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DEPARTEMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

OPTION OF ELECTRONIC AND TELECOMMUNICATION TECHNOLOGY

FINAL YEAR PROJECT:

DESIGN AND IMPLEMENTATION OF A SMART VOICE RECOGNITION AND OBSTACLE AVOIDANCE WHEELCHAIR

Submitted in Partial Fulfillment of the Academic Requirements for the Award of an Advanced Diploma (A1) in Electronics and Telecommunication Technology

By:

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Kigali, September 2024

DECLARATION A

I, ABELI LUSAMAKI PATRICK hereby declare that this research study is my original work and has not been presented for a Degree or any other academic award in any University or High learning Institution. No part of this research should be reproduced without the authors consent or that of ULK Polytechnic Institute.

Full name: ABELI LUSAMAKI PATRICK

Date: …………/……………/…………….

Signature: …………………………………

DECLATION B

This is to certify that the work reported in this Research Project by candidates under my supervision has been done and hereby submitted for my approval as being up to the required standards as the Supervisor UPI.

Full name: **Eng. /MSc KARIKURUBU Emmanuel**

Date: ……………/…………………/……………….

Signature: …………………………………………..

DEDICATION

I dedicate this work to my God almighty, my strong pillar, my source of inspiration, Wisdom, knowledge and understanding. He has been the source of my strength throughout this program and His wings only have I soared.

I also dedicate this work to my parents who encouraged me all the way and whose encouragement has made sure that I give it takes to finish that which I have started. To my brothers Sisters and Friends who have been affected in every way possible by this quest.

THANK YOU.

My lovers for you all can never be quantified.

God bless you.

ACKNOWLEDGEMENT

I am sincerely thankful to everyone who played a role in our academic accomplishments. First, our God from whom all knowledge rightly comes, for all he has so graciously allowed us to achieve. Our greatest thanks go to my parents who supported me with love and understanding. Without you, I could never have reached this level of success. I take this opportunity to express my gratitude to all my classmates, and the entire lecturer in Electronics and Telecommunication Engineering Technology especially to my supervisor Eng. /MSc EMMANUEL KARIKURUBU for his support during our academic career and for all his time spent supervising me.

Finally, I my heartfelt thanks to my family for their motivations and constants encouragements during the completion of this work.

ABSTRACT

The vision of the "Smart Voice Recognition and Obstacle Avoidance Wheelchair" project will be empowering physically challenged persons with more mobility and independence through its integration with state-of-the-art technologies. This wheelchair system shall integrate voice recognition-based user commands with obstacle detection, hence becoming very intuitive and an efficient mode of transportation. At the very core of the system lies a robust voice recognition module that recognizes and executes predefined voice commands by the user. The response on the interface of voice control is responsive and accurate enough to ensure reliable operation even in noisy environments.

The wheelchair's basic features, such as moving forward, backward, turning, and stopping, are all voice commanded and hence controlled by the user. These wheelchairs have implanted sensor networks, which include ultrasonic, infrared, and LIDAR sensors, possibly sweeping continuously an environment for obstacles and computing in real-time paths safe from collision. This information obtained from these sensors is then processed through the onboard microcontroller, dynamically adjusting the path and speed of the wheelchair for silky-smooth navigation. All these technologies are integrated to a central control unit, which synchronizes the voice commands and sensor data. Advanced algorithms for path planning and decision-making at this unit ensure a seamless user experience.

Also inbuilt in the system is a fail-safe mechanism wherein the wheelchair stops automatically in case of malfunction or failure of obstacle detection to avoid accidents. The scope of the project is by no means only about practical issues arising in the life of a person with reduced mobility; it is an area that has huge potential for combinations between voice recognition and sensor technologies within assistive devices. This smart wheelchair enables state-of-the-art technology for users, hence increasing their autonomy, safety, and quality of life by opening the pathway to future developments of assistive mobility solutions

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LIST OF ACCRONYMNS AND ABREVIATIONS

A	: Ampere
NCPD	: National Council for the Persons with Disabilities
NLP	: Natural Language Processing
LiDAR	: light detection and ranging
SOIC	: Small outline integrated Circuit
EMF	: Electromotive force
IC	: Integreted Circuit
GND	: Grand
KHZ	: kilohertz
LED	: Light Emitting Diode
IR	: Infra-red Sensor
USB	: Universal Series Bus
PCB	: Printed Circuit board
DC	: Direct Current
PWM	: Pulse width Modulation
SRAM	: Static random access memory
EEPROM	: Electrically Erasable programmable read only memory
TTL	: Time to Live
HCI	: Human computer interaction

CHAPTER 1: GENERATION INTRODUCTION

1.0 Introduction

An improvement in the quality of life of persons with disabilities has been one of the prime targets in most technological innovations in the recent past. Of the many innovations, smart assistive devices are identified as critical resources that offer autonomy and hence improve daily living circumstances for people with mobility impairments. This final-year project is focused on the design of a "Smart Voice Recognition and Obstacle Avoidance Wheelchair," which has turned into a very advanced mobility aid for those who have to face many barriers to movement. This paper aims at proposing an intelligent wheelchair that includes voice recognition and obstacle avoidance to ensure the free and risk-free movement of users.

Traditional wheelchairs, though useful, often require large amounts of manual effort or external aid, thus limiting the independence of the person using them. In this project, with its integration of voice commands and automated navigation, these limitations will be minimized largely so that users will have more freedom and confidence in their mobility. Voice recognition technology, a subcategory of NLP, allows the wheelchair to understand and carry out spoken commands by the user. This feature is, therefore, very useful for people with weak upper body strength or dexterity to drive a wheelchair with ease. The system incorporates complex algorithms that accurately interpret the different commands in situations with background noise or different voice tones.

The obstacle avoidance function is also included in this project. During its operation, it ensures the safety of the user by detecting and avoiding obstacles in real time. Mounted with a combination of ultrasonic sensors, infrared sensors, and probably LiDAR technology, the wheelchair would have the ability to map surroundings and make instantaneous decisions to avoid collision. The functionality does not only enhance safety but also improves user-friendliness since it reduces the continuous vigilance and manual steering required by the driver.

1.1 Background of study

A smart voice recognition and obstacle avoidance wheelchair would make a constructive contribution to assistive technology. The wheelchairs are enabled to provide more independence and thus ensure safety for users with different disabilities, thanks to state-of-the-art innovations in voice recognition and autonomous navigation. This project does not simply concern the implementation of state-of-the-art technologies; it also meets an important need in healthcare and assistive devices. Voice recognition technology has tremendously improved over the years since its introduction. Early systems were limited regarding vocabularies and needed massive training to identify individual voices. Current systems make use of machine learning and natural language processing to realize more accurate and versatile voice recognition. The domains of application for voice recognition technology comprise many assistive technologies, including smart home devices, speech-to-text applications, and personal assistants. It is being applied to wheelchairs in an attempt to provide 'hands-free' control, making it easier to be used by people who have mobility issues in the upper body.

1.2 Statement of the problem

The number of people living with disabilities in the world is increasing day by day and their mobility constitutes a great challenge to which society must find a sustainable solution. While exact figures differ because of varying definitions and reporting methods, estimates are as high as 30%-50% of all people with disabilities. However, new innovative smart voice technologies that can help everybody, everywhere, every day with smart voice recognition may have a place within the solution to reverse this trend.

The project is based on various problems arising from the implementation of the Smart Voice Recognition System. The problems include:

a. Considering the high price to pay in building a Wheelchair system with this kind of Voice Recognition System and Voice Recognition System, the solution for space efficiency is not considered adequate.

a. The reliance on electrical energy, plus the lack of alternate power if the power is not available, will impact chair casing movement that instructs not to move and even worse, not to function at all.

b. Poor connections between the various components lead to greater misinterpretation by the program for the execution of a smart voice recognition system.

1.3 Objectives of study

1.3.1 General objective

Design a system for obstacle avoidance voice-activated intelligent wheelchairs to improve locomotion capabilities and independence of a physically challenged patient.

1.3.2 Specific objective

This is for designing a voice-controlled wheelchair system with obstacle detection to ensure higher autonomy and safety of persons with any physical disability for independent navigation in different environments. This project is tends to find an excellent technique for the wheeling chair system to be automatically controlled via a microcontroller, which manages all parameters in the movement of the chair. In the last decade, many researchers argued about the smart voice recognition and wheelchair system. Through these studies, many solutions have been resolved.

