Automated Voice controlled Wheel-Chair

Capstone Project Report

End Semester Evaluation

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ABSTRACT

Thousands of disabled people face difficulty in moving around even in their own house. People who have sacrificed for our country or senior citizens of our nation consider themselves as burden on others because they need someone to help them move around. Not only these people but also the people who suffer from injuries like limb amputation, paralysis etc. need a caretaker to help them with their daily needs, not only in their own house but also outside too. So, to cope with this problem we thought about an idea with which the control of their movement would be given to these people who suffer daily. We are therefore proposing AUTOMATED VOICE CONTROLLED WHEEL-CHAIR. This chair would be controlled by user's own voice. Whichever direction or in whichever motion the user wants to operate the chair he/she can do it. They would not require any external help from others and also will help the community by boosting the well-being of our elders.

DECLARATION

We hereby declare that the design principles and working prototype model of the project entitled Automated Voice Controlled Wheel-Chair is an authentic record of our own work carried out in the Computer Science and Engineering Department, TIET, Patiala, under the guidance of our mentor Dr. Prashant Singh Rana during 7th semester (2019).

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They always wanted the best for us and we admire their determination and sacrifice.

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LIST OF ABBREVIATIONS

Abbreviation	Full Form
AD	Analog to Digital
APP	Application
DC	Direct Current
IDE	Integrated Development Environment
IEEE	Institute of Electrical and Electronic Engineers
LED	Light Emitting Diode
ML	Machine Learning
MVC	Model View Controller
NLP	Natural Language Processing
UI	User Interface

Chapter 1
INTRODUCTION

This chapter gives an overview of what the project is, what all components are required to make the wheelchair functional and what methodologies have been used to accomplish our goals.

1.1. Project Overview

The idea of using voice activated technology for controlling the motion of the wheelchair is to prove that it can be a unique concept that would stand apart from the rest of the average projects. The use of this new technology in conjunction with a mechanical system in order to simplify everyday life and it would spark interest in an ever growing modern society. Many people with disabilities do not have the dexterity necessary to control a switch on an electrical wheelchair. This can be a great for the quadriplegics who is permanently unable to move any of the arms or legs. They can use their wheelchair easier only using voice commands. The aim of this study is to implement an interesting application using small vocabulary word recognition system. The methodology adopted is based on grouping a microprocessor with a speech recognize development kit for isolated word from a dependent speaker. The resulting design is used to control a wheelchair and home appliances for a handicapped person based on the vocal command [1].

1.1.1. Technical Terminology

The following are the technical terminology which have been used in our project:

1. **Development environment:** It refers to the computer language used for developing the said product. In this case we are using Arduino development environment and python for the project.
2. **Microcontroller:** It refers to a device that can be coded externally to control other peripheral devices such as motors, LED's etc. It consists of a Microprocessor along with memory to implement the code.

3. **Voice recognition module:** It refers to a module which is used to convert user's voice into machine readable form. This machine readable form helps the microcontroller to control the peripheral devices according to the user's demand.
4. **Motor Shield:** This device helps user to control the DC motor's motion according to the input provided to the microcontroller, it can accommodate up to four motors but only two have been used.
5. **DC motors:** This device is used to convert electrical energy into mechanical motion by using magnetization and electric flux conversion.
6. **Chassis:** It refers to the basic structure of the model, which is made using mild steel. The chassis weighs three kilogram and is forty centimetre in length, thirty centimetre wide and thirty centimetre high.
7. **Battery:** It stores electrical energy in form of chemical energy. The battery used is 12Volts and gives .34Ampere.
8. **Application Development:** It refers to the development of mobile application for certain purposes such as controlling the wheel chair.
9. **Android Studio:** It is the IDE for android based mobile applications which will then control the wheelchair.

1.1.2. Problem Statement

The problem is the lack of options for physically disabled people to move around. They need to rely on others for help. Research from University of Notre Dame, 2000, suggests that the current power wheelchair control interfaces used may not, be adequate to provide truly independent mobility for substantial number of person with disabilities. The Respondents to the survey reported on average that approximately ten percent of the patients trained to operate a power wheelchair cannot use the chair upon completion of training for activities of daily living or can do so only with extreme difficulty. So, we need a better option for helping these physically disabled people. Not only these but old aged people can also use a solution for this problem.

1.1.3. Goal

The goal of this project is to understand the concepts that lie behind the controlling motion of the dc motors, to develop understanding of microcontroller and how they

operate under various circumstances and last but not the least to develop deep understanding of Natural Language and its processing using machine learning.

1.1.4. Solution

The Solution is to create a scaled prototype of a wheel chair that can take user voice as input and use this input to control the motion of the wheel chair. The wheel chair could be only control by a specified person as the chair uses voice recognition system for the use of the voice based commands. Also, a Mobile Application will be developed as a secondary control option.

1.2. Need Analysis

There are various people who face difficulty in going from place to place be it either due to a physical injury or age factor. These people find it difficult to move around not only outside but inside their own houses too. So the need is there to help these people and help the community because due to this problem these people with some dexterities get cut off from the community. They think of themselves as burden on others. Not only them but the people who have to take care of these people also get nauseated due their continuous needs. Hence, they send their old aged parents or disabled people into care homes away from their close ones. Hence, to prevent these people from all these troubles. Due to this these people can have a life without needing care from others and leading a happy self-serving life[2].

1.3. Research Gaps

The research these days is focused on how to improve the voice recognition and speech synthesis. Various firms R&D department continuously focus on how to improve the user experience. But none of these ever has imagined how that would result in hardware implementation. Advances in speech synthesis requires dedicated hardware and software system which is not possible for embedded system approach. Rather, we have to settle for most rapidly available and suitable rather than a technically superior one.

Hence, there exists a research gap in between these approaches. This gap leads to underpowered products which could be more efficient by using special hardware. Also, this research gap in our country also leads to lagging of our nation behind in terms of hardware

based product services. India is a service based industry but if we want to advance our country we should help it by making it a product centric industry, which would lead to development of revolutionary ideas and efficient products for consumers.

1.4. Problem Definition and Scope

By using the 5W1H approach the voice automated wheelchair problem has been defined as follows:

Question 1: Who does it effect?

The people who are impaired of their limbs, who need an external help in their movement and the people who have aged and are not able to walk without any support are directly affected hence it can help a wide variety of people who are not able to move from one location to another on their own. There also exist people who can walk but are at a risk of losing consciousness while walking or put high amounts of physical strain on their body hence the wheelchair model can help them also.

Question 2: What happens?

The people are not able to do their daily choirs without any help from others. People need caretakers and full time servants whether they can afford them or not. Also, people who are alone and have no caretaker usually have short life span, they are cut off from the community, self-confidence is shaken, hope to live dies. Minimal effort is needed to control the wheelchair while using the voice commands or the mobile application. The power of an electric wheelchair makes it easier for you to go up or down hills.

Question 3: Where and When does it happen?

This is a universal phenomenon; more than a million cases are seen across the world every year. This is a major cause after any injury or trauma disorder. Also the age factor is a main reason behind this problem. The number of people significantly increase every year due natural and mad made disasters.

Question 4: Why and How does it happen?

It mainly happens due to any limb injury where a person has lost the limb or is unable to control it. Also due to paralysis and other neurological diseases leaves a person without the sense of his/her limb. Lastly, people who have aged and cannot lift up their own weight due to various skeletal disorders are the targeted users.

