Arab American University

Faculty of Engineering and Information Technology

Computer Systems Engineering

SENIOR PROJECT (*II*)

Eye Controlled Wheelchair

Fall 2022/2023

Students Statement

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Masa Mubaslat (201811212)

Roaa Qudaih (201811219)

Na'Ema Bsharat (201810820)

Supervised by: *Dr. Mujahed Eleyat*

Computer Systems Engineering Dept.
Submitted in partial fulfillment of the requirements of B.Sc. Degree in Computer Systems Engineering

Fall 2022/2023

Supervisor Certification

This to certify that the work presented in this senior year project manuscript was carried out under my supervision, which is entitled:

“Eye-Controlled Wheelchair”

Masa Mubaslat (201811212) *Na'Ema Bsharat (201810820)*

Roaa Qudaih (201811219)

I hereby that the aforementioned students have successfully finished their senior year project and by submitting this report they have fulfilled in partial the requirements of B.Sc. Degree in ____ Engineering.

I also, hereby that I have read, reviewed, and corrected the technical content of this report and I believe that it is adequate in scope, quality, and content and it is in alignment with the ABET requirements and the department guidelines.

Dr. Mujahed Eleyat

ACKNOWLEDGMENT

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ABSTRACT

Many people worldwide suffer from Amyotrophic lateral sclerosis Locked-in syndrome and many diseases that affect the nerve cells and spinal cord. As a result, they are unable to move. Most of these people have difficulty speaking. So, they always need someone to help them in all aspects of their life.

The main purpose of our project is to reduce their dependence on other people and increase their confidence. By embedding a system into a wheelchair so that it can be controlled by these patients using their eye movement. The system includes a camera that is mounted in front of the user. It captures the image of the two eyes and passes them to the raspberry pi 4. Which processes the images to determine the required action and then communicates with an Arduino UNO board to control the movement of the wheelchair motors. The processing of the image is to decide the position of the eye and identify eye blinks as they are translated to commands to control the wheelchair. Moving it left, right, forward, backward, or stopping it. To make it safer to use, there are sensors mounted in front of the wheelchair to detect obstacles or check the stability and the wheelchair is automatically stopped accordingly.

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LIST OF SYMBOLS AND ABBREVIATIONS

Cases

1 CHAPTER 1: INTRODUCTION

In our lives, what makes us feel valued and enhances our self-confidence is our ability to rely on ourselves, to fulfill our needs without anyone's help. But what if we can't. There are people who can't see, can't speak, can't walk or move any of their limbs.

Today, with the technological progress and its role in trying to make life easier and to provide assistance to those who can't. Many techniques have been developed, including electric wheelchairs that help people who can’t walk or use any of their limbs, it can be controlled by bio-signal which use electrooculography (EOG)electroencephalography (EEG), and electromyography (EMG). Others can be controlled by a joystick, voice, tongue, and Inhalation and exhalation.

But what if patients can't speak or move any of their limbs. There are many diseases cause that like Amyotrophic Lateral Sclerosis and Locked In Syndrome. The Symptoms of infection vary from person to person depending on which neurons are affected. The effect begins with muscle weakness that increases with time until the inability to accomplish simple daily tasks like walking or eating. In addition, the effect on speech begins from slurred speech until it becomes completely unclear, don’t forget the breathing weakness. But what distinguishes these two diseases is that they do not affect the senses, including vision.

ALS is a disease of the motor neurons, which is caused by the death of motor neurons. These cells extend from the brain to the spinal cord and muscles throughout the body. When these cells stop sending nerve impulses, the muscles lose their ability to move and weaken.

The main symptoms of the disease are:

1. Muscle spasms in the leg, tongue or arm.
2. Difficulty in chewing and swallowing.
3. Stuttering in speech.
4. Weakness in the muscles may lead to weakness in the neck and diaphragm.

The incidence of ALS worldwide is about one in 50,000 people per year, equating to about 5,760 to 6400 diagnoses annually (3). It affects people of different ages, but the most vulnerable are those in their fifties. Figure (1) shows the rate of amyotrophic sclerosis by age group in the United States of America 2012-2015.

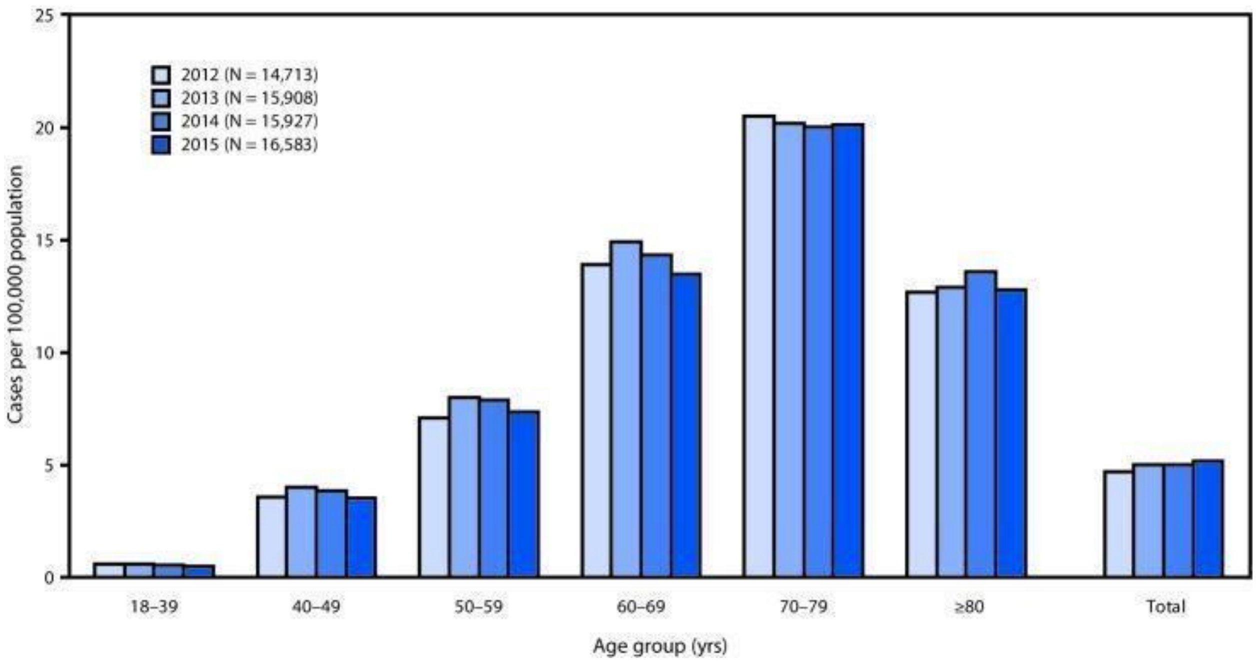


Figure 1 Estimated prevalence of ALS in the United States by age group, 2012–2015

The causes of these diseases are not completely clear until this moment, but scientists and doctors described it as a genetic disease that is transmitted to people through family genes, but it is not the only cause of the disease. Scientists were able to discover many of these genes, which makes them detect the disease early.

People with this disease receive some medicines that help them to facilitate swallowing and eating, but no cure has been discovered at this moment.

Our aim is to help these patients do simple tasks that they are unable to do, such as moving from room to room without relying on anyone, which enhances the feeling of self-confidence. We will come up with a wheelchair that can be controlled by the eye as it is not affected by these diseases.

1.1 Problem Statement and Purpose

The main problem that we think this project will solve is building an eye movement controlled wheelchair. Many manual wheelchairs in the market are controlled by a joystick or sound. The spinal cord diseases patients cannot speak or move their limbs so they are unable to use a joystick or voice controlled wheelchair. There are many other side problems, the patient always needs someone to move him on the chair and stay with him wherever he wants, this leads to tiredness the patient companion and preoccupation with his work, as the patient feels that his movement is limited to the person.

All these problems are pushing us to find a way to make a wheelchair that can be controlled by the eye. This provides independence to make their lives easier and more comfortable. So they do not always need anyone's help. This will give them more confidence and be more active in their community.

1.2 Project and Design Objectives

The main objective of this project is to build a wheelchair that can be controlled by the spinal cord patients which increases their integration in working, educational and social life and makes them feel better as they become able to move around in a wheelchair by themselves.

The following are the main objectives that the project aims to achieve:

1. The ability to move the wheelchair with eye movement (right, left, forward, backward, stop) based on eye movements (right, left, center, up, blinking).
2. Stopping the wheelchair automatically when approaching an obstacle or barrier and turning on a buzzer as a warning.
3. Stopping the wheelchair automatically when a sharp change occurs in balance.
4. Produce a voice that expresses the command.

1.3 Intended Outcomes and Deliverables

The outcome of this project when completed will be a wheelchair that can be controlled by the eye movement of the user. It accurately detects eye movements, with the camera capturing images of eye movements and sending them to the Raspberry pi for processing and detecting the eye's movements to send signals to the movement engine, and reflects the movement direction by speaker audio, to assure the patient that the system understand his command.

If there be any obstacle in front of the wheelchair, the wheelchair will stop. These are the most important expected results that will be provided.

1.4 Summary of Report Structure

The project report will be discussed in five chapters. In the first chapter, we presented an overview of the project clearly and concisely, in addition to the expected results and outputs. The second chapter contains an explanation and description of how the project idea was built, and some of the existing projects. The third chapter gives a detailed case of the tools, design, how they will work, and the technology used to achieve the goal of the project. In the fourth chapter, we discuss and discuss the final results of the project. The fifth chapter talks about project management, and we will explain the cost of the project and whether it is possible or not. In Chapter six, we discuss the impact of our project on the environment, the economy, society, and ethics. In the last chapter, we present conclusions and recommendations.

2 CHAPTER 2: BACKGROUND

In this chapter, we will discuss existing systems that are close to our project or similar in terms of working principle.

O v e r v i e w

Wheelchair systems

The incidence of disability around the world is estimated at approximately 15% of the world's population. Studies have shown that nearly 131 million people in the world need wheelchairs, and the number is increasing by 2 million people every year (4).

There are many wheelchair systems on the market that assist people with disabilities. There are manual wheelchairs. It consists of a frame, a seat, one or two footrests, four caster wheels in the front and two large wheels in the back. Figure (2) below is for this type of chair (5).

Figure 2 Wheelchair 1 (6)

There are automatic wheelchairs that move by electric motors and batteries Small electric chairs consist of four wheels, with front or rear wheel drive. The larger one has six wheels, with smaller wheels at the front and rear and larger powered wheels. It is moved by a companion or by the patient controlling it with a small joystick that is attached to the armrest, or to the upper back of the armrest (4) as shown in figure (3).

Figure 3 wheelchair (7)

There are wheelchairs that are controlled by voice control, head movement and hand movement. But what about those who cannot use any of these systems. The spiral cord patients like ALS and LIS patients cannot move their limbs and they cannot speak, just their eye muscles do not be affected. Eye controlled wheelchair will be very suitable for them. There are many systems that solve the same problem for wheelchairs and the principle of operation is still many differences, but they all discuss eye-movement wheelchair systems.

Each system has advantages and disadvantages, some systems have a lot of parts, some are very expensive, some processes are slow and there is a delay in movement.

All of these factors helped us figure out what our system needs, how it will be implemented, how it will contribute to solving these shortcomings, and how it will provide the desired goal for the ALS and LIS patients to be able to move in their wheelchairs properly.

2.1 Related Work

EXSISTING SYSTEM

1. Wheelchair Control System based Eye Gaze

This system develops an eye-controlled wheelchair. It depends on eye tracking and image processing. Using Arduino Uno and a laptop to process the image. There is a camera fixed on the chair that detects eye movement. The direction is determined from the captured image after some processing on MATLAB. Then sent the order to the Arduino Uno board which controls the wheelchair movement. They used a laptop because Arduino UNO cannot run an open CV (8).

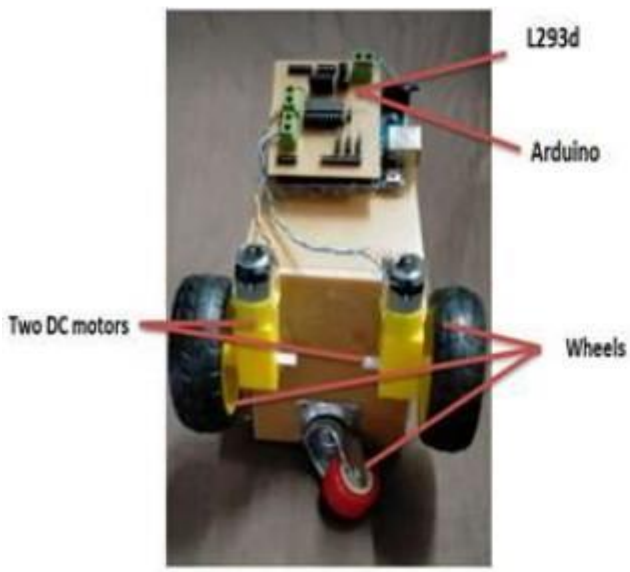


Figure 4 Wheelchair Back Architecture

2. Eye-Controlled Wheelchair using Infrared Detection
   A design of a microcontroller-based wheelchair controlled by the motion of the eye. It is designed to move forward and turn left, right, half left and half right. This system contains glasses with Arduino nano installed on it and Arduino. The electronic glasses detect eye movement via infrared sensors. Then use a converter to convert the ray to signal and transmit it by Arduino nano using Bluetooth to the Arduino uno. Arduino uno processes input signal and

translates it to voltages applied to the motors and moves the wheelchair. In this system there is a button to turn on and off the chair controlled by patient companion but this is not flexible. In addition, it is a useless system due to the use of infrared rays (9).

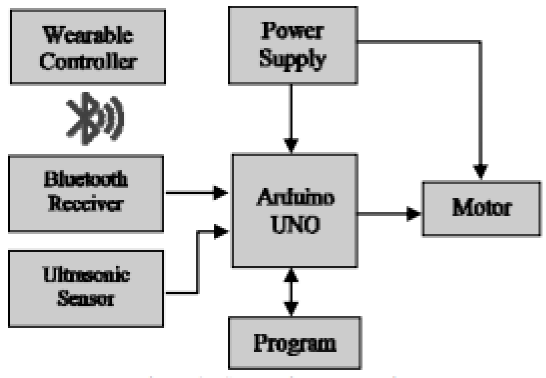


Figure 5 System interconnection

3. Autonomous Camera based Eye Controlled Wheelchair system using Raspberry Pi

In this System they develop an eye controlled wheelchair. There is a camera mounted on the chair, it takes images of any one of the patient's eyes, sends it to a Raspberry pi board that processes these images to track the position of the eye. Based on eye position the wheelchair motor will be directed to move forward, left or right. In addition there is an ultrasonic sensor mounted in front of the wheelchair for safety, if there is any obstacle the wheelchair will automatically stop (10).