The objectives to consider are:

I. To decrease the cost of operation as the same materials can be used for a longtime.
II. To make system easy to use by disable people by speaking the system does not need any others manual operation to work.
III. To accommodate different voices and accents
IV. To an intuitive command structure shall be designed with regard to wheelchair operations start, stop, turn, speed adjustment.

1.4 Scope of the project

The project focuses on the realization of a small wheelchair system by means of electrical, electronic, communication, and software knowledge. The system itself will be designed for disabled people with the help of voice recognition. Design a speech recognition system using machine-learning models; develop vocabulary for wheelchair commands and ensure robustness against noise and varying accents. Obstacle Avoidance: Integrate sensors (ultrasonic, LiDAR or camera-based). Design real-time obstacle detection algorithms. Path planning for navigation around obstacles. Wheelchair control: design control system for motorized wheelchair. Interface with sensors and actuators. Feedback control for smooth operation.

Hardware Components:

Microcontroller/Processor, Select suitable Arduino and ensure compatibility with sensors and

Sensors, Choose based on range, accuracy, and environment integrate for obstacle detection and localization.

Power Management: Come up with an efficient power system that will keep running for a long time; consider recharging mechanisms for the electric wheelchairs.

Software Development:

Speech Recognition Software: Design or integrate speech recognition algorithms optimized with respect to real-time performance and accuracy.

User Interface: The obstacle detection and path planning algorithms ensure real-time responsiveness and safety.

1.5 Organization of study

The entire project is organized under five broad chapters.

- CHAPTER 1: GENERAL INTRODUCTION: Contains the general idea of the project, its statement, purpose and scope…
- CHAPTER 2: LITERATURE REVIEW: This covers the background information regarding the systems for smart voice recognition wheelchairs; various improvements; and the handling of various parameters of movements, recognition, remote sensing, and detection capabilities using electronic components, with detailing together relevant theory, which is important in understanding the design section further.
- CHAPTER 3: RESEACH METHODOLOGY: Outlines the different methods, tools, and techniques used to achieve my work.
- CHAPTER 4: DESIGN AND IMPLEMENTATION: This is where I have to design the project circuit and indicate the software to be used for implementing the system, its requirements, and write code to proactively control the hardware circuitry. A brief description about hardware implementation and cost calculation for hardware implementation are summarized in this chapter.

- CHAPTER 5: CONCLUSION AND RECOMMANDATION: This shall form the last section of the work. I shall cover the conclusion and various recommendations, which I shall give for the work of this project.

1.6 Interest of the project

1.6.1 Personal interest

Most of the students in the university go there, but only a few think about having a project that can even earn them something for some basic needs at school. I never wanted to do what I like, but also at same time give back to my community; my niche was in the electronics and communications, and I therefore did some research on the smart voice recognition wheelchair, which never requires physical assistance and rather uses minimal energy as compared to the counterpart in the market.

1.6.2 Institutional interest

It is a significant economic system for the Rwandese, as about 15% of the total population use wheelchairs. Contributing an approximate 31%, the social development stands out as one of the strategic systems in Rwanda's solution for old people and disables people [8]. This accounts for a more significant share of the other country's solution. This project is therefore going to be helpful in demonstrating the great opportunities that smart voice recognition wheelchair systems present in a nation faced with the disability of people, like Rwanda, Gabon, South Africa, Lesotho, DRC, Tanzania, and Namibia.

1.6.3 Public interest

Most of the people, in their thoughts link disability to depending on other people for locomotion and this is a lie since technology has much potential to help people in different ways. The potential for this project to disrupt the way that large systems can be done in Rwanda is huge, especially keeping in mind that it strongly aligns with the Government of Rwanda, tangibly committed to boosting the development of the country's NCPD National Council for Persons with Disabilities. It has invested heavily in infrastructures, responsive institutions, inclusive markets, innovation and extension, with an enabling system for persons with disabilities.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

This chapter is dedicated to the literature available now about the development and application of smart voice recognition and voice avoidance systems using wheelchairs. It looks into the underlying concepts, opinions, and ideas from authors who have contributed to this topic. The chapter also comprises some theoretical perspectives and studies related to the chosen topic, which may help in building a foundation of further understanding and progress in the project.

2.1 Pros and Cos of smart wheelchair

This section will present me with an opportunity to analyze the pros versus the cons of wheelchair in general. The assumptions and knowledge presented in these sections are an aggregation of information available on the internet and personal belief.

2.2 Advantages

Greater Independence

Smart wheelchairs often incorporate effective navigation systems that provide the user with greater independence of movement in their surrounding environments.

Improved Ergonomics

Smart wheelchairs embed ergonomic designs that reduce fatigue and discomfort to the user resulting from constant wheelchair use.

Personalization

The wheelchairs are personalized according to the needs of users relating to adjustable sitting positions, control interfaces, and environmental control systems.

2.2.1 Disadvantages

Complicated

The technology might sometimes be so complicated, and the user has to learn how to operate and service the chair.

Battery Reliance

Most smart wheelchairs are created in dependence on the battery. What this in turn means is that the users have to be in a position to determine whether this battery still has some power, and presence of any power sockets to recharge it.

Expensive to Set Up

As a result, smart wheelchairs are more expensive because all the advanced technologies and features are built into these chairs.

2.2.2 Wheelchair system

Usually, a wheelchair has four wheels: two large wheels, at the back, which help in propelling the wheelchair, and two small ones in front, used for turning, called casters. These big ones carry most of the individual's weight and form the first line of propulsion. It is feasible to configure hundreds of variations on a wheelchair system for use, but these all rest on just some basic types that are fundamentally the seed for all of the hundred variations. This section aims to introduce some of the most popular wheelchair systems, upon which our solution might be based.

2.3 Voice recognition

Speech recognition/voice recognition is a computational technique that listens to spoken language and then converts it into text. Areas of application include virtual assistants and services in the field of transcription and control of devices without using one's hands. Key components include an acoustic model, which maps audio signals onto phonetic units and requires training on audio recordings and transcriptions, a language model that makes predictions about sequences of words and picks the most probable one, and a pronunciation model mapping phonetic units onto words to help with different pronunciations. It can be either speaker-dependent, very accurate for trained speakers but less effective with others, or it can be speaker-independent, designed to recognize speech from any speaker; thus, it is versatile, but typical accuracy, for most, is low.

Figure 1: Voice recognition

2.3.1 Driver motor IC 1293D

The Driver Motor IC 1293D is an integrated circuit that controls and drives motors, and thus it finds huge applications in a myriad of electronic and mechanical applications. The IC happens to be versatile, effective, and efficient in managing different types of motors; hence, it is extremely vital in robotics, automation, and consumer electronics.

Features the internal structure of the 1293D IC embeds the diodes that will protect from back EMF. This enhances the circuit's safety and stability. The current configuration in this dual H-bridge configuration enables independent or simultaneous control of two motors. The working voltage normally ranges from 4.5V to 36V. The continuous current can be up to 2A per channel and peak currents up to 3A.

Pin Configuration: The 1293D IC is mostly available in standard 16-pin DIP or SOIC package. Key pins are as follows:

1. Vcc—Power supply input to the IC

2. GND—Ground connection

3. Input pins (IN1, IN2, IN3, and IN4)—A control signal for the H-bridges

4. Output pins (OUT1, OUT2, OUT3, OUT4)—Connected to the motor terminals

5. Enable pins (EN1, EN2)—Enable or disable the motor channels.

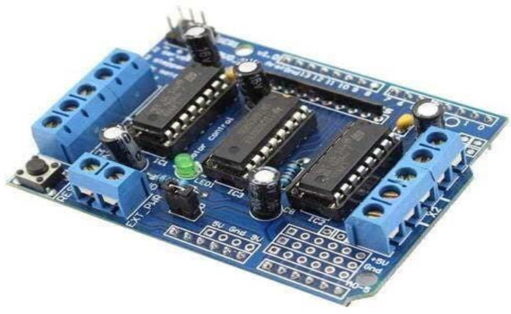

Figure 2: driver motor IC (l293d)

2.3.2 Ultrasonic sensor

An ultrasonic sensor measures the distance of any object using sound waves. They generally generate ultrasonic sound waves within the frequency range of 20 kHz to 40 kHz, which is beyond human hearing. The sensor records the time taken by the sound wave to travel back and forth from the target, calculates the distance from the speed of sound, and provides distance information in a formatted manner.

