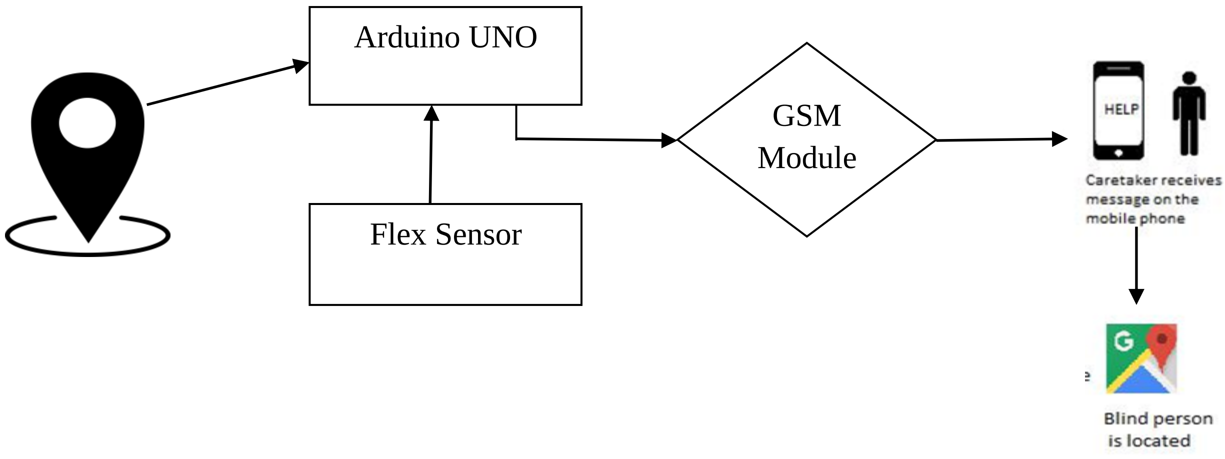


Fig. 5.9 DFD for Safety Alert System

Gesture based Wheelchair

The transmitter section consists of an accelerometer embedded glove, along with a RF communication mechanism. The Receiver which consists of RF Receiver and DC motor driver and motor gets operated on receiving the appropriate command from the transmitter.

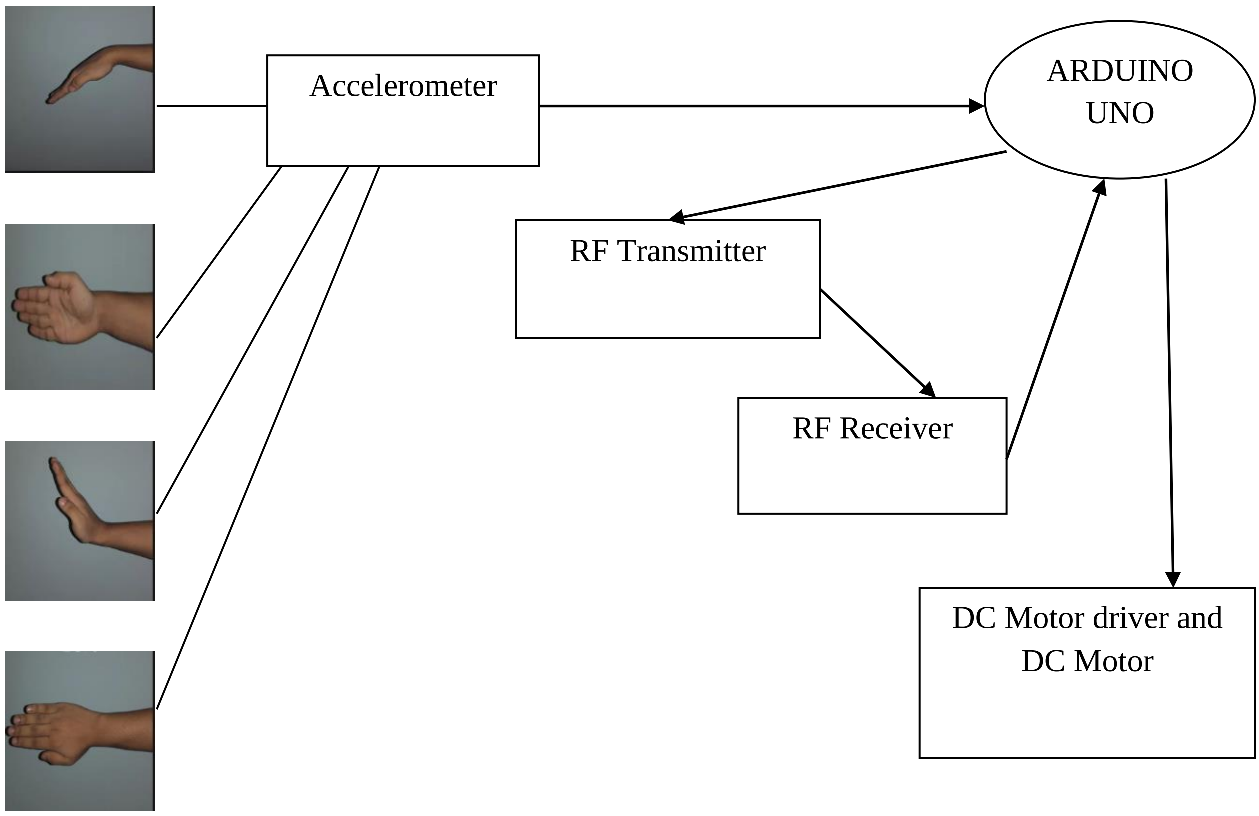


Fig. 5.10 DFD for Wheelchair operation

5.3.3 Sequence Diagrams

A Sequence diagram is an interaction diagram that shows how processes operate with one another and what is their order. It is a construct of a Message Sequence Chart. A sequence diagram shows object interactions arranged in time sequence. It depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. Sequence diagrams are typically associated with use case realizations in the Logical View of the system under development. Sequence diagrams are sometimes called event diagrams or event scenarios.

A sequence diagram shows, as parallel vertical lines (lifelines), different processes or objects that live simultaneously, and, as horizontal arrows, the messages exchanged between them, in the order in which they occur. This allows the specification of simple runtime scenarios in a graphical manner.

Gesture Based Wheelchair

The sequence diagram for this module is as follows.

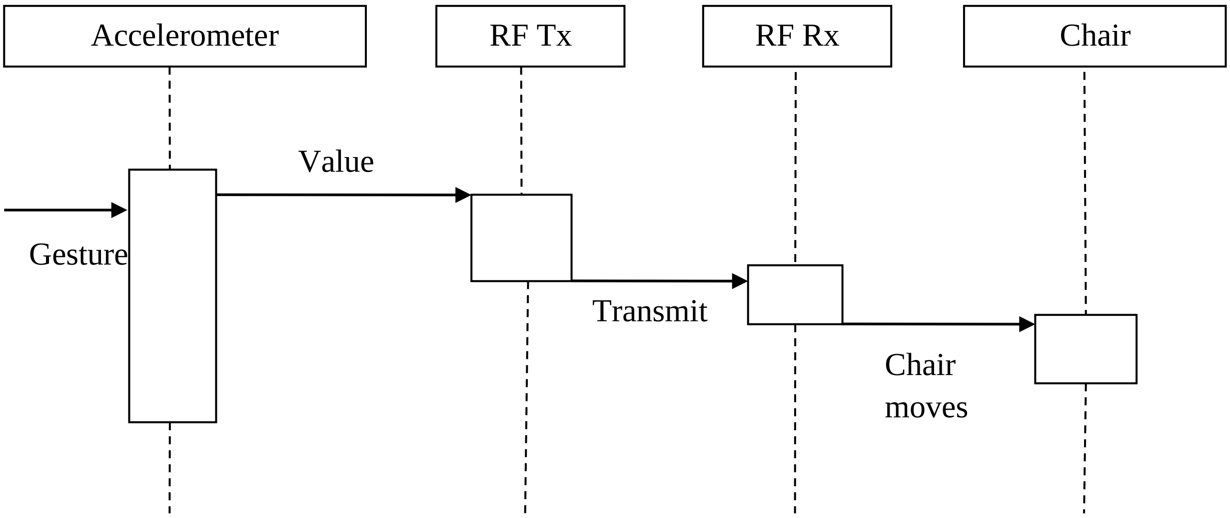


Fig. 5.11 sequence diagram for gesture recognition module

- The Accelerometer sensor senses gestures.
- The gesture values are then transferred wirelessly using RF transceiver.
- Chair receives these values and moves in that direction.

Safety Alert System

The sequence diagram for safety alert system is as follows.

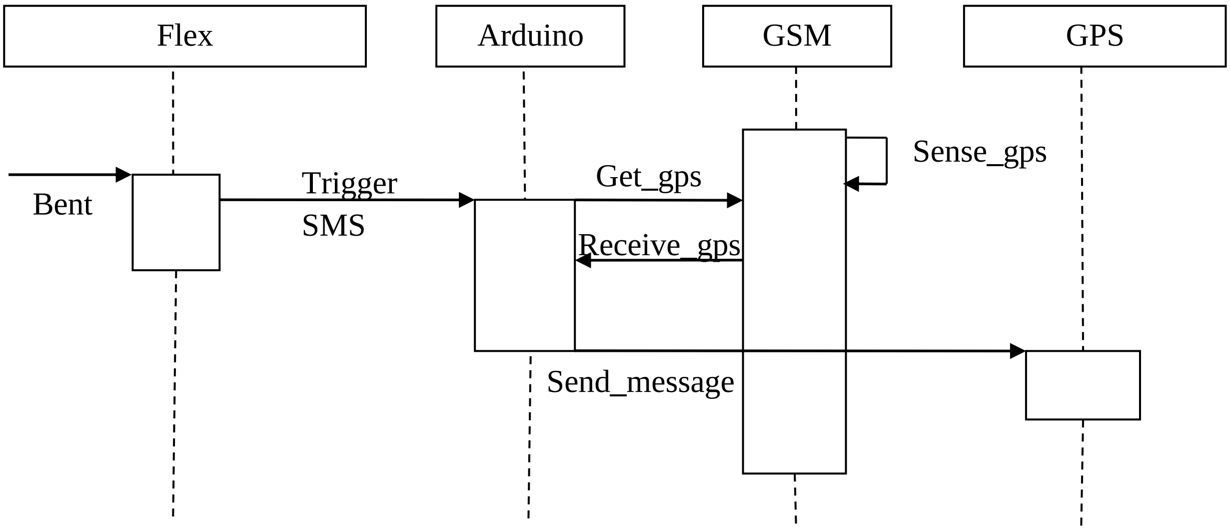


Fig. 5.12 sequence diagram for Safety Alert System

- The user bends the flex sensor, whenever the flex value exceeds the threshold value; the arduino is triggered to send a sms.
- The gps module continuously senses location.
- The arduino activates gps module which sends the message.

