AN-NAJAH NATIONAL UNIVERSITY

FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY

COMPUTER ENGINEERING DEPARTMENT

Hardware Graduation Project:

Smart WheelChair

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Presented in partial fulfillment of the requirements for the Bachelor's degree in Computer Engineering.

1 Acknowledgment

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2 Disclaimer

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3 Abstract

In the era of bringing technology to the physical world, facilitating the difficulties that people with impairment face, providing them with the technologies to make them comfortable to handle what they go through everyday.

Our project consists of features for a wheelchair that gives the opportunity for those in need that have suffered conditions out of their control, to make the chair applicable to very different conditions and handle many different cases of illness:

- Manual Control : the patient control the chair with a mobile application.
- Voice Control : the patient control the chair with voice commands.
- Automatic Movement: the chair uses a camera to move the chair automatically in a certain path.

4 Introduction

4.1 Problem Statement

For people with impairment there are a lot of difficulties that they face depending on their condition and they need to use a wheelchair, but sometimes their condition would require a person to accompany them, if their condition lead them to not be able to move the wheelchair using their hands then somebody is required to be with them, and their might be various conditions that could be solved with technology so in our project we try to cover many different scenarios and cases that would make it easier for those that need it.

4.2 Objectives and Scope

The project main goal is to provide a chair that could handle the problems of a patient with a disability and to preform the job which is moving the person from a place to another, however the different cases that the patient who is not able to walk might be in needs to be taken in mind, so the project handles the following:

- The patient requires a wheelchair that could control manually with his hands. So we provide a mobile application that would connect wirelessly with the microcontroller to move the chair in the direction that the patient choose.

- The patient suffers from a condition that limits him from moving the chair with his hands, So we provide a microphone that is connected to a module which is connected to the microcontroller, the microphone will get the voice commands and with the previous trained voice commands the module would compare the input voice to the trained commands and depending on it will move the chair, and we implemented object avoidance algorithm so if an object is in front of the chair we don't want to pump into it.

- The patient suffers a long term illness that prevents him from moving or communicating and is stuck resting on the bed, in these conditions the patient every once in a while need to get out of his room and move around as advised by their doctor, it is beneficial for their mental health, normally in these nursery homes a nurse carry them to the chair and accompany them for a walk in the garden. So for this case we used a camera connected to a Raspberry Pi to analyze where the chair is supposed to move, so the garden has a specific way and we use signs to control the chair to walk in these paths with our the requirement of a nurse to accompany them always in the garden.

4.3 Significance

The project tries to help patients with any accidents and conditions they faced and to help them overcome them. and the chair can handle this very well for different kind of conditions, the patient may not always be accompa-

nied by someone so they something more intelligent. It saves time and effort and help them with the fact that not at all times someone might be with them.

5 Constraints

5.1 Lack of funds

Some of our options in choosing parts required for the project, required expensive options, but to the limit of our budget we used what parts would do the job not precisely but does the work.

5.2 Lack of Experience

In our case, we faced a lot of issues because we were not familiar with some of these parts and ideas, so most of our time was spent on testing each feature, and a lot of time was spent on understanding our raspberry pi understanding its operating system and how much accurate it is and how much it can handle.

5.3 Lack of Mechanical Experience

Our project is about transporting the patient sitting on the chair, so there is the weight factor on the wheels and also the friction of the wheels with the

ground which the movement always differ between types of ground.

5.4 Lack of Tools

Our project required tools that are always available at the hands of students, we had to rent some tools to be able to build the chair.

5.5 Difficulties of Transporting

There were times were moving from city to another impossible, so we as a group had problems to be able to work together for physical work, and necessary tools that are in the university lab was off our hands.

5.6 Environment Noise

While the voice commands are pretrained and they compare the commands that are input from the microphone with them, noise can have a huge effect on it, one of the things is that the rubber on the wheels producing really loud noise that prevents us from entering the next voice commands so we made the chair move for a certain amount of time and to avoid collision in the time of its movement we implemented an avoidance algorithm for any object detected infront of the chair.