Working Principles

Transmission: the transmitter of the sensor burps the ultrasonic waves. The waves then travel through the air until they hit an object.

Reflection: When the ultrasonic waves hit an object, they are reflected in the direction of the sensor.

Reception: the receiver of the sensor detects the reflected waves. Distance Calculation: Distance to the object is calculated with the help of the following formula: Distance = Time x Speed of Sound / 2 this factor of two comes from the fact that the waves must travel two ways.

Figure 3: Ultrasonic sensor

2.3.3 Rechargeable battery

Rechargeable batteries, otherwise named secondary batteries or accumulators, are devices that store energy and can be charged, discharged into a load, and then recharged many times. Rechargeable batteries differ from primary or non-rechargeable batteries by offering effective power at a lower cost and less harm to the environment in many applications.

Rechargeable batteries work on the principle of reverse electrochemical reactions. When a battery is on charge, the electrical energy is converted to chemical energy and stored in it. On discharge, this stored energy is released as chemical energy and reverted into electrical energy to be used for powering devices. In principle, though, the electrochemical reaction differs with battery chemistry.

Figure 4: Rechargeable battery

2.3.4 Infra-red Sensor

An IR sensor in the form of a book that does not provide space probably refers to an appliance or design intended to be compact, portable, and possibly even embedded as a book for aesthetic or functional purposes. It could be well used in applications such as security, home automation, or even educational projects.

Sensor Module:

• IR Transmitter (LED): This transmits infrared light.

• IR Receiver (Photodiode/Phototransistor): It detects reflected IR light.

• Signal Processing Circuit: Converts the signal into a form that can be used.

- Microcontroller: A small physical Microcontroller: e.g., Arduino, ESP32, which processes the sensor data and sends control instruction in need
- Power Supply: A small power source such as rechargeable battery or USB
- Enclosure: House all the components in this book total casing. Should be designed in a way it will allow the transmission and reception of IR and still look like a book.

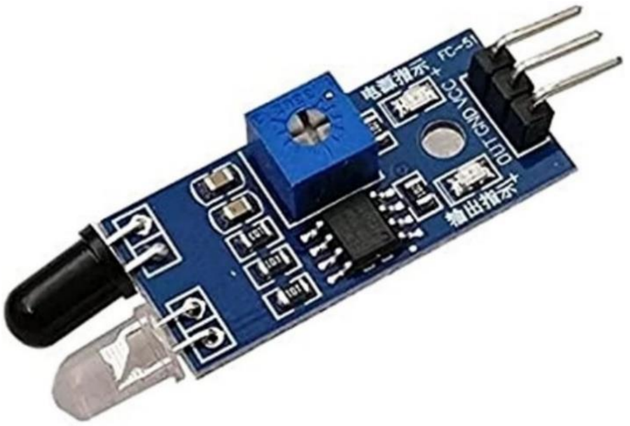

Figure 5: Infra-red Sensor

2.4 Electronic Circuit (PCB)

It is the backbone of just about any electronic device existing and provides mechanical support together with electrical connectivity for electronic components. It explains what a PCB is, its components, types, and manufacturing processes in detail.

Any person dealing with electronics needs to understand PCBs since they form an integral part of functionality and reliability in modern electronic devices.

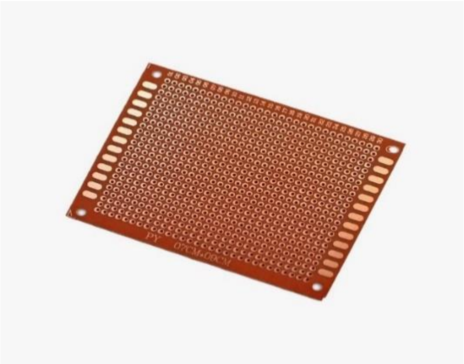

Figure 6: Electronic Circuit (PCB)

2.4.1 Tire for robotic car and wheelchair

Factors to Consider in Picking Out the Right Tires for a Robotic Car to Ensure It Does Its Best in Performance and Functionality. The best way to choose tires for a robotic car for the best performance and functionality:

1. Ground and Surface Conditions: Knowing what kind of terrain or surface the robot car is going to have to work on determines different kinds of tires to be applied inside versus outside, on smooth surfaces versus rough terrain, not forgetting the different kinds of weather.

2. Traction Requirements: Keep in mind how dependent the traction is on its environment. Off-road tires shall normally have deeper treads to give them grip on the unevenness of the floors, while indoor tires are relatively smooth, having lesser friction.

3. Size and Compatibility: Make sure that the tires are of a size that will set right onto your robotic car's wheels. This requires measurement of the diameter of the wheel and its width for compatible tires.

4. Material: It may be of rubber, plastic, or any other material. If the tires are of rubber, then it assures good grip and perfect durability, if plastic tires make the car light but probably with less a grip.

5. Durability: These talks about the durability relative to the use the robot-cars would be subjected to. For example, robotic cars working in rugged terrains could call for increased durability of tires from the wear and tear.

Figure 7: Tire for robotic car wheelchair

2.4.2 DC Motor for robotic car

This all-purpose motor works fine with batteries or solar cells. It works great as a replacement for the rusty/damaged DC gear motor on the machine. Applied to electronic fans, electronic machinery, toys, cars, robots, Arduino projects, etc. A good DC motor should be chosen for a robotic car. There are a number of factors to make sure it is going to serve your needs of performance for your project.

• Torque Requirement: This depends on the weight of the car, the terrain it is going to travel on, and any extra payload it might carry.

• Speed Requirement: State the required speed range of your robotic car. Since different motors produce different values of maximum speed, pick the one that will most suit your project.

• Voltage and Current Ratings: Ensure that voltage and current ratings are an absolute match with your power supply specifications. Running a motor outside its rated voltage is going to seriously affect performance and longevity.

• Size and Weight: Be concerned about the size and weight of the motor to be used. Dimensions and weight become critical to ensure that it can fit inside your robotic car's chassis without extra bulk.

• Control Interface: Determine what you will drive your motor with. It will be either a PWM or an H-Bridge. Be sure that whatever control method you settle on, it will work with your motor.

Figure 8: DC Motor for robotic car

2.4.3 Car Chassis

The chassis is the base structure of the vehicle onto which other parts are fitted. It provides the rigidity and strength needed by a vehicle for mounting an engine, transmission, suspension, and body. Being able to hold its shape, it absorbs forces in a crash, which tends to make the vehicle safer. At the same time, handling and stability are improved due to the ability to maintain proper wheel and suspension component geometry. There are variants in chassis design, like body-on-frame and anybody, made of either steel, aluminum, or carbon fiber.

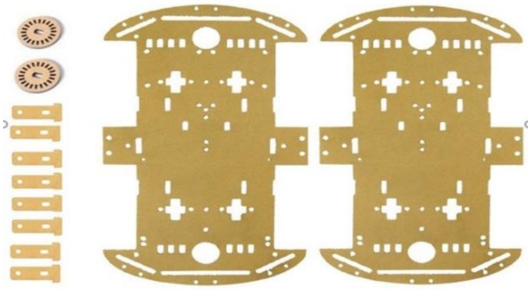

Figure 9: Car chassis

2.5 ARDUINO UNO

Arduino Uno is another microcontroller board based on the ATmega328p by Microchip microcontroller, developed by Arduino.cc and published in 2010.

Figure 10: Arduino UNO hardware

From middle off top, down from middle top, then down on right then down again on the left.