Obstacle and Pit Avoidance Module

The sequence diagram is as follows.

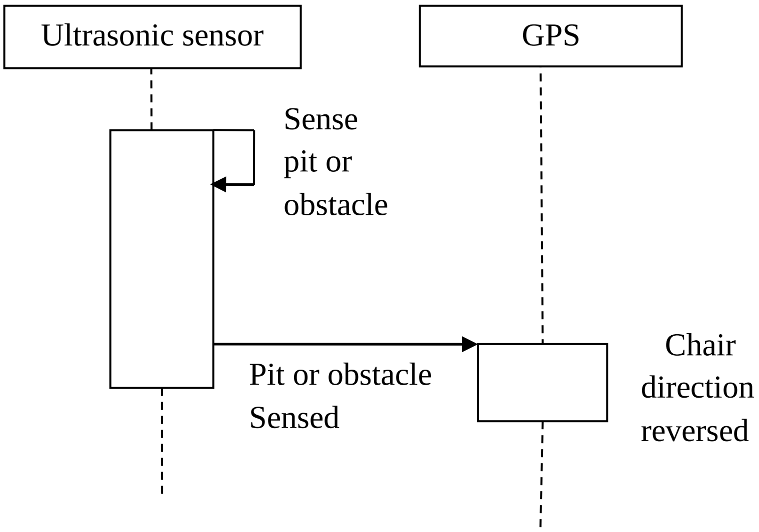
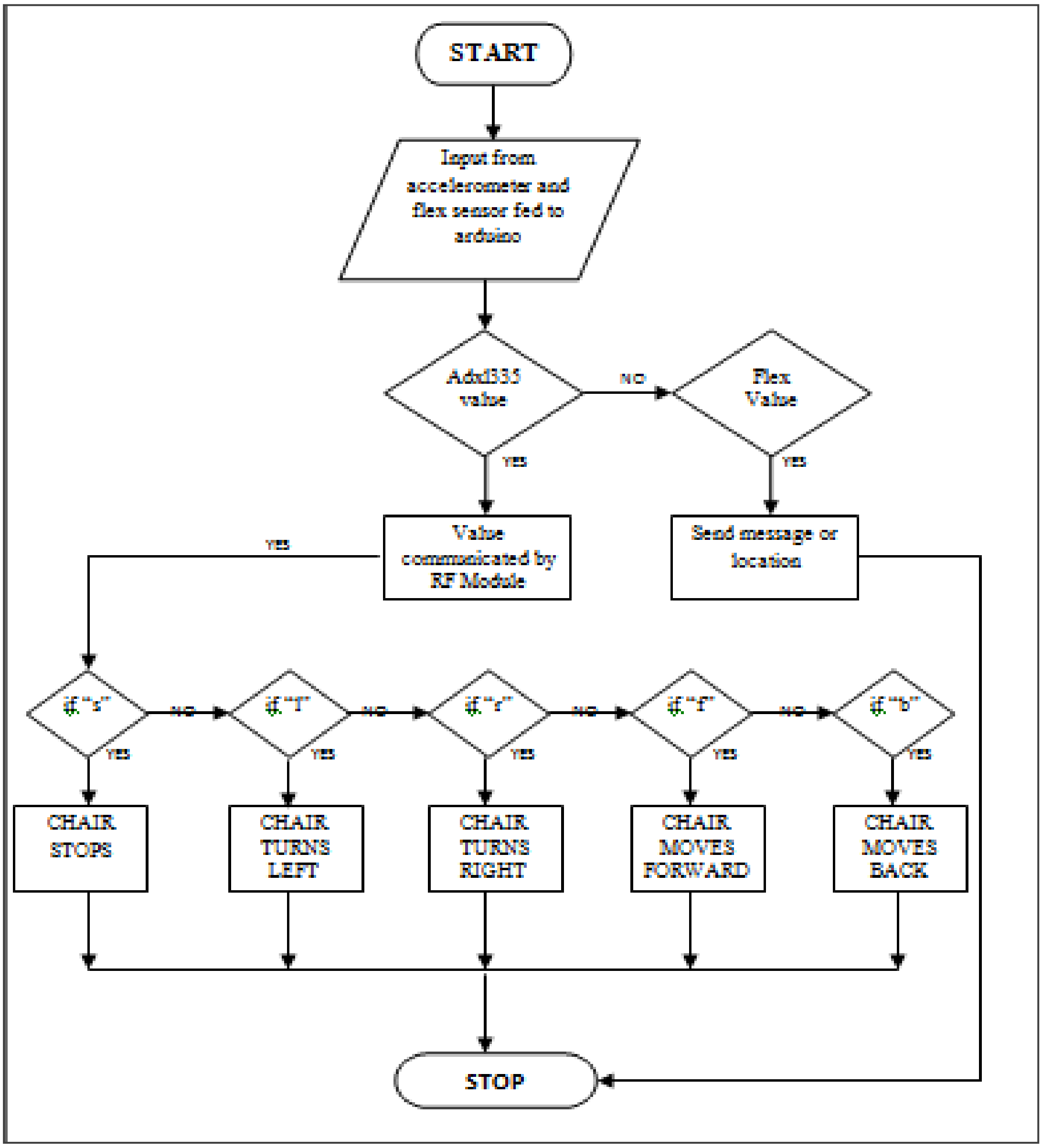


Fig. 5.12 sequence diagram for the pit and obstacle avoidance module

- The ultrasonic sensor continuously collects distance values
- If the value is found to be less than 20cm then the obstacle is sensed and the chair reverses direction of motion.
- For pit detection if the depth is found to be greater than 5cm then the direction of motion is reversed.

5.4 Flowchart



CHAPTER 6

IMPLEMENTATION

6.1 Gesture based Wheelchair

The system consists of a Transmitter and a Receiver Section. The right glove Transmitter section consists of an accelerometer and an RF transmitter integrated with arduino uno. The accelerometer measures the orientation of the hand in Triple Axis coordinates i.e. X, Y, Z axis. Since the motion is done in 2 dimensions hence only the X and Y axis coordinates are used. Tilting of hand along X axis causes forward or backward motion, whereas tilting hand along Y axis causes sideward motion. The accelerometer measures analog values which are sent to the arduino, the arduino uses inbuilt ADC (Analog to Digital Converter) to convert the incoming analog values to digital values. These values are further compared with the threshold values of all the four directions. If the measured value exceeds the threshold value then the arduino sends a one byte character (f, b, l, r) using the RF Transmitter. The following figure demonstrates the circuit.