1.5. Assumptions and Constraints

TABLE 1.1: Assumptions and Constraints

Sno.	Assumptions & Constraints
1.	The path of the wheelchair will not consist of any pot holes or speed bumps which may cause damage to the DC motors, it may also lead to damage to the circuitry hence we have assumed that there will be no damaging mechanical shocks to the wheelchair.
2.	The wheelchair will have a continuous long clear path so that the wheelchair does not stop frequently causing damage to the wheelchair and causing a rocky motion.
3.	The speed of the wheelchair will be limited to a few Kilometres per hour as it would put extreme load on the batteries.
4.	The weight of the user is also not considered as an it would put an immense load on the structure of the wheelchair and the battery of the wheelchair.
5.	The battery will not be able to sustain prolong use hence the wheelchair should be used for short distant usages. The short distant usage include the neighbourhood
6.	The surface on which the wheelchair will not be inclined as increases the load on the DC motor and hence increasing power consumptions and the wheelchair may tilt also.
7.	The background noise while using the microphone will be negligible as it would interfere with the efficiency of the speech to text synthesis module

1.6. Approved Objectives

The following objectives have been approved by the mentor and capstone panel:

1. Building Hardware for the Wheel Chair Prototype.
2. Using Mobile Application to control the wheel chair.
3. Applying Natural language processing to control wheel chair with voice.
4. Using Speech Recognition to control the chair.

1.7. Methodology Used

The methodology used in this project is iterative in form of a spiral. In this we are developing the product and iterating it to produce a better product. The spiral model is a risk-driven software development process model. Based on the unique risk patterns of a given project, the spiral model guides a team to adopt elements of one or more process models. The iteration helps in continuous inspection and control of the development of the product. If in this, we face a problem we can go back to the previous stage where the problem can be fixed and then repeated the entire process again. This helps in maintaining the product quality and helps in developing the product with the Agile methodology.

Agile tells us to be flexible and be ready for change because we cannot attain a product in a specific manner. Over the course of development, we have to change some of our techniques to get the desired product. A Tree that does not bend in storm fall down but the one that bends sees the light of another day [3].

1.8. Project Outcomes and Deliverables

The outcomes and deliverables from this wheelchair project will be:

1. A Scaled Wheel-chair model (Hardware) designed to work on voice commands as well as commands from mobile application.
2. A mobile application that can control the chair as a secondary controlling option which has been developed using the Android Studio IDE.
3. The main outcome of this project will be the understanding of the concept of project management.
4. Deep learning of the concepts of Language processing using machine learning.

5. Learning of the hardware components like Arduino and how these control the peripheral devices according to the user needs.
6. This project will also help us learn team work and time management during project development.

1.9. Novelty of Work

Our project has various prototypes already in the market but none of them use Natural language processing to convert audio to text. We also use voice recognition so as only the authorized person will be able to control the chair. Due to this we need not to use other models if a new language is developed to work with the machine. We can add more language support only by software updates making it completely autonomous even for regional languages in the future.

Chapter 2

Requirement Analysis

This chapter deals with the research and the requirement analysis of this project. This describes the theory related to the subject, research currently being performed, problem analysis and the tools and technologies being used.

2.1 Literature Review

This section deals with the literature and research required in this project and the advances that have been made in the hardware section.

2.1.1 Theory Associated with Problem Area

There have been several studies regarding the project which indicate that independent mobility can be given by automated wheel chair to all those who are unable to move on their own. Independent mobility has increased vocational and educational opportunities for the people who are impaired and reduces their dependencies on their medical aid, hence promoting the feelings of independence. The patients of younger age self-sufficient mobility serve such as the base structure advance learning. Non ambulatory children do not have access to the riches of actions afforded by the self-ambulating people. Mobility difficulties also happen to be strong predictors of Activities of Daily Living (ADL) and instrumental ADL disabilities because of the need to move to accomplish many of the desired activities.

In addition to that the impaired mobility often leads to decrease in opportunities to interact with other people which leads to separation and despair. While the needs of many individuals with disabilities can be satisfied with traditional manual or power wheelchairs, a segment of the disabled community finds it very hard to use wheelchairs independently [4].

While the needs of most people with some kind of impairment can be satisfied with standard manual or smart powered wheelchairs, a part of the disabled society finds it hard to use wheelchairs independently. This group of people include, but is not limited to, people with

impaired vision or several kinds of cognitive defects. These particular individuals often rely on a others to push them in a manual wheelchair.

To assist this group of people, several researchers have used various methods originally developed for mobile robots to create electric wheelchairs. A smart wheelchair usually consists of either a ordinary powered wheelchair to which a computer and a collection of sensors have been added or a mobile robot base to which a seat has been attached. Smart wheelchairs are designed to steer the user in a number of different directions, such as assuring clash-free travel, helping in the performance of certain tasks and freely transporting the user between several locations.

There are multiple advantages of integrating the voice automated wheelchair technology in the original power wheelchair, but most importantly the user's input can be given directly into the microprocessor to the wheelchair's DC motors, bypassing the proprietary controlled electronics. This removes the need to reverse engineer the protocol that the wheelchair manufacturer uses to communicate between the joystick and the motor controller. An additional benefit of stiff incorporation is the ability to incorporate optical encoders to the wheels, which allows the wheelchair to track its speed. Systems designed as add on units must connect to the underlying wheelchair through the limited interface options provided by the wheelchair company.

Smart wheelchairs have been used to discover a several alternatives to the more conventional four input methods associated with power wheelchairs. Voice recognition has been used for smart wheelchairs because of the low price and extensive accessibility of profitable voice recognition hardware and software. More unusual input methods that have been executed include discovery of the wheelchair user's path that is where the user is looking through Electro Oculographic (EOG) activity or the use of computer vision to calculate the position and orientation of the wheelchair user's head.

To evade obstacles, voice automated wheelchairs require sensors to be able to perceive their environment. By far, the sensor most frequently used by smart wheelchairs is the ultrasonic acoustic range finder that is ultrasonic. Ultrasonic sensors are very accurate when the sound wave emitted by the sensor strikes an object at a right angle or directly. As the angle of incidence is incremented the likelihood that the sound wave will not reflect back toward the direction of sensor increases. This effect is more enhanced if the object is smooth or sound absorbent or both.

Ultrasonic sensors are also susceptible to noise which occurs when the signal generated by one of the sensors generates an echo that is picked up by a different sensor.

People who are investigating the issue have taken a several approaches for implementing the control software for voice automated wheelchairs based on the functions supported by the smart wheelchair and the various sensors it uses. There are several different Universities that have both developed smart wheelchairs that use neural networks to reproduce various different routes. The NavChair is using an obstacle density histogram to join the information obtained from its ultrasonic sensors with joystick input from the user, also the SWCS and SPAM use rule-based approaches.

Very small number of voice automated wheelchair researchers have involved people with impairments in their assessment activities. Further there are no such voice automated wheelchairs has been subjected to a intense, controlled evaluation that involves extended use in real-world settings. Conducting user trials with smart wheelchairs is difficult for several reasons. Some wheelchair users do not show any immediate improvement in navigation skills when using a smart wheelchair on a closed course in a laboratory setting.

The main obstacles for conducting long-term studies is the unaffordable hardware costs associated with creating enough voice automated wheelchairs. Long-term studies are needed because the genuine effects of using a voice automated wheelchair for a large amount of time are still unknown.

2.1.2 Existing Systems and Solutions

The already existing systems and solutions for a voice automated wheelchair have been listed below:

1. **Assistive devices:** These are the devices which help us to walk using a cane, crutches or walkers but these devices are not meant for paralysed people.
2. **Electric power driven devices:** These are electromechanical devices installed on manual wheelchairs to make it easier for the user to self-propel, which use a high powered battery.

