Mohamed Khider University of Biskra
Faculty of Science and Technology
Electrical Engineering Department

Final Year Project Report in View
Of Obtaining
MASTER

Science and Technology
Electronic
Embedded System

Ref. :………………………

Presented and supported by:
Aoun Seddik

On: June ,2022

Eye controlled wheelchair using Arduino and OpenCV

Jury:

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Academic Year: 2021 - 2022

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Signature Favorable opinion of the President of the Jury

Mme.   Medouakh Saadia   .

Stamp and signature

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Dedication

Acknowledgements

All praise and thanks to ALLAH, who provided us with the ability to complete this work. We hope to accept this work from us. We are grateful of our parents and family who are always providing help and support throughout the whole years of study. We hope we can give that back to them.

I also offer my sincerest gratitude to my supervisors, Associate Prof **Mme. MERIEM FEDIAS** and all the administrators and teachers at the Department of electronics At the University of Biskra who have supported me throughout my thesis with their patience, knowledge and experience.

Finally, I would thank my friends and all people who gave me support and encouragement.

Abstract

Wheelchair controlled systems are an important point in recent research. The goal of this project is to achieve a wheelchair control system that depends mainly on eye movement using the OpenCV library and Arduino, so that the user faces the camera, and the OpenCV library processes images and analyzes them to extract the eye movement data and send it to the Arduino. According to the The position of the eye, motor will be directed to move (Left, right, and forward). The use of the eye is mainly aimed at persons with disabilities who are completely paralysed.

ملخص

تعد أنظمة التحكم في الكراسي المتحركة نقطة مهمة في الأبحاث الحديثة. الهدف من هذا المشروع هو تحقيق نظام تحكم على كرسي متحرك يعتمد بشكل أساسي على حركة العين باستخدام مكتبة الاوبن سيفي و الاردوينو ، بحيث يواجه المستخدم الكاميرا ، وتقوم مكتبة الاوبن سيفي بمعالجة الصور وتحليلها لاستخراج بيانات حركة العين و أرسلها إلى الاردوينو . وفقًا لموضع العين ، سيتم توجيه المحرك للتحرك (يسار ويمين وأمام). يستهدف استخدام العين بشكل أساسي الأشخاص ذوي الإعاقة المصابين بالشلل التام.

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List of acronyms

USA	*United States of America*
HOG	*Histogram of Oriented Gradients*
SVM	*Support Vector Machines*
EAR	*Eye Aspect Ratio*
AGM	*Absorbent Glass Mat*
DC	*Direct Current*
HCI	*Human Computer Interface*
HMI	*Human Machine Interface*
EEG	*Electroencephalogram*
ECG	*Electrocardiogram*
BCI	*Brain–Computer Interface*
ALS	*Amyotrophic Lateral Sclerosis*
SnP	*Sip-and-Puff*
EOG	*Electrooculography*
V	*Volt*
USB	*Universal Serial Bus*
FTDI	*Future Technology Devices International Limited*
GND	*Ground*

List of algorithms

IC   *Integrated Circuit*

SPI   *Serial Peripheral Interface*

PWM   *Pulse Width Modulation*

I/O   *Input/Output*

IDE   *Integrated Development Environment*

KB   *KiloByte*

RPM   *Revolutions Per Minute*

General Introduction

Millions of people all around the world are paralyzed, paralysis is usually caused by diseases or accidents that lead to chronic damage in the spinal cord preventing the electrical communication between the brain and body parts. One of the most serious and significant concerns of people with disability is mobility. As a Result of the technological evolution, researchers have created so many inventions to help people with disability to perform daily tasks that include movement. Several wheelchair systems have been designed for people with a disability such as a hand gesture-based wheelchair systems and Voice recognition-based wheelchair systems , since complete paralysis are the main interest of our project it has inspired us to build a wheelchair system based on eye movement recognition**(Eye Controlled Wheelchair System)**, the main principle is capturing the eye using OpenCV and interpreting the signal into a mechanical movement (right, left and forward).

This thesis is organized as follows:

In the first chapter **"Overview and literature review"**, We will discuss the wheelchair and its various varieties, as well as an overview of the numerous sorts of research that have been employed in developing control mechanisms, as well as their advantages and limitations.

In the second chapter **"Arduino board"**, We discuss the various Arduino boards, their benefits, and how to use them in terms of hard and soft parts.