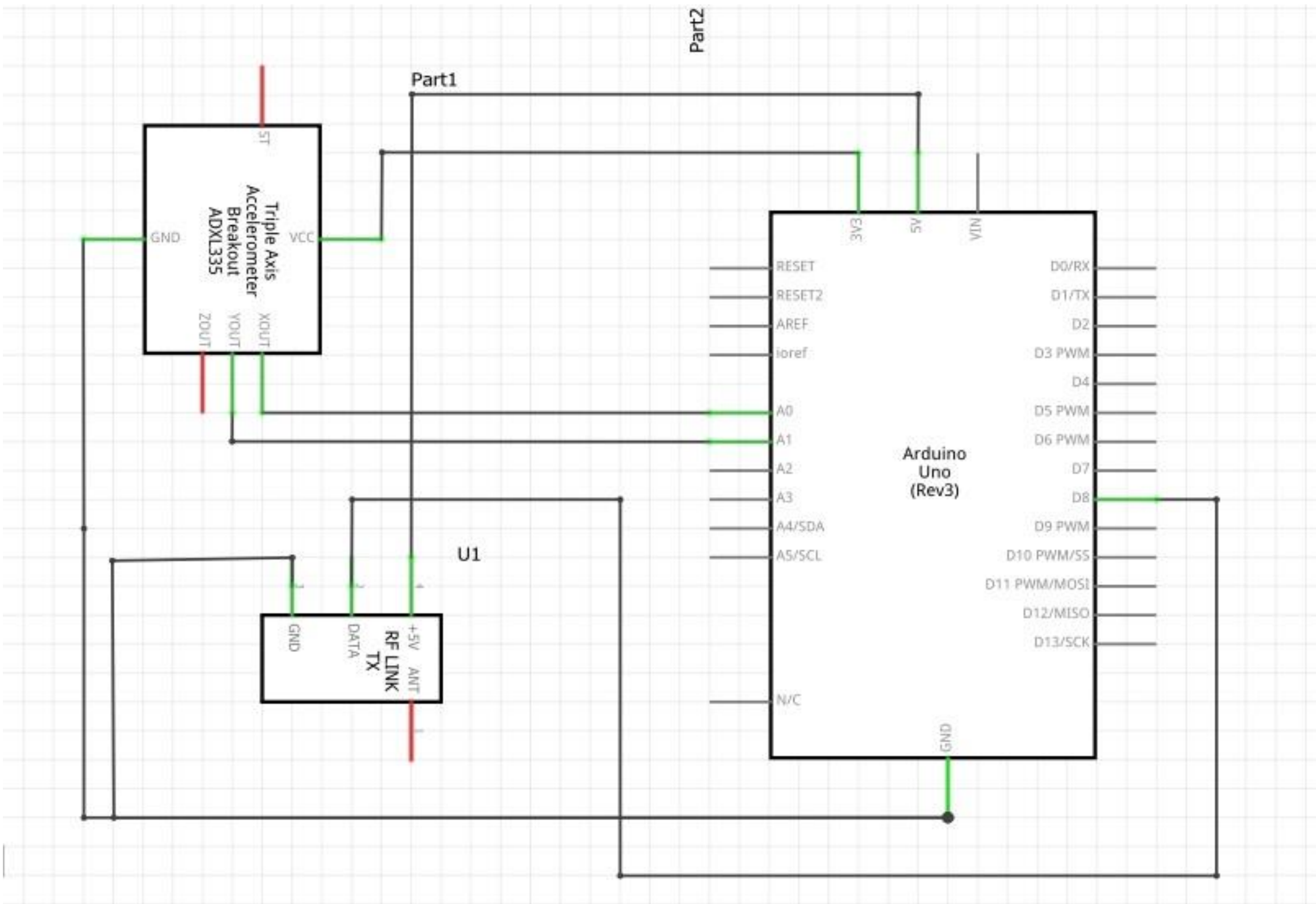


Fig. 6.1 Right Glove Transmitter Schema

The following code snippet is used to code the arduino.

```
xval=analogRead(xpin);
yval=analogRead(ypin);
xmap=xval/100;
ymap=yval/100;
if (xmap==4&&ymap==3) //forward(transmitter tilted forward)
   {
      digitalWrite(ledpin,HIGH);
      send("f");
      Serial.println("forward");
      }
if (xmap==2&&ymap==3) //backward(transmitter tilted backward)
   {
     digitalWrite(ledpin,HIGH);
     send("b");
     Serial.println("back");
     }
if (xmap==3&&ymap==4) //left(transmitter tilted to left)
  {
     digitalWrite(ledpin,HIGH);
     send("l");
     Serial.println("left");
    }
if (xmap==3&&ymap==2)//right(transmitter tilted to right)
   {
    digitalWrite(ledpin,HIGH);
    send("r");
    Serial.println("right");
    }
```

Fig. 6.2 Transmitter code

The Receiver section of the wheelchair receives the 1 byte command from the transmitter and sends it to the arduino, the RF tx-rx are able to function using the API's defined within the VirtualWire library. The library is included in the code. On receiving the command the motor driver accordingly operates the clockwise or anticlockwise motion of the DC Motor. When an f is received the motor driver sets the motors to clockwise motion, when b is received the motor driver sets motor to anticlockwise motion. Similarly on receiving an r the right motor is set low and the left motor is set in clockwise motion. On receiving an l the left motor is set low and the right motor is set in clockwise direction. The following code snippet demonstrates the operation.

```
if (buf[i]==0x73)//Stationary  {
        digitalWrite(lm,LOW);
        digitalWrite(lmr,LOW);
        digitalWrite(rm,LOW);
        digitalWrite(rmr,LOW);
       digitalWrite(ledPin,LOW); }
      else  {
        if(buf[i]==0x66)//Forward {
          digitalWrite(lm,HIGH);
          digitalWrite(lmr,LOW);
          digitalWrite(rm,HIGH);
          digitalWrite(rmr,LOW);
          digitalWrite(ledPin,HIGH);  }
        if (buf[i]==0x62)//Backward   {
          digitalWrite(lm,LOW);
          digitalWrite(lmr,HIGH);
          digitalWrite(rm,LOW);
          digitalWrite(rmr,HIGH);
          digitalWrite(ledPin,HIGH);  }
        if (buf[i]==0x6C)//Left          {
          digitalWrite(lm,LOW);
          digitalWrite(lmr,LOW);
          digitalWrite(rm,HIGH);
          digitalWrite(rmr,LOW);
          digitalWrite(ledPin,HIGH);  }
        if (buf[i]==0x72)//Right  {
          digitalWrite(lm,HIGH);
          digitalWrite(lmr,LOW);
          digitalWrite(rm,LOW);
          digitalWrite(rmr,LOW);
          digitalWrite(ledPin,HIGH); } }
```

Fig 6.3 Receiver Code

In the above code he incoming characters are stored in a buf [] and are compared against there hexadecimal value. The following figure depicts the circuit of the receiving section consisting of the receiver, the motor driver and DC motors.

6.2 Safety Alert System

The safety alert system is important because it becomes necessary for the patient to convey his needs to other people. The patient might not have a distinctive speech or might be mute in such cases all that patient has to do his bend his fingers. The left glove transmitter section consists of flex sensors stuck on the fingers whenever the patient is in the house and needs assistance, he bends one of his fingers, and this triggers the GSM module to send an SMS to the caretaker. The SMS states “I’m at home, I need assistance”. If the patient is out and is stuck or has lost his way, all he needs to do his bend another flex sensor and this sends the GPS coordinates to the caretaker. The GPS module of the transmitter always collects the GPS coordinates in the form of NMEA sentences which are parsed using TinyGPS library, the only useful sentence amongst those NMEA sentences are $GPRMC which consists of the latitude and longitude. On receiving a flex value which is greater than the threshold value the GSM sends these coordinates to the caretaker. The SMS states “I need help-I’m here-<Google maps link>”. Whenever $GPRMC is followed by V this means that the latitude and longitude collected are not reliable, and when it is followed by A then the latitude and longitude are correct. The following statement is an example of the $GPRMC sentence.

$GPRMC,170330.263,A,1252.7153,N,07732.8123,E,1.25,233.91,270418,,,A*66

The GSM Module (SIM900) takes 2-3 seconds to register to a network, we use AT commands to access the functionality of the GSM module. The module needs to have a sim card inserted in it in order to make calls or receive messages, the module supports GPRS using which 3g sim card could be used in the module. The following snippet shows the AT commands used to send text messages to the caretaker.

```
Gsm.print("AT+CMGF=1\r");
Gsm.print("AT+CMGS=\"+91xxxxxxxxxx"\"”);
Gsm.print("I'm at home, I need assistance");
Gsm.println((char)26); // End AT command with a ^Z, ASCII code 26
```

Fig. 6.4 Gsm Code

The following code snippet shows how the GPS coordinates are sent as an SMS to the assistant.

```
Flexval=AnalogRead(flexpin);
while (Serial.available()) {
  char c = Serial.read();
  Serial.print(c);
  if (gps.encode(c))
  newData = true;   }
if (newData && (flexval<=25 && flexval>20))      //If newData is true {
float flat, flon;
unsigned long age;
gps.f_get_position(&flat, &flon, &age);
Gsm.print("AT+CMGF=1\r");
Gsm.print("AT+CMGS=\"+91xxxxxxxxxx"\’”);
Gsm.print("I need help-I'm here-");
Gsm.print("http://maps.google.com/maps?q=loc:");
 // Gsm.print("Latitude = ");
Gsm.print(flat == TinyGPS::GPS_INVALID_F_ANGLE ? 0.0 : flat, 6);
//Gsm.print(" Longitude = ");
Gsm.print(",");
Gsm.print(flon == TinyGPS::GPS_INVALID_F_ANGLE ? 0.0 : flon, 6);
Gsm.println((char)26); // End AT command with a ^Z, ASCII code 26
  }
```

Fig. 6.5 Gps Code

The following schematic shows how the safety critical system is integrated.

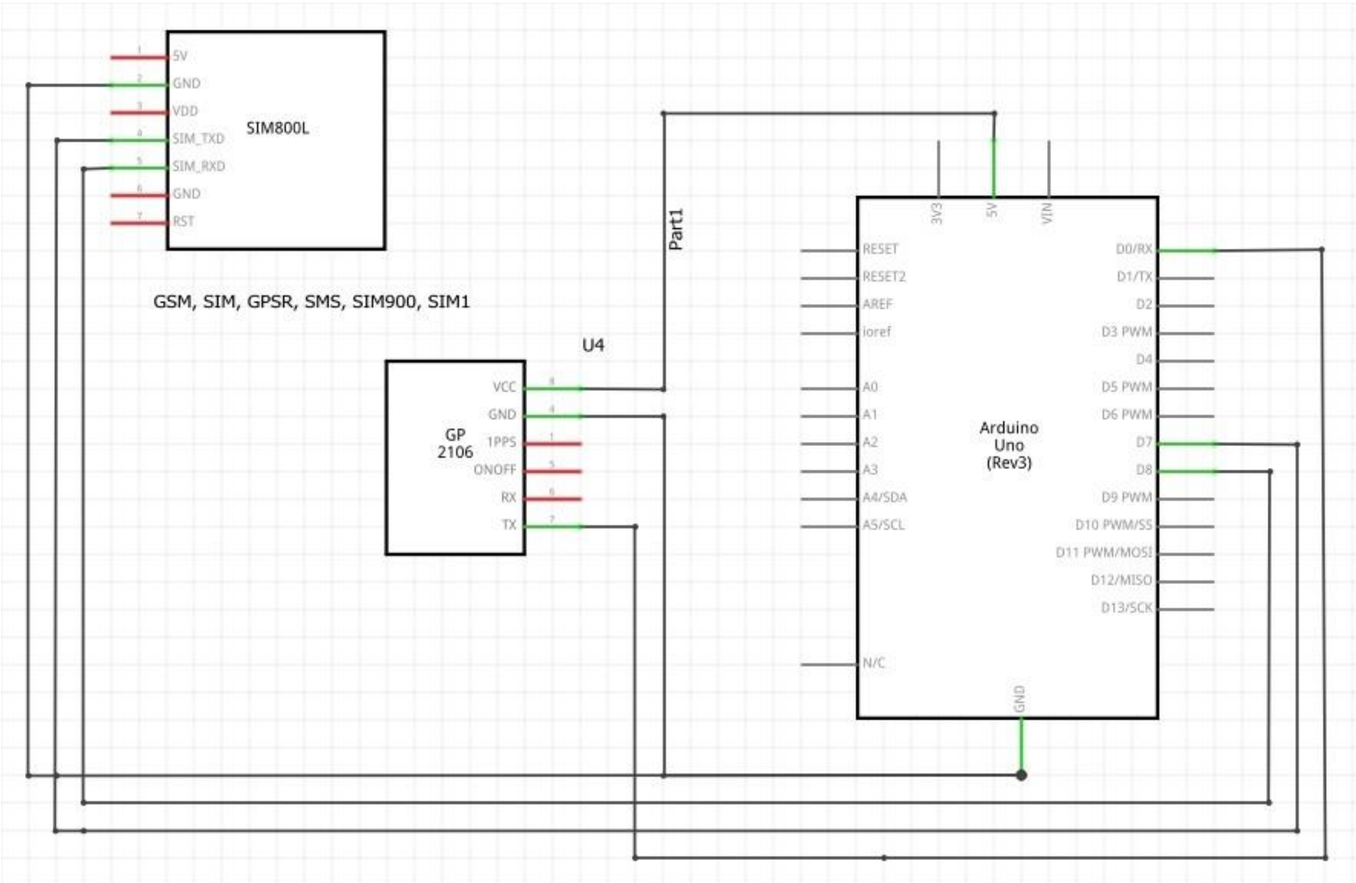


Fig. 6.6 Safety Critical System Circuit

6.3 Obstacle Detection

The developed wheelchair consists of mechanism which can prevent the system from colliding with an obstacle or falling into a pit. There are 2 ultrasonic sensors located at the front of the wheelchair and 2 at the back. The ultrasonic sensor in the front continuously measures the distance, if the distance from an obstacle is found to be less than 20cm then the wheelchair moves backward and continues to do so until the distance is greater than 20, the same mechanism is carried out by the ultrasonic sensor at the back except in this case the chair moves forward and continues to do so until the distance is greater than 20. For pit detection the sensor points downwards and continuously measures the distance from the ground, if the distance is found to be greater than 5, then a pit is detected, wheelchair avoids it by continuously moving back until the distance from the ground is constant, the sensor at the back makes the chair move forward to avoid the pit. In this way any obstacle or a pit is avoided and the patient is saved from all the dangers.