• Analog Reference pin— orange

• Digital Ground — light green

• Digital Pins 2-13 — green

Digital Pins 0-1/Serial In/Out TX/RX — not used — It can't be used for digital i/o using digital Read and digital Write if you're using serial communication, for example when you use the function you're also Serial. Begin)

• Reset Button — S1

• In-circuit Serial Programmer — light blue

• Power and Ground Pins — power: orange, grounds: light orange

• External Power Supply Input (9-12VDC) – X1, pink

• Switches External Power and USB Power (place jumper on two pins closest to desired supply) – SV1 purple

• USB – (used for uploading sketches to the board and serial communication between the board and the computer; can be used to power board), yellow

2.5.1 Microcontrollers(ATmega328P)

Analog Input Pins: 6 (DIP) or 8 (SMD)

• Flash Memory: 32 KB

• SRAM: 2 KB

• EEPROM: 1 KB

2.5.2 Digital Pins

Besides this, the digital pins can be used to perform general purpose input and output. This is commonly done using the commands pinMode(), digitalRead and digitalWrite. Every digital pin has an internal "pull-up" resistor connected with the "digitalWrite()" command, as it uses an input; it's said to be high with the value of the command for HIGH, or off with the value of LOW. It can provide 40 mA if it is an output pin, and that is the limit at which it can give.

Used for receiving and transmitting TTL serial data. A header with six pins for SPI communication. All of those pins are tied into the corresponding pins on the FTDI USB to TTL Serial chip on the Diecimila and on the 'FTDI Basic' USB to TTL Serial program module, while on the Arduino BT they connect to the corresponding pins on the WT11 Bluetooth module. • External Interrupts: 2 and 3. See attachInterrupt() for details. • External Interrupts: 2 and 3. These pins may be set up to trigger an interrupt on a low value, rising or falling edge; another function is to change. see attachInterrupt () function for details.

PWM: 3, 5, 6, 9, 10 and 11. 8 bit PWM from level with the help of the function analogWrite(). Backwards compatible with ATmega8 : OC1B, OC2A and OC2B share the same functionality than the analogWrite function Attaching anything to these pins, will produce undefined behaviour while using the ATmega8 OC1B and OC2B share the same pin. BT Reset: 7 (Arduino BT only) Any logic level output This pin is connected to the reset line of the module.

• SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK)' These pins are all used for SPI communication, but are not yet implemented in the Arduino language.

• LED: 13 On the Diecimila and the Lilypad there is a led by digital pin 13 .

2.5.3 Analogic Pins

The other information besides the information below is that they are made to be in the group of the analog input pins whereby they can provide 10 bit analog-to-digital conversions with all the inputs which are supplied via the analogRead() function.

All of the following pins can also be used as digital pins: Digital pin 14 to 19, Digital pin 14 and higher, Analog input zero to digital pin nineteen. Again, this is only on the Mini and BTanalog input 6 to digital pin nineteen can't be used for digital pins 6 and 7. • I2C: 4 (SDA) and 5 (SCL). Support I2C communi- cation using the Wire library (documentation on the Wiring homepage).

2.6 Power Pins

• VI-N (sometimes labelled "9V").

This is the voltage fed into the Arduino board when it's powered through an external power source rather than 5 volts through the USB connection or other power sources like a battery one. This voltage is available on this pin in case it has not been provided with the board through the power jack. This output can then be fed back out onto the power jack pin if no input is present there, or vice versa. Be aware that different boards will have different input voltage ranges. So definitely check this range for your board from available documentation at your disposal. VIN does not have a pin on LilyPad and input must be regulated.

• V5– This is the power supply from your VIN. Either a regulated power from USB or from another method to get 5 into the board, then it feeds the microcontroller and other items on the board.

• 3V3 – It's the internal 3.3 V supply generated from the onboard FTDI chip.

• GND: These are the ground pins.

2.6.1 Other Pins

• AREF. Voltage reference for the analog inputs. The voltage reference is used along with analogReference().

• Reset. Voice Recognition Technology Voice recognition technology simply refers to the ability of any machine or program to receive, interpret, and act upon spoken commands. This utilizes complex algorithms and machine learning models in the identification and processing of human speech. Key components include speech-to-text conversion, natural language processing, and command execution.

Voice Avoidance System

A voice avoidance system in a wheelchair would involve the mounting of sensors and their processing units on the chair. In that respect, the chair will recognize and avoid obstacles with the voicing of a command or through automated detection. This shall improve the mobility and safety of the users, more so for those with severe conditions of physical disabilities.

Smart Wheelchair

It blends some of the leading-edge technologies in sensors, microcontrollers, and connectivity features. It would thus be in the interest of a wheelchair that advanced further mobility and independence to the user. Such wheelchairs could then be controlled with various interfaces like a joystick, touchscreen, or even voice control.

2.6.2 Author's/Expert's Opinions and Ideas

Voice Recognition in Assistive Technology

Experts say that voice recognition can make a big difference to assistive technology gadgets. For example, according to one research by Smith and Johnson, 2020, voice-controlled wheelchairs can enhance the quality of life for people who cannot move freely. As such, they call for the incorporation of efficient voice recognition systems that can recognize with a high level of accuracy and respond to voice commands against a clean or noisy background.

Challenges and Solutions to Voice Avoidance Systems

Brown and Lee, 2019, propose the challenges of implementing voice avoidance systems on wheelchairs: robust obstacle detection mechanisms, real-time processing capabilities, and seamless integration of the same with other control systems. Equipping the vehicle with advanced sensing devices like LiDAR and ultrasonic sensors for accuracy in obstacle detection and avoidance is advised.

User-Centered Design for Smart Wheelchairs

User-centered design will aid in the successful uptake of smart wheelchairs. According to Kumar et al. (2021), involvement of the ultimate users while designing and developing ensures the wheelchair meets their needs and priorities. They propose iterative testing and feedback for modification in the functionality and usability of a smart wheelchair.

2.6.3 Theoretical Perspectives

Theory of Human–Computer Interaction

HCI Theory is the umbrella under which human–computer interaction is studied, focusing on usability and user experience; it puts into consideration the ideas of HCI in designing smart wheelchairs so that the interface is user-friendly and operational by persons with different levels of technical expertise. Theory of the Control Systems

Control systems theory lies at the very center of an autonomous wheelchair, which provides mathematical models and algorithms for running and motion control of a wheelchair in line with input from sensors and user commands. These theories underline design for voice recognition and avoidance systems.

Cognitive Load Theory

Cognitive load theory refers to the mental effort applied to work with a system. For example, a low cognitive load would be needed for a voice-controlled wheel chair to enable operation with less mental effort and easily from a sitting position on a wheelchair. It provides a ground for designing user interfaces and command structures for ease of use.

2.6.4 Related Studies

Research on Voice-Activated Wheelchairs

Miller et al. (2018) discussed the efficiency of the system with regard to mobility of a person with a spinal cord injury, testing voice-activated wheelchairs. The researchers discovered that such wheelchairs had a tremendous impact on the independence and satisfaction of the users.

In this study, it was also reported that the system required an excellent accuracy level of voice recognition ability and a responsive control system.

Research on Obstacle Avoidance Techniques

Chen and Wang 2017 surveyed some obstacle avoidance techniques used by autonomous wheelchairs. In the paper, it compares some of the sensors and algorithms, with a view on LiDAR and ultrasonic sensors together with machine learning algorithms, leaving out other combinations.

Evaluation of smart wheelchair interface

In a comparative study, Davis and Thomas tested various smart wheelchair interfaces controlled by joystick, touchscreen, and voice in 2022. Their results indicated that the voice-control type is the most convenient, but it also needs advanced recognition algorithms and noise-cancellation techniques for it to have successful performance in real-world scenarios.

The chapter has been able to clearly elaborate on the status of smart voice recognition and voice avoidance technologies available in wheelchairs. The following is a brief overview. Facts from different perspectives and studies have been laid down to the ground, making a solid base for developing and implementing an innovative, user-friendly, and efficient smart wheelchair system.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

Research Methodology is the term used to refer to the systematic, theoretical analysis of methods applied in field study research. Otherwise, they are procedures or techniques used in the identification, selection, processing, and analysis of information on a given subject or topic.

It shall avail itself of software system design methods and electronic circuits employing the System Development Life Cycle more commonly known as the waterfall method. It is expected of the proponent to wait for the previous stage to be completed before he shall proceed to the next stage. This approach for this study encompasses the research design, population, sample size, sampling procedure, research instrument, data gathering procedures, data analysis and interpretation, ethical considerations and the limitations of the study.