3. **Manual wheelchair:** It is a chair with wheels designed to allow you to move yourself or be pushed along by an helper.
4. **Scooter:** Most of these devices are three-wheel designs while some of them are four-wheel models containing an electric motor and a tiller for steering. A scooter is an effective mobility device that does not look like a wheelchair.
5. **Power driven wheelchairs:** Front, mid and rear-wheel drive options are available. These chairs are operated by a DC electric motor and are controlled using a joystick or using a different control device, most offer more than one seating options such as power seating.

2.1.3 The Problem That Has Been Identified

A large population of the world consists of people with some form of disabilities or people who are physically handicapped. They are dependent on others for their daily needs and face problems in their mobility. Previous attempts made to make a medical wheelchair to help such people weren't devoid of defects. This project could be part of an assistive technology, it is for more independent, productive and enjoyable living.

2.1.4 Survey of tools and technologies being used

The following course subjects are being used in order to build the voice automated wheelchair:

1. **Natural Language Processing:** It is required for understanding the meaning of the sentence spoken by the user.
2. **Machine Learning:** It is required for voice and speech recognition of the user.
3. **Computer Networking:** Controlling wheelchair through Android application using Bluetooth interface.
4. **Android Application Development:** Developing a fully functional Android application for controlling wheelchair.
5. **XML:** It is required for creating the front end of the Android application.
6. **C++/C:** It is required for controlling the microcontrollers Arduino Uno and the several sensors that are connected to it.
7. **Electrons Engineering:** It is required for understanding and joining of the various electronic components.

8. **Kotlin/Java:** It is required for creating the android application structure and other software modules which function as the programming logic of the application being used in the project.
9. **Python:** It is required for creating the voice and speech recognition module along with NLP module.

2.2 Standards

The following Institute of Electrical and Electronics Engineers (IEEE) standards have been incorporated in the wheelchair capstone project:

1. The Bluetooth IEEE standard 802.15.6. is being used for wireless communication between the wheelchair and mobile device.
2. Software requirement specification standard IEEE 830 lists down the recommended.
3. software practices required for making the project.
4. The IEEE 260.1-2004 is being used for the representing standard symbols of measurement.
5. The standard IEEE 802.9 has been used integrated voice and data access.
6. The IEEE 29119 standard will be used for software testing and debugging the errors discovered in the software used to drive the voice automated wheelchair.
7. The IEEE 310:1969 standard is used for adjusting the values of resistors having values from .01ohm to 1 Mega ohm.

2.3 Software Requirements Specification

This following section deals with the software requirements of the project with the project scope and the audience the project is targeting.

2.3.1 Introduction

This section introduces us to the purpose and targeted audience of the project. Also, this describes the project perspective including hardware and software perspectives.

2.3.1.1 Purpose

The Solution is to create a scaled prototype of a wheel chair that can take user voice as input and use this input to control the movement of the voice automated wheel chair. The

wheel chair could be only control by a specified person as the chair uses voice recognition system for the use of the voice based commands. Also, a Mobile Application will be developed as a secondary control option.

2.3.1.2 Intended audience and reading suggestions

The following are the intended audience of the voice automated wheelchair:

1. People with amputations due to accidents or birth defects making them unable to walk on their own.
2. Patients with paralysis can also use the wheelchair.
3. Aged people who are unable to put high physical strain on their body can also use the wheelchair.

2.3.1.3 Project Scope

This project is associated with Voice Controlled Wheelchair System by using the speech recognition module and an Android application developed using Android Studio IDE. The main objective of this project is to facilitate the movement of people who are disabled or handicapped and the elderly people who are not able put large amounts of physical strain on their body. The end result of this project will allow a lot of people with impairment to live a life with less dependency on other people. Speech recognition technology is the primary feature which may provide a new way of human interaction with machines or tools.

The Android application on the smart phone device is connected through the Bluetooth interface module and replaces the traditional stick in most of the automated wheelchairs. In the project voice module interface is the program which recognizes the voice that will in turn controls the movement of wheelchairs. The capstone project uses the Voice module and the Arduino Uno microcontroller along with Direct Current powered motors to create the movement of the smart wheelchair. Since the motorized wheelchair can move at a fair speed, it is imperative that it is be able to avoid obstacles on its own in real time, with these requirements in mind we propose an automated wheelchair with real-time obstacle avoidance capability [5].

2.3.2 Overall description

This section describes various perspectives of the intended model and the features and interface requirements of the project.

2.3.2.1 Product perspective

There are two product perspective which include:

1. **Software Perspective:** In software perspective we have a voice recognition module and an activation command module which use user generated voice and they convert that voice to machine readable text. This text is then used to generate commands to control DC motors. The motion of DC motors includes forward, backward, left and right, rotate as well as no motion. We also use Arduino IDE to control the DC motors.

2. **Hardware Perspective:** It includes hardware components like wheelchair chassis, DC motors, microcontroller, Bluetooth module, motor shield, battery, etc.

2.3.2.2 Product features

The product features of the wheelchair include: -

1. A voice recognition system for identifying the commands given by user.
2. Microcontroller based DC control system for running the chair.
3. DC motors (12V and 300RPM) for running the wheelchair.
4. Arduino Uno R3 microcontroller for executing the instructions.
5. Voice module for processing the commands and then passing the instruction to the Arduino.

2.3.3 External interface requirements

This section describes the various user, hardware and software interfaces required in this project.

2.3.3.1 User Interface

The user interface feature includes the following items:

1. Microphone for user based voice input with voice recognition.

2. Mobile based Android application for controlling the wheelchair.
3. Buttons for stopping the wheelchair in emergency conditions.

2.3.3.2 Hardware Interface

The hardware interface includes:

1. Microcontroller (Arduino Uno R3) for performing the programming operations.
2. Voice module has been used for processing the voice commands given by the user
3. DC motors for running the wheelchair in the desired direction.
4. Wheel chassis is the physical structure of the wheelchair.

2.3.3.3 Software Interface

The software interface requirements include:

1. Speech recognition system using Voice module for Arduino.
2. Communication between voice module and microcontroller.
3. Using Arduino UNO R3 IDE for DC motor control for wheelchair motions.

2.3.4 Other non-functional requirements

The other non-functional requirements of the voice automated wheelchair are:

2.3.4.1 Performance Requirements

The following are the performance requirements of the wheelchair project:

1. The microcontroller should be able to decode the instruction within 4 seconds.
2. The wheelchair ride should be smooth and not be haphazard in nature.
3. The noise immunity of the microphone should be as high as possible.
4. The wheelchair battery should be able to work for long durations and no rechargeable issues should occur.
5. The Android application should be designed for maximum optimization so that the phone does not lag.
6. Instant transmission of data from mobile phone to wheelchair using Bluetooth module.

2.3.4.2 Safety Requirements

The safety features of the wheel chair include:

1) Power ON/OFF button for emergency stopping the wheelchair during malfunction or when user wants to stop the wheelchair at a certain instance which puts the user at the risk of being harmed.

2) Safely grounding and sealing the electrical connections to prevent electrical shock and using Pulse Width Modulation to change the speed of wheelchair so that the chair travels at moderate speed.

3) Ultrasonic sensor to prevent collision with objects or oncoming people which cause physical damage to the user and the chair.

2.3.4.3 Security Requirements

The security features of the wheelchair model include password access to the android application so that user can control the wheelchair along with voice recognition incorporated so that the authorized user can only operate the wheelchair with his voice.