The following snippet shows the working of the sensors.

```
 digitalWrite(triggerPin, HIGH);
 delay(10);
 digitalWrite(triggerPin, LOW);
 duration = pulseIn(echoPin, HIGH);
 distance = (duration/2) / 29.1;
if(distance<20||distancepit>5){
            digitalWrite(lmr,HIGH);
            digitalWrite(rmr,HIGH);
            digitalWrite(lm,LOW);
            digitalWrite(rm,LOW); }
```

Fig. 6.7 Ultrasonic Sensor Code

The following diagram demonstrates the receiver section of the wheel chair.

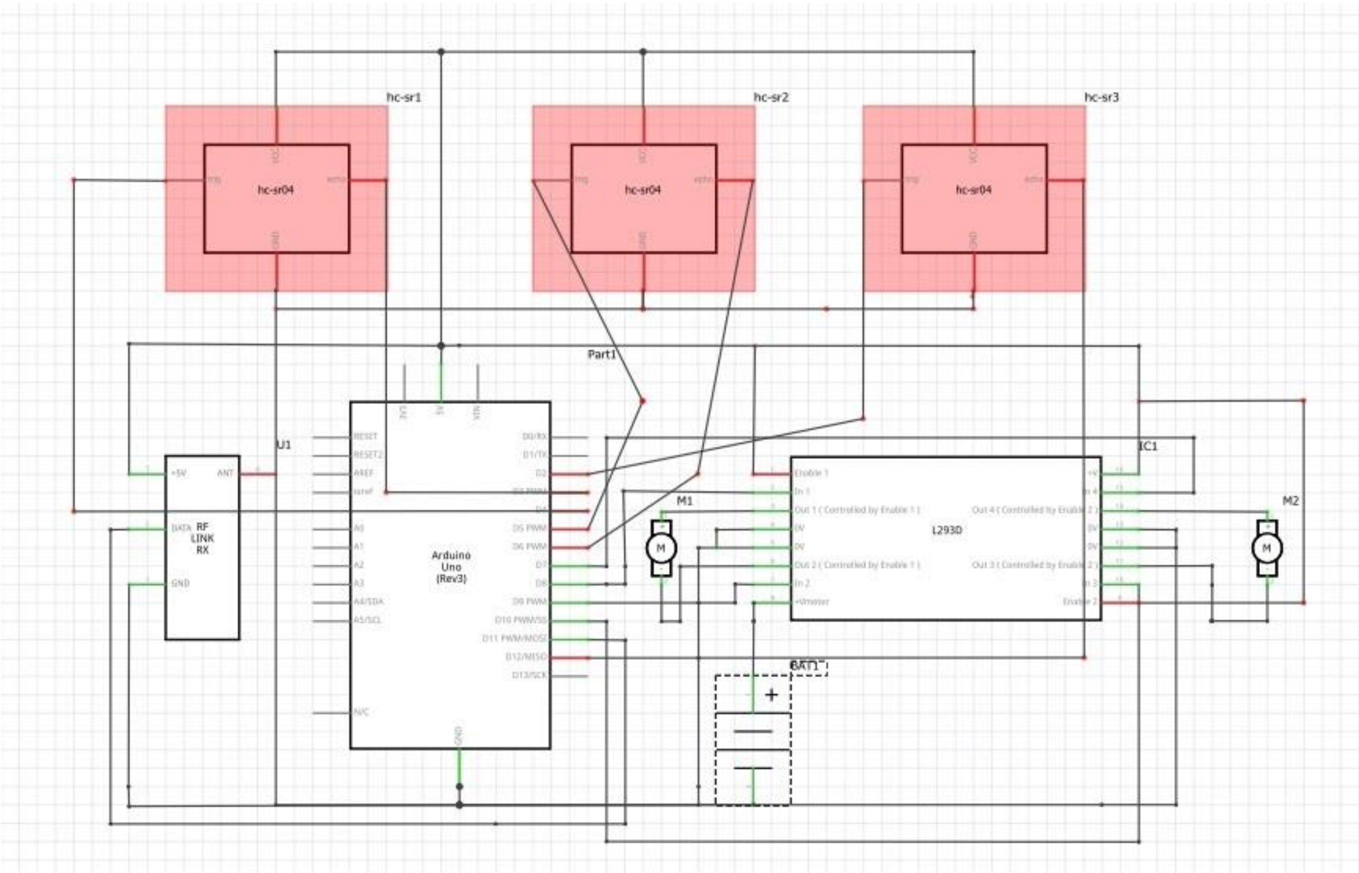


Fig. 6.8 Receiver schema

6.4 Downloading Arduino Software

Arduino is open-source software which can be downloaded from the website Arduino.cc. Arduino software supports various platforms such as Windows, Mac, Linux etc. There are various versions of Arduino software. If there is any problem with current version of software, the previous version of the software can be downloaded and still if the problem is there in the software, help can be taken from Arduino community.

6.5 Uploading the Code

Once the code is written, Arduino mega is connected to the system such that the type of Arduino version is selected (in this case, Arduino Mega). The port to which the Arduino is connected is also selected. Once all this is done, the code is compiled and is checked for errors. If any error found then the error is debugged such that the compiled code is error free. When the code has successfully compiled, then the code is uploaded in the Arduino. Figure 6.5 shows Arduino mega which will be used for the project.

Fig 6.9. Uploading Code on Arduino

CHAPTER 7

TESTING

Testing is the process of examining an application to ensure it fulfils the requirements for which it was designed and meets quality expectations. More importantly, testing ensures the application meets customer expectations. The aim of testing stage is to discover defeats/errors by testing individual program components. These components may be functions, objects or modules. During system testing, these components are integrated to form the complete system. At this stage, testing should focus on establishing that the system meets its functional requirements, and does not behave in unexpected ways. Test data are inputs which have been devised to test the system whereas test cases are inputs to test the system and the outputs are predicted from these inputs if the system operates according to its specification.

Several factors contribute to the importance of making testing a high priority of any software development effort. These include:

- Reducing the cost of developing the program. Minimal savings that might occur in the early stages of the development cycle by delaying testing efforts are almost certainly bound to increase development costs later. Common estimates indicate that a problem that goes undetected and unfixed until a program is actually in operation can be 40 – 100 times more expensive to resolve than resolving the problem early in the development cycle.
- Ensuring that the application behaves exactly as you explain to the user. For the vast majority of programs, unpredictability is the least desirable consequence of using an application.
- Reducing the total cost of ownership. By providing software that looks and behaves as shown in your documentation, your customers require fewer hours of training and less support from product experts.
- Developing customer loyalty and word-of-mouth market share. Finding success with a program that offers the kind of quality that only thorough testing can provide is much easier than trying to build a customer base on buggy and defect-riddled code.

7.1 Types of Testing

There are various types of testing, explained in the following sections.

7.1.1 Black Box Testing

Black-box testing is a method of software testing that examines the functionality of an application without peering into its internal structures or workings. This method of test can be applied to virtually every level of software testing: unit, integration, system and acceptance.

Specific knowledge of the application's code/internal structure and programming knowledge in general is not required. The tester is aware of what the software is supposed to do but is not aware of how it does it. For instance, the tester is aware that a particular input returns a certain, invariable output but is not aware of how the software produces the output in the first place. Typical black-box test design techniques include:

• Decision table testing

• All-pairs testing

• Equivalence partitioning

• Boundary value analysis

• Cause–effect graph

• Error guessing

7.1.2 White Box Testing

White-box testing (also known as clear box testing, glass box testing, transparent box testing, or structural testing) is a method of testing software that tests internal structures or workings of an application, as opposed to its functionality as in Black Box Testing. The various levels of White box testing are:

• **Unit testing:** White-box testing is done during unit testing to ensure that the code is working as intended, before any integration happens with previously tested code. White-box testing during unit testing catches any defects early on and aids in any defects that happen later on after the code is integrated with the rest of the application and therefore prevents any type of errors later on.

• **Integration testing:** White-box testing at this level is written to test the interactions of each interface with each other. The Unit level testing made sure that each code was tested and working accordingly in an isolated environment and integration examines the correctness of the behavior in an open environment through the use of white-box testing for any interactions of interfaces that are known to the programmer.

• **Regression testing:** White-box testing during regression testing is the use of recycled white-box test cases at the unit and integration testing levels.

7.2Unit Testing

Unit testing is the process of testing individual components in the system. This is a defect testing process, so its goal is to expose faults in these components. The primary goal of unit testing is to take the smallest piece of testable software in the application, isolate it from the remainder of the code, and determine whether it behaves exactly as expected. Each unit is tested separately before integrating them into modules to test the interfaces between modules.