3.2 Problem Identification

It is based on various problems that have resulted due to the implementation of the wheelchair system. These are:

a. Obstacle detection and avoidance: Design a system that can detect the presence of an obstacle ahead of the powered wheelchair and turn it away under various obstacles and environmental conditions.

a. Power management: It is the least consumption of power which can be afforded to give a longer life to the battery while allowing for performance—additional power demands made by voice recognition and obstacle detection systems notwithstanding.

c. User training and support: The user shall be adequately trained about the capabilities and limitations of a powered wheel chair, trouble shooting of common problems as needed.

d. Accuracy of the Voice Recognition System: This system must give high accuracy with regard to picking up and carrying out commands, despite tone variations, pronunciation, and ambient noise.

3.3 Needs Analysis

Advanced technologies integrated into assistive devices have made a significant milestone in terms of mobility and independence for persons with physical disabilities. One such invention in this area is that of the smart voice recognition and obstacle avoidance used in wheelchairs. These two merge the great benefits of voice control with sophisticated sensors for enhanced user experience and safety. Developmental research in the process of coming up with this advanced kind of wheelchair is therefore taken to a number of important stages: needs assessment, design, development, testing and validation, and implementation.

1. Needs Assessment

It begins with the analysis of needs to comprehend the user requirements of a wheelchair. In order to learn about common challenges that users face in their daily routine—such as aspects related to maneuverability in limited spaces or how not to hit something—researchers and engineers conduct observational studies accompanied by surveys and interviews. It is the valuable input from healthcare professionals and even users themselves that point out major features to be included for enhancing functionality and usability in a wheelchair.

2. Design and development

The smart wheelchair design is then made based on a clear understanding of the user's needs. In the design phase, integration of the following two primary technologies will be included: voice recognition and obstacle avoidance.

a. Voice-Based Navigation: An engineer designs a voice control system facilitating wheelchair driving by voice command. This should be able to adjust to the variation of perceived commands with varying environmental conditions. Researchers select appropriate voice recognition algorithms and work on enhancing the accuracy and responsiveness of the system.

b. Obstacle avoidance: Mixing sensors like ultrasonic, infrared, and cameras, an obstacle avoidance system now can be developed. The sensing component of this system will detect any obstacle that may come in the way of a wheel chair and hence passes on the feedback information to the control system. Hence, development of algorithms that cater to sensor data processing and which can make decisions within sub seconds about navigation around obstacles for safe and smooth movement will be very important.

3. Testing and Validation

The wheelchair is designed and then tested once or twice to ensure that it works and is safe to use. Most of the tests run in controlled conditions where tests for the voice recognition and

obstacle avoidance systems are conducted. The functionality of the wheelchair would be noted by the researchers on interpreting voice commands correctly and avoiding obstacles.
Inbuilt in this phase are user trials whereby participants in situations of real life to provide feedback about the performance and usability of the system try out prototype wheelchairs. This kind of feedback is quite essential in iterative design improvements so that the wheelchair turns out to meet the diverse needs of the users.

4. Implementation

After successful tests and validation, a smart voice recognition and obstacle avoidance wheelchair is ready for mass production. The researcher works face-to-face with the manufacturers to ensure that quality and reliability are observed in the course of production. This goes hand-in-hand with staff training materials and user guides to acquaint users on how to use the new technology to exploit its maximum efficiency.

A smart wheelchair, voice-recognized and capable of obstacle avoidance, is very complex to develop since it demands an understanding of user needs, innovation in design, rigorous testing, and careful implementation. It should make sure that the final product increases not only the mobility and independence of the end user but also offers a much safer and more intuitive user experience.

This stage is conducted by gathering data and information about the needs required by the researcher in the process of making a "Design and Implementation of Smart Voice Recognition and Obstacle Avoidance Wheelchair". Besides that, researchers also conduct needs analysis regarding software and hardware that can possibly be used to support research processes. In this study, needs groups were divided by researchers into 3 parts.

3.3.1 Wheelchair System

Requirements needed in a hydroponic system can be categorized into 3. Of these are the tool needs, system series needs, and basic movement needs.

Table 1 explains the needs.

N	Wheelchair for the movement	Wheelchair Tools	Basic Needs
1	Power 1	Battery holder	Voice command system
2	Car chassis 1	Hot glue	Processing power
3	Wheels 4	Screwdriver	Obstacle detection
4	Motors 4		Data security

Table 1:Needs and Analysis of Wheelchair System

3.3.2 Microcontroller Circuit

Tools and Materials Needed in the Preparation of Microcontroller Circuit. Tools and materials needed during the preparation phase of the microcontroller circuit are divided into 2 parts: software and hardware. Table 2 need analysis of the microcontroller circuit is displayed in Table 2

N	Hardware	Software
1	ARDUINO UNO	ARDUINO IDE
2	Voice recognition module	
3	Ultrasonic sensor	
4	DC motor	
5	Jumper cable	

Table 2:Microcontroller Needs Analysis

The analysis of needs in making an electronic circuit is divided into two parts: hardware and supporting tools. The requirements are shown in Table 3 below.

N	Hardware	Cables
1	Infra-red sensor	USB cable
2	Driver motor IC (L293D)	Ties cable
3	Robot car assembling kit 1	Cables
4		Solder

Table 3:Needs Analysis in respect of Electronic Circuit

3.4 System requirement

3.4.1 Functional requirements

Our system goes through different stages, and these stages can be located in figure 13:

1. **Activation by Voice Command**

The system shall recognize voice commands for activation of the wheelchair.

The system shall react upon predefined voice commands like "start," "stop," "move forward," "move backward," "turn left," and "turn right."

2. **Language Support**

It should be able to support many languages depending on the need of the user. The system shall be able to change languages based on voice command.

3. **Command Confirmation**

The system shall acknowledge a received command audibly. The system shall confirm critical commands, "Are you sure you want to stop?".

4. **Sensor Integration**

The system shall integrate sensors of types ultrasonic, infrared and/or LiDAR for obstacle detection. All integrated sensors shall detect an obstacle from a minimum of 2 meters.

5. **Obstacle Detection**

The system shall continuously lookout for any obstruction in the pathway of the wheelchair. The system shall sense obstructions at the front, back, and left and right sides of the wheelchair.

6. **Auto Stopping**

The system shall automatically stop the wheelchair if an obstruction is detected within a safety range. The system shall give an audible alert upon obstruction detection.

7. **Obstacle avoidance**

In case of obstacle detection by the system, it itself shall adjust the path to avoid it.

If the adjustment of a path is needed because of the avoidance of obstacles, then the system shall bring this to the notice of the user.

3.4.2 Non-functional requirements

Easy to implement

In addition, the materials that will be used in this project need to be easily installed such that a successful project would be no problem. In addition, the materials need to easily connect to each other such that this project could be built and becomes more effective. In addition, the materials in this project have to be easily replaced in case of damage.

Open source

The controller used in this project is open source; therefore, the price of used hardware is relative low-cost and the development software is free.

Strength

The tools that shall be used in the project have to be strong to keep running for a long time to get the required success. Also, beside the reach, one of the important goals that should be gained is saving the cost.

Quality

Good tools should be utilized in the construction of such a project in order to serve for a long time. In matters of materials quality, one has to be very selective in order to avoid monetary loss, technical problems of these devices, and disturbance of the process. For this project, one can only use excellent quality in order to come out with a desired success.

Source of material: The material to be used shall be chosen based on its modifiability. This is because designs and connections are common; then, it would be easy to replace or modify if need be in the future.

Accuracy

All data is read in detail for it is saved in an SD card for analysis and research.

Performance

Real-time operation of the system

Operation

It is an automatic system.

Cost

This can't be an expensive system because we are going to decrease workers, which means reducing money in the voice recognition process yet solving one of the major problems.

This is going to be the stakeholders, users, and clients who will use the proposed system. This is because this system is established for the purpose of solving various problems in the wheelchair process, and thus the targeted ones are the Ministry of Health, the Mental Institutions, the Disabled, and even the Aged. There is a need for research into the conditions and requirements at this level; after this, adaptation should follow so that this project can solve the problem.

System Stakeholders

Project Sponsors: Those persons or organizations who would be willing to provide the much-needed financial resources for developing the smart wheel chair. They of course would be interested in the output of this project since their money is to be spent fruitfully.

3.4.3 System stakeholders, users, and client

Regulatory Bodies: They ensure that the wheelchair will fall well within the standard limits of safety, accessibility, and medical parameters. They are very crucial in letting the product get into the legal and safe reaches of the market.