COMPARISON OF SYSTEM

In our system we enhance the bad sides in related work system, for example we did not use infrared rays because it damages the eye. Rather, we preferred tracking eye movement using image processing technology, and we use raspberry for process the images instead of using laptop with Arduino, because it not flexible to be laptop with component. Our system is the same with Autonomous Camera based Eye Controlled Wheelchair system using Raspberry Pi, but we used landmark predictor with dlib to detect the face and eyes instead of using Haar Cascade as it is not accurate. (11)

Project Name	Main Hardware	Production Year	possible actions of wheelchair	Challenges/Problems
Wheelchair Control System based Eye Gaze	Arduino Uno. Laptop. Camera. Power supply. Ultrasonic Sensor.	2021	Right Left forward	Can't do image processing using Arduino itself, there must be a laptop with the chair.
Eye-Controlled Wheelchair using Infrared Detection	Arduino Uno Arduino Nano Camera Motors Electronic eyeglasses. Convertor Ultrasonic Sensor		forward only turn around half Left half Right full left full Right	Infrared rays damage the eye, even if it is in a small amount. Its damage is great, and also causes the death of cells in the eyelid (12). Controlling the status of the system on or off is done by a button, this doesn't suit the paralyzed patient who can never move his limbs.
Eye Controlled Wheelchair Using Raspberry pi based on image processing	Raspberry Pi Camera. LCD Display. Power Supply. Ultrasonic sensor. DC Motor	2015	Right Left forward	Captured one eye to detect the direction and this is not accurate.
Eye Controlled Wheelchair	Raspberry Pi. Camera. Audio Speaker. Ultrasonic Sensor. Power Supply. Relays. Dc Motor. Gyroscope sensor.	2022	Right Left Forward backward Stop	

Table 1 Related Works

3 CHAPTER 3: METHODS AND MATERIALS

In this chapter we will introduce the architecture and design of the system and detail how it works, in addition we will explain all the hardware components used in the system, how they will work, why they are used and what are the alternatives. We will explain the flowcharts and the block diagram and we will program and operate the system by following the flowcharts and how they work exactly.

3.1 System Design and Components

SYSTEM ARCITUTURE

Our system has many hardware and software components which are very important to guarantee safety and effectiveness. The eye-controlled wheelchair system has a webcam which stands in front of the patient's face, captures the image and then sends it to a Raspberry pi 4. The Raspberry Pi 4 board is used to perform the processing of the image and detect the eye pupil position to understand the patient's request. We used trained model to detect the face and image processing to detect the eye pupil position.

Based on the location of the eye pupil the raspberry Pi 4 sends the commands to the Arduino uno then Arduino uno controls the DC motors according to commands, like run the motors in clockwise and anti-clock wise direction and stop the motors. In order to move the chair forward, backward, left, right and stop. For the safety purpose we used sensors, an ultrasonic sensor is mounted on the wheelchair to detect if there is obstacle. If the sensor gets the obstacle very close to the wheelchair, the Arduino uno sends a signal to stop the DC motor. Also, we used the gyroscope sensor to check the stability of the wheelchair, it will send a signal to the Arduino uno to stop the motors if the wheelchair not balanced.

HARDWARE DESIGN

1. Wheelchair

Wheelchairs mainly consist of a chair and it has wheels that many people use when they are unable to walk. Wheelchairs serve these people and allow them to move around and see the outside world and not feel helpless and unable to move. There are many types and shapes of these chairs, some of them are regular, including automatic or electric.

Figure 6 Wheelchair

2. Raspberry Pi 4 B+

The Raspberry Pi is a low-cost single board computer that is sometimes used instead of a computer due to its cost. It can be connected to a monitor or a keyboard for easy control. It can perform a variety of tasks such as web browsing, word and image processing. The Raspbian OS and a Linux distribution for the Raspberry Pi will be used and the Python programming language will be the main programming language. It contains four USB ports, 40 pins general purpose inputs and outputs (GPIO), Ethernet port, HDMI output, Micro SD card, USB-C power supply and wireless Bluetooth (13).

Raspberry is the main component of our project. It is as a brain for the system. It controls all the components and links them together. It will interact with all parts of the system. In our project a Raspberry Pi 4 which has 8GB of RAM is used. We will need this memory to cover all processes such as processing the frames and sending commands (14).

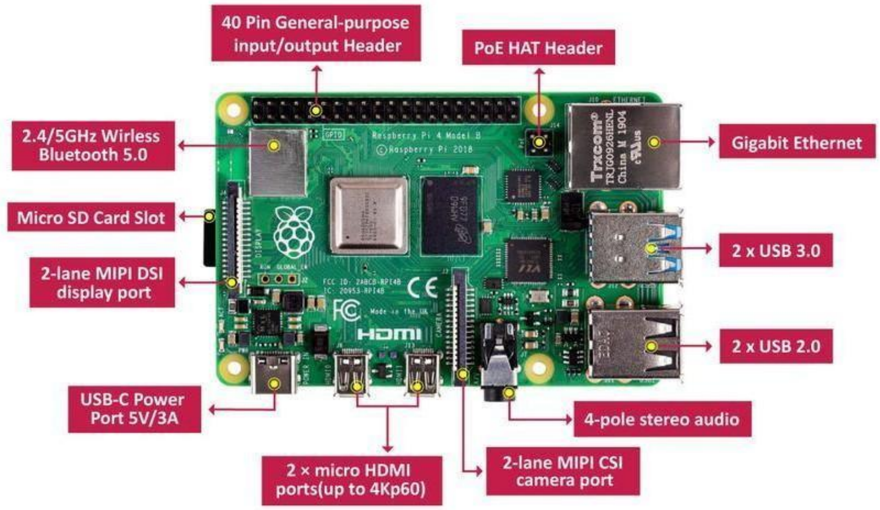


Figure 7 Raspberry Pi 4

3. Arduino Uno.

Our project is also built on open-source board called Arduino Uno. Which is composed of a microcontroller, some LEDs, a reset button, 14 digital input/output pins, and six analog inputs. We decided to use it because it is considered as new compared to other Arduino boards. This board comes up with numerous features that help us to use this in our project. It uses the Atmega16U2 microcontroller that helps to increase the transfer rate and contain large memory compared to other boards. (15)

In our project, we use Arduino uno to control the movement part and safety system.

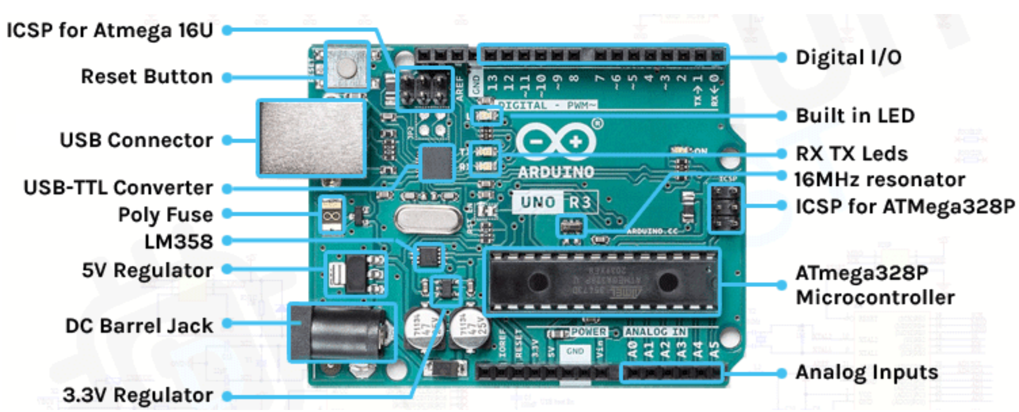


Figure 8 Arduino uno (16)

4. Webcam

A webcam is a small digital video camera that broadcasts its image in real time. It is capable of capturing images as well as high-definition videos. It is used for a variety of purposes for meetings, online communication, for study purposes, and it has become popular for home security and baby monitoring systems. In our project we need this camera in order to capture a patient's eye images. It is connected with raspberry via USB. It will take pictures and send them to the Raspberry Pi 4. We will use a quality HD 1080p Web Camera, USB PC Computer Webcam with Microphone, Laptop Desktop Full HD Camera Video Webcam 110 Degree Widescreen (17).

Figure 9Webcam (18)

5. Power Supply

A power supply is an electrical device that supplies electric power to the load. It converts electrical current from source to the correct voltage, current and frequency to power the load.

All electrical systems need a power supply to meet their basic requirement, so we need it in our project. It is necessary to give the proper power supply to individual components like raspberry pi, camera, sensors and motors. In our project we used 24volt. (19).

6. Ultrasonic Sensor

The Ultrasonic sensor is an electronic device that is used to avoid obstacles. It contains a transducer that is used to send waves of a frequency above the range of human hearing and to receive the echo. It measures the distance of the obstacle by emitting ultrasonic sound waves and measuring time lapses between the sending and receiving of the ultrasonic pulse. In our project we need the ultrasonic sensor to sense if it is an obstacle in front of the wheelchair. Then if there is an object the wheelchair must stop and let the user decide which direction needs to go. We will use the Ultrasonic Distance Sensor - HC-SR04 module. A non-contact measurement range of 2 centimeters to 400 centimeters is provided by this sensor, and its range accuracy can reach up to 3 millimeters (20) (21).

Figure 10 Ultrasonic Sensor(22)

7. Relay

The relay contains a coil and one or pair of contacts. When the current passes through the coil a magnetic field is generated in the coil, so the contact is opened or closed.

The relay has many uses. It is used as a switch and it can also be used to control high voltage and current such as motors, fuses and AC loads. It is designed to interface with microcontrollers like Arduino, PIC and so on. In our project we will be using MY2N-J 4 relays as switches each relay consists of 8 pins. The relay was connected to the Arduino and the motors . A relay was used because the wheelchair needs a 24v motor to operate it and the Arduino will control it but we cannot connect it directly to the Arduino because it will burn from the high voltage that it will reach. We have two motors so we need 4 relays for each motor 2 relays. The signal reaches the relay from the Arduino and either the switch is opened or closed according to the required signal.

Figure 11 relay (23)

8. DC Motor

Direct current (DC) motor consists of two parts, a stator and a moving part. The rotor is inside the motor and the stator is outside. The moving part consists of coil windings that are operated by direct current. As for the second moving part it consists of electromagnetic coils. When the motor is running with DC a magnetic field is created in the stator attracting the magnet to the rotor causing the rotor to start spinning. In our project we chose a dc motor because it is able to control its speed. We used two 24v motors one on the right and the other on the left were connected to a 24V battery source and then for the relays. Both dc motors will turn on clockwise when the wheelchair moves forward and counterclockwise when the wheelchair moves backward (24).

Then if it moves on the right just the motor on the left side will work and if the wheelchair moves on the left just the motor on the right side will work. The two motors are stopped when there is any obstacle or imbalance in the chair or when the patient wants to stop it.

Figure 12 DC Motor (25)

9. Gyroscope sensor

A gyroscope is a sensor that measures the direction, speed, and angular motion of moving objects. Angular velocity is measured in degrees per second, which is the change in the angle of rotation of an object per unit time. Gyroscopes are installed using the principle of angular momentum. A resistive force is used to bring the moving gyroscope back to rest. There are many types and shapes of this sensor, including: circular laser gyroscope, fiber optic gyroscope, quantum gyroscope, vibration gyroscope (26) (27). In our project, we will use the gyroscope to measure the angular motion of a wheelchair.

Figure 13 Gyroscope sensor (28)

10. Buzzer

A buzzer is an audio device used to emit a buzzing or whistling sound and is used to warn of something happening and also in many applications such as fire alarms, electric bells and many other alarm applications and technologies. The buzzer comes in many shapes and types. In our project, we will use the buzzer frequency 3000±500 in the safety system to warn the patient in the event of an imbalance in the wheelchair, or tilting, and when the distance between the chair and the object becomes less than or equal 30cm. The buzzer will issue an alert sound and the wheelchair will stop. (29)

Figure 14 Buzzer (30)

11. LM2596 DC-DC Step Down Converter

LM2596 DC-DC Step Down Converter is a complete voltage regulator circuit stepper adjustable regulator meaning step up and down voltage regulator It is capable of driving a 3.0 A load with excellent line and load regulation. The LM2596 operates at a switching frequency of 150 kHz. The voltage is lowered and raised by means of the existing potentiometer. The voltage is entered through the voltage input (IN+) (IN-) and is set according to the voltage value on which the connected component operates through the potentiometer and the voltage is output through the voltage output to the component.

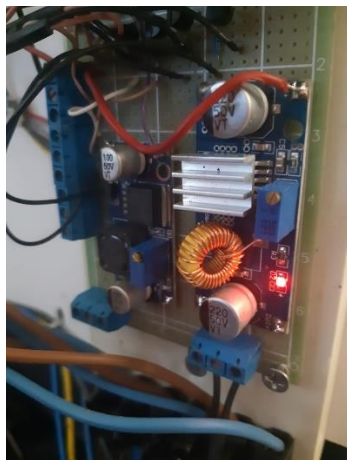


Figure 15 Step down converter (31)

12. Transistor

The transistor is a semiconductor device. It has terminals labeled base, collector, and emitter. It is used to regulate or control current and voltage flow, and also it is used to amplify signals and this is why we used it in our project, we need to drive the relay from Arduino Uno but the output signal from it is only 40 milliamps at the most, so it will not be enough to turn on the coil of the relay so we need a transistor to amplify this signal. In our project we used a 2n2222 transistor.

2N2222A	
1	Emitter
2	Base
3	Collector

Figure 16 Transistor (32)

13. Audio speaker

The speaker is an energy conversion device that converts electromagnetic waves into an audio signal. The sound is entered into the speaker through devices such as computers, mobile phones, or other devices. The two speakers amplify the electromagnetic waves into sound, and the frequency of the wave determines how high or low the sound is. (33) In our project We used TOSHIBA TY-WSP70 that was connected to the Raspberry pi4 and the speaker will output a sound when the patient takes commands (left, right, forward, backward, stop). In this way, the patient is sure that the command has been taken for execution.