If Unit Testing is not performed and the whole system is tested at once it'll be very hard to find where actually the defect comes from. For example, if we have two units and decide it would be more cost effective to glue them together and initially test them as an integrated unit, an error could occur in a variety of places:

- Is the error due to a defect in unit 1?
- Is the error due to a defect in unit 2?
- Is the error due to defects in both units?
- Is the error due to a defect in the interface between the units?
- Is the error due to a defect in the test?

Finding the error (or errors) in the integrated module is much more complicated than first isolating the units, testing each, then integrating them and testing the whole. Individual functions or methods are the simplest type of component and our tests are a set of calls to these routines with different parameters.

SI No. of Test Case	01
Name of test	Test Case for proper Gesture Recognition by the wheelchair
Feature being tested	The Accelerometer and the RF communication
Sample Input	Hand tilted in all the 4 directions
Expected Output	Wheelchair moving in all the 4 directions.
Actual output	Same as Expected.
Remarks	Test passed.

Table 7.1 Test Case for proper Gesture Recognition by the wheelchair

In the table 7.1, In this particular test case the wheelchair should successfully obey all the commands sent from the transmitter section and should move in those directions. When tested, the expected and the actual output were the same. So, the test case execution was successful.

Fig. 7.1 Gesture to move Forward

Fig. 7.2 Gesture to stop

Fig. 7.3 Gesture to move back

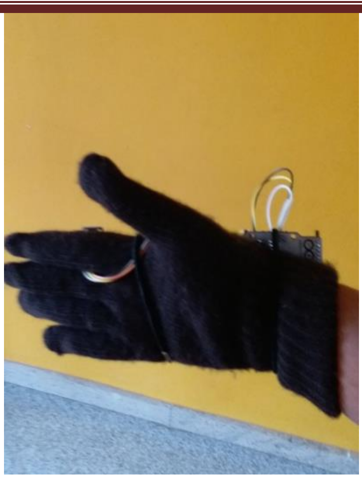


Fig. 7.4 Gesture to move Right

Fig. 7.5 Gesture to move Left

SI No. of Test Case	02
Name of test	Test Case for Obstacle and Pit Avoidance
Feature being tested	Distance measuring sensor
Sample Input	Analog values generated by the sensor when the wheelchair is moving
Expected Output	Successfully avoiding collision and falling in a pit
Actual output	Same as Expected.
Remarks	Test passed.

Table 7.2 Test case for Obstacle and Pit Avoidance

In the table 7.2, the test case shows how the wheelchair should behave whenever it approaches any obstacle or a pit, if any of them lies ahead of the wheelchair then the sensor should detect it and keep the wheelchair from moving forward, the same mechanism should be observed when the obstacle lies behind the chair in that case the sensor should keep the chair from moving back. When tested, the expected and the actual output were the same. So, the test case execution was successful.

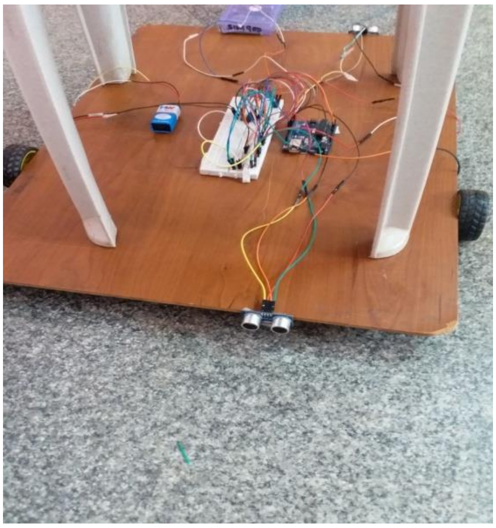


Fig. 7.6 Sensor at the back of the chair

Fig. 7.7 Sensors at the front of the chair for obstacle and pit avoidance

SI No. of Test Case	03
Name of test	Test Case for safety critical system
Feature being tested	To test the left glove transmitting Section
Sample Input	Value generated by the flex sensor and the GPS module
Expected Output	SMS received by the caretaker
Actual output	Same as Expected.
Remarks	Test passed.

Table 7.3 Test case for safety critical system

In the table 7.3, in this test case, an SMS should be sent whenever the flex sensor is bent. We should obtain proper SMS whenever the safety critical system is operated. When tested, the expected and the actual output were the same. So, the test case execution was successful.

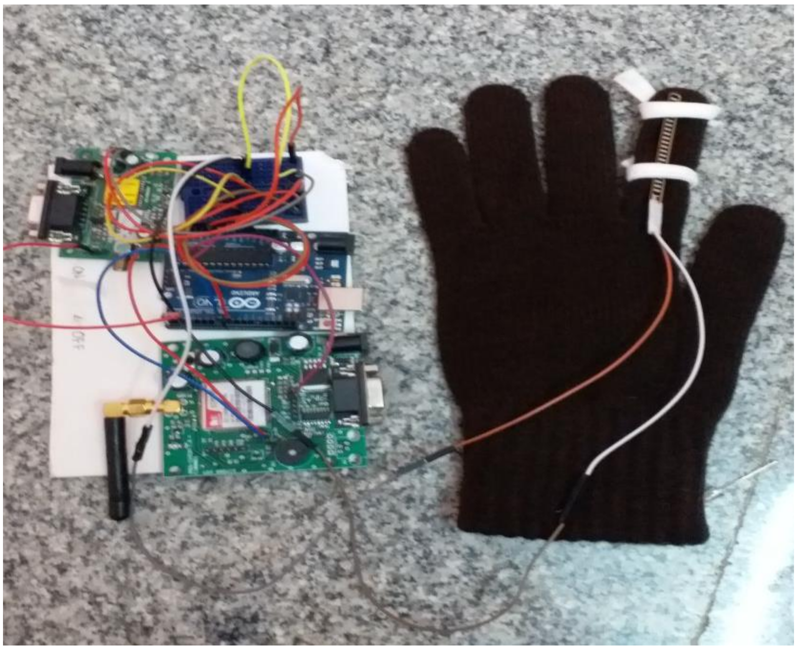


Fig. 7.8 safety critical system

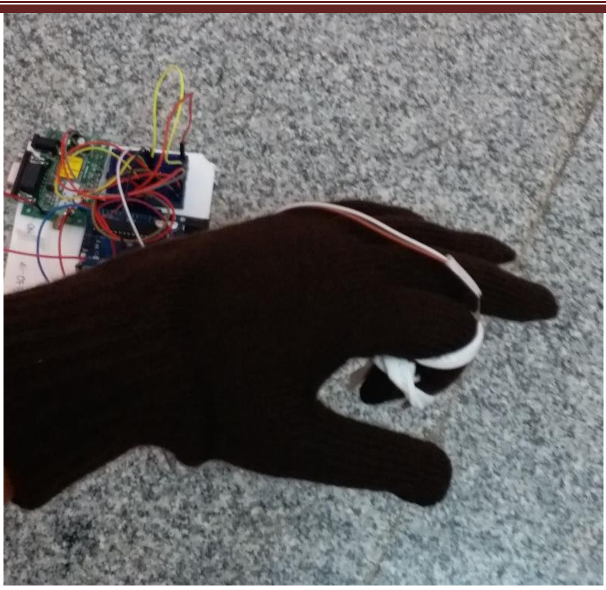


Fig. 7.9 bending of flex sensor

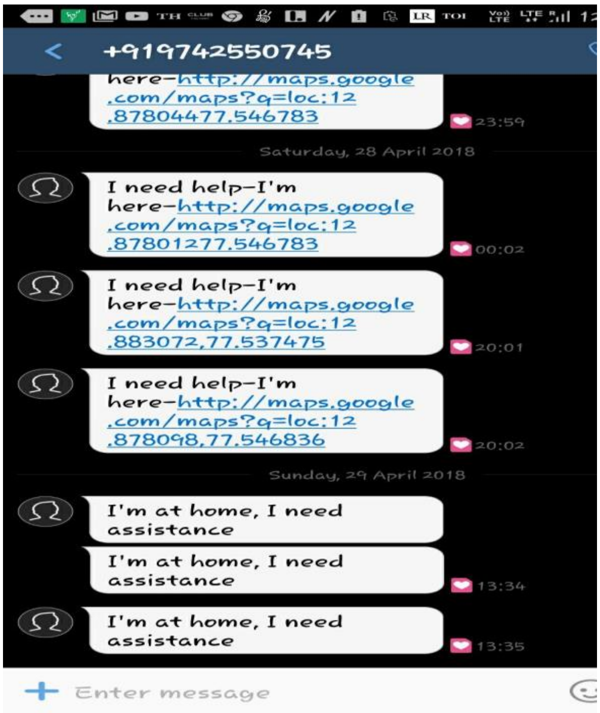


Fig.7.10 receiving SMS

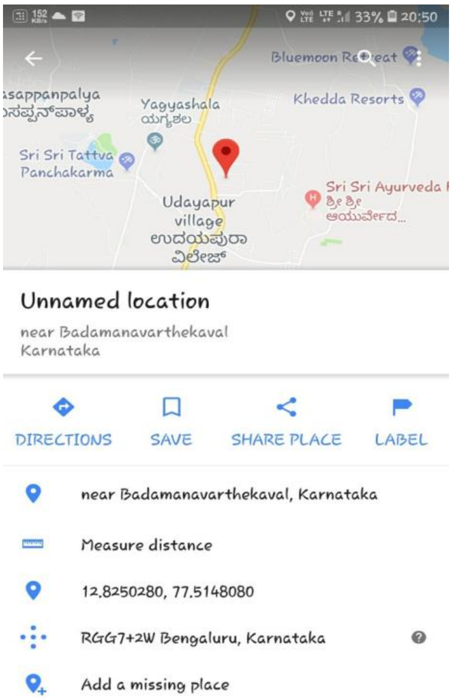


Fig. 7.11 Mapping location on Google Maps

7.3 Integration Testing

Integration testing (sometimes called integration and testing, abbreviated I&T) is the phase in software testing in which individual software modules are combined and tested as a group. It occurs after unit testing and before validation testing. Integration testing takes as its input modules that have been unit tested, groups them in larger aggregates, applies tests defined in an integration test plan to those aggregates, and delivers as its output the integrated system ready for system testing.

On integrating all the individual modules together there wasn't any errors and the system was working according to the expectations. In our project unit testing and integration testing have the same test cases.