Developers/Engineers: They are the personnel responsible for developing the technology to be used on the wheelchair. They design and build the systems in charge of voice recognition and obstacle avoidance.

Health Professionals: These include the doctors, therapists and other medical professionals who may use their experience to give suggestions on how the wheelchair should function to most benefit those using it.

Insurance Companies: These are the agencies which may be involved in assessing the wheel chair to ascertain its covering, its feasibility of usage by their clients and also the valuation of the equipment.

Manufacturer

These are the companies that physically manufacture the wheelchair. It takes designs produced and transforms them into touchable products ready for use.

Users

Persons with Mobility Impairment: A person with a mobility impairment is the main user of a wheelchair. They take advantage of advanced features of the chair to help them travel more easily and, in most cases, safely.

The Caregivers: They help the users to manage and run the wheelchairs. Therefore, they will need to learn how to use the technology properly and how to service it accordingly.

Medical Staff

Those health professionals who, may be called upon to set up the wheelchair to ensure that it is well configured to suit the needs of the user. Clients

End Users

Those who would actually use the wheel chair, they would be the ones who are going to use the device daily and live with its features.

Healthcare Providers: Any institution, like a clinic or a hospital, which may prescribe or purchase the wheel chair for the patients.

CHAPTER 4: DESIGN AND IMPLEMENTATION OF A SMART VOICE RECOGNITION AND OBSTACLE AVOIDANCE WHEELCHAIR

4.0 Introduction

The system **"Design and implementation of a smart voice recognition and obstacle avoidance wheelchair"** is coming up to solve difference problems involved while controlling the movement process of wheelchair by controlled distance parameters in the Electronic circuit using various Electronics components, Especially Arduino Uno component which is a microcontroller that connects hardware part and software part.