2.4 Cost analysis

The following table shows the cost analysis of the capstone wheelchair project:

Table 2.1: Cost Analysis

Sno.	Materials	Unit Cost(₹)	Quantity	Total Cost(₹)
1	DC geared Motors	₹ 540.00	3	₹ 1,620.00
2	Chassis	₹ 600.00	1	₹ 600.00
3	Tyres	₹ 100.00	2	₹ 200.00
4	Voice Module	₹ 2,800.00	1	₹ 2,800.00
5	Arduino Uno	₹ 500.00	1	₹ 500.00
6	Ultrasonic Sensor	₹ 180.00	2	₹ 360.00
7	LEDs	₹ 2.00	10	₹ 20.00

8	Battery	₹ 1000.00	1	₹ 1000.00
9	Wires	₹ 1.00	20	₹ 20.00
10	Castor Wheels	₹ 165.00	4	₹ 660.00
11	Bluetooth Module	₹ 500.00	1	₹ 500.00
13	Motor Shield	₹ 350.00	1	₹ 350.00
14	Microphone	₹ 300.00	1	₹ 300.00
	TOTAL COST			**₹ 8,930.00**

2.5 Risk analysis

The Risks for the automated voice controlled wheelchair prototype have been listed below in the table:

Table 2.2:Risk Analysis

S.No.	Risks to the wheelchair
1	The path of the wheelchair will not consist of any pot holes or speed bumps which may cause damage to the DC motors, it may also lead to damage to the circuitry hence we have assumed that there will be no damaging mechanical shocks to the wheelchair.
2	The wheelchair will have an continuous long clear path so that the wheelchair does not stop frequently causing damage to the wheelchair and causing a rocky motion.
3	The speed of the wheelchair will limited to a few Kilometres per hour as it would put extreme load on batteries.
4	The weight of the user is also not considered as an it would put an immense load on the structure of the wheelchair and the battery of the wheelchair.

5	The battery will not be able to sustain prolong use hence the wheelchair should be used for short distant usages. The short distant usage include the neighbourhood
6	The surface on which the wheelchair will not be inclined as increases the load on the DC motor and hence increasing power consumptions and the wheelchair may tilt also.
7	The background noise while using the microphone will be negligible as it would interfere with the efficiency of the speech to text synthesis module.

CHAPTER 3
Methodology Used

This chapter discusses the tools and techniques used for investigating the problem. This section also deals with the Solution of the problem we propose and work breakdown structure and tools and technologies used for the project development.

3.1 Investigative Technique

There are many research papers published related to "Smart Automated Voice Control Wheelchair". So, Experimental technique will be used as an investigative technique. In the Experimental Technique, commands will be given as input to wheelchair and their results are recorded. In our project, natural language processing (NLP) is applied in which the user will first give the activation command to the wheelchair. In this mechanism, two processes will take place.

Firstly, the wheelchair will run a voice recognition module to do voice recognition of a person. If voice recognition process is successful, wheelchair authenticates the user and activates the wheelchair to receive further commands or directions for the movement of wheelchair. Further the command will be processed and directions are fetched and converted into text in Voice module.

This text is converted into code format and is send to the Arduino and then to motor driver and finally to the left and right motors. If any one of the above given steps failed to execute, wheelchair will not move conveying the fault or failure of some process or tools. In the process of controlling the wheelchair by mobile application, firstly the mobile using the application will have to be paired with the Bluetooth module attached to the Arduino using verification code. After authentication, Mobile is ready to control the wheelchair and directions from mobile is sent through direction buttons embedded in the application.

3.2 Proposed Solution

Physically impaired people find it very hard to use a standard wheelchair such that their hands are not capable of operating the normal wheelchair effortlessly. Hence the voice controlled wheel

chair is built to overcome the problems faced by such people and enable them to operate the wheelchair. The wheelchair will be operated using the voice commands through the given input using natural language processing and through mobile application. The Arduino will take care about all the directions the user wants. The instruction for each and every direction is written in the form of the program in the Arduino itself. The inbuilt library in the Arduino IDE helps Arduino microcontroller to convert the given voice commands into the desired output and the wheelchair will move as a result in the desired direction, given the wheelchair control system people will then become more independent. The wheelchair control system uses a voice recognition system for starting and controlling all its movements. By using the system, the users are able to operate the wheelchair by simply speaking to the wheelchair's microphone. The basic movement functions include forward, reverse, left and right turns as well as stop. The spoken words are linked to the voice recognition process via a flexible microphone [6].

3.3 Work Breakdown Structure

The following diagram shows work breakdown structure of project:

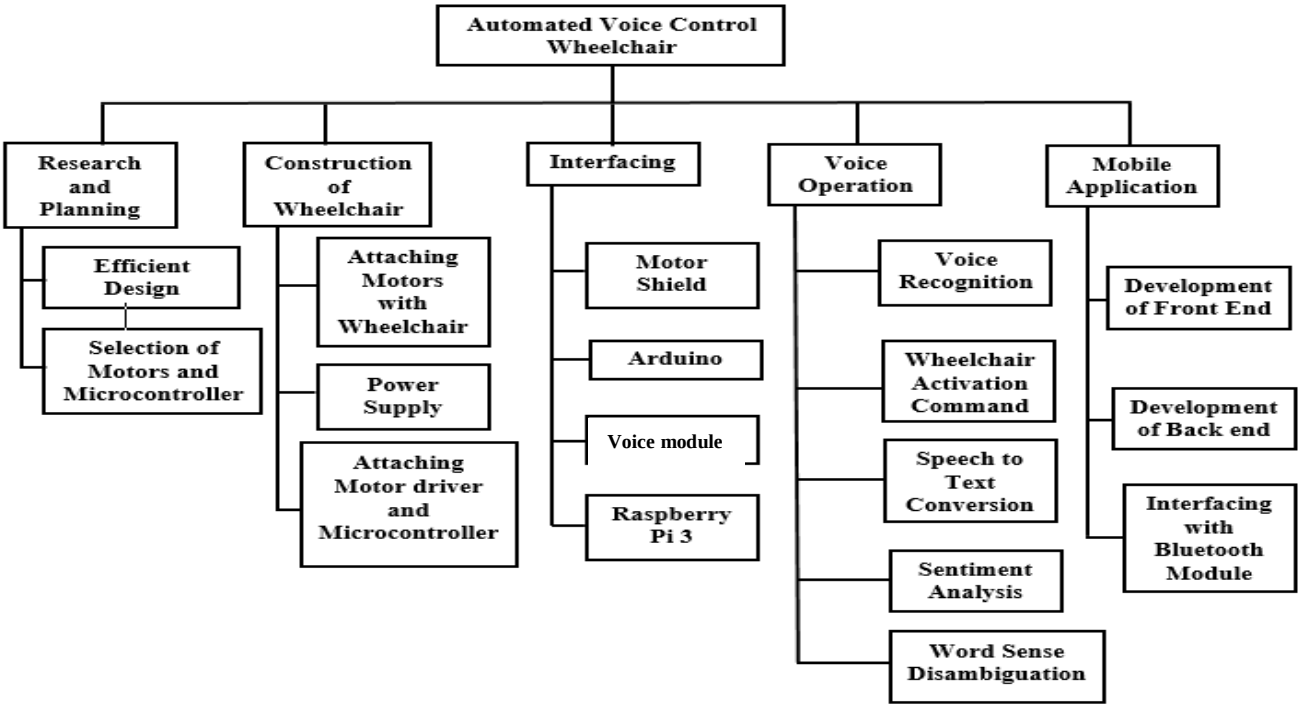


Figure 3.1: Work Breakdown

3.4 Tools and Technologies used

These are the tools and technologies being used in this project:

1. **Natural language processing:** Used for processing commands provided by the user through the microphone.
2. **Voice module:** Used for natural language processing like voice recognition and activation command.
3. **Arduino:** Used for controlling the motors of the wheelchair through L293 IC and also controlling the various sensors attached to the wheelchair.
4. **Motor driver:** Implementing directions given by Arduino through left and right motors using L293D IC.
5. **Android Studio:** An IDE used for building android based mobile applications.
6. **Bluetooth module:** Connecting the mobile application with Arduino.
7. **Microphone:** Command input from user to Voice module.