6 Earlier Course

6.1 Microcontrollers

These classes covered the basic use of the Arduino and how to deal with and understand microcontrollers, including as basic serial communication and controlling motors.

6.2 Wireless Communication

We used the esp8266 wifi module to be able to communicate the mobile with the arduino wirelessly.

6.3 Image Processing

We were able to analyze the frames that the camera detect and be able to analyze the signs in what the chair is supposed to move.

6.4 Operating System

This class helped a lot with the understanding of the Raspberry Pi since it uses Kali version of linux, and how to use it sufficiently for the work we needed.

6.5 Critical Thinking

This class provided us how to conduct a research and be able to write a report.

7 Literature Review

In doing our project, we first discussed how applicable it would be and if it could be affordable and how would it be logical, and what exactly are the components and parts that we need and the behavior of the program which would be as follows:

7.1 Regular Use of wheelchairs

The regular use of wheelchairs plays a vital role in facilitating mobility and independence for individuals with mobility impairments. Wheelchairs serve as a lifeline for people who are unable to walk due to various medical conditions or physical disabilities. These individuals rely on wheelchairs as their primary means of transportation, allowing them to navigate their surroundings, perform daily activities, and participate in social interactions.

For individuals with permanent disabilities, such as spinal cord injuries, wheelchairs become an integral part of their lives. These wheelchairs are custom-designed to provide optimal support.

In medical settings, wheelchairs are essential for transporting patients within hospitals, clinics, and rehabilitation centers. They enable healthcare professionals to safely and efficiently move patients from one location to another.

Furthermore, wheelchairs are not only limited to indoor use but also facilitate outdoor mobility. Specialized wheelchairs, such as all-terrain or sports wheelchairs.

7.2 Smart WheelChair Idea

In our project we tried to think as much as logical on how it would perform on a patient normal day, so even for the manual mode giving the patient the ability to control it using an application it would be more convenient than moving it with hands, and for the voice controlling we kept in mind so that what if an object happens to be in front of it, certainly we don't want to pump into it so we built an avoidance algorithm to avoid it, and for the camera mode it was designed for a close environment and its purpose is to move according to signals that lead the chair to move in a certain path.

7.3 Similar Projects

One of the Similar projects we could find is an electrical wheelchair that moves by using a joystick, but in our case we used a mobile application the difference is that through a mobile application there are much more things that can be used if the project is going to be further developed, one downside

of using a mobile application is that the mobile device might run out of power, but since our project also relies on power we can connect a charger to handle this for the patient.

8 Methodology

In this section, we will talk about the details of the components and techniques we used to build our project, from building the wheelchair to connecting it with the arduino and raspberry pi and controlling the different modes.