4.1 Flow chart

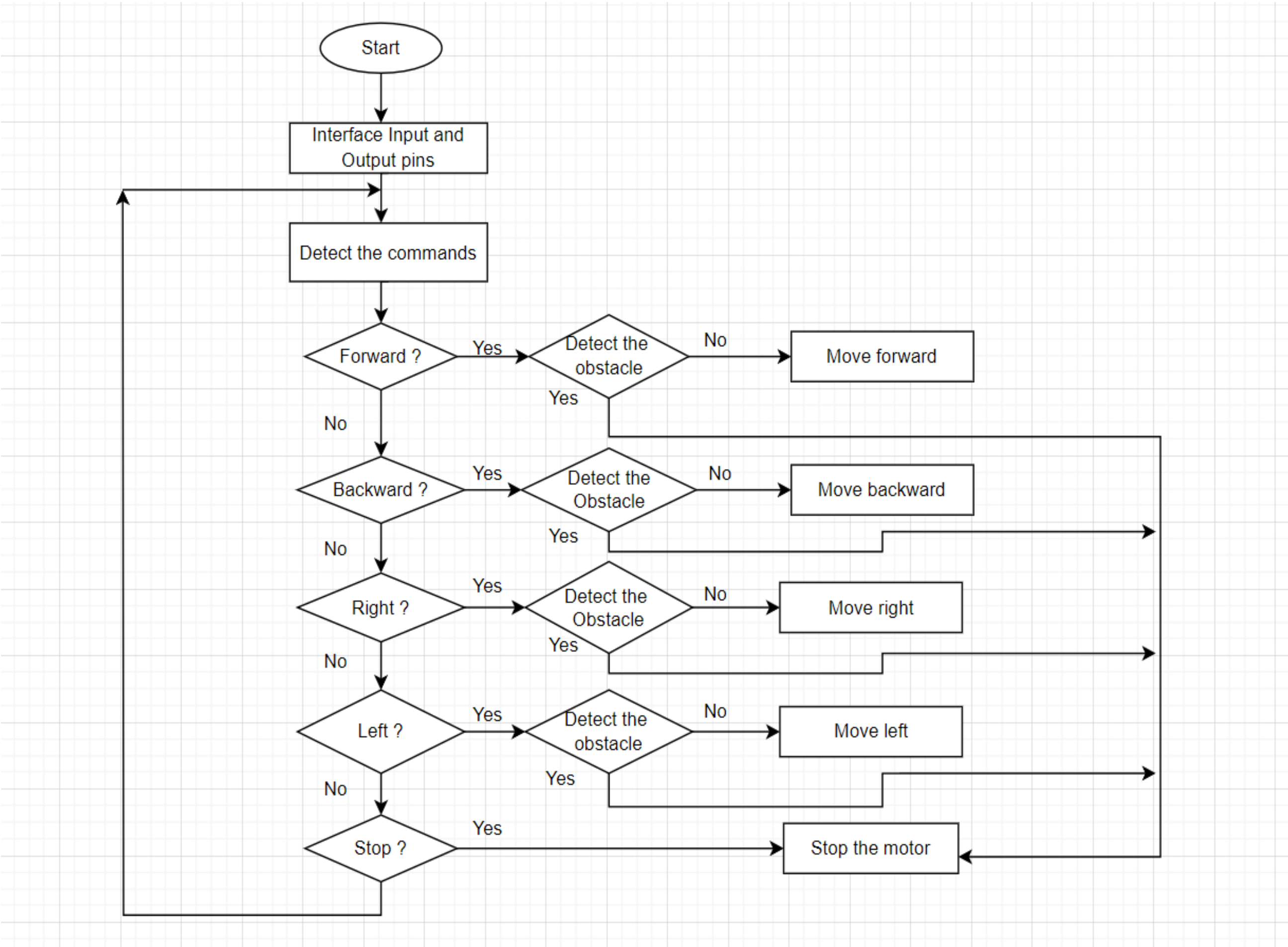

Figure 11: Flow chart of the circuit

4.2 Block diagram

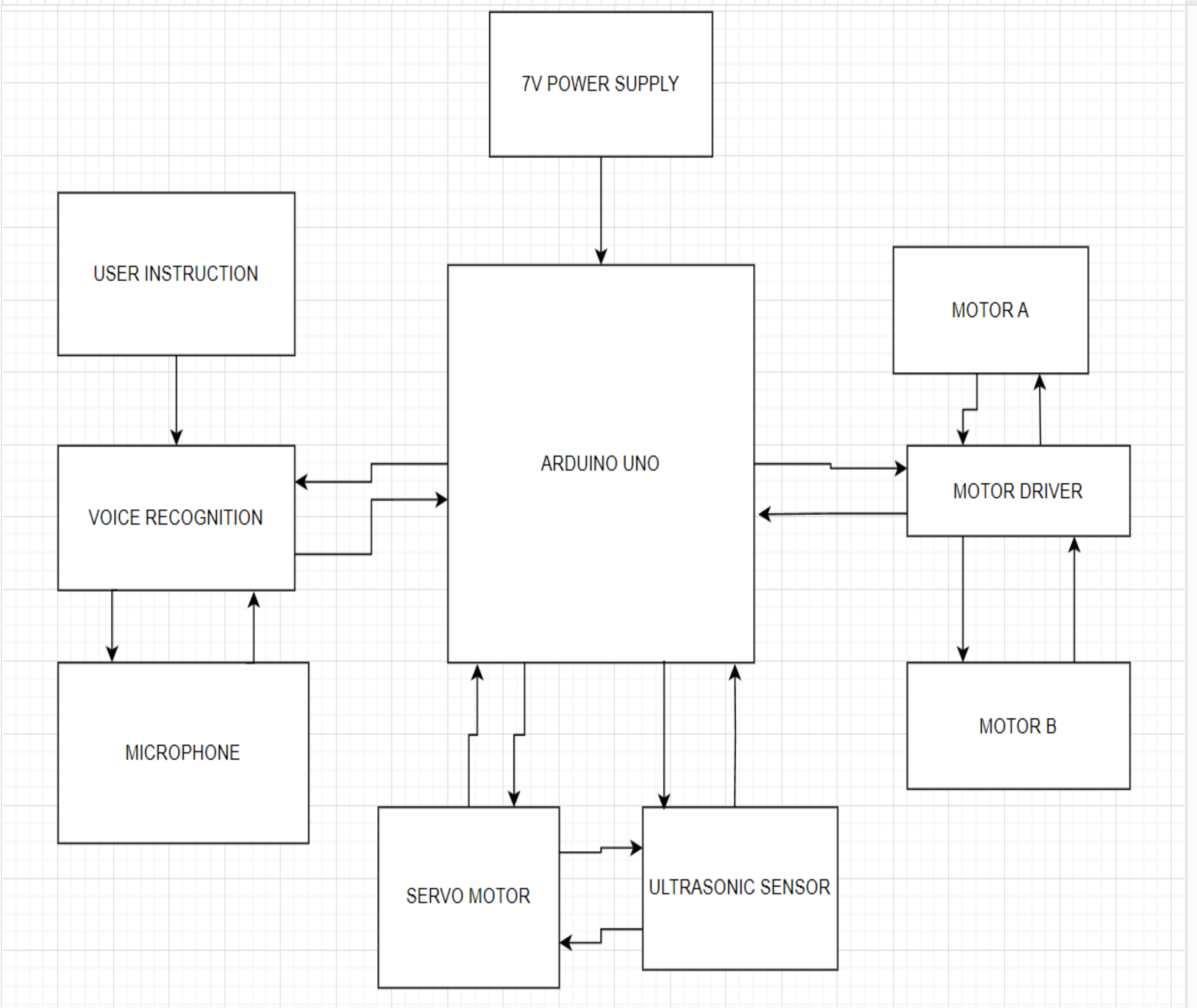

Figure 12: Block diagram of the circuit

4.3 Circuit diagram

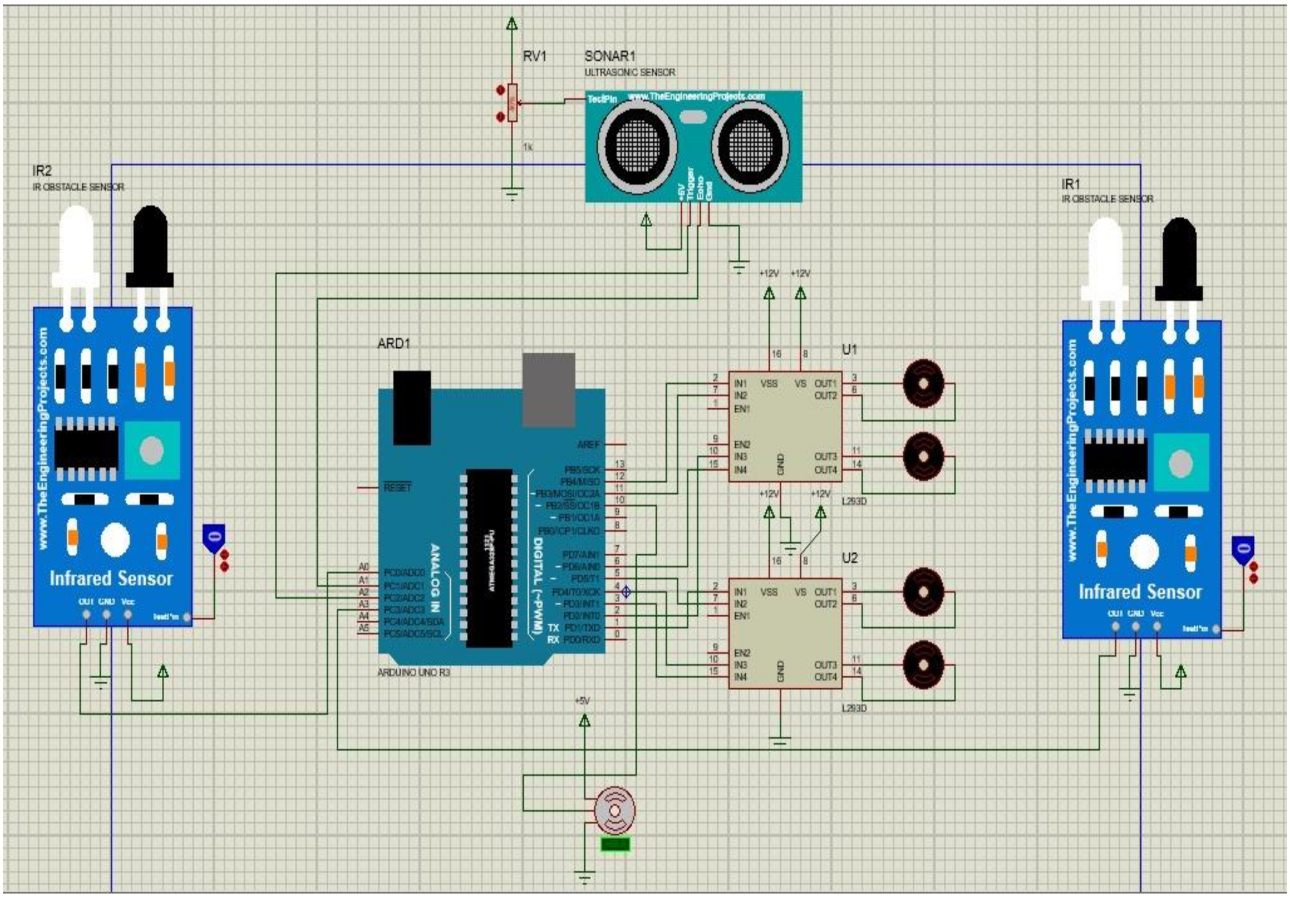

Figure 13: Circuit diagram

4.3.1 Working principle

My system has hardware and software parts all over the world. The former includes all the physical devices used by this project, while the latter comprises codes of our software. Communication between the hardware part and the software part is made through Arduino programming.

a. Hardware part

My system works through different stages and these stages can be found in (figure 12)

1. Basically, when the circuit is powered, it uses a Voice Recognition Module that translates voice commands. Wheelchairs can be driven by voice commands such as "move forward," "turn left," "stop," etc. All commands mentioned are interpreted by a module in real time, which in turn decodes it to drive the actuation of motors in a wheelchair.

2. To ensure safe navigation, the wheelchair is equipped with Infra-red Sensors and Ultrasonic Sensor the infrared sensors are mounted to the entire body of the wheelchair, detecting obstacles nearby through the emission of light from the infrared portion of the electromagnetic spectrum by measuring the reflection. Thus, it may detect data of an obstacle located at a close distance, such as furniture, or even walls, which may help in avoiding collision.

3. Ultrasonic sensor would be complemented by object detection at distances through sound waves by the ultrasonic sensors. They emit high-frequency sound waves that are reflected from obstacles and return to the sensor. By calculating how long it takes the echo to bounce back, the system would estimate the distance toward potential obstructions.

4. All these sensors together feed data into the wheelchair's control system, which processes this information to drive around obstacles on its own. The voice module allows users to give commands to the wheelchairs hands-free. This kind of integration will be smooth and intuitive, driving for better mobility to the physically challenged.

b. Software part

For the software part, I used Arduino programming to automate this system. The programming process of Arduino is a step of translating the system design so that the machine, in this case, a microcontroller can understand it. Thus, the results of the analysis and design must be transformed into a form that can be understood by the machine, which is a programming language through the coding process (Suhendar, 20217). This stage is the implementation process of the automated system design. At this stage, the program was divided into small modules adjusted to the sensors used and determined the environmental parameters which later be read by the sensors and then combined in the next stage (17)