7.4 Functional Testing

Functional testing is a quality assurance (QA) process and a type of black box testing that bases its test cases on the specifications of the software component under test. Functions are tested by feeding them input and examining the output, and internal program structure is rarely considered. Functional testing usually describes what the system does. The table 7.4 shows the various functional test cases.

Test ID	Components	Test Case	Expected Output	Actual Output	Results
4	Ultrasonic Sensors	Should detect obstacles and pits	The chair should reverse its direction of movement	The chair reverses its direction	pass
5	Rf TX-RX	Should send values from transmitter to receiver	The right glove transmits and the chair receives	Same as the expected output	pass
6	Accelerometer	Gesture Sensing	Gesture values should be recorded and sent to arduino	Same as the expected output	pass
7	DC Motor and Motor driver	Chair movement	Should receive the commands from arduino and should move the chair	Same as the expected output	pass
8	GPS Module	Location detection	Should send the gps coordinates to arduino	Same as the expected output	pass
9	GSM Module	Sending message	Should send message to the caretaker with location	Same as the expected output	pass

10	Flex Sensor	Raising distress call	When bent by the user gsm should be triggered to send the message	Same as the expected output	pass

Table 7.4 Functional Testing and Results

7.5 System Testing

System testing of software or hardware is testing conducted on a complete, integrated system to evaluate the system's compliance with its specified requirements. System testing falls within the scope of black box testing, and as such, should require no knowledge of the inner design of the code or logic. The system testing should be done in the end user’s point of view. The table 7.5 shows the various system test cases.

Test ID	**Components**	**Test Case**	**Expected Output**	**Actual Output**	**Results**
11	Working of smart wheelchair	Functionalities executed by the chair	The chair should sense gestures made by the user and should move in that direction, should sense all the obstacles and pit, should send the distress message.	Same as expected output	pass

Table 7.5 System Testing and Results

Chapter 8

RESULTS

8.1 Results

All the test cases covered in the previous section demonstrate that we have successfully made a smart wheelchair which aids in mobility of the paralytic patient. The patient becomes self sufficient to loco mote from one point to another, as a result of which he gains confidence and becomes independent. Such kind of system is necessary to boost the confidence of a paralytic patient. The wheelchair moves accordingly by sensing the gestures made by the user, it effectively avoids any pit or obstacle and also informs the caretaker about the whereabouts of the patient.

8.2 Applications

The application of this system is 3 fold

- It can be used by all the quadriplegic patient, if the patient faces difficulty in operating the glove then the section could be integrated onto the back of his head, which could be tilted to move the wheelchair.
- The wheelchair could be effectively used by all the patients who are currently suffering and are trying to get better through medication.
- The wheelchair could be used by the elderly at home or all the people at old age homes.

Chapter 9

CONCLUSION & FUTURE ENHANCEMENT

9.1 Conclusion

We conclude this topic by stating that it is just not right to neglect that section of the society who is disabled and who can't make use of their limbs or any body part. Being a part of the same society it is our responsibility to come out with such inventions by adopting technologies like Internet of Things which could ease the life of those people and assist them in mobility.

This project is one step towards fulfilling that responsibility.

9.2. Future Enhancement

We can improve the system by implementing voice guided navigation from one place to another. The system could be made more efficient if we could control the speed of the motor. Image processing technology could be adopted which can scan the area for any obstacle or a pit, using this we don't have to rely on the sensors. Moreover we can enhance the wheelchair by integrating a feature for moving it along the stairs.

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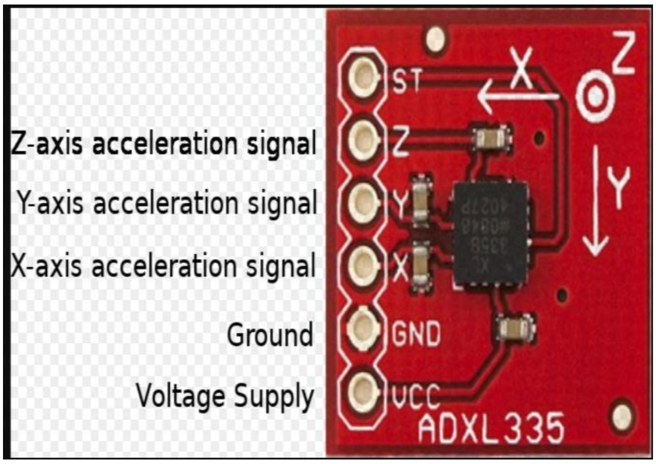
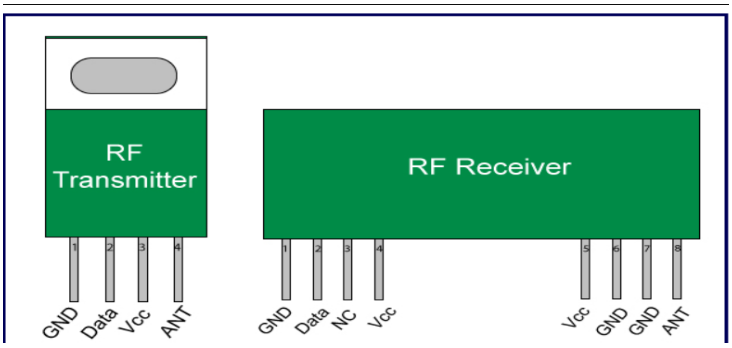
APPENDIX-A