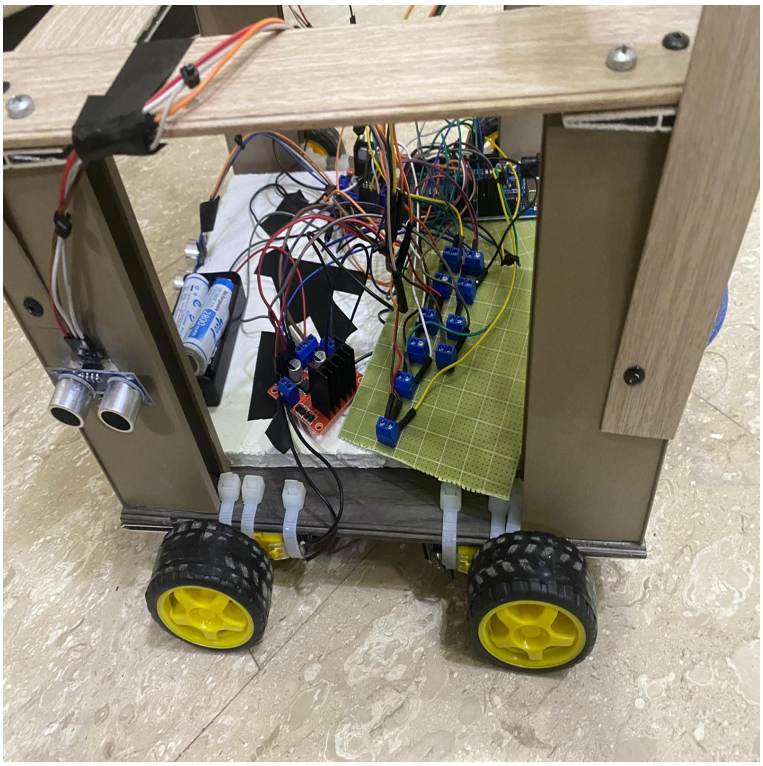

Figure 1: Wheelchair Image

8.1 Project Design

In our project, we built a chassis for the wheelchair with the following things to keep in mind:

- A convenient shape for a wheelchair.
- The wheelchair should provide space for the hardware components to put in because since it is moving and not stationary the chair is expected to hold them.
- The chair should have a light weight to make sure that the wheels can move, so that the chair can operate.
- A good place to assemble the wheels on to work properly.

So, the structure we ended with is as the following figure, the chair is made of aluminium and assembled and put together using bolts and drill.

Figure 2: Wheelchair Skeleton

After we built the chair, we drilled holes at accurate measures to place the wheels and make sure they are placed correctly so we couldn't face in the future any improper movements due to the placement.

8.2 Parts

8.2.1 Arduino Mega 2560

The arduino will act as the brain of the brain for our project, it will provide each part in our project with the signals necessary for them to work.

Figure 3: Arduino Mega

8.2.2 Raspberry Pi 3 Model B

the raspberry pi 3 is single board computer, we uses it to access complex libraries that is essential for the camera to analyze using image processing (OpenCV), and we used the GPIO pins on it to provide a signal for the arduino on the output of the image processing.

Figure 4: Raspberry Pi 3

8.2.3 5v DC Motor

We used four motors to be able to provide the chair with movement, each pair of these motors are connected with the opposite pair of the same side, because for them to fit on the chair each side has two motors facing each other with means that the signals for each motor on one side should have the opposite signal on the same side.

Figure 5: DC Motor

8.2.4 H-Bridge Motor Driver L298N

We used this part to drive the DC motors with the speed and direction we find necessary, the h-bridge requires an external voltage to provide it with the required voltage to operate to which we connected with Lithium Batteries, and the other pins used for driving the motors we connected it with the arduino.

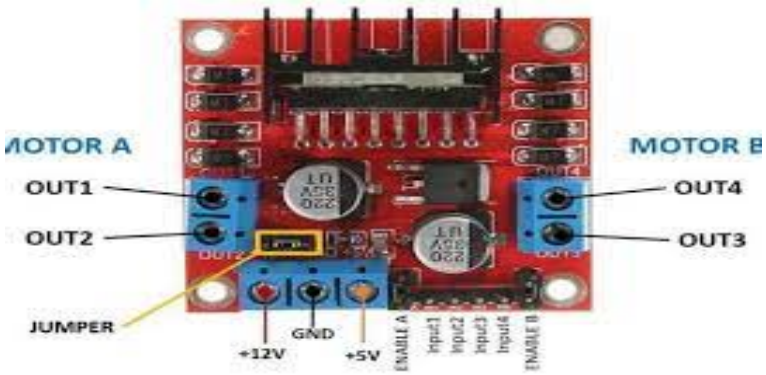

Figure 6: L298N Motor Driver

8.2.5 Ultrasonic SR-04

We used this sensor to detect the distance between the chair and the object that would face it, we used three sensors to apply a specific avoid object algorithm so when a particular object is in the chair path it will avoid it,the sensors are placed in front of the chair and at both sides of the chair there is a sensor.

Figure 7: UltraSonic Sensor

8.2.6 Voice Recognition Module

This device is used to enable other components to understand and interpret human speech. It converts spoken words into digital data, allowing for interaction with other systems.