CHAPTER 4
DESIGN SPECIFICATION

This chapter discusses the architecture and various design level and interface diagrams which describe the project in detail.

4.1 SYSTEM ARCHITECTURE

Component diagrams are used to visualize the organization and relationships among components in a system. These diagrams are also used to make executable systems. In the above diagram we have shown how different physical components have attached to each other to form a fully functioned system which will drive our voice automated wheelchair [7].

1. **Microphone:** Here the input is taken from the user in the form of voice data which is in analog form.
2. **Voice module:** As the voice module takes digital input hence we apply A-D converter to form a digital signal for voice module. The module is the main computation unit which will give all the commands to other components to generate the desired result for the user.
3. **Arduino:** The Arduino works as a platform for all the hardware components. It gets instructions from Voice module and executes it on all the hardware components.
4. **Motor:** It is the driving force of the system. It receives instruction from Arduino and gives motion to the wheelchair.
5. **LED:** It is used to display the battery content of the wheelchair.
6. **Obstacle Detection Sensor:** It is a sensor which is used to detect obstacle in front of the wheelchair. It requires digital input hence we apply A-D converter to generate digital signals.
7. **Mobile:** Here Mobile as used to run the app which is used for remote controlling of the wheelchair.

4.1.1 COMPONENT DIAGRAM

The following diagram shows the component diagram of the project:

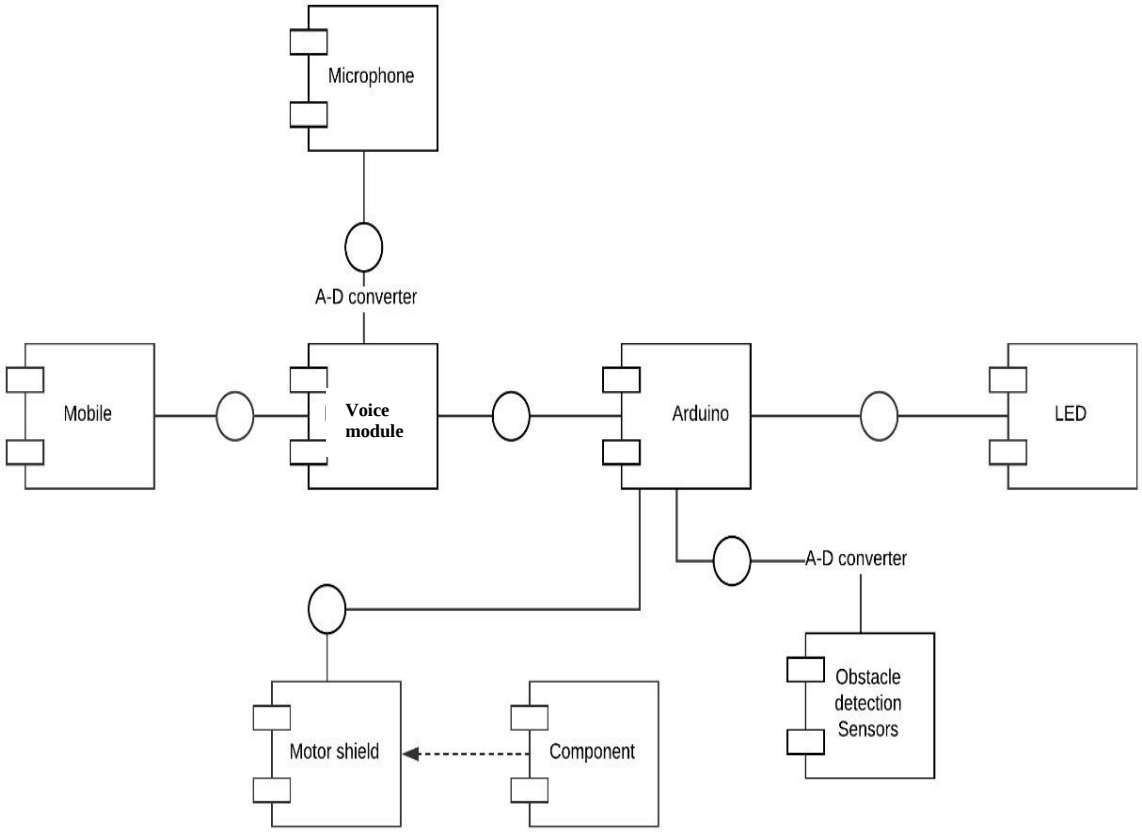


Figure 4.1: Component Diagram

4.2 DESIGN LEVEL DIAGRAMS

The Model View Controller (MVC) design pattern specifies that an application consist of a data model, presentation information, and control information. MVC mostly relates to the UI or interaction layer of an application. The diagram given below shows the design we used to regulate the command, from user, for working of the wheelchair.

1. **Views (Voice module):** The Voice module comes under the Views section. It sends the input from the user to the controller for generating the action.
2. **Controller:** It manipulates the Model section of the diagram to generate the desired result and updates it to the Views section.

3. **Model(Motor):** The motor comes under the Model section which is manipulated by the Controller to generate the desired result. It updates the Views after generating the output.

4.2.1 MVC Architecture Design Diagram

The following diagram depicts the MVC Architecture of the project:

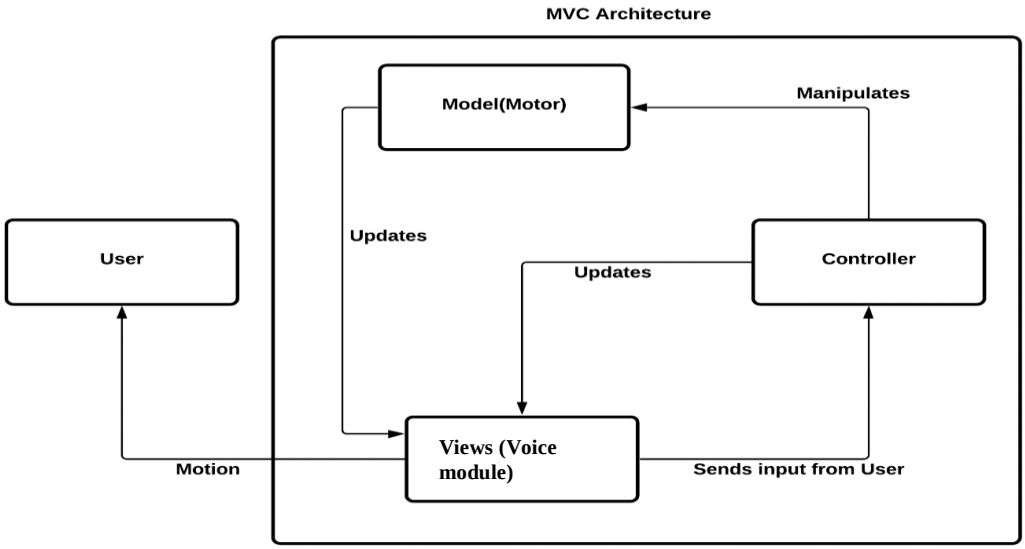


Figure 4.2: MVC Architecture

4.2.2 Context Data Design Diagram

A system context diagram is a diagram that describes the boundary between the system and part of a system as well as its environment, showing the objects that interact with it. This diagram is a high level view of a system. The above diagram shows the data flow design we used for showing the movement of data among different components.