In the third chapter **"Computer Vision"**, talks about high-level understanding from digital images. The beginning of creating the image and extracting data from it, in which we learn about the OpenCV library and the techniques used to detect faces and eyes using (HOG+SVM, 68 facial landmarks) and track pupil movement using EAR.

In the fourth chapter **"Conception and Realization"**, speaks about the wheelchair system that we built, which is divided into two parts: hard and soft, where we will discuss the controlling elements in the hard part and the mechanism system in the soft part.

In the fifth chapter, **"Result"**,It depicts the project's ultimate outcomes in terms of the chair's final shape and the embodiment of the chair's movement in accordance to the movement of the pupil of the eye.

Chapter 1

Overview and literature review

1.1   Introduction

The biggest obstacle for a disabled person is free movement and mobility. A wheelchair is a chair with wheels, used when walking is difficult or impossible due to illness, injury, problems related to old age, or disability. He can do so manually by pushing the wheelchair with his hands. However, many individuals have weak upper limbs or find the manual mode of operating too tiring. Hence, it is desirable to provide them with a motorized smart wheelchair that can be controlled by bio-signal & non bio-signal approach. Since The wheelchair can be moved with minimal effort and precision motion. There are types and Various techniques of wheelchairs that are open to discussion.

1.2   Wheelchair

Wheelchairs are a type of medical device that is used to improve accessibility for people who are mobility challenged. Wheelchairs are used by people for whom walking is difficult or impossible due to illness like physiological or physical, injury or disability. In some form or another, wheelchairs have been used for many thousands of years, but it would not be until the beginning of the twentieth century that a standard wheelchair design would be developed. There are a number of different wheelchair designs and models available, but they are basically classified as either manual or electric. [1]

1.3   Types Of Wheelchairs

Around the world the amount of wheelchair users is estimated in 68 millions (1%) Just over 2.62% of population in the USA uses assistive devices to help them with mobility. From the wheelchair users, 90% or 1.5 million persons use manual wheelchairs. 155,000 use electrically powered wheelchairs.[2] Here is countless different kinds of wheelchairs designed and manufactured especially over the last half-century. Everything from simple, manual wheelchairs to electric standing, tilting, and reclining power wheelchairs. we have compiled all the different kinds of chairs available here.

All the wheelchairs included on our list are not every possible kind of chair out there. However, this is a fairly comprehensive list. We discuss the different types of wheelchairs.[3]

1.3.1   Manual Wheelchair

Manual wheelchairs are wheeled chairs that are powered by the use of the user's hands. By grabbing the handling around the wheels, the user propels the chair forward, backward, and pivots as well. In addition, manual wheelchairs can be pushed by someone else standing behind the wheelchair user. For this reason, manual chairs have handles located behind the backrest.

There are Different Types of Wheelchairs that are manual chairs to emphasize different uses. For example, lightweight and foldable chairs are often convenient for placing into a smaller vehicle when moving from a chair and into a vehicle. Alternately, heavy-duty chairs are useful for holding more weight and are typically more durable.

Manual wheelchairs are great for people who can operate them independently. However, the downside is that users can quickly become fatigued especially if they are traveled long distances or moving around for an extended period of time on their own. Additionally, constant use of manual wheelchairs can lead to health problems if the user never spends time in a standing position. The two main types of manual wheelchairs are Self-Propelled or Transit pushed by a carrier.[3]

A self-propelled wheelchair

Is a chair that the user propels themselves. Whilst they may have handles which enable the user to be pushed, the main design for these wheelchairs is for the user to be able to maneuver the chair themselves without the need for assistance. These chairs have much bigger rear wheels which are what you use to propel the chair along. They have push-rims fitted to them, which makes moving the chair yourself much easier.[4]

Figure 1.1: self-propelled-wheelchair.
[4] .

A Transit Wheelchair

A Transit Wheelchair, or sometimes known as a transport wheelchair, is normally attendant propelled and therefore unlike a self-propelling wheelchair has smaller back wheels. This means that the carer or family member can quickly and easily enable the wheelchair user to move locations.