Snapshots

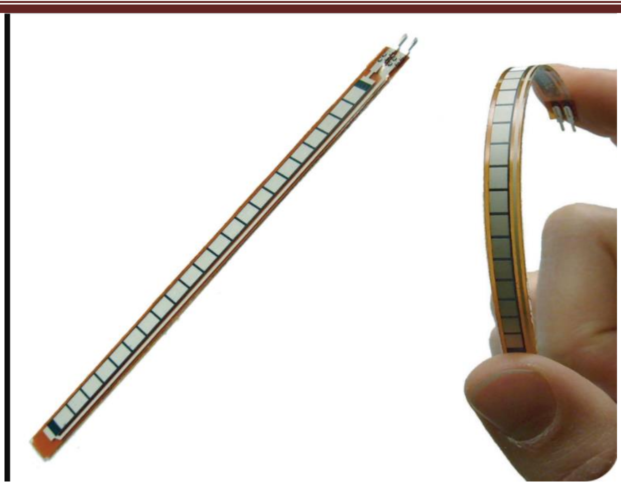


Accelerometer

Ultrasonic Sensor



RF Tx-Rx

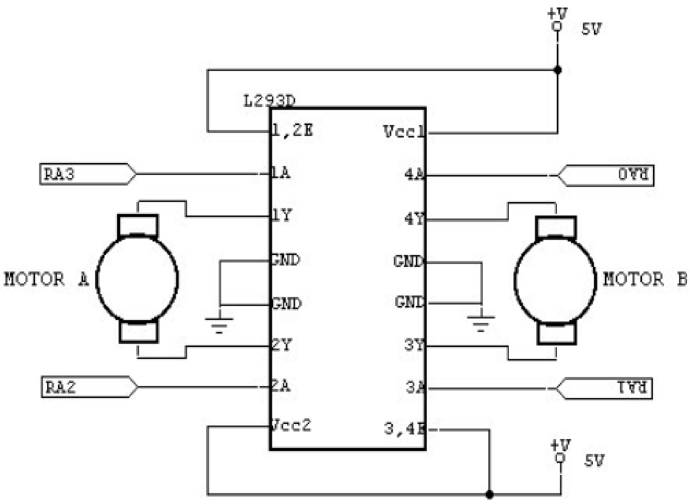


Flex Sensor

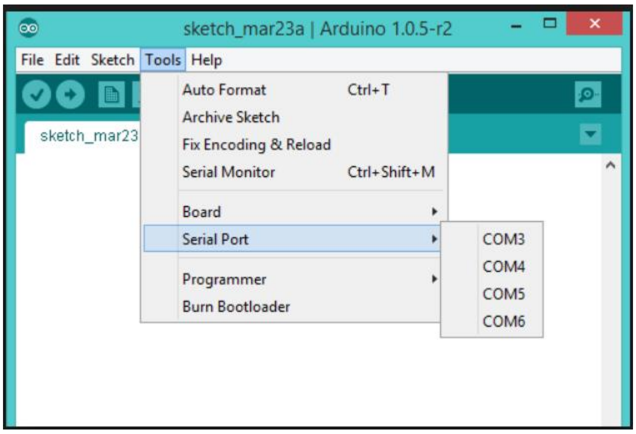
GPS Module

DC Motor

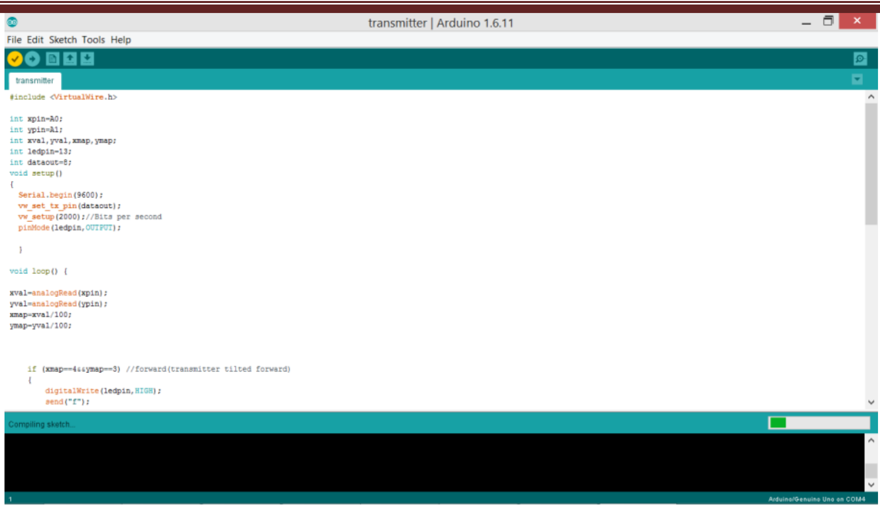
GSM Module



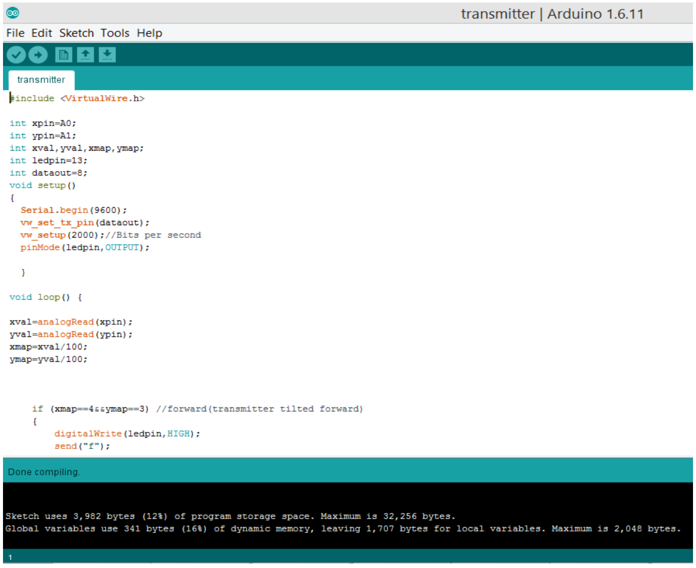
L293D Motor Driver



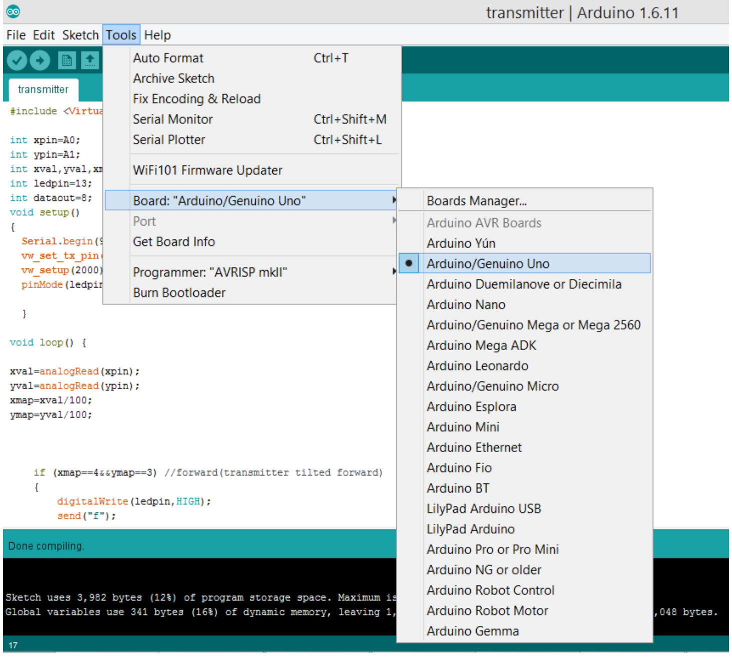
Arduino port



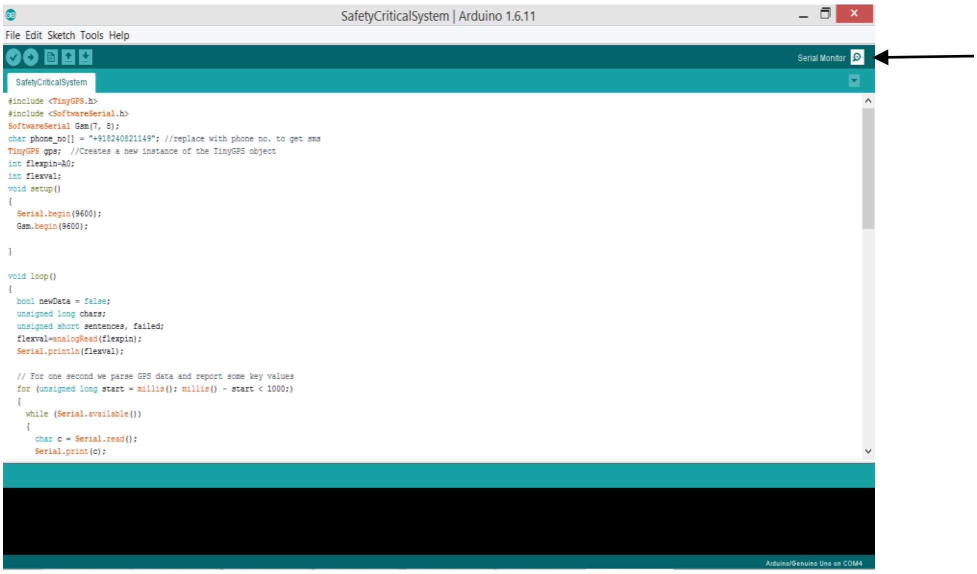
Arduino code verification



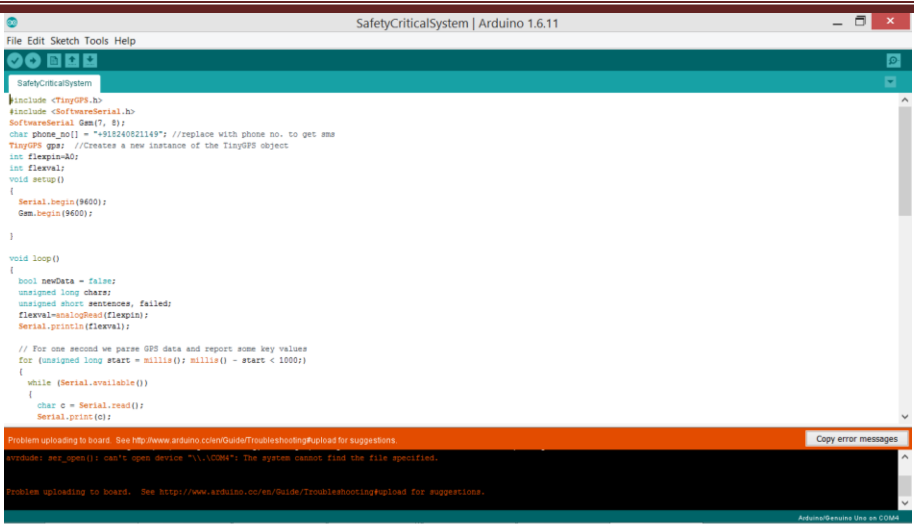
Arduino code compiling and upload



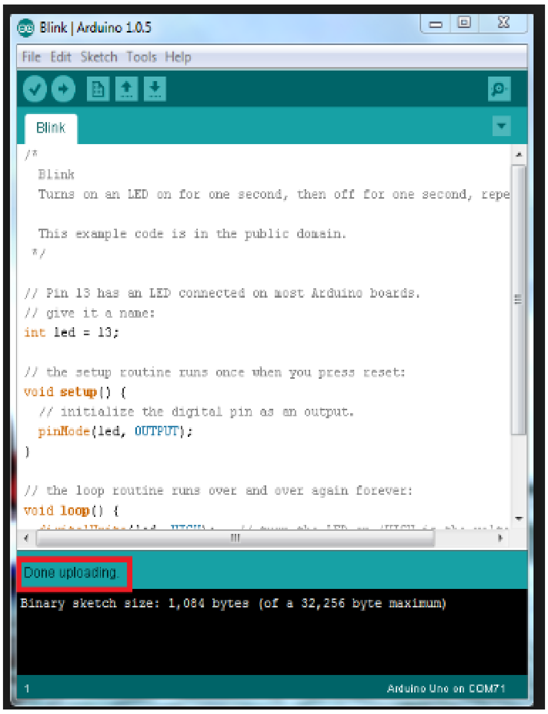
Arduino board selection



Arduino serial monitor

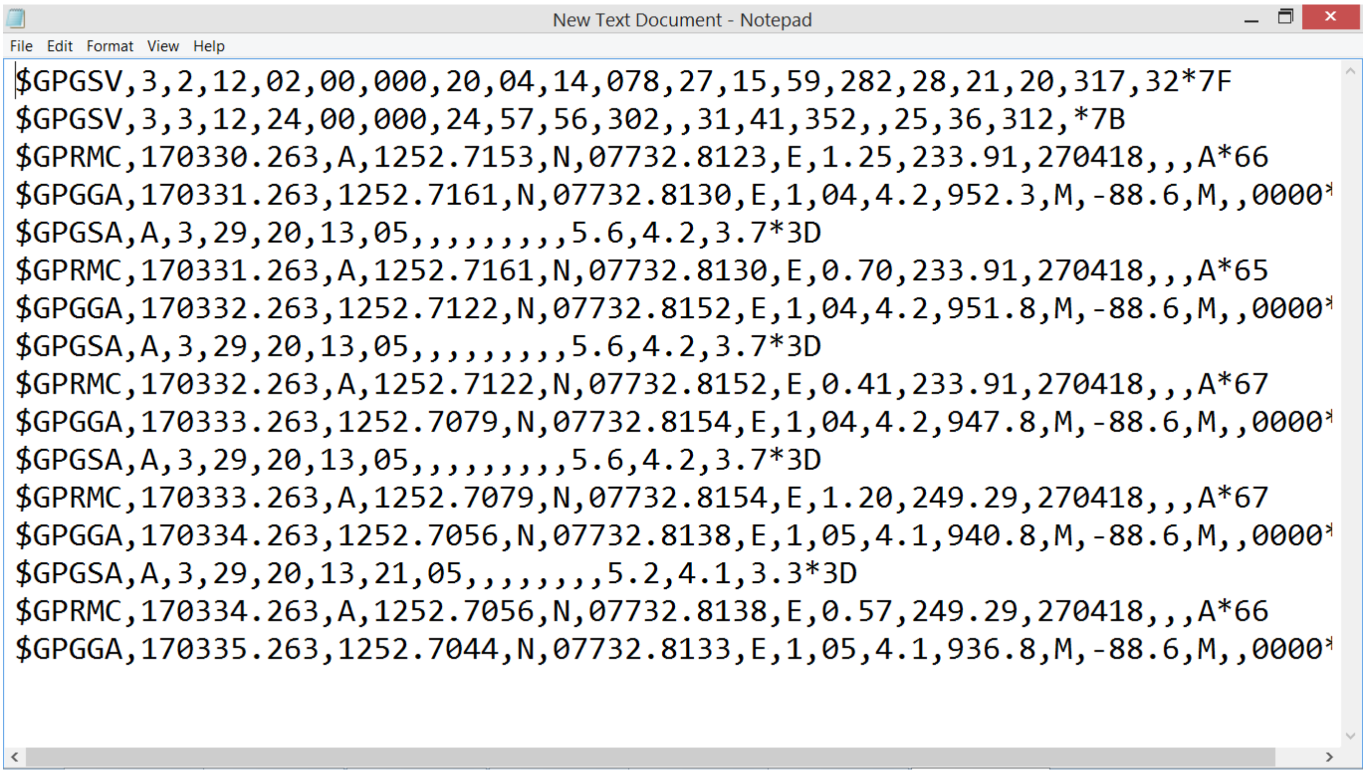


Arduino code upload (ERROR)