1. **User:** The User gives the voice/speech data to the automated wheelchair system.
2. **Voice module:** It gives interpreted data to the automated wheelchair system from the interpretation of the User command.
3. **Arduino:** It is the system platform which gives the hardware component data to the automated wheelchair system.
4. **Motor:** It is the driving force of the system and provides with the movement data to the automated wheelchair system.

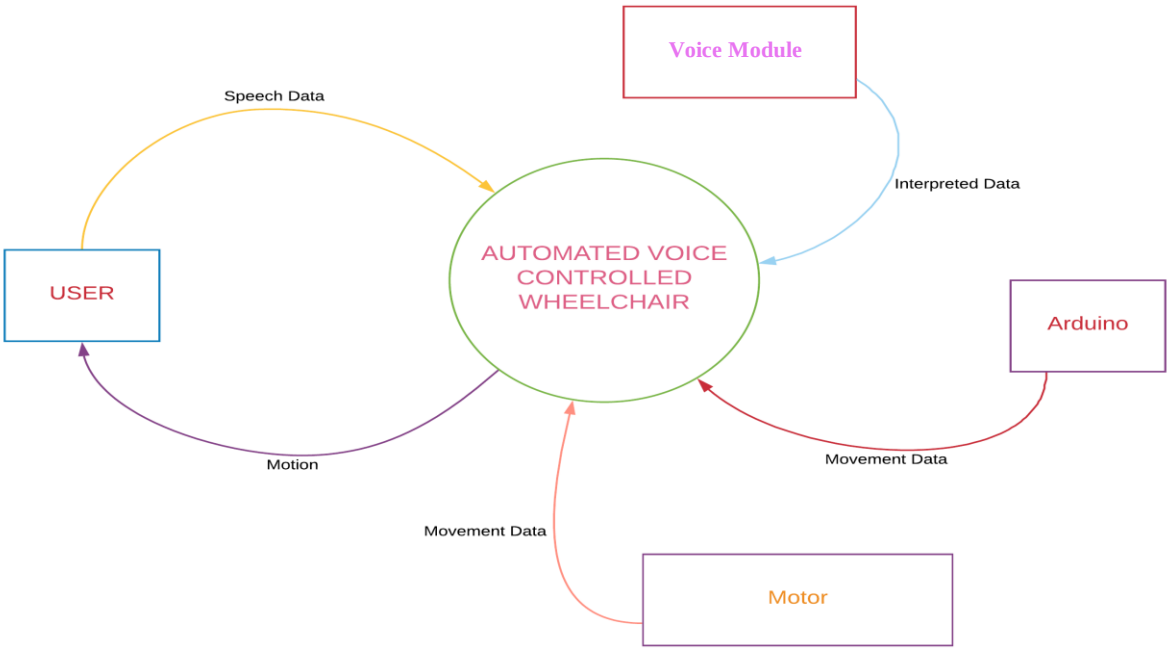


Figure 4.3: Context data design

4.2.3 3-Tier Architecture Design Diagram

A 3-tier architecture is a king of software architecture which is made up of three tiers or layers of rational computing. The diagrams are used in applications as a specific type of client-server system. The 3-tier architectures provide several benefits for design production and development environments by modularizing the user interface, and data storage layers. The above diagram shows the overview of our system which is divided into three layers as:

1. **Presentation Tier:** It consist of the User Interface which will used by the user for interacting with the system. It is the top layer and it consist of Mobile app using Android Studio for interaction with the system.
2. **Logic Tier:** It consist of the logic framework/design which is implemented to work according to the user command. It is the middle layer which is not visible to the user and is used to run the system. Here it consists of Voice module, Arduino and Obstacle detecting sensor.
3. **Data Tier:** It consist of the Database which is used to store the data generated in the middle layer. It is the bottom layer and as we are storing the voice data hence we use the NLP database.

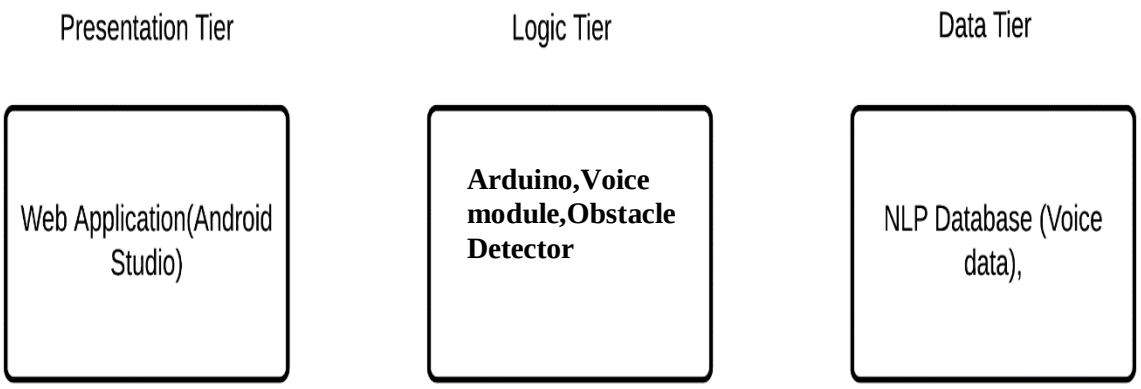


Figure 4.4: Tier Architecture

4.3 USER INTERFACE DIAGRAM

The following diagram is a high-level view diagram that represents interfaces as annotated components. This diagram is similar to a data-flow diagram and is referred to as a Component Interface or Interconnection View diagram. The below diagram represents the interface design we implemented for making our user interface.

1. **Response Time:** It tells about the response time of the user interface and after seconds of input data the system becomes operational.
2. **Command and Action structure:** It defines the commands and the related actions which the user interface can imply on the system.
3. **Error Handling:** It defines the exceptions or error occurs during the normal execution of commands. Here there are two exceptions occurring, the obstacle detection in path which is handled by the obstacle detecting sensor and the multiple commands which is handled by the database which contains command inputs.