Figure 17 audio speaker (34)

14. Circuit breaker

A circuit breaker is an electrical safety used in many electrical circuits to protect them. There are many sizes of circuit breakers. When a high current passes through the electrical circuits, the circuit breaker closes the circuit and can be connected and disconnected manually.
In our project the breaker was installed on the hand of the wheelchair to allow the system to turn on and off, also represents an emergency breaker for any problem in the electrical circuit we disconnect it manually. (35)

Figure 18 circuit breaker(36)

SOFTWARE DESIGN

1. Raspbian

Raspberry pi is a single board computer (SBC). It needs an operating system to work. There are many operating systems that can run it. The famous one is Raspberry pi os who was previously called Raspbian. Is a Debian based operating system. It has been provided by the Raspberry pi foundation as a primary os for the Raspberry family (37).

2. Eye detection algorithm

We use a combination of computer vision techniques including:

- Bilateral filter for smoothing and preserving edge information in the eye frame.
- Erosion to remove small noise in the filtered frame.
- Thresholding to binarize the eye frame.

- Contour extraction to detect the iris.
- Calculation to estimate the centroid of the iris and thus the position of the pupil.

The algorithm can be seen as a combination of image processing and feature extraction techniques in computer vision.

3. Open CV library

OpenCV is a large open-source software library for computer vision and machine learning. This library contains many algorithms, whether they are machine learning algorithms or computer vision algorithms. Some of them are able to discover and face detection, classify objects, track camera movements, follow eye movement, and find slanted images from the database, in addition to many of the operations carried out by the open cv. In our project we will use the eye-tracking technique.

It contains many programming languages, including C++, python, C, java. It supports many systems such as Windows, Linux, Mac OS, IOS, and Android. (38) (39).

4. Python

Python is a high-level computer programming language that is easy to learn, write and read. It is one of the most popular programming languages around the world. The Python programming language is used in web development, machine learning applications, data analysis and also can be used for many programs. It is not limited to a specific program or problem. In Python there are many libraries for machine learning such as TensorFlow and Keras (40) (41).

5. Arduino IDE

The Integrated Development Environment (IDE) is an open-source Arduino Software. It has a text editor for writing code. It makes writing code and uploading it to the board easy. This software can be used with any Arduino board. The programs are written in terms of C and C++ functions that can be run on Windows, mac OS, and Linux. (42)

6. Dlib

Dlib is an open-source modern C++ library/toolkit containing machine learning algorithms. The facial landmark predictor is a part of the dlib library (43). It's a machine learning model that is trained to identify and locate specific landmarks or features on the human face. In our project the facial landmark predictor is not used directly. However, the dlib library is being utilized to extract iris frames from the eye frames and to calculate the iris size, which is used for finding the best binarization threshold for the person and the webcam.

3.1.1 SYSTEM BLOCK DIAGRAM

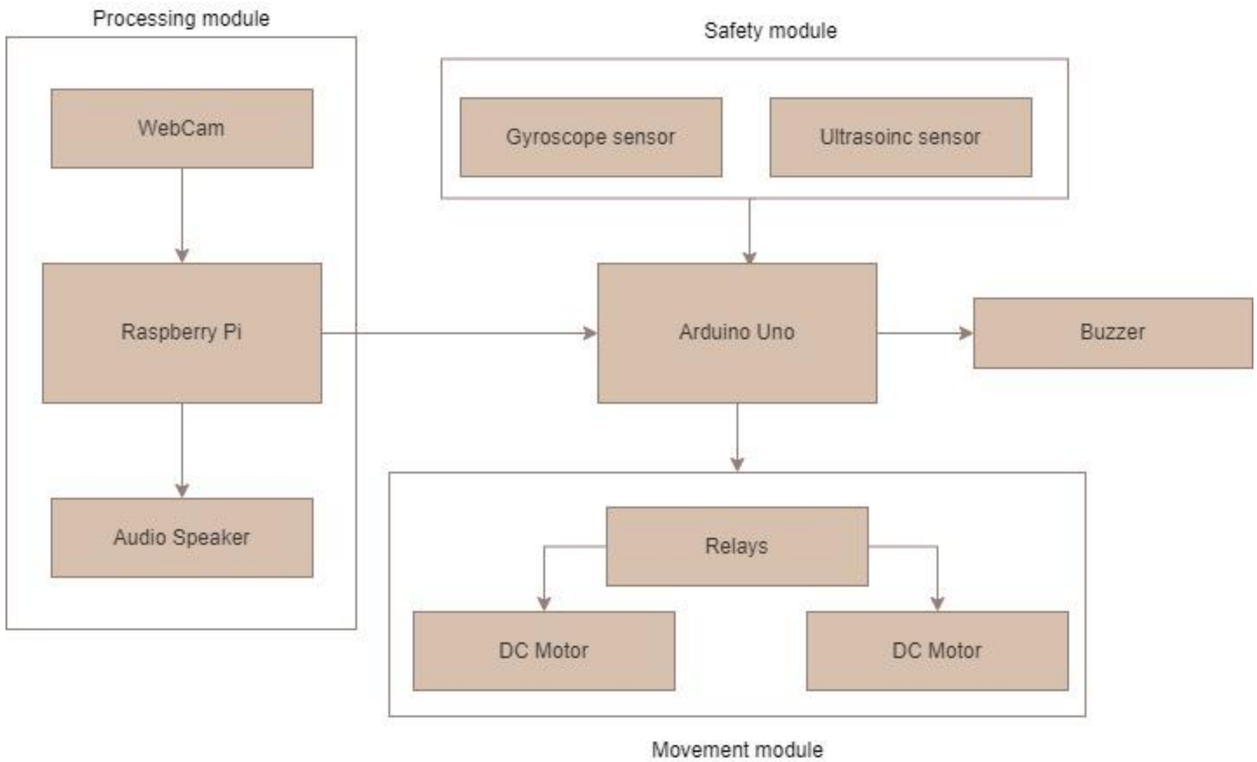


Figure 19 System Block Diagram

The block diagram in figure (19) describes the hardware components used in our project and how they interact to meet the desired requirements. This system is a totally autonomous system, and all the modules will work independently of each other. The diagram basically consists of two parts, the eye-controlled wheelchair based on two microprocessor and microcontroller Raspberry pi4 and Arduino uno. The Raspberry pi is the soul of our system. The movement of the wheels is controlled based on the eye's pupil movement. After activating this system by turn on the circuit breaker, the camera installed on the chair in front of the patient will start continually capturing images for his eye. Then send the image to the raspberry board which will take the image and process it to take a decision. The raspberry will detect the eye direction and send commands to the Arduino uno. According to the order received from the raspberry board Arduino uno controls the DC motors. There are two DC motors, each one on one side of the wheelchair, and the relays controls them based on eye direction. Then the raspberry pi sends commands to the speaker to play the audio for this command, to assure the patients that the raspberry understands the order. Our system has many sensors in order to guarantee the safety for our patient such as ultrasonic sensors and gyroscopes. The ultrasonic sensor detects if there are any obstacles in front of the wheelchair, it measures the distance between the wheelchair and obstacle, if the distance across the minimum distance threshold value this sensor will alert the Arduino uno and stop the Wheelchair, at the same time the buzzer will activated by Arduino uno to alert patient about that. Then the user decides which direction to go. The gyroscope sensor checks the stability of the wheelchair, if the wheelchair is not stable the gyroscope will send an alert to the Arduino uno board and it will stop the wheelchair automatically and alert the patient about that.

USECASE DIAGRAM

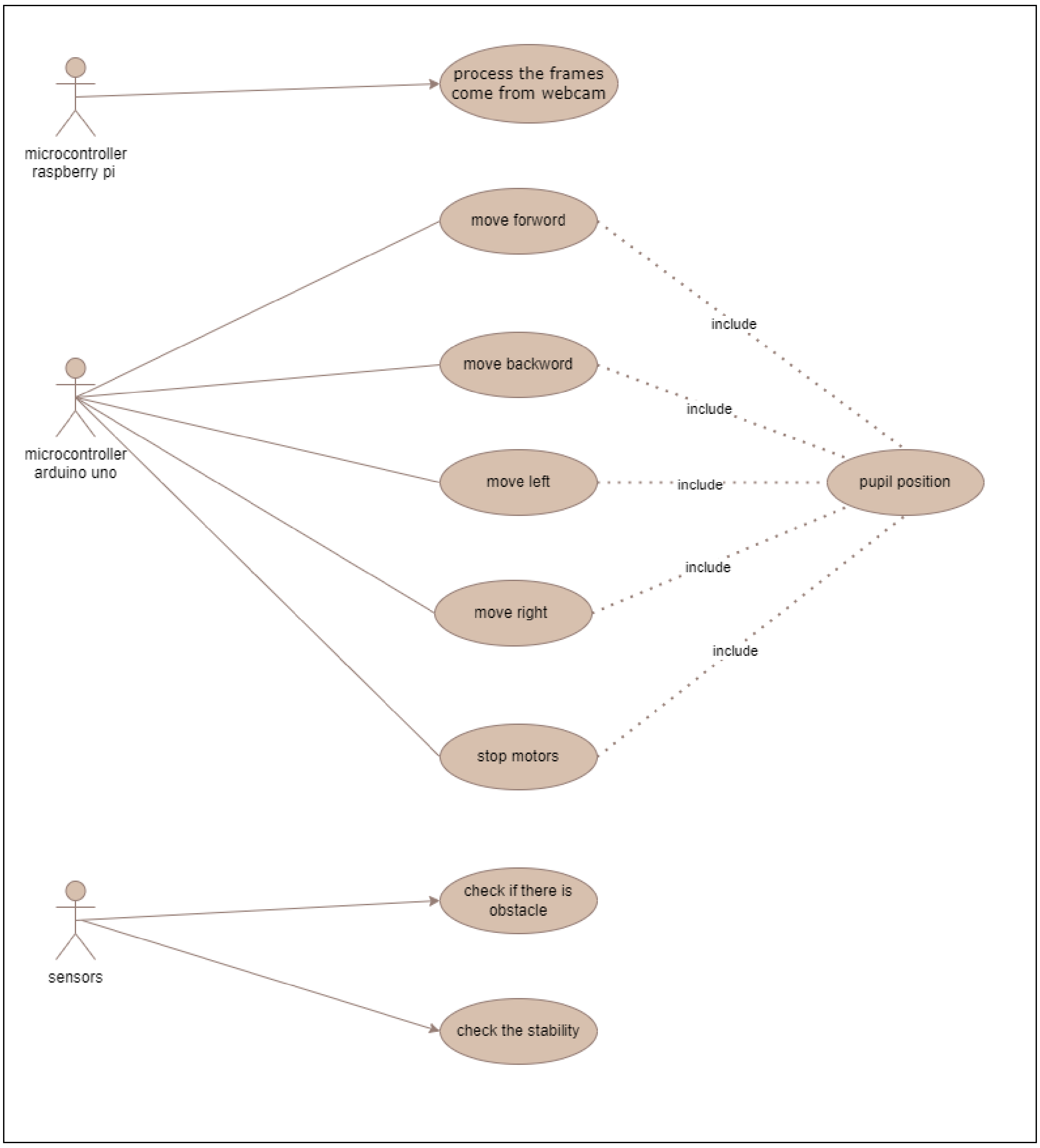


Figure 20 Use case diagram

Use Case	**move forward**
Actors	Arduino uno
Type	Primary and essential.
Description	When the patient blinks two times then looking center for two second, the Arduino uno sends commands to relays to control the dc motors and move the chair forward.

Table 2 Move Forward

Use Case	**move right**
Actors	Arduino uno
Type	Primary and essential.
Description	When the patient blinks two times and looking right for two seconds, the Arduino uno sends commands to relays to control the dc motors and move the chair right.

Table 3 Move Right

Use Case	**move left**
Actors	Arduino uno
Type	Primary and essential.
Description	When the patient blinks two times and looking left for two seconds, the Arduino uno sends commands to relays to control the dc motors and move the chair left.

Table 4 Move Left

Use Case	**Move backward**
Actors	Arduino uno
Type	Primary and essential.
Description	When the patient blinks three times and looking left for two seconds, the Arduino uno sends commands to relays to control the dc motors and move the chair backward.

Table 6 Move backward

Use Case	**stop the motor**
Actors	Arduino uno
Type	Primary and essential.
Description	When the patient blinks two times and looking up, the Arduino uno sends commands to relays to control the dc motors and stop the chair.

Table 7 Stop the motor

Use Case	**detect obstacle**
Actors	Ultrasonic Sensor
Type	Primary and essential.
Description	The ultrasonic sensor detects if there is any obstacle close to the wheelchair to alarms the Arduino uno about that.

Table 8 Detect obstacle

Use Case	detect the stability
Actors	Gyroscope Sensors
Type	Primary and essential.
Description	The gyroscope sensor checks if the wheelchair is not stable to alarms the Arduino uno about that.