4.4 Implemented Circuit

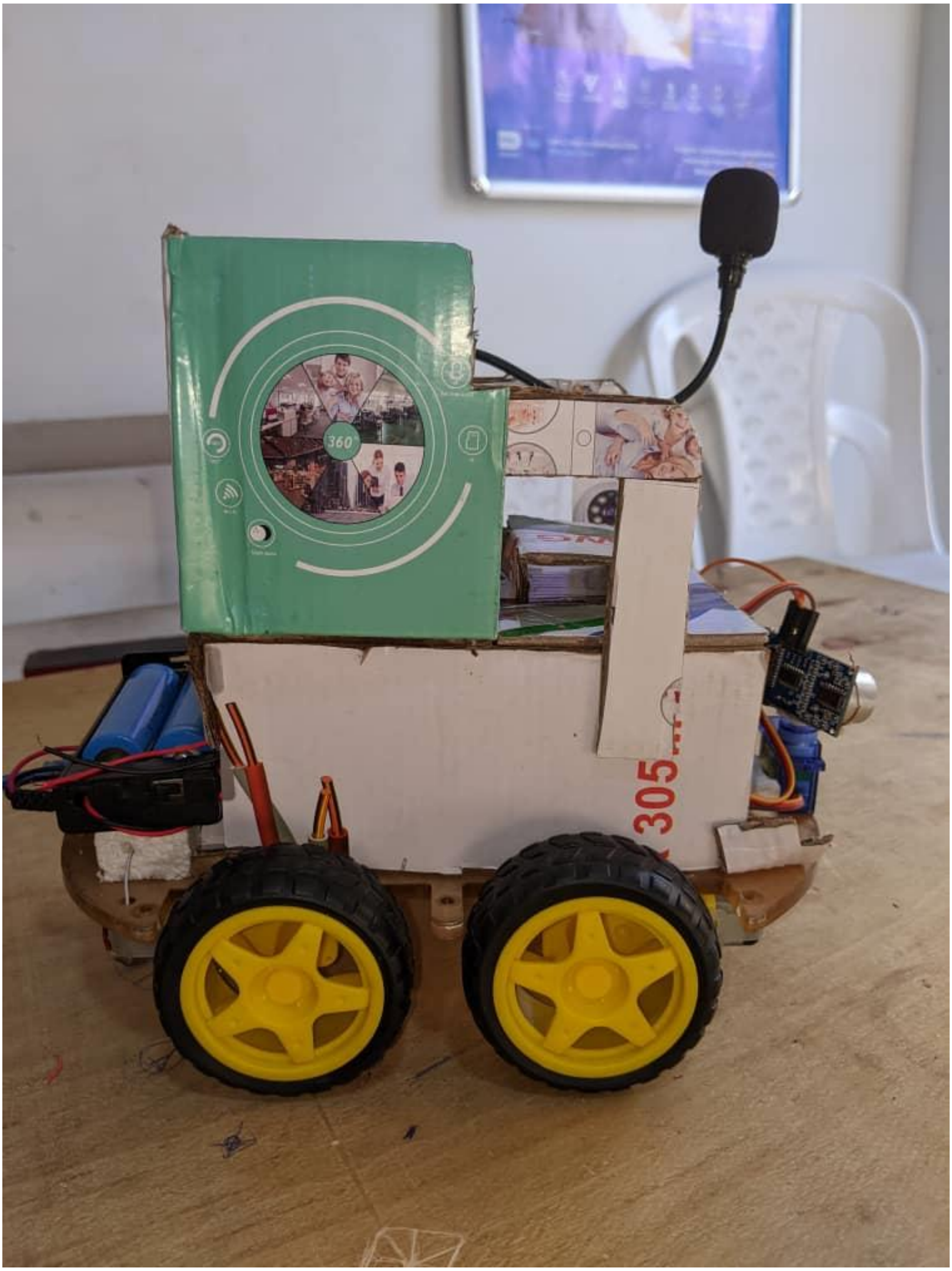

Figure 14: implementation of the circuit

MATERIALS USED AND COST ESTIMATION

Number	Materials Name	Quality	Price for one piece (Frw)	Total price of pieces (Frw)
1	Arduino UNO	1	15 000	15 000
2	Voice recognition module	1	45 000	45 000
3	PCB	1	5 000	5 000
4	Ultrasonic Sensor	1	4 500	4 500
5	Rechargeable Battery	4	18 000	18 000
6	Infrared-Sensor	4	10 000	10 000
7	Robot Car assembling kit	1	20 500	20 500
8	Jumper cables	30	3000	3000
9	Driver motor IC (L293D)	1	4 500	4 500
10	Battery Holder	1	2000	2000
Total				127 500

Table 4: Cost estimation

CHAPTER 5: CONCLUSION AND RECOMMANDATION

5.0 Introduction

This project comes from a long process of three years including the efforts of many people and institutions. By the way, with the help of this study, I have learned new programming languages, use new software, basics of wheelchair construction and put into the practice all the background gained from school including the group work behaviors and auto expertise.

5.1 Conclusion

The goal of this project was to construct a reliable wheelchair system for disabled people and user autonomy. This book includes the study of wheelchair in general, analysis of hardware, software and available technologies, design and implementation of wheelchair system and finally, the evolution of the entire system operation. In the last chapter, I have illustrated how the result functions and given some outputs of the installed system logs. Obstacle avoidance algorithms implemented in the systems improved further the effectiveness of real-time navigation, minimizing risks that emanate from collisions. This kind of technologic coupling is not only one that improves the functional areas of the chair but largely contributes to the user experience in comfort and reliability.

Results presented in this chapter are very promising but also pointed out several areas that need further refinement. This can be related to aspects like the accuracy of voice commands for use in a noisy environment or the obstacle avoidance system response time in case the scenario is complex. This may involve more concentration on the optimization of such parts of the system in future work and in the development of other features that can enhance its performance and satisfaction among users. The numerous discoveries that are laid down in this chapter form the foundation stones of the major steps forward in smart wheelchair technology and lay the groundwork for disruptive innovation that may achieve sweeping changes to existing mobility solutions for the end-user with different types of physical disabilities.

5.2 Recommendation

My project has been carried out with assistance of my supervisor and friends accordingly to the available time, resources, the objectives fixed have been attended, and the project can be implemented in a huge number of samples.

I delighted to highly recommend to anyone who will need to improve the project with the interesting and innovative ideas nevertheless, there is a lot of place for further development and improvement, which would bring the system quality to another level. The regulation of the parameters will become even more effective, if the Artificial Intelligence is introduced into the system. In addition, there is a great opportunity to develop a front-end application that will be summarizing and displaying the measured data in the form of graphs and charts. Finally, the collected sensor values can be used to create improvement obstacle avoidance systems: Obstacle detection algorithms would need to become increasingly sophisticated as the environment became more complex and dynamic. More sophisticated sensors or fusion techniques could provide the capability for improved real-time obstacle detection.

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APPENDIX

ARDUINO CODE

```
int red = 3;

int blue = 2;

int green = 4;

int ena = 6;

int enb = 7;

int in1 = 8;

int in2 = 9;

int in3 = 10;

int in4 = 11;

int IRSensor = 5;

byte com = 0;


void setup()

{

Serial.begin(9600);

pinMode(red,OUTPUT);

pinMode(green,OUTPUT);

pinMode(blue,OUTPUT);

delay(2000);

Serial.println("voice recognition");

pinMode(in1,OUTPUT);

pinMode(in2,OUTPUT);
```

```
pinMode(in3,OUTPUT);

pinMode(in4,OUTPUT);

pinMode(ena,OUTPUT);

pinMode(enb,OUTPUT);

pinMode(IRSensor,INPUT);

analogWrite(ena,255);

analogWrite(enb,255);

digitalWrite(in1, LOW);

digitalWrite(in2, LOW);

digitalWrite(in3, LOW);

digitalWrite(in4, LOW);

Serial.write(0xAA);

Serial.write(0x37);

delay(1000);

Serial.write(0xAA);

Serial.write(0x21);

delay(1000);


}

void loop()

{

while(Serial.available())

{

com= Serial.read();
```

```
switch(com);

{

case 0x11:

color(255,255,255); //white

digitalWrite(in1, HIGH);

digitalWrite(in2, LOW);

digitalWrite(in3, LOW);

digitalWrite(in4, HIGH);

Serial.println("forward");

break;

case 0x12:

color(255,0,0); //red

digitalWrite(in1, LOW);

digitalWrite(in2, LOW);

digitalWrite(in3, LOW);

digitalWrite(in4, LOW);

Serial.println("stop");

break;

case 0x13:

color(0,255,0); //green

digitalWrite(in1, HIGH);

digitalWrite(in2, LOW);

digitalWrite(in3, LOW);

digitalWrite(in4, LOW);
```

```
Serial.println("forward");

break;

case 0x14:

color(0,0,255); //blue

digitalWrite(in1, LOW);

digitalWrite(in2, LOW);

digitalWrite(in3, LOW);

digitalWrite(in4, HIGH);

Serial.println("forward");

break;

case 0x15:

color(0,0,0); //blue

digitalWrite(in1, LOW);

digitalWrite(in2, HIGH);

digitalWrite(in3, HIGH);

digitalWrite(in4, LOW);

Serial.println("forward");

break;


}

}

}
```