4.3.1 Interface Diagram

The following diagram shows the interface diagram for the project:

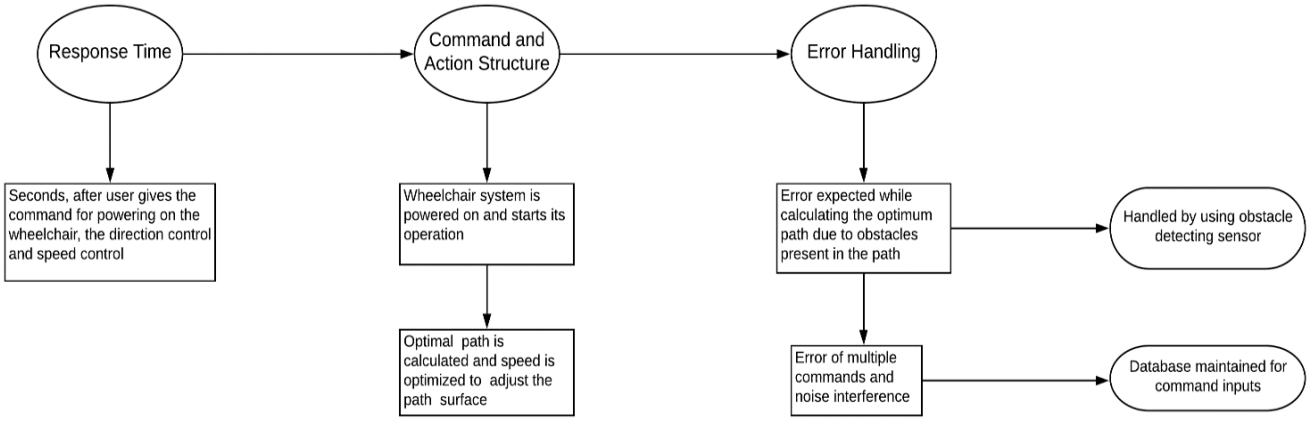


Figure 4.5: Interface Diagram

4.4 SYSTEM SCREENSHOTS

The following collection of photographs have been taken in order in to show the physical layout of the wheelchair:

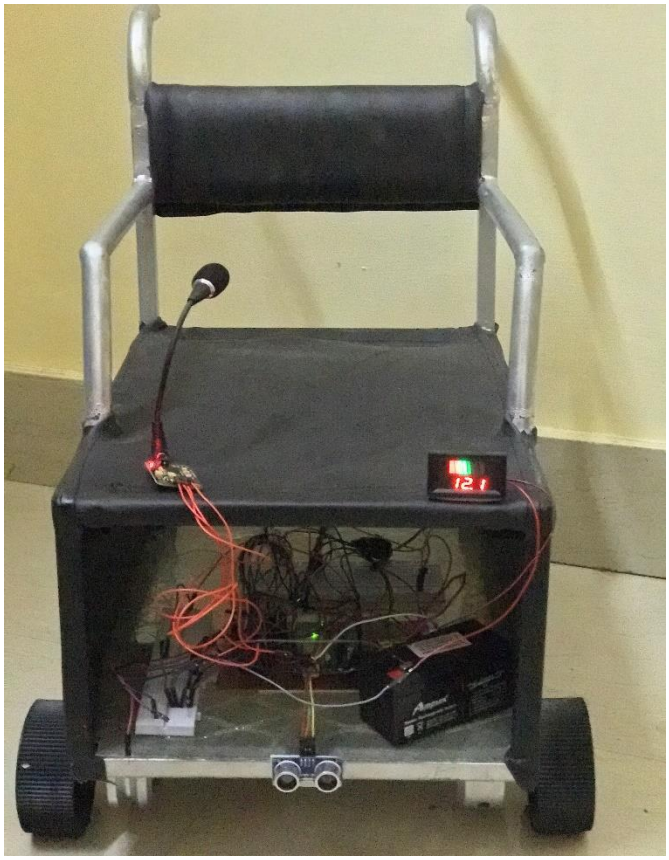


Figure 4.6: Front View

Figure 4.7: Side View

CHAPTER 5

IMPLEMENTATION AND EXPERIMENTAL RESULTS

This chapter deals with the results and the working of the project. It includes the experimental setup of the prototype of the wheel chair which includes the hardware components and the logic behind the working of the chair using voice recognition system with the help of the voice module.

5.1 Experimental Setup

We have designed a robotic chair model consisting of mechanical designing with electronically controlled wheels run by DC motors which can be operated through voice recognition by the user through either Bluetooth enabled mobile application or by using the voice module with embedded voice recognition capabilities. The interfacing with Arduino board is done through the voice recognition module and HC-05 Bluetooth module to interface with the mobile application. The ultrasonic sensor in the chair is used to detect obstacles and to stop the chair if any obstacle comes into the way of the chair.

The motion of the chair is forward, backward, turning left, turning right rotating etc. The device is designed to operate on the command of user. There are certain voice commands that can be trained into the voice module to make the chair function in a certain way. Also, the mobile app is designed to operate the chair by voice commands. The motors are controlled by the L293D IC chip which acts as the H bridged motor driving chip. The motors are driven by a 12-volt external battery as source.

5.2 Experimental Analysis

In this we describe the details and parameters of the experiment. The assumptions and constraints of the experiment are considered and the parameters on which the prototype is evaluated are described here.

5.2.1 Data

The data includes the input and output data including the voice commands, sensor data etc. The data includes:

1. Voice commands to move the chair.
2. Sensor data from Ultrasonic sensor to detect obstacles.
3. Data from Bluetooth module to control the chair from mobile application.
4. Arduino code embedded into the microcontroller to control the DC motors.
5. Training of the voice module with the voice commands.

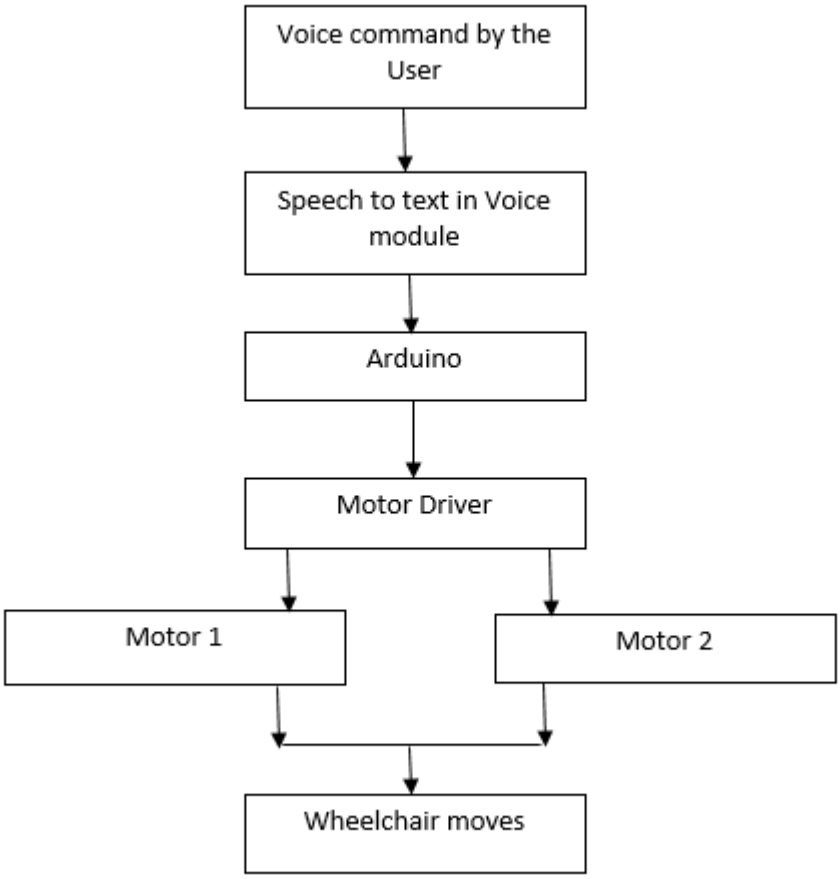
5.2.2 Performance Parameters

The performance of the prototype is tested on various parameters:

1. Time delay in speech to text conversion
2. Delay in Bluetooth transmission.
3. Accuracy of the voice and speech recognition along with chair movement.
4. Object detection by the Ultrasonic sensor.
5. Time delay between voice command and movement of wheelchair