Table 9 Detect the stability

FLOWCHART DIAGRAM

1. System Flowchart

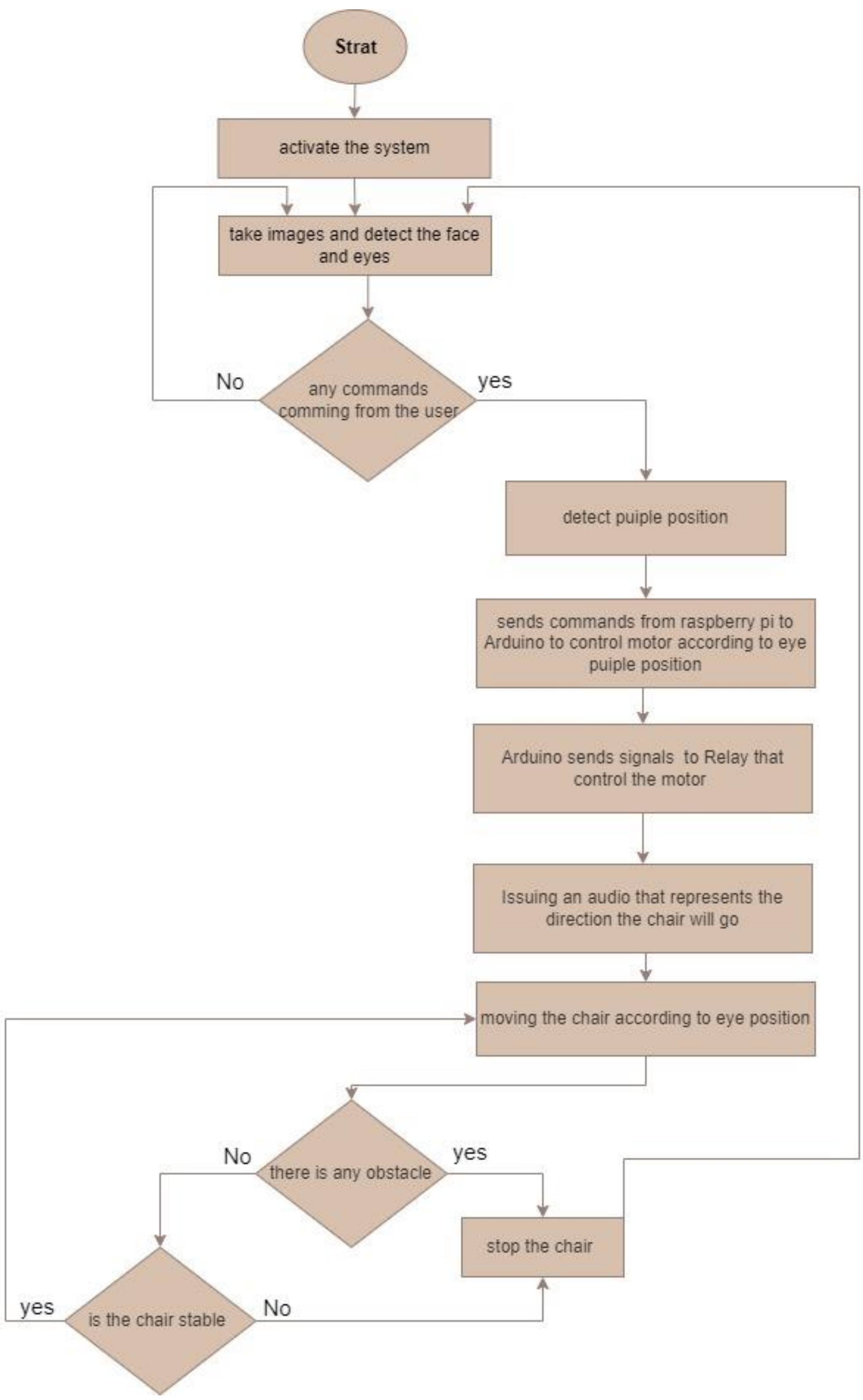


Figure 21 System Flowchart diagram

The flowchart in Figure (21) shows how a wheelchair works. In the beginning the patient is in a wheelchair and the circuit breaker turned on. A webcam takes the image and sends it to the Raspberry Pi. Face and eyes are detected. We used blinking in this system to alert the raspberry pi that there is a command coming from the patient. If the blinking number is two this means that the patient needs to move forward, left, right or stop according to looking to the desired direction for two seconds. If the blinking number is three this means that the patient will need to move backward by looking to the left for two seconds as shown in figure (22).

During the movement of the chair in any of the mentioned directions, if an imbalance occurs in the wheelchair, the Gyroscope sensor will send an alarm to the Arduino uno to stop the DC Motors. At the same time if the wheelchair facing any obstacle in its way the Ultrasonic sensor will send an alarm to the Arduino uno to stop the DC motors.

Flowchart of chair movement

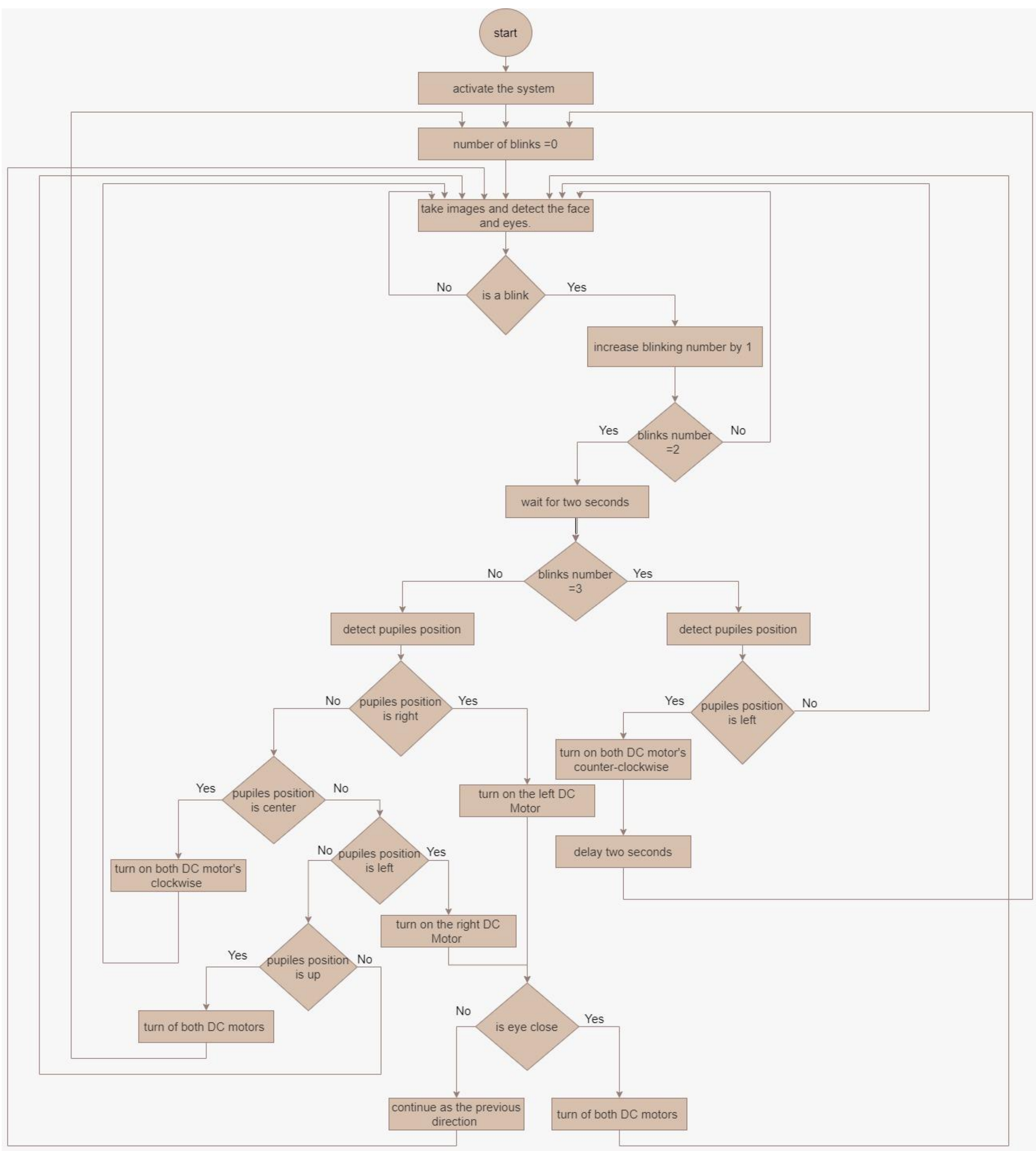


Figure 22chair movement Flowchart

3.2 Design Specifications, Standards and Constraints

DESIGN SPECIFICATIONS

Functional Requirements

- The system shall move forward when the patient blinks two times then looking center for two seconds.
- The system shall move right when the patient blinks two times then looking right for two seconds.
- The system shall move left when the patient blinks two times then looking left for two seconds.
- The system shall move backward when the patient blinks three times then looking left for two seconds.
- The system shall stop when the patient blinks two times then looking up.
- The system shall stop if there is any obstacle or is not stable.

Non-Functional Requirement

- Reliability: System failure is unacceptable, when the raspberry receives the frame it will respond to patient order.
- Accuracy: The raspberry will recognize the eye direction well, and take the right decision.
- Ease of use: Any patient can use this system.
- Affordability: The price of the wheelchair should be reasonable and affordable.
- Performance: the system must respond in real time.

CONSTRAINRTS

- We designed our project under certain constraints to ensure validity, applicability and sustainability of our proposed solution.
- The camera module is mounted in front of the user eye. An important part is the distance between eye and camera device is fixed. It may be 10cm to 14cm.
- The system works perfectly on environmental light and in a room light.

3.3 Design Alternatives

1. Raspberry PI Alternative for Arduino Uno

There is a choice to choose just Arduino Uno and laptop to process image on MATLAB, but we choose raspberry pi because it is a microprocessor, we can process the image with it and don't need a pc, unlike Arduino uno that can't do any process on it, it is just a microcontroller that can read or write from sensors and buttons. We need a high-definition Multimedia Interface (HDMI) port for LCD display and sound port.

2. Machine Learning Alternative for IR

We choose machine learning for detect the face and eyes because it is a modern technique and safety. Unlike infrared rays that harm the eyes and may cause vision loss after a period, even if the amount we use is small, the damage also reaches the eyelids and leads to the death of the cells in them.

3.4 System Analysis and Optimization

Artificial intelligence is the ability of a computer or robot to perform human-related tasks. It is a part of computer science with the design of intelligent computer systems in the sense of systems that have special characteristics of intelligence in human behavior and intellectual processes such as the ability to think, discover meaning, learn from past experience and solve problems. There are many fields for AI Such as Expert Systems, Speech processing, Computer Vision, Natural Language Processing, Machine Learning. (45) (44)

Computer vision is a field of artificial intelligence that enables computers to extract, understand, and analyze content from images and videos and take actions based on them. Computer vision works like human vision. It relies on machine learning technology to discover things by algorithm-based models. (47) (46) There are many applications of computer vision including self-driving vehicles, facial recognition, reading verification and medical imaging.(48)

Machine learning is a subset of artificial intelligence that allows systems to learn obtain results and improve through experiment and data training. In other words, the computer or system learns through training or experience without human intervention. The machine learning includes many algorithms so that the data set is entered into these algorithms and training of this data is done until it makes classifications and predictions. There are three types of machine learning:

1. Supervised learning

2. Unsupervised learning

3. Reinforcement learning.

Face detection is one of the most important applications of computer vision. (49) Face Landmark Detection is an important task in computer vision. Facial characteristics are detected and extracted from the face. There are many methods for face landmark detection but they all find the same main features mouth, right eyebrow, left eyebrow, right eye, left eye, nose and jaw. (50) In our project, the eyes will be detect from the face by using the 68-facial landmark predictor included in the dlib library.

A training set of face landmarks on an image. These images are manually categorized, with specific (x, y) coordinates indicated for the previously mentioned key regions of the face. A face landmarks detector pre-trained within the dlib library for python is used for feature detection, to estimate the location of the 68 points or (x, y) coordinates that define the key points of a face. The image (23) below shows a visual representation of the locations of the face landmarks.

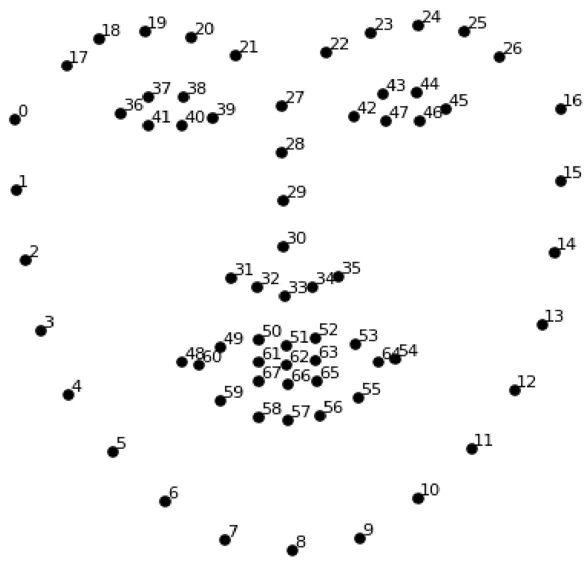


Figure 23 landmark

(51)

This model has been trained on the iBUG-300 W dataset and contains images and their corresponding 68 face landmark points.(52) This data set contains a wide range of images in which the face appears in different sizes, as well as lighting conditions and different positions of the face.

After face and eye detecting we will explain how to detect the eye pupil position.

The eye consists of three main parts as shown in the figure (24) below:

- The pupil, which is the black circle in the middle.
- The iris is the largest circle and varies in color from one person to another.
- Sclera is the part white (53).

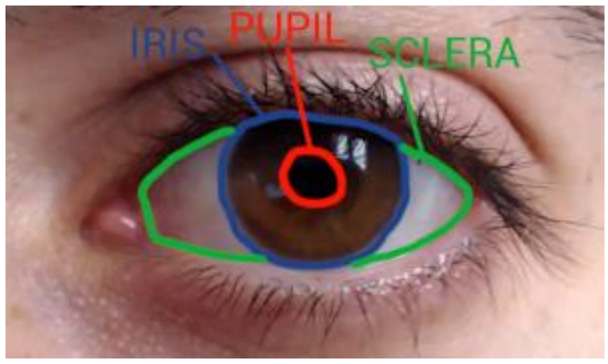


Figure 24 people eye (54)

The system relies on four eye movements as shown in the figure 25 which are left, center, right and up.

Figure 25 iris positions

How to determine the position of the eye pupil?

In our project we use the open CV library in order to detect the eye pupil position. We use a sequence of several steps where the algorithm of each step is implemented as part of the OpenCV.

The first step is convert the RGB image to gray scale image through cvtColor () function as we see figures 22 , 23 below. (55)

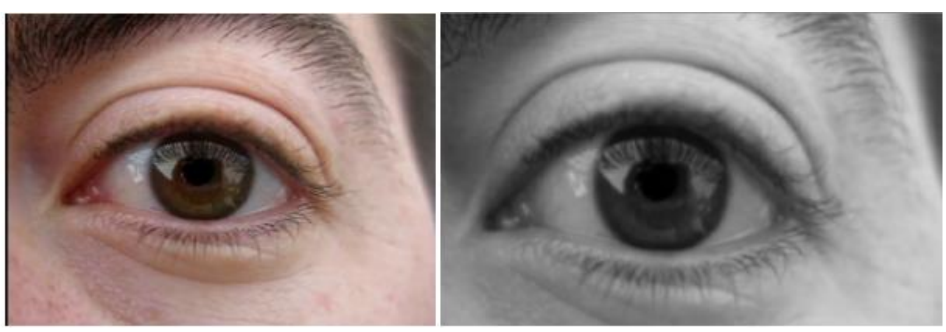


Figure 26 gray scale to the eye frame

The next step is Blurring image by using bilateral Filter () function shown in figure 24, to improve the image quality that can increase the accuracy of the iris detection.

Figure 27 Blurring Image (56)

Then we use erosion function to reduce noise and let iris detection easier.

The next step is binarize the eye frame by using threshold which is simple image processing technique used to distinguish the black and white color.