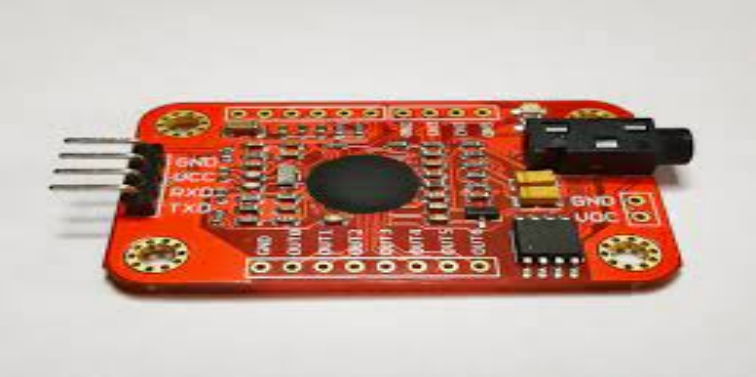

Figure 8: Voice Recognition Module

8.2.7 ESP8266 Wifi Module

We used this module to be able to provide a stable and secure connection between the arduino and the mobile in which the application will be on.

Figure 9: ESP8266 wifi module

8.2.8 Camera module

This camera is used to connect to the raspberry pi to be able to capture image and video stream,it is connected on the Camera Serial Interface of the raspberry pi, we used it so it can capture signals and analyze them to give a command to the arduino on how the chair's wheels should move by controlling their dc motors.

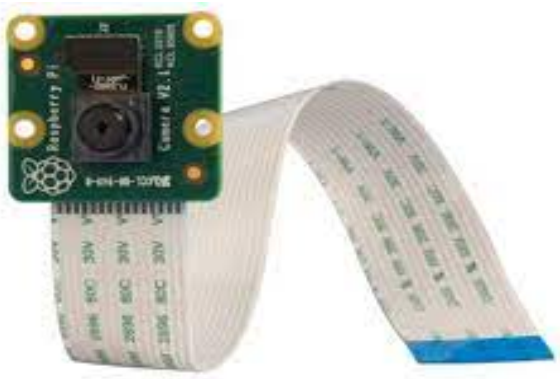

Figure 10: Camera Module

8.2.9 Mobile Application

We used an open source website that allows us to design the interface for our application, with the ability to also assign the name of variable for each part so we can control the application for what we require.