5.3 Working of the Project

The wheelchair prototype is functions with the voice commands input by the user as well as the mobile application. The user enters the voice command into the mic which is connected to the voice module. The voice module is pre-trained with the set of commands used to move the wheelchair. The voice module will convert those voice commands into the ASCII codes and will send them to the Arduino. In the Arduino, the code is embedded and these ASCII codes are compared to the directions in which the user wants to move the wheelchair. The Arduino will send the signal to the motor driver whether the motor should move in clockwise direction or in anti-clockwise direction. Using the mobile application, firstly the mobile has to be connected to the Bluetooth embedded in the prototype. The application will send the ASCII code to the Arduino via Bluetooth module And the rest of the operation of comparing is same as that of voice module. The workflow of voice module is shown below:


Voice command by the User
Speech to text in Voice module
Arduino
Motor Driver
Motor 1
Motor 2
Wheelchair moves

5.4 Testing

After the prototype is fully constructed, an immense testing is required to validate the objectives that we have before making this prototype

5.4.1 Test Plan

5.4.1.1 Features to be tested

The features of the prototype to be tested are:

1. Speech to text conversion of voice module
2. Implementation of embedded code in the Arduino
3. Motor driver in driving the motors
4. Transfer of data through blue-tooth module
5. Working of mobile application
6. Battery charge Indicator
7. Motors and castor wheels

5.4.1.2 Testing Strategy

Here testing strategy will be an experimental technique. After the successful completion of the prototype, for the voice module, it will be tested by passing the voice commands into the mic to see whether the wheelchair moves in a particular direction as wished by the user. For the mobile application, the user presses the button having the specific direction and the transfer of data will be via Bluetooth module embedded on the prototype to see whether the chair moves in the desired direction prescribed by the user

5.4.2 Test Results

The following table shows the relationship between the corresponding input and outputs:

Table 5.1: Test results

S.No	Input	Expected Output	Actual Outcome	Test Result
1.	FORWARD	Prototype should move forward	Prototype is moving forward	Pass
2.	BACKWARD	Prototype should move backward	Prototype is moving backward	Pass
3.	RIGHT ROTATE	Prototype should move right rotate	Prototype is moving right rotate	Pass
4.	LEFT ROTATE	Prototype should move left rotate	Prototype is moving left rotate	Pass
5.	PAUSE	Prototype should stop	Prototype stops	Pass

5.5 Validation of Objectives

S. no.	Objectives	Status
1	Speech to text conversion by voice module	Achieved
2	Transfer of data through Bluetooth module	Achieved
3	Training of voice module through voice commands	Achieved
4	Movement of motors in a specific direction	Achieved
5	Removes the need of the caregiver	Achieved

CHAPTER 6

CONCLUSIONS AND FUTURE DIRECTIONS

6.1 Conclusion

As a conclusion of our work in this semester we designed the body(Chassis) of the Wheel-chair and also we built the model from scratch. We used hollow metal tubes to build the chassis and poly carbon material for holding the dc motors. Also we used the DC geared motors for motion of the chair. We have collected the items for the future use and also we have developed our design idea for the implementation of the different kinds of motion to control the movement of the wheel chair in real life. The challenges we faced include the friction in between the tubes and tyres, Structure integrity of the chassis etc. All in all, we have worked to complete the hardware objectives of our project so that we can work on our software component in the next semester.

6.2 ENVIORNMENTAL, ECONOMIC AND SOCIETAL BENEFITS

- **ENVIRONMENTAL:** There are no direct environmental effects.
- **ECONOMIC:** Economic benefits are that it has indigenous design and has cheap labour cost.
- **SOCIAL:** The main benefit of this project is to make the life of disabled people easier and be user friendly.

6.3 REFLECTIONS

Our project outlines the modern approach to the old system of wheel-chair. Currently huge man-force is involved in this project, which can be replaced by much more efficient and cheap technological systems. Use of these modern approaches make the work much easier and provide significant help to the physically disabled people and old people.

6.4 Future Works

The future aspects of the prototype include:

1. The scaling of the prototype into real life model
2. Using better integrated chips for the working of hardware.

3. Using high power source and DC Motors.
4. Using regional languages as voice command.
5. Floor mapping of the dedicated location.

CHAPTER 7
PROJECT METRICS

7.1 CHALLENGES FACED:

The following are the challenges faced during project development:

1. Processing power constraint due to low budget of the project.
2. Low power DC Motor due to low budget of the project.

7.2 RELEVANT SUBJECT:

The subjects we found relevant are as follows:

Table 7.1: Relevant Subjects

Subject Code	Subject Name	Description
UCS503	Software Engineering	Used to set constraints and assumptions for the project.
UML501	Machine Learning	Used for recognition of speech.

7.3 Interdisciplinary Knowledge Sharing:

The basic The basic principles of software engineering helped in figuring out concisely what is to be implemented and what is to be discarded. Diagrams like use case, sequence, data flow etc. were essential building blocks to make us understand clearly how to go step by step in the coding phase.
Machine Learning helped us in figuring out how to predict the price of stocks using various machine learning models and perform language processing as well.

7.4 Peer Assessment Matrix:

Table 7.2: Peer Assignment Table

Evaluated by	Evaluation of			
	Tushar	Vasudev	Vibhor	Vikas
Tushar	5	5	5	5
Vasudev	5	5	5	5
Vibhor	5	5	5	5
Vikas	5	5	5	5

7.5 ROLE PLAYING

Table 7.3: Work Plan

TASK	START DATE	FINISH DATE
Structure Design	15-01-19	02-02-19
Hardware Component Assembly	12-06-19	20-11-19
Software Diagrams	02-02-19	10-02-19
SRS	12-02-19	27-02-19
Aesthetics	01-11-19	21-11-19
Documentation	10-11-19	15-11-19

Table 7.4: Role Playing

Team Members	**Role in Development Process**
Vibhor Khanna	• Hardware Component Design • Voice Module • Arduino Circuit • DC Motors
Vikas Sidhar	• Hardware Component Design • Testing • Bluetooth Module • Obstacle Detection System
Tushar Shrivastava	• Hardware Component Assembly • Bluetooth Interface Development • Aesthetics • Battery Indicator Module
Vasudev Sharma	• Arduino(Software) • Voice Module • Testing • DC Motors

7.6 Student Outcomes Description and Performance Indicators

Table 7.5: Student Outcome Description

Sno.	Description	Outcomes
1.	Applying engineering Techniques for effective Speech Recognition	Learning of Language Processing
2.	Applying engineering principles in building Structure of the Prototype	Structural Design and implementation
3.	Using appropriate hardware components	Using voice module, Arduino, Bluetooth module, DC motors, L293D IC.
4.	Analyse results from the testing and verifying the data.	Using Data to interpret results and performing corrections.
5.	Able to evaluate the ethics and cultural aspects and social need of the project	Using the prototype to benefit the user and help him/her in some way

7.7 Brief Analytical Assessment

The project was tested for the movement of the wheel chair using trained voice after the design and development of the self-automated wheel chair with its various interfacing units.

- On the basis of the accuracy of the voice system. This would be implemented for disabled people. Firstly, the voice recognition system will be tested in a quiet room with only one single user. Every word was correctly recognized.
- For a next time, we will test it with a different user on whom the system was not trained. For example, words like “right” were recognized as “write” in this way about 5% errors occurred in this case.

This was because the recognizer heard a different pronunciation. However, after the user had to speak the word a number of times the system had enough examples and properly determined what pronunciation the user speak for the word.

Appendix A
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Capstone Project

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