Figure 28 threshold eye fram

Then we use contour function to specify the shape for the iris. It put curve by joining all the continuous points having the same color.

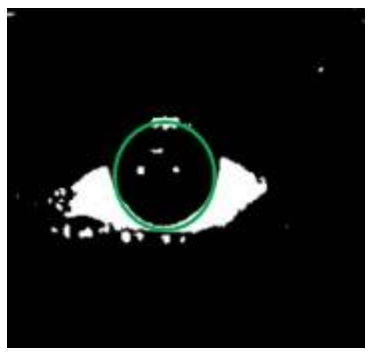
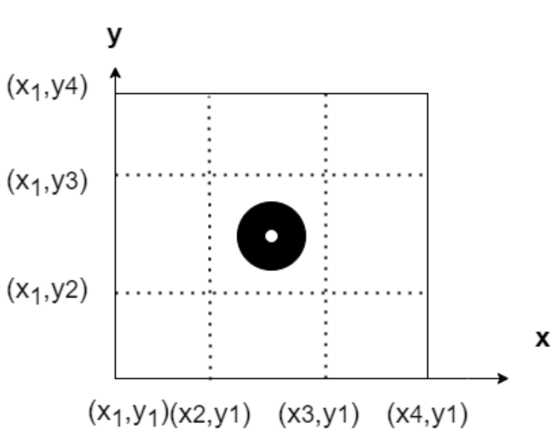


Figure 29 contours the frame

After locating the iris, we will locate the pupil, as it is located in the middle of the iris. There is a function that helps us discover the centroid called Moments Function. Using this, we will determine the x- and y-coordinates of the pupil, where moments gives an intensities to each point, either negative or positive, according to its color, and then we calculate the intensity of all points on the specified mass and intensity on the x- and y-axis. The x-coordinate is determined by dividing the total intensity of the x-axis moments by the total intensity of all moments, and the same for y-coordinate.

After detecting the pupil, we will determine its position in the eye. We will do that by dividing the eye width by the iris width. We define a specific threshold value because the iris is unstable and constantly shaking, so we can't consider any small movement as an order. This ratio will determine where is the iris. If this ratio is less than 0.35 on the horizontal ratio, it means that the iris at the right, if the ratio is between 0.35 and 0.65, it means that the iris is in the center and if the ratio is more than 0.65, it means that iris in the left, and the same for up on the vertical ratio. We determine the edges using canny edge function, that help us to determine both eye width and height. We will explain this in figures 27,28,29,30 below.



As we see in figure 30, The eye pupil is in the center as the X-axis between (x2,y1) and (x3,y1),and Y-axis between (x2,y2) and (x2,y3)

Figure 30 Center eye position

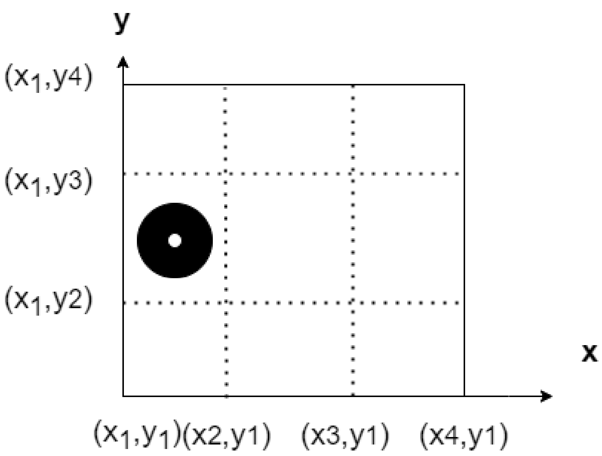


Figure 31 Left eye position

As we see in figure 31, The eye pupil is in the left as the X-axis between (x_1,y_2) and (x_2,y_2), and Y-axis between (x_1,y_2) and (x_1,y_3)

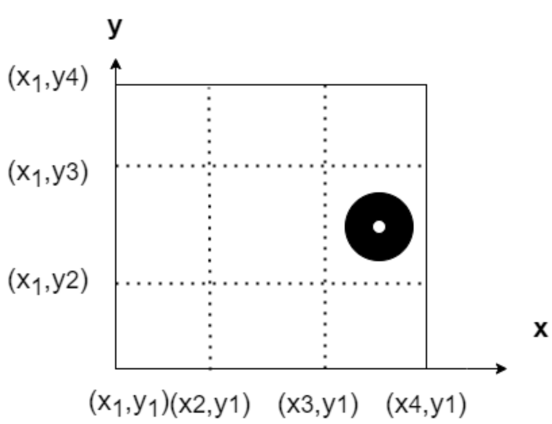


Figure 32 Right eye position

As we see in figure 32, The eye pupil is in the right as the X-axis between (x_3,y_2) and (x_4,y_2),and Y-axis between (x_3,y_2) and (x_3,y_3)

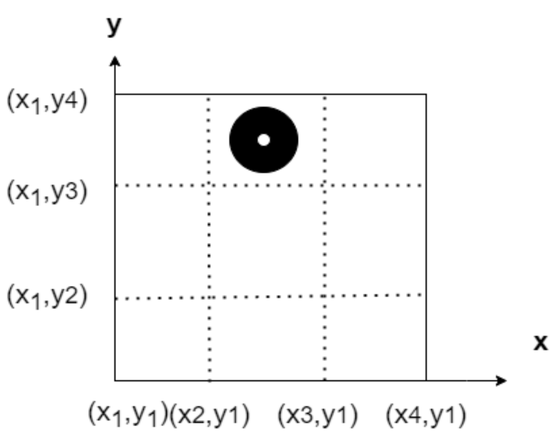


Figure 33 Top eye position

As we see in figure 33, The eye pupil is in the top as the X-axis between (x2,y3) and (x3,y3), and Y-axis between (x2,y3) and (x3,y4)

How the system work:

There is a circuit breaker on the hand of the chair turned on by patient's assistant to activate the system and pass current and voltage. A webcam installed on the chair in front of the patient's face, which continuously takes images of his face and sends them to the Raspberry to process them. When the images arrive at the Raspberry, it processes them by converting the image to gray scale to make it easier to analyze, then applies a pre-trained model using Machine Learning called 68-facial landmark predictor to locate the face in the image and detect the eyes inside the face. After that, the elements of the eye, such as the iris and the pupil are determined using image processing, so that eye movement can be tracked. The system starts taking eye movements as commands to move the chair after a certain number of long blinks. It is determined whether a person blinks or not based on a mathematical equation by taking the ratio between the width of the eye to its height. If the ratio is above 5, this means that the eye is closed, if it is less than 2.5, then this indicates that the eye is open. After knowing the state of the eye we count the blinks to know what direction the patient wants because every eye movement after each specific number of blinks indicates a different direction. If the number of blinks is two this means that the person wants to move forward, left, right or stop according to eye movement center, left, right or up. But if the number of blinks is three, this means that the person wants to move backward if he looked to the left for two second figure (32) below explained this process.

When the patient needs to move right or left, he can blink for one time to stop the motors so take the fit angle.

After knowing the desired direction, a voice is played through speaker audio installed on the chair, which reflects the direction that person wants, to tell the patient which direction the chair will move. Where there is a sound file for each movement. The Raspberry sends commands to the Arduino, where each command reflects a specific direction as shown in table 5.

Direction	Bit Representation
Forward	1010
Backward	0101
Right	0010
Left	1000
Stop	0000

Table 5 direction's signals

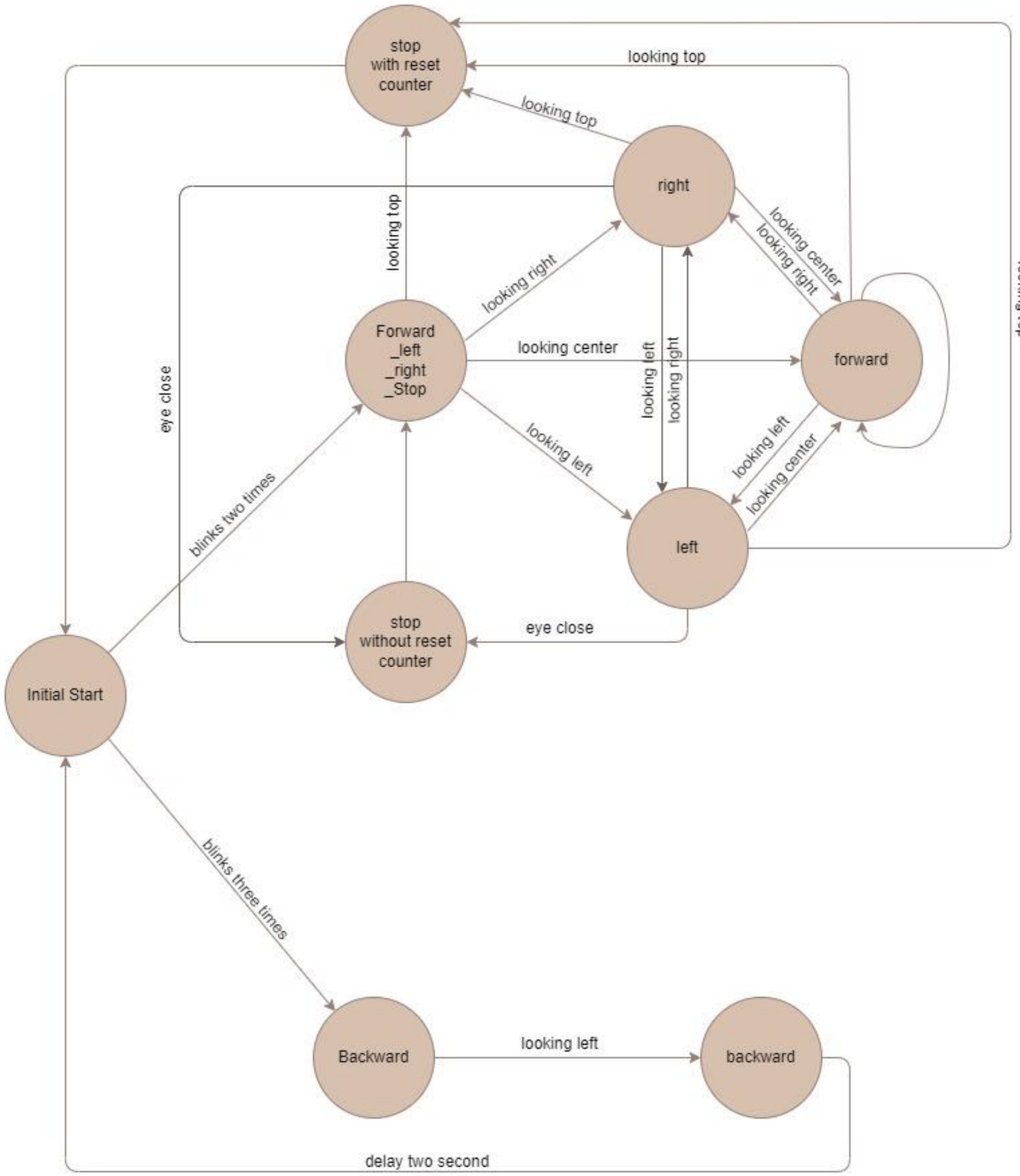


Figure 34 State Diagram

When the Arduino receives the commands, it analyzes them to send signals to the power circuit shown in figure (34).

In our project, we used a circuit to control the motors in a safe way. It consists of a regulator, transistor, and relays. We used 24-volt 5A relays to control which motor will power on or off, an LM2596S regulator to control the voltage, it takes an input voltage from power supply and converts it to the required voltage using potentiometer to power the raspberry, and transistors to pass the signals to relays.

The whole process starts with the transistors taking the signals from Arduino Uno, amplifying them to fit the relays, and turning on the coil. because the signals that come out of the Arduino are not enough to turn the contact of the relay. We have two motors each of them connecting with two relays one to move it forward and the other to move backward. If the patient needs to go forward Arduino gives a 1010 signal to power two motors in the forward situation and so on. Figure (35) below shown the power and control circuit.

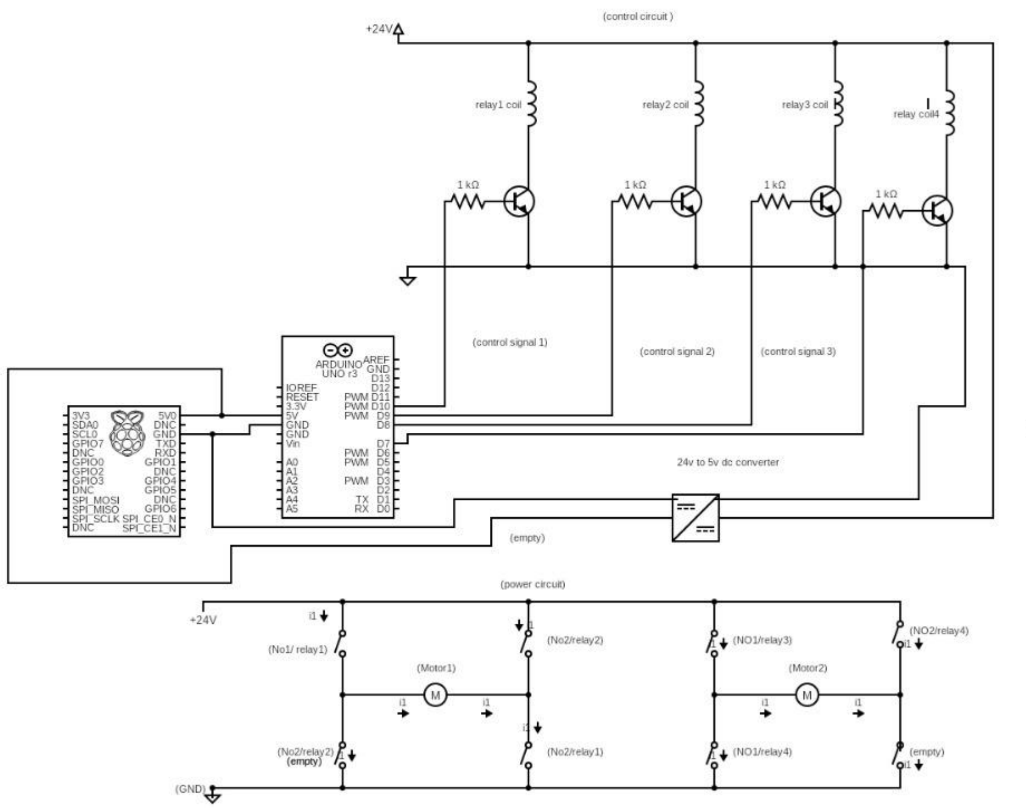


Figure 35 System design

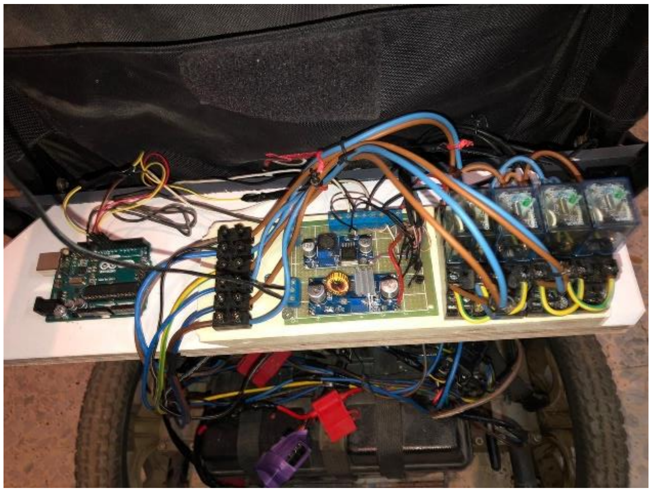


Figure 36 circuit

In the safety system applied on the wheelchair to protect the patient from any emergency event that may cause the chair to fall or collision. The ultrasonic sensor and gyroscope were used.