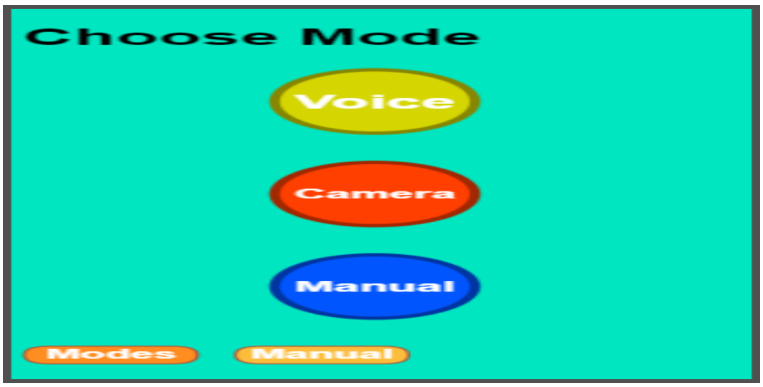

Figure 11: Mobile Application Page 1

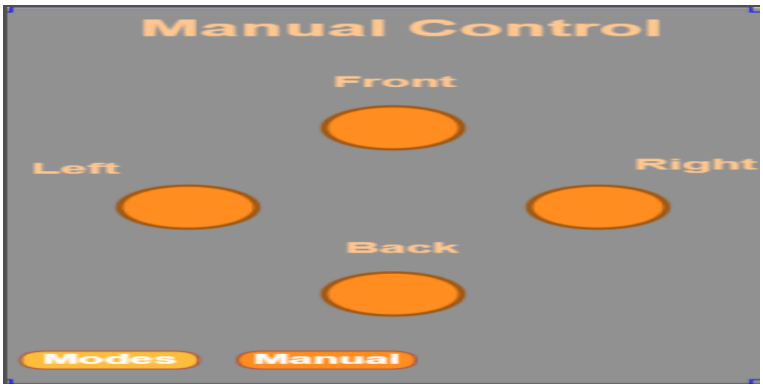

Figure 12: Mobile Application Page 2

8.2.10 Lithium Batteries

we use Lithium batteries to provide the h-bridge with the external voltage it requires to operate, it provides high energy density, portable, rechargeable, and has long cycle life.

Figure 13: Lithium Batteries

8.2.11 Wires

We used wires to be able to connect the components to each other, so we can provide necessary signals for required parts.

Figure 14: Wires

8.2.12 Copper Board

We used this to be able to connect wires with components to make sure they are well placed and fixed.

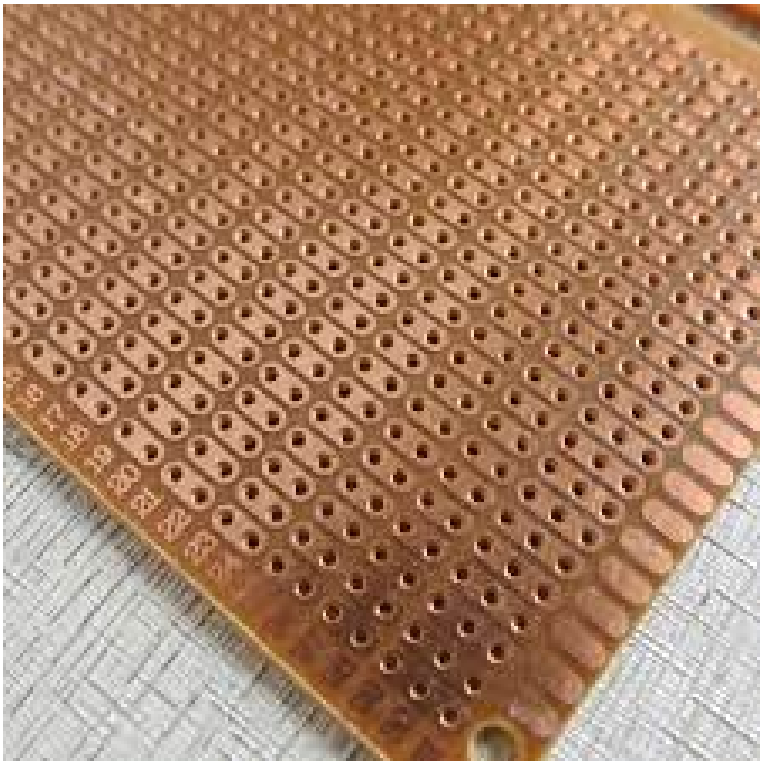

Figure 15: Copper Board

8.2.13 Microphone

The microphone is used to receive voice input to the voice recognition module.

Figure 16: Microphone

8.3 Functionality

In this section we will discuss the operating of the wheelchair and it's functionality.

The chair chassis is the part where all of the components would be placed inside so we put them all inside after having placed a layer to provide their placement.

The wheels are attached in their place so we can connect them to the DC motors that are attached to the chassis, after that we connect two DC motors on each side to one h-bridge each, we do this to prevent malfunction or overheating to h-bridge, so instead of one h-bridge connected to all four motors we used two h-bridge.

Then we connect the batteries to the 15 volt input on the two h-bridges and the same goes for the Ground input, with this now done we can focus on the connection of the components and the arduino (Note that in the connection we will use the sockets on the Copper Board).