Arduino code upload (successful)

Arduino UNO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File Edit Format View Help

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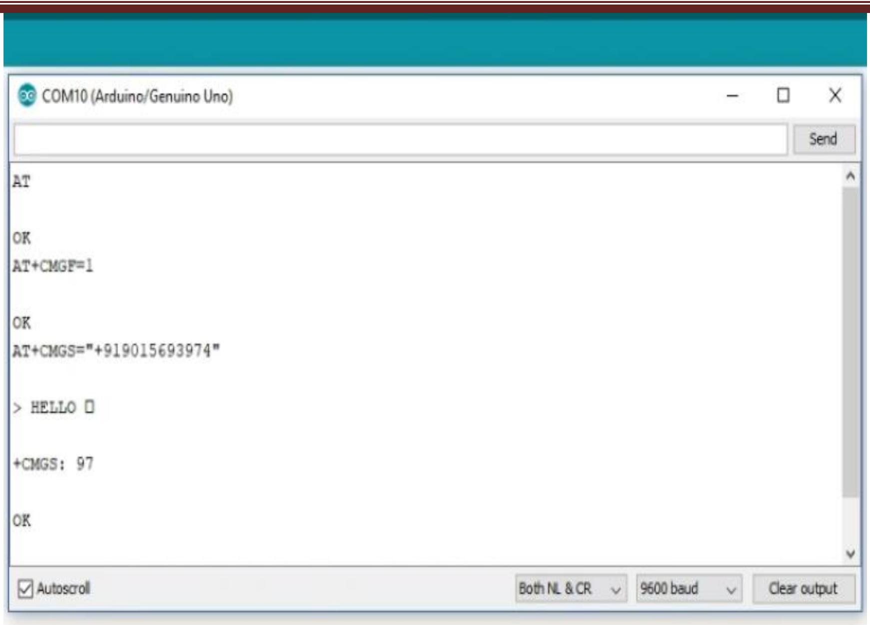
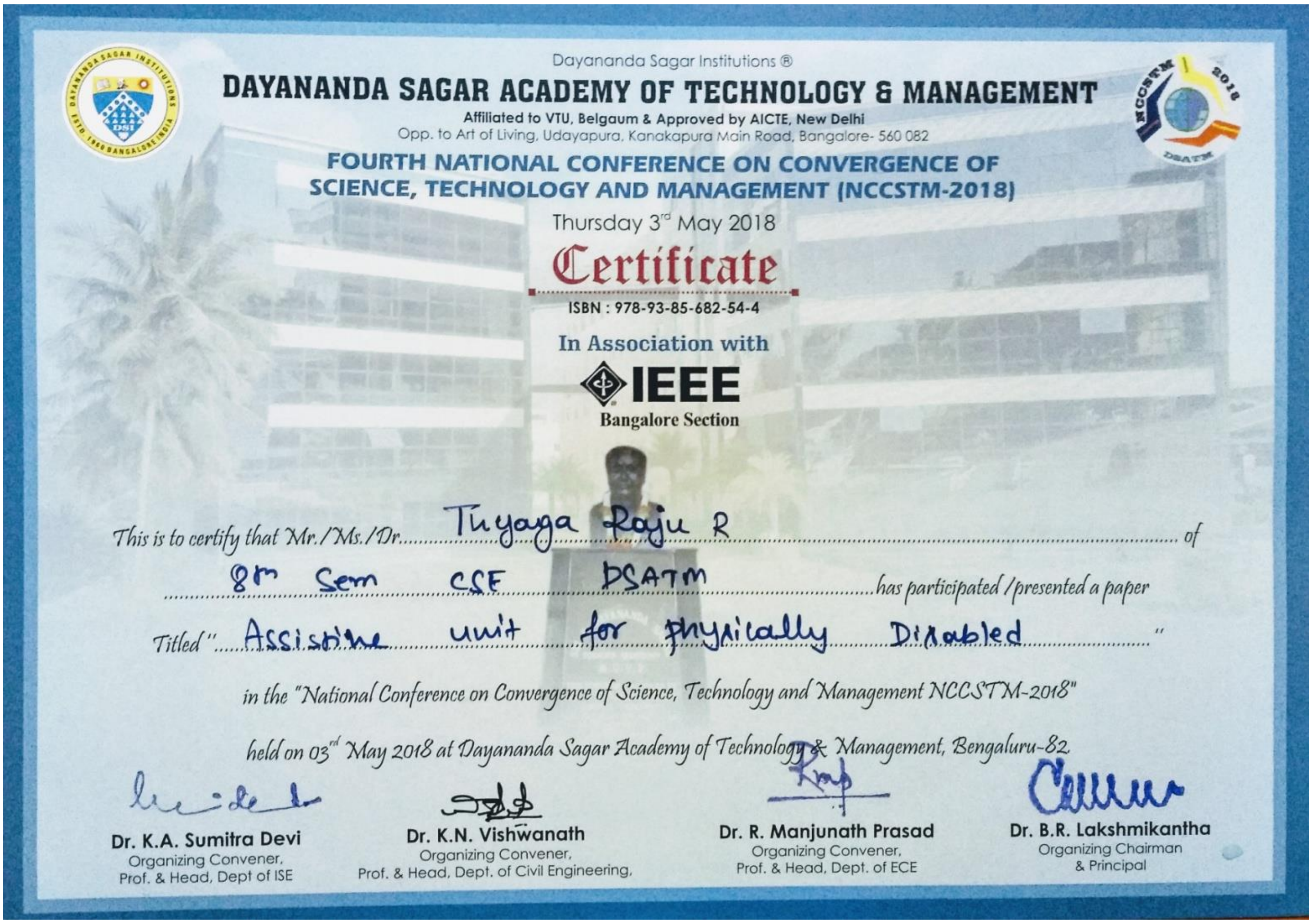
NMEA sentences generated by GPS Module



AT commands on the Serial Monitor

APPENDIX-B

Certificates



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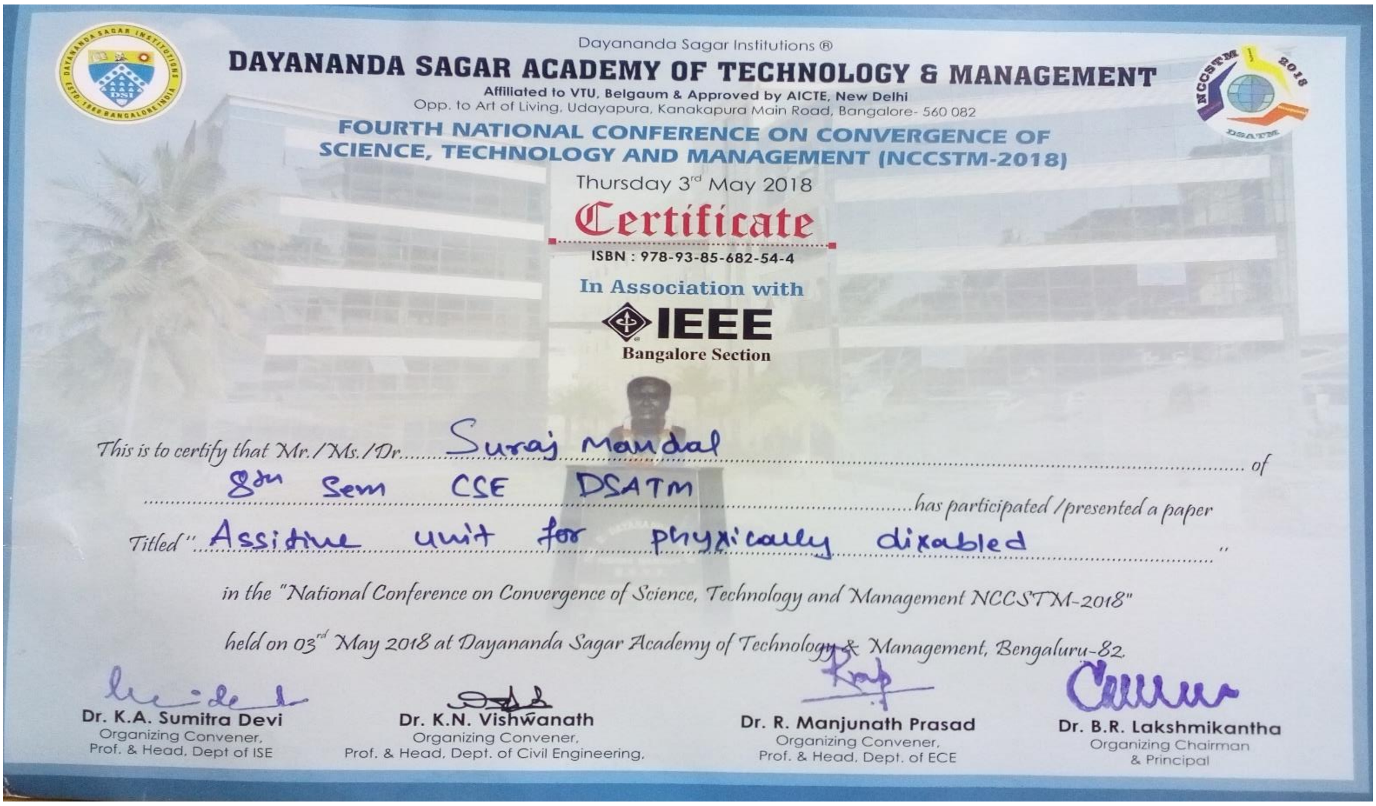

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