The HC-SR04 ultrasonic sensor includes a transmitter and a receiver this sensor measures the amount of time it takes for a sound wave to be sent and received by the distance between the sensor and the object. the distance it measures ranges from 2 cm to 400 cm. This sensor consists of 4 pins: VCC, GND, Trig, which outputs sound waves and the Echo pin which receives sound waves as they bounce back from the object as shown in figure (59) . (57)

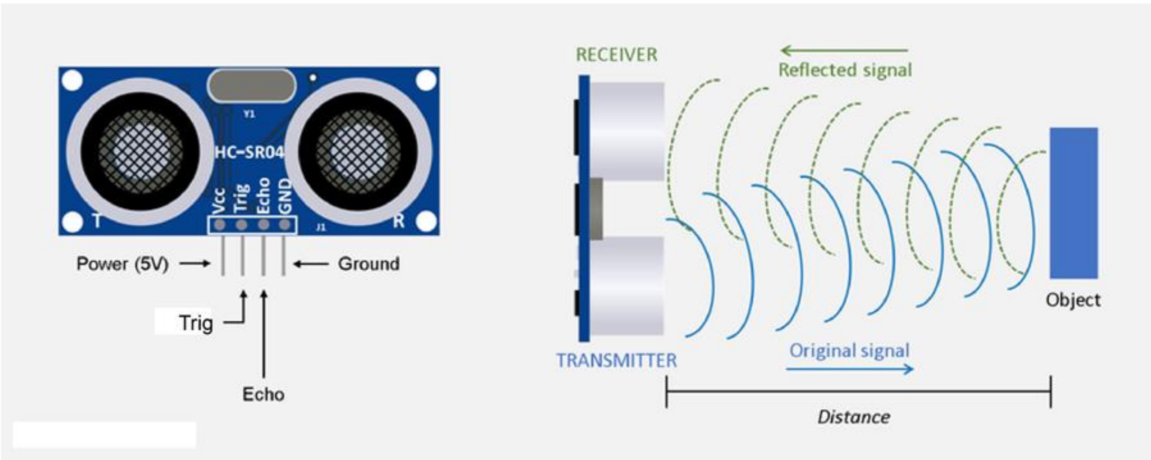


Figure 37 ultrasonic sensor (58)

The second sensor that was used to keep the wheelchair safety was the gyroscope sensor. This sensor measures rotational speed and rate of change of angular position along the X, Y and Z axes. Its output is in degrees per second, and to get the angular position, we need to integrate the angular velocity. (59)

This sensor has 8 pins INT, AD0, XCL, XDA, SCL, SDA, GND and VCC.

We used pins 4 when connecting vcc, gnd, and SCL Serial Clock pin will connected with A5 from Arduino uno pin. SDA Serial Data pin will connected with A4 from Arduino uno pin. The sensor measures the acceleration of gravity along the three axes, and using trigonometry, the angle at which the sensor is placed can be calculated, and from the calculations of acceleration and the angle at which it is placed, the angle of inclination is calculated.

3.5 Simulation and/or Experimental Test

TESTING THE LANGUGE OF THE WHEELCHAIR

We start with applying the commands on screen then reflect them on LEDs as shown in figure (38).

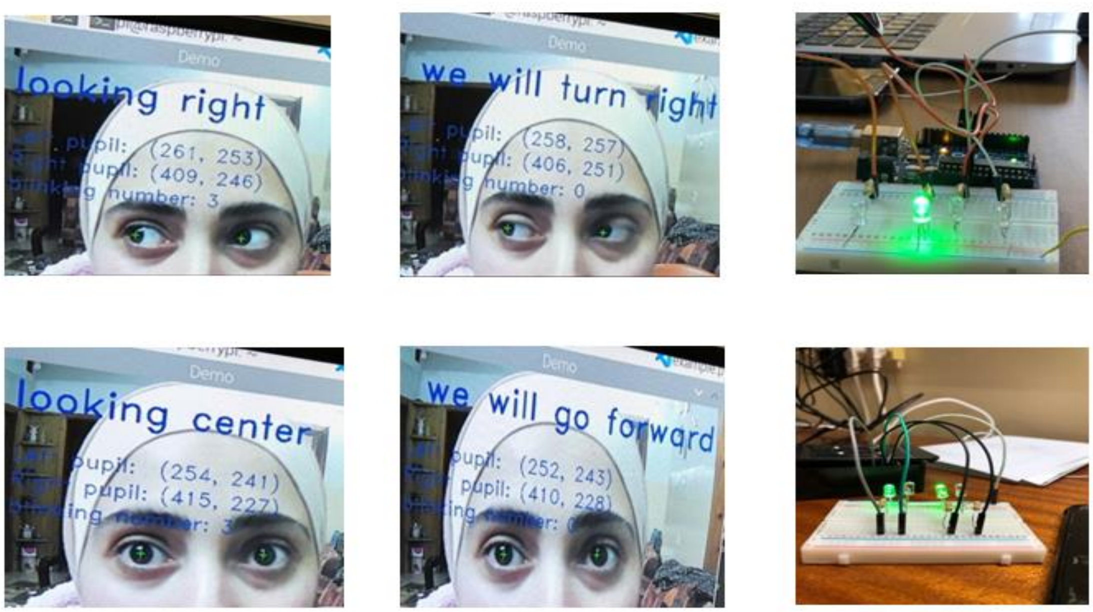


Figure 38 reflects command on LEDs

TESTING OBSTACLE DETECTION

In our system, three ultrasonic sensors were used, one installed in the back and two in the front corners as shown figure (39). The sensors and the buzzer have been connected to the Arduino uno so that if the distance between the chair and the object reaches 30 cm, the buzzer will sound an alarm and signals will be sent to the relays to stop the wheelchair.

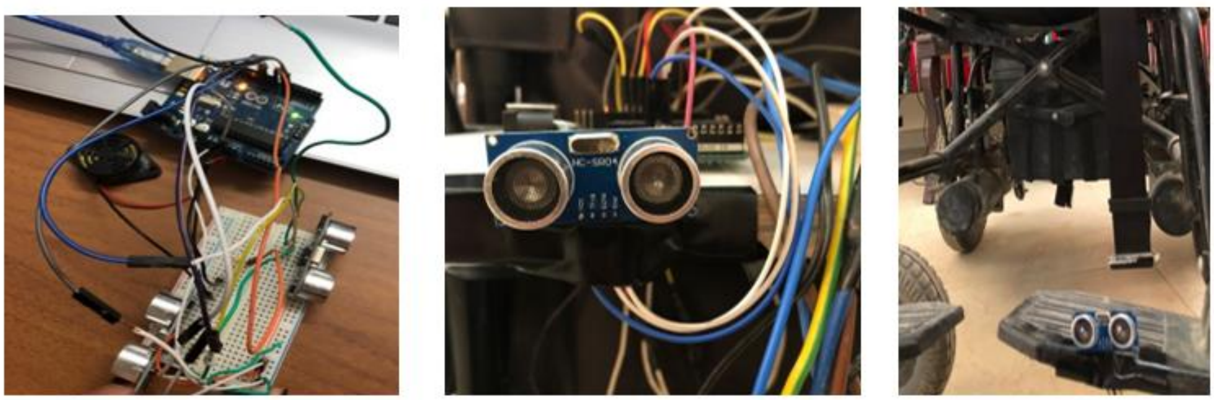


Figure 39 the position of ultrasonics

In the simulation, the program called tinkercad was used to simulate the existing components and understand these components in detail. We used two components to make the simulation like the ultrasonic sensor and the buzzer. The following figure shows a simulation of a buzzer that has been confirmed. For us that equation we used to map frequency with distance works.

correctly:

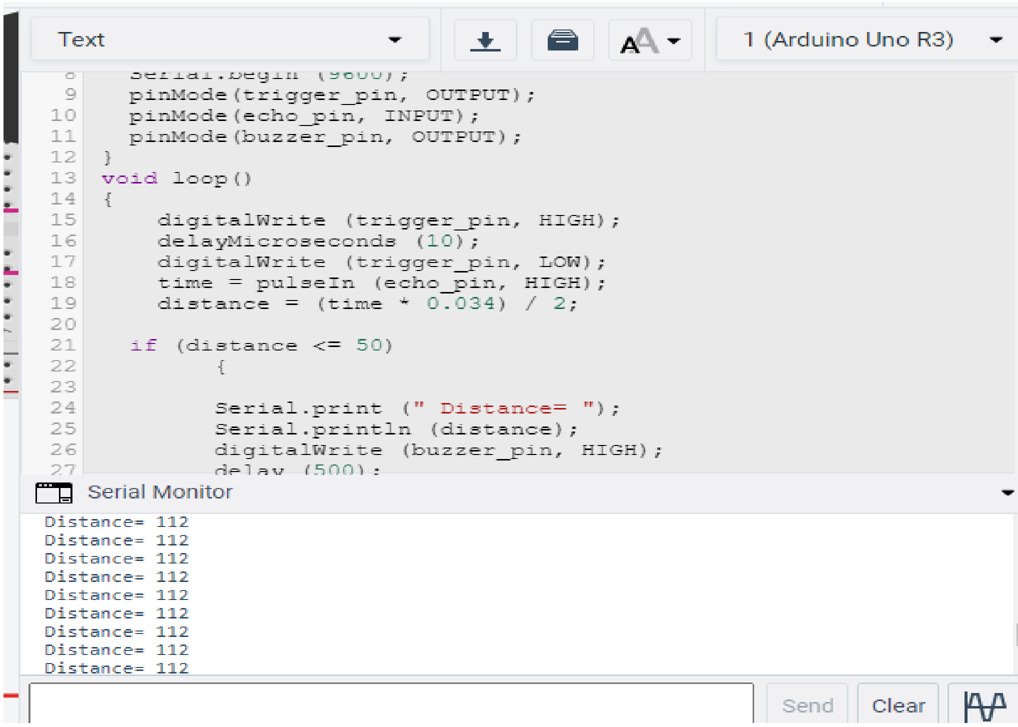


Figure 40

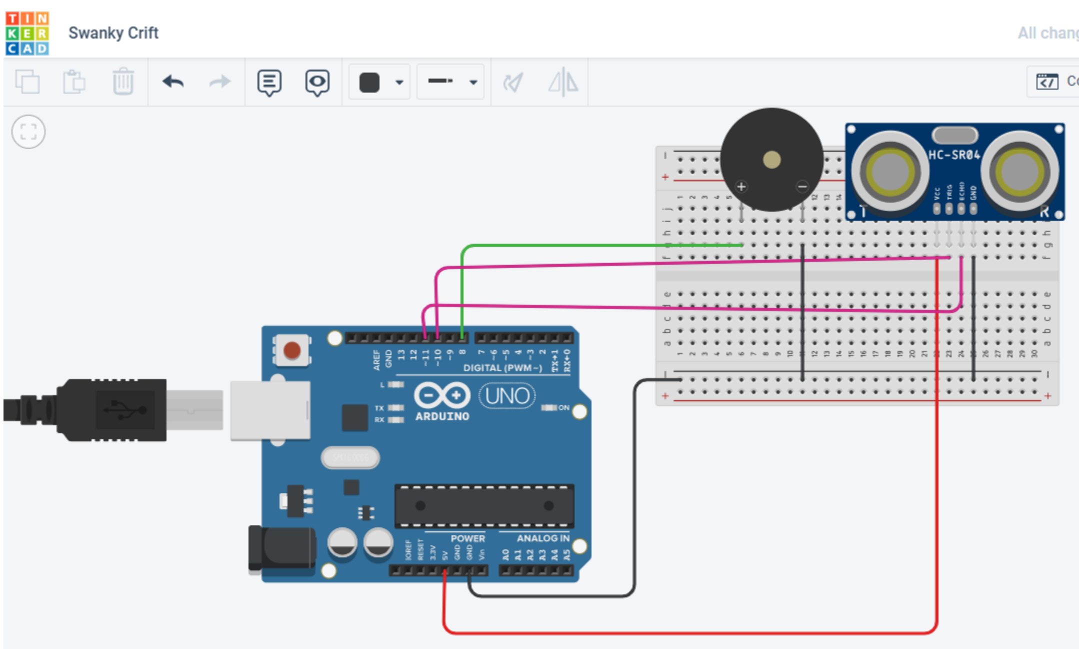


Figure 41 ultrasonic sensor simulation

4 CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Results

After completing the implementation of the system we conducted experiments to verify its response by taking paths and applying it to the language of the eye taking many possibilities for the patient's movement, and knowing how much time it takes for the person to start from a point and get to the place he wants. We also conducted experiments on the safety system and to see how well it responds when the wheelchair approaches any obstacle or when the chair tilts and an imbalance occurs.

Experiment 1:

- **Path 1:**

  The figure(42) below shows the first path as the patient wants to move from the guest room to the kitchen first moving forward then moving to the right and then forward.

Figure 42 path1

- **Path 2:**

  The figure(43) below shows the second path, as the patient wants to move from the guest room to the home garden, first moving to the right and then forward to exit the room door.