8.3.1 Driving Motors

we connect the arduino mega with the two h-bridges to control the speed and the direction of the wheels, the h-bridge expects an input so the arduino pins will give us an output, for movement the following is configured:

- Forward: all motors will move in the same direction to the front.
- Right: The right side motors will not move, and the left side motors will move to the front.
- Left: The Left side motors will not move, and the right side motors will move to the front.
- Backward: all motors will move in the same direction to the back, the opposite direction of front.

As for the speed, we will use the maximum speed since moving at a slower rate would make the chair not moving properly due to it's weight.
Although this may not be the best possible solution for moving to a different direction, it is the most efficient, despite building the chair with light materials it still affects the motors functionality, so changing direction by using the motors on the same side was the best option.

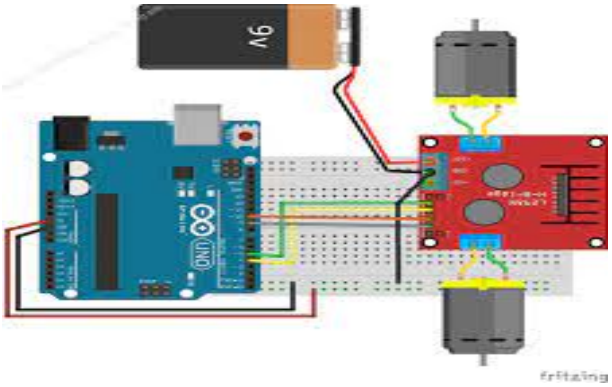

Figure 17: Driving Motors

8.4 Mobile Application

We built the mobile application and we will connect it with the arduino, the wifi module is connected with the serial communication of the arduino, the mobile will connect wirelessly with the module by using its SSID and password.

Any button pressed on the mobile application will be transmitted as data to the arduino, and from the arduino we analyze these data to do their tasks.

The mobile application would provide the ability to choose the different modes for the chair, and for the manual mode provide an interface for the movement for any of the directions.

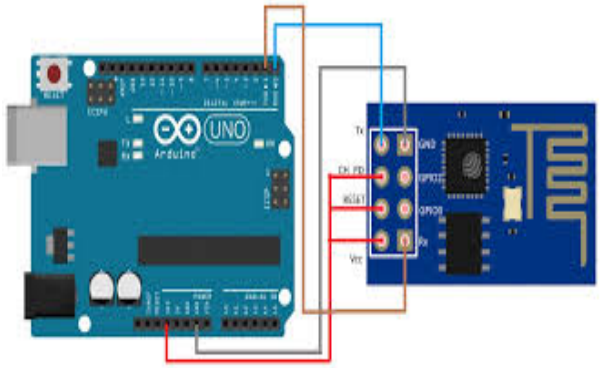

Figure 18: wifi connection

8.5 Voice Commands

We connect the microphone with the voice recognition module and train it separately for the voice commands it is expected to receive and apply the commands to, so we trained the module for the directions the chair would move which are:

- Forward : the trained command is "North"
- Right : the trained command is "East"
- Left : the trained command is "West"
- Backward : the trained command is "South"

We used these specific words, because we have to take in mind the noise and the different voice frequencies that these voice commands would have when the module analyze them, and these words under testing had good

behavior and good response on them for the module to recognize them in there pretrained samples.

Notice that a Stop command is not there, the Front and Back commands move for a specific time before stopping to receive another command, this is because as we discussed in the constraint section the wheels friction with the ground produce a loud noise that makes the module unable to identify the other voice commands.

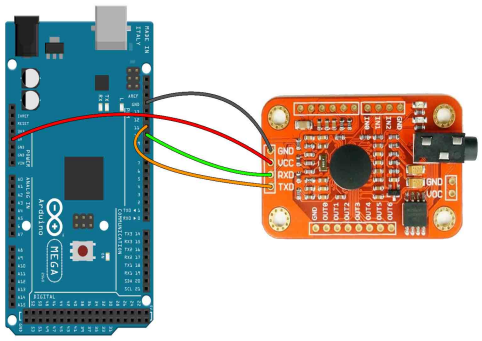

Figure 19: Voice Recognition

8.6 Object Avoidance

The ultrasonic sensors we placed on the chair are used to avoid the obstacles that the chair might run into, this algorithm is used for moving forward to avoid the objects that it might face.
these are the different scenarios that will trigger the object avoidance:

- An object is in front of the chair but on both sides there is nothing, the chair would avoid the object from the left.
- An object is in front of the chair and at the left side there is an obstacle, the chair would avoid the object from the left.
- On both sides and on the front there are obstacles blocking the path, the chair would move backwards and turn to the right.