Figure 43 path2

Path	Distance	Time
Path1	30 m	3 m
Path2	5 m	1 m

Experiment 2:

In the second experiment on safety system we check with the ultrasonic sensor and examined its response when there is obstacles when he is moving. The figure(44) below shows the path, when the patient is moving, he faced a wall 30 cm away. As a result the buzzer will alert and the wheelchair will stop.

Figure 44 experiment 2

4.2 Discussions

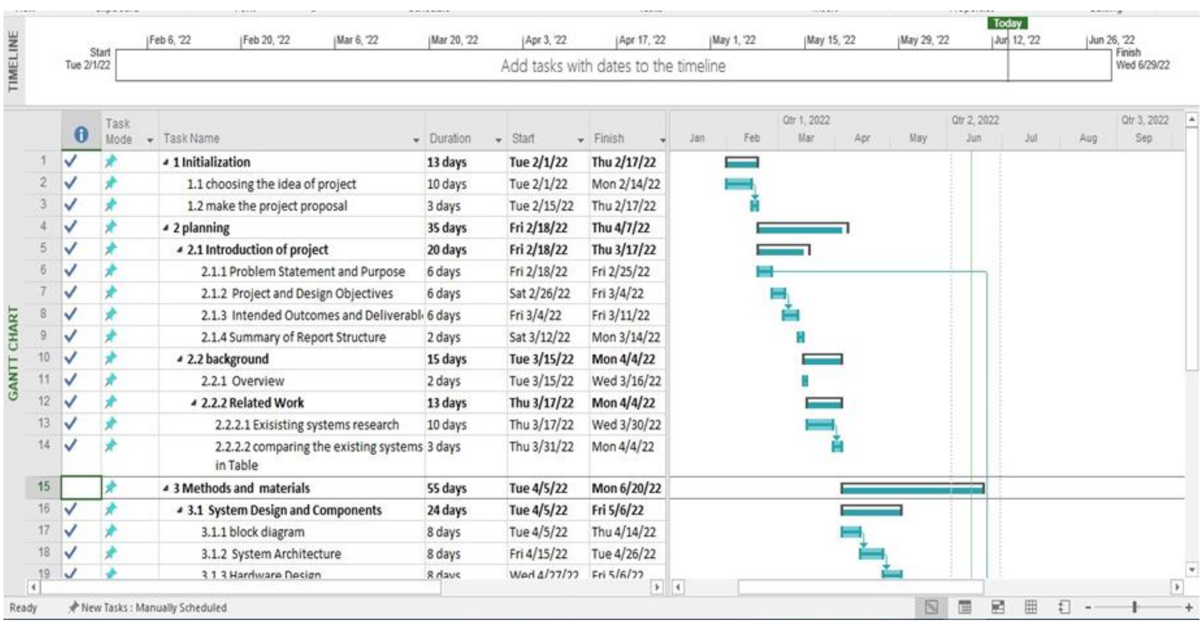
According to above experiments we noticed that the system response approximately in real time. The path takes longer time than normal but it better for safe patient life. The sensor works almost in real time and stop if any things happen emergency.

5 CHAPTER 5: PROJECT MANAGEMENT

In this chapter we have built the project schedule scheduling all tasks completed main and subtasks as well estimating the time of each task, how many days it will take and scheduling the date for each of the tasks. And we calculated the cost of the components that were used and the cost of complete the project.

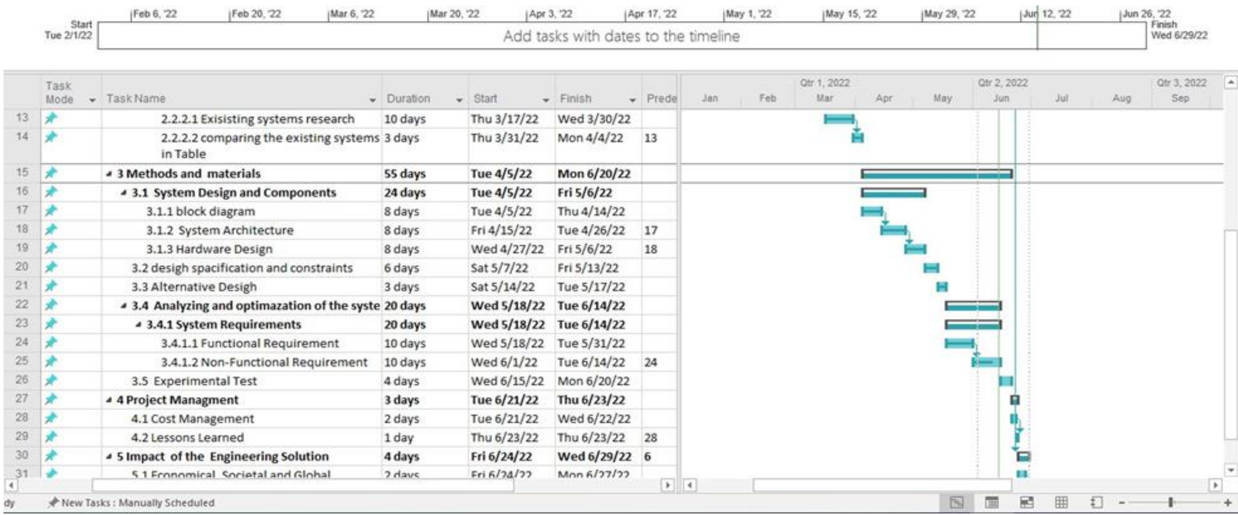
5.1 Tasks, Schedule and Milestones

In this section, as shown in the figures below, we built a schedule for the project and all the tasks that we done throughout the project period until its completion.



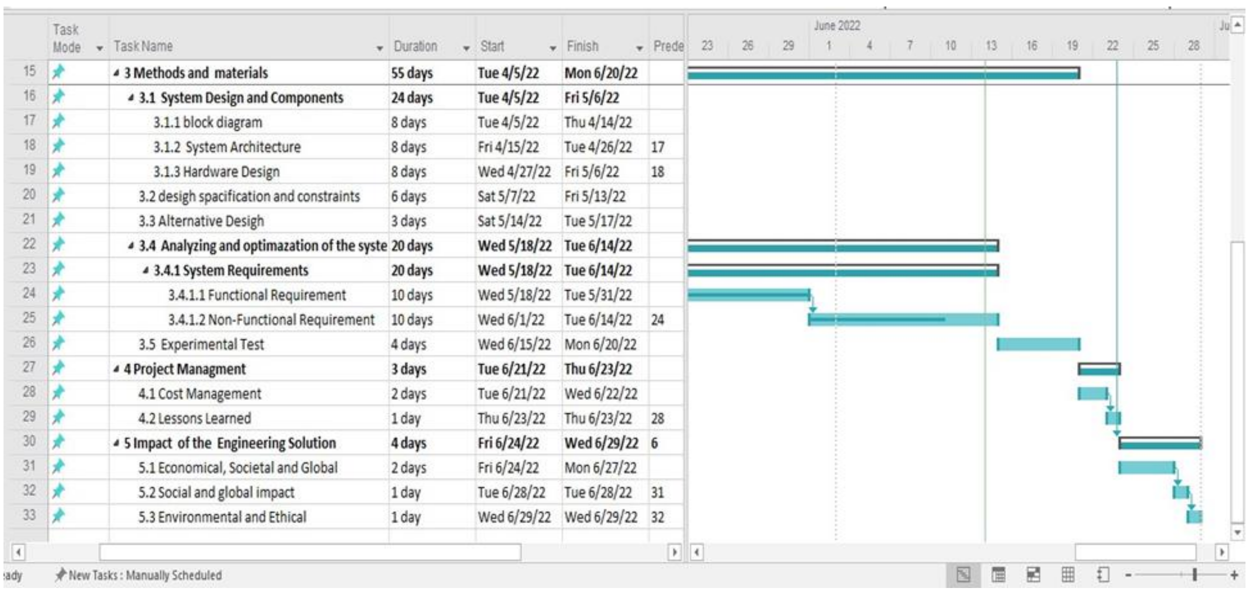
	Task Mode	Task Name	Duration	Start	Finish
1		1 Initialization	13 days	Tue 2/1/22	Thu 2/17/22
2		1.1 choosing the idea of project	10 days	Tue 2/1/22	Mon 2/14/22
3		1.2 make the project proposal	3 days	Tue 2/15/22	Thu 2/17/22
4		2 planning	35 days	Fri 2/18/22	Thu 4/7/22
5		2.1 Introduction of project	20 days	Fri 2/18/22	Thu 3/17/22
6		2.1.1 Problem Statement and Purpose	6 days	Fri 2/18/22	Fri 2/25/22
7		2.1.2 Project and Design Objectives	6 days	Sat 2/26/22	Fri 3/4/22
8		2.1.3 Intended Outcomes and Deliverabl	6 days	Fri 3/4/22	Fri 3/11/22
9		2.1.4 Summary of Report Structure	2 days	Sat 3/12/22	Mon 3/14/22
10		2.2 background	15 days	Tue 3/15/22	Mon 4/4/22
11		2.2.1 Overview	2 days	Tue 3/15/22	Wed 3/16/22
12		2.2.2 Related Work	13 days	Thu 3/17/22	Mon 4/4/22
13		2.2.2.1 Exisisting systems research	10 days	Thu 3/17/22	Wed 3/30/22
14		2.2.2.2 comparing the existing systems in Table	3 days	Thu 3/31/22	Mon 4/4/22
15		3 Methods and materials	55 days	Tue 4/5/22	Mon 6/20/22
16		3.1 System Design and Components	24 days	Tue 4/5/22	Fri 5/6/22
17		3.1.1 block diagram	8 days	Tue 4/5/22	Thu 4/14/22
18		3.1.2 System Architecture	8 days	Fri 4/15/22	Tue 4/26/22
19		3.1.3 Hardware Design	8 days	Wed 4/27/22	Fri 5/6/22

Figure 45 project schedule1



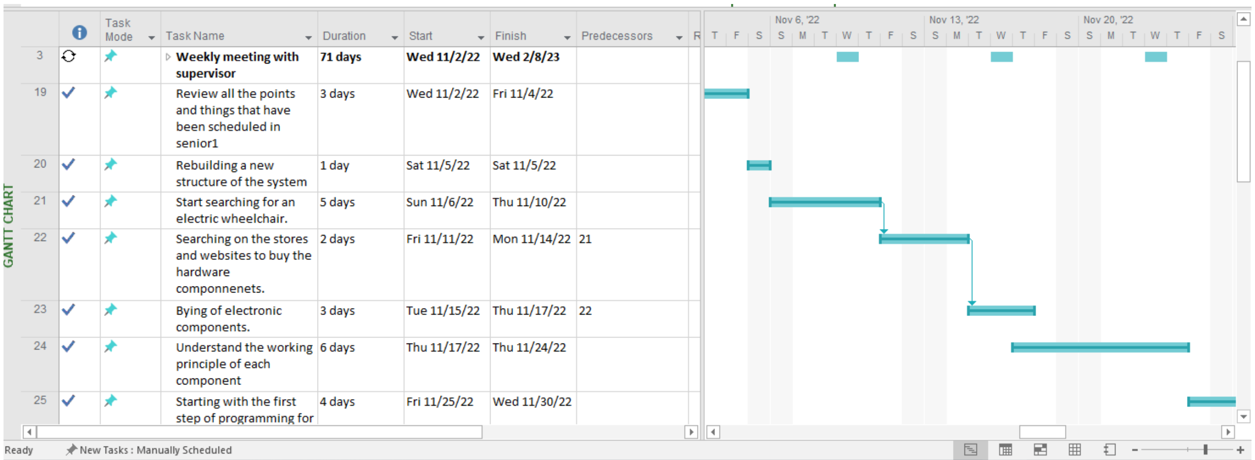
	Task Mode	Task Name	Duration	Start	Finish	Prede
13		2.2.2.1 Exisisting systems research	10 days	Thu 3/17/22	Wed 3/30/22	
14		2.2.2.2 comparing the existing systems in Table	3 days	Thu 3/31/22	Mon 4/4/22	13
15		**3 Methods and materials**	**55 days**	**Tue 4/5/22**	**Mon 6/20/22**	
16		**3.1 System Design and Components**	**24 days**	**Tue 4/5/22**	**Fri 5/6/22**	
17		3.1.1 block diagram	8 days	Tue 4/5/22	Thu 4/14/22	
18		3.1.2 System Architecture	8 days	Fri 4/15/22	Tue 4/26/22	17
19		3.1.3 Hardware Design	8 days	Wed 4/27/22	Fri 5/6/22	18
20		3.2 desigh spacification and constraints	6 days	Sat 5/7/22	Fri 5/13/22	
21		3.3 Alternative Desigh	3 days	Sat 5/14/22	Tue 5/17/22	
22		**3.4 Analyzing and optimazation of the syste**	**20 days**	**Wed 5/18/22**	**Tue 6/14/22**	
23		**3.4.1 System Requirements**	**20 days**	**Wed 5/18/22**	**Tue 6/14/22**	
24		3.4.1.1 Functional Requirement	10 days	Wed 5/18/22	Tue 5/31/22	
25		3.4.1.2 Non-Functional Requirement	10 days	Wed 6/1/22	Tue 6/14/22	24
26		3.5 Experimental Test	4 days	Wed 6/15/22	Mon 6/20/22	
27		**4 Project Managment**	**3 days**	**Tue 6/21/22**	**Thu 6/23/22**	
28		4.1 Cost Management	2 days	Tue 6/21/22	Wed 6/22/22	
29		4.2 Lessons Learned	1 day	Thu 6/23/22	Thu 6/23/22	28
30		**5 Impact of the Engineering Solution**	**4 days**	**Fri 6/24/22**	**Wed 6/29/22**	**6**
31		5.1 Economical, Societal and Global	2 days	Fri 6/24/22	Mon 6/27/22	

Figure 46 project schedule2



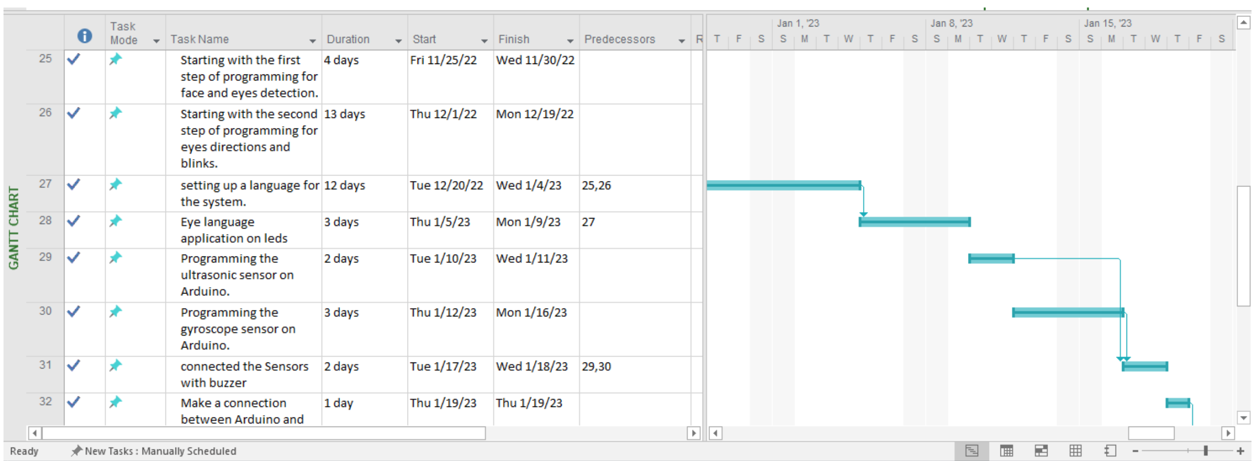
	Task Mode	Task Name	Duration	Start	Finish	Prede
15		**3 Methods and materials**	**55 days**	**Tue 4/5/22**	**Mon 6/20/22**	
16		**3.1 System Design and Components**	**24 days**	**Tue 4/5/22**	**Fri 5/6/22**	
17		3.1.1 block diagram	8 days	Tue 4/5/22	Thu 4/14/22	
18		3.1.2 System Architecture	8 days	Fri 4/15/22	Tue 4/26/22	17
19		3.1.3 Hardware Design	8 days	Wed 4/27/22	Fri 5/6/22	18
20		3.2 desigh spacification and constraints	6 days	Sat 5/7/22	Fri 5/13/22	
21		3.3 Alternative Desigh	3 days	Sat 5/14/22	Tue 5/17/22	
22		**3.4 Analyzing and optimazation of the syste**	**20 days**	**Wed 5/18/22**	**Tue 6/14/22**	
23		**3.4.1 System Requirements**	**20 days**	**Wed 5/18/22**	**Tue 6/14/22**	
24		3.4.1.1 Functional Requirement	10 days	Wed 5/18/22	Tue 5/31/22	
25		3.4.1.2 Non-Functional Requirement	10 days	Wed 6/1/22	Tue 6/14/22	24
26		3.5 Experimental Test	4 days	Wed 6/15/22	Mon 6/20/22	
27		**4 Project Managment**	**3 days**	**Tue 6/21/22**	**Thu 6/23/22**	
28		4.1 Cost Management	2 days	Tue 6/21/22	Wed 6/22/22	
29		4.2 Lessons Learned	1 day	Thu 6/23/22	Thu 6/23/22	28
30		**5 Impact of the Engineering Solution**	**4 days**	**Fri 6/24/22**	**Wed 6/29/22**	**6**
31		5.1 Economical, Societal and Global	2 days	Fri 6/24/22	Mon 6/27/22	
32		5.2 Social and global impact	1 day	Tue 6/28/22	Tue 6/28/22	31
33		5.3 Environmental and Ethical	1 day	Wed 6/29/22	Wed 6/29/22	32

Figure 47 project schedule3



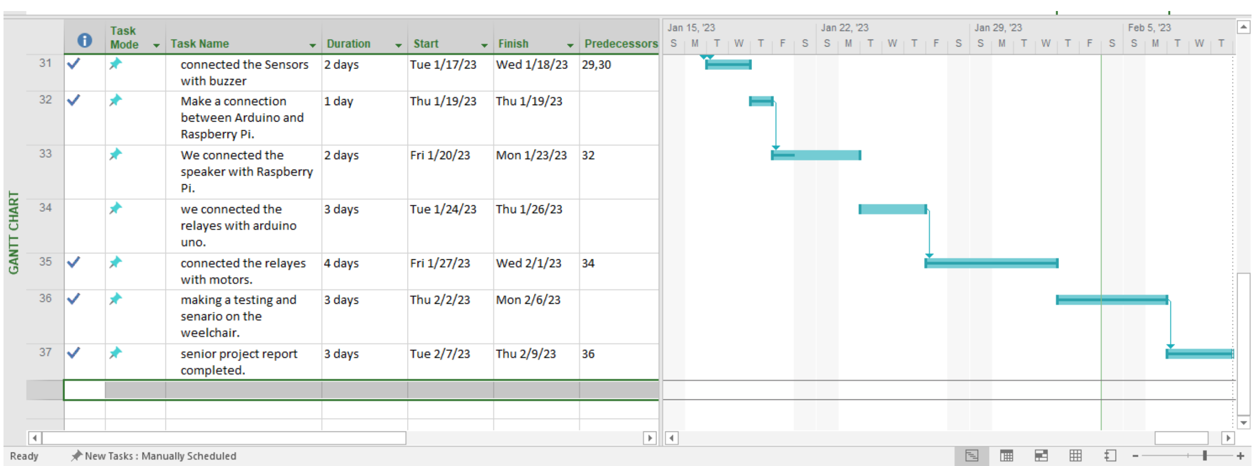
	Task Mode	Task Name	Duration	Start	Finish	Predecessors
3		**Weekly meeting with supervisor**	**71 days**	**Wed 11/2/22**	**Wed 2/8/23**	
19		Review all the points and things that have been scheduled in senior1	3 days	Wed 11/2/22	Fri 11/4/22	
20		Rebuilding a new structure of the system	1 day	Sat 11/5/22	Sat 11/5/22	
21		Start searching for an electric wheelchair.	5 days	Sun 11/6/22	Thu 11/10/22	
22		Searching on the stores and websites to buy the hardware componnenets.	2 days	Fri 11/11/22	Mon 11/14/22	21
23		Bying of electronic components.	3 days	Tue 11/15/22	Thu 11/17/22	22
24		Understand the working principle of each component	6 days	Thu 11/17/22	Thu 11/24/22	
25		Starting with the first step of programming for	4 days	Fri 11/25/22	Wed 11/30/22	

Figure 48 project schedule4



	Task Mode	Task Name	Duration	Start	Finish	Predecessors
25		Starting with the first step of programming for face and eyes detection.	4 days	Fri 11/25/22	Wed 11/30/22	
26		Starting with the second step of programming for eyes directions and blinks.	13 days	Thu 12/1/22	Mon 12/19/22	
27		setting up a language for the system.	12 days	Tue 12/20/22	Wed 1/4/23	25,26
28		Eye language application on leds	3 days	Thu 1/5/23	Mon 1/9/23	27
29		Programming the ultrasonic sensor on Arduino.	2 days	Tue 1/10/23	Wed 1/11/23	
30		Programming the gyroscope sensor on Arduino.	3 days	Thu 1/12/23	Mon 1/16/23	
31		connected the Sensors with buzzer	2 days	Tue 1/17/23	Wed 1/18/23	29,30
32		Make a connection between Arduino and	1 day	Thu 1/19/23	Thu 1/19/23	

Figure 49 project schedule5



	Task Mode	Task Name	Duration	Start	Finish	Predecessors
31		connected the Sensors with buzzer	2 days	Tue 1/17/23	Wed 1/18/23	29,30
32		Make a connection between Arduino and Raspberry Pi.	1 day	Thu 1/19/23	Thu 1/19/23	
33		We connected the speaker with Raspberry Pi.	2 days	Fri 1/20/23	Mon 1/23/23	32
34		we connected the relayes with arduino uno.	3 days	Tue 1/24/23	Thu 1/26/23	
35		connected the relayes with motors.	4 days	Fri 1/27/23	Wed 2/1/23	34
36		making a testing and senario on the weelchair.	3 days	Thu 2/2/23	Mon 2/6/23	
37		senior project report completed.	3 days	Tue 2/7/23	Thu 2/9/23	36

Figure 50 project schedule6

5.2 Resources and Cost Management

In this section we estimate the project resources and the cost of each hardware component that we used in this project. We put each component in the number of units we need in this project and the total cost of the project.

Item	# Unit	Unit Cost	Subtotals
Wheelchair	1	500$	500$
Arduino uno	1	30$	30$
Raspberry pi 4	1	230$	230$
Webcam	1	11$	11$
Power Supply	2	51$	102$
relays	4	13$	52$
Regulator	1	22$	22$
Gyroscope sensor	1	4$	4$
Ultrasonic Sensor	4	2$	8$
Buzzer	1	3$	3$
Audio speaker	1	20$	20$
Circuit breaker	1	4$	4$
Total senior project estimate	11	890$	986$

Table 6 Total Cost for Senior Project Items

5.3 Lessons Learned

1. Did the project meet scope, time, and cost goals?

   Yes, achieve it.

2. What was the success criteria listed in the project scope statement?

   We will design a wheelchair for spinal cord patients. They can move and use it without need any one help, and is able to detect obstacles and warn against them.

3. Reflect on whether or not you met the project success criteria.

   We analyze and study all aspects of the project. All possibilities and scenarios have been considered. We also focused on choosing the right ingredients, in addition to that, we work together in an integrated and team spirit. All this will certainly lead to the success of the project.

4. In terms of managing the project, what were the main lessons your team learned?

   - Organizing time and scheduling all tasks and completing tasks in the required time.
   - Distribute tasks to team members according to their skill and efficiency.
   - Study the impact of the project on society, the environment and human resources.

5. Describe one example of what went right on this project.

   We divide the tasks equally, and each person takes the task that suits her.

6. Describe of what went wrong on this project.

   Challenges:

Due to the high cost of electric wheelchairs, we could not buy one. It is also difficult for us to find a used chair in good condition, as there is rarely a person who has two or a spare chair. Due to our lack of sufficient knowledge of the electronics, an electric short occurred that led to the burning of the board responsible for the movement of the chair, and the cost of repairing it was very high, so we had difficulty finding another chair similar to the type of the old chair, its board is in good condition, then replacing the old chair board with the new one.

After installing the operating system on the Raspberry, the system did not recognize the camera, and we downloaded 5 operating systems, and none of them recognized the camera, then we bought a webcam that the system recognized quickly.

Creating a special eye language for the movement of the chair so that these commands do not interfere with the patient's natural eye movement, and try to make the movement fas for the patient to be able to stop the chair quickly.

6 CHAPTER 6: IMPACT OF THE ENGINEERING SOLUTION

Eye controlled wheelchair system has many effects on various aspects, such as environmental, ethical, economic, social and global. Which it will be discussed in this chapter.

6.1 Economical, Societal and Global

Eye controlled wheelchair system will have an impact on society in a significant way. It helps these categories of people to integrate into society and make them feel that they are able to do thing alone. This will increase their confidence, and it becomes possible to dispense with permanent companions for the patient. It will reduce the effort on their family especially if the person who cares for the patient is elderly. This system does not create new jobs.

Economics (cost) impact

The most important thing that we aspire to do in our system is doing the best thing at a lower price. To be suitable for all who need it. Using this system will reduce the patient's dependence on the family and he doesn't need the nurse all the time, so it will reduce the cost for the parents if the patient has a nurse.

6.2 Environmental and Ethical

This system is environmentally friendly. It does not emit toxic gasses.

7 CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary of Achievements of the Project Objectives

In our system we will produce an eye-controlled wheelchair system that will help ALS patient to move his wheelchair by himself. We know the component and choose the suitable type that take the need power, voltage and current. We identify an appropriate algorithm to detect the eye movements and blinks. We explain the methodologies by flowcharts and use case. We show the component and how connect in block diagram.

7.2 New Skills and Experiences Learnt

- The skills that we have gained:

    1. Report writing skills.
    2. The skills of dealing with the hardware component.
    3. scheduling tasks and time management skills.
    4. Team working skills.

- The Experience learned:

    1. Connecting hardware components.
    2. Programming Raspberry pi 4.
    3. Programming Arduino.
    4. Dealing with different types of the hardware component.
    5. Problem-solving

7.3 Recommendations for Future Work

1. It is possible to replace the Raspberry Pi with a Jetson Nano for its speed, as it can process a greater number of frames per second, which makes the system more accurate and reduces delay, and we can do without Arduino.

2. In the case of first use by the patient, pictures of his eye can be taken in both cases, with eyes open and closed, in order to take the correct proportion of the patient's eye in the case of blinking.

3. Developing the system by making it safe to travel outside the home , and a feature can be added to send a message to the phone of the person in charge of the patient if something emergency happens.

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APPENDICES

Appendix A:

Component description

1. Raspberry pi

Attribute	Value
Raspberry pi	Raspberry pi 4
Operating Voltage	5V
CPU SPEED	1.5GHz
input/output pins	40 pins
USB	2x USB-A 3.0 2x USB-A 2.0
DC Current per I/O Pin	3A
SD Card	64GB
RAM	8GB
CPU	64-bit ARM Cortex-A72 (4x 1.5 GHz)
Price	230$
Length	85 mm
Width	56 mm
Weight	66 g

Table 7 Raspberry pi

2. DC Motor (2)

Attribute	Value
Input voltage	24V
Speed	300 RPM
diameter	42 mm
Dimensions	9.7 x 4.2 x 4.2 cm
Length	66.7 mm
Material	Copper

Table 8 DC Motor

3. Ultrasonic sensor (3)

Attribute	Value
Type	HC-SR04
Input Voltage	5V
Current Draw	20mA (Max)
Width	20mm
Length	43mm
Ultrasonic Frequency	40kHz
Height	15mm
Price	2$

Table 9 Ultrasonic Sensor

4. Gyroscope sensor

Attribute	Value
Type	MPU-6050
Input Voltage	5V
Width	16mm
Length	20mm
Gyroscope Frequency	400 kHz
Price	4$

Table 9 Gyroscope sensor

5. Webcam

Attribute	Value
camcorder type	Video Camera
Video Capture	1080p
Specification	2592 x 1944 Resolution, 1080 p @ 30 FPS, 720 P @ 60 FPS
Image Capture	60 fps
Price	11$

Table 10 Web Cam

6. Buzzer

Attribute	Value
Type	SFM-27
Rated Voltage	3-12V
Current Draw	20mA (Max)
Width	3 cm
Length	4.8 cm
Resonant Frequency	3500 - 500Hz
Weight	25g
Price	4$

Table 11 Buzzer

7. Relay

Attribute	Value
Type	MY2NJ
Voltage	24V
Current Draw	5A
Total Size(L*W*H)	27x20.5x35mm
Contacts	gold plated silver
LED color	green
Price	13$

Table 12 4-Channel Relay