8.7 Auto Movement (Camera Mode)

For the Auto Mode, we used the camera to be able to recognise different signs on the path to keep the chair on the correct path, for this mode we used the raspberry pi to operate the analyzing of the frames captured by the camera and it send using its GPIO pins signals for the arduino to alter the movement of the chair, in the raspberry pi we used OpenCV library in writing a python code that would be executed, it would analyze different signals if none detected proceed with the previous command if it detects a signal alter the movement, we have to keep in mind that the raspberry

pi needs careful and thoughtful optimization because making the operation more complex leads into a significant drop in performance.

9 Results and Problem Discussion

To drive the motors and control the movement of the wheelchair, we use the Arduino Mega 2560. The Arduino is programmed to receive signals from various input sources and send appropriate signals to the motor driver (L298N) to control the motors.

For manual control, we developed a mobile application that communicates with the Arduino via the ESP8266 Wi-Fi module. The application allows the user to control the wheelchair's movement by sending commands to the Arduino, which in turn controls the motors accordingly.

For voice control ,at first, we controlled the voice commands through the Raspberry Pi, but there was a delay in processing the voice commands and implementing what was required, so we solved this problem through we integrated a voice recognition module with the Arduino. The module receives voice commands through a microphone and converts them into digital data. The Arduino compares the received voice commands with pre-trained commands and triggers the appropriate motor movements based on the recognized command.

To enable automatic movement, we incorporated a camera module connected to a Raspberry Pi 3 Model B. The camera captures video frames, and the

Raspberry Pi uses image processing techniques (OpenCV) to analyze the frames. The processed information is then sent to the Arduino, which controls the motors to move the wheelchair along a predefined path in a garden, for example.

To ensure the safety of the wheelchair and avoid collisions, we integrated ultrasonic sensors (SR-04) at the front and sides of the wheelchair. These sensors continuously measure the distance to nearby objects, and the Arduino uses this information to implement an obstacle avoidance algorithm. If an object is detected within a certain range, the Arduino adjusts the wheelchair's movement to avoid the obstacle.

The overall functionality of the wheelchair is achieved by integrating these components and ensuring proper communication between them. The user can choose between manual control, voice control, or automatic movement modes, depending on their specific needs and capabilities.

10 Conclusion

10.1 Summary

We created a chair with excellent abilities provided different feature for different purposes. The project may not be working precisely with very high accuracy due to constraints, of lack of resources, tools, and lack of experience, however we built a project that does the job sufficiently and effectively

with a lot of room for further improvement, and we hope to achieve the best of it more in the future.

10.2 Improvements

There are needs of improvement in this project, from having better wheels and DC motors for accurate moving in direction without being heavily affected by the type of floor, providing Low pass filter to the microphone so any noise wouldn't affect the voice commands, having a better raspberry pi with powerful components so we can improve the performance of image processing and providing actions.

10.3 Future Work

The project can be used to be far more useful, it can be improved so that the object avoidance is very accurate, it could also be improved so that on the mobile application you could choose places to be and it would smartly guide you there automatically while also applying object avoidance without losing your path, we could also improve the mobile application and add different feature to it such as displaying the camera view on the mobile and what it detects, last but not least improving the image processing using a powerful raspberry pi so that it can identify many different objects and shapes so that if a person is walking towards you it could horn and if its a hole avoid it and so on.

10.4 Outcome

we have built a good and an effective chair that is convenient for people with different disabilities to use and can provide assistance depending on their conditions which would be more useful and practical for those people.

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