1.3.2 Electric Wheelchairs

electric wheelchair, also called electric-powered wheelchair, motorized wheelchair, or powerchair, any seating surface with wheels affixed to it that is propelled by an electrically based power source, typically motors and batteries. The first motor-powered wheelchairs appeared in the early 1900s; however, demand for them did not exist until after World War II. The first commercially produced electric wheelchairs were merely heavy-duty

manual folding-frame wheelchairs that were powered by lead-acid batteries, motors, drive belts, and pulleys. Those systems, known as conventional power wheelchairs, were very simplistic. They required the use of a joystick to control the wheelchair's movement, and programmability did not exist. The seating system typically consisted of a sling seat and back upholstery, which significantly limited postural support for the individual. The ad-

vent of the power base, which sits beneath the seat and contains the motor and batteries, allowed for significant mechanical advancements in electric wheelchairs. The power base separated the electric wheelchair into two components: the base, which provided the mobility, and the seating system, which provided the postural support. At the same time that a shift from a conventional power wheelchair to a power-base wheelchair was taking place, significant advancements were occurring in electronic systems. Some of those mechanical and electrical advancements included the ability to add power tilt and recline systems and programmable performance settings (e.g., forward speed, turning speed, and acceleration). Joysticks, the most basic and common devices used to control electric wheelchairs, came to resemble those used with computer game consoles. Advancements in control systems allowed individuals to control a wheelchair by using any voluntary movement.[5] Two types of drive mechanisms are used on electric wheelchairs: indirect drive and direct

drive systems. Indirect drive systems (pulleys and drive belts) are used on conventional electric wheelchairs, whereas direct drive systems (gear boxes) are used on power-base wheelchairs. The vast majority of contemporary electric wheelchairs use a power base with a direct drive system. Typically, two 12-volt batteries in series (24-volts total) are needed to power an electric wheelchair. Wet cell batteries, gel batteries, or absorbent glass mat (AGM) batteries may be used in electric wheelchairs. Electric wheelchair batteries typically are rechargeable. Electric wheelchairs also can be classified on the basis of the

location of the drive wheels. There are three types of electric wheelchairs: front-wheel drive, mid- or centre-wheel drive, and rear-wheel drive. Traditionally, rear-wheel drive electric wheelchairs were preferred because of their similarity to manual wheelchairs in design and maneuverability. However, centre-wheel drive wheelchairs have gained popularity because they provide increased maneuverability.[5]
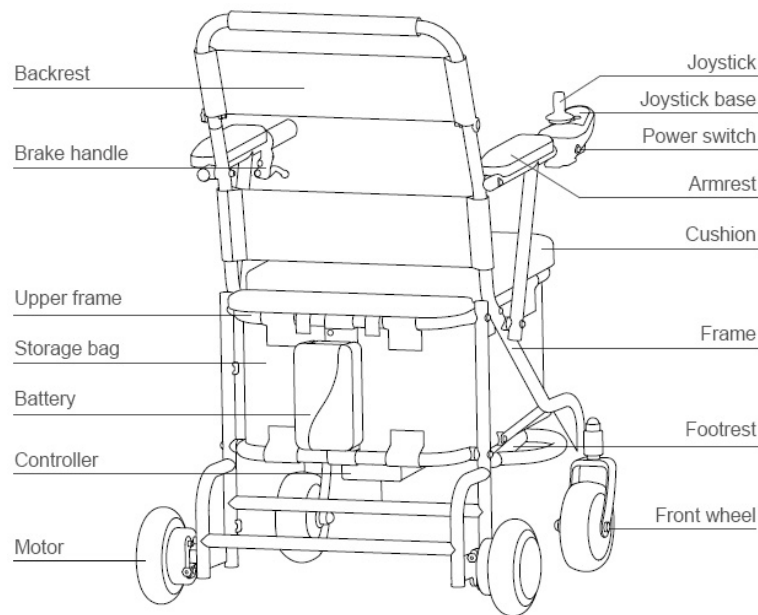
Figure 1.2: Electric Wheelchair.
[6]

1.3.3   Standing Wheelchairs

A standing wheelchair is a chair that allows the user to move from sitting to standing according to the person's purpose in performing his daily tasks [7].

Manually operated standing wheelchair [7]

The wheelchair uses bicycle chains to transfer power from tank tread-like push bars to the wheels or the system that lifts the user. It consists of a unique hand drive mechanism that allows users to drive the wheels of the wheelchair while seated, standing or in the range of positions in between (1.3) [7]

Figure 1.3: Manually operated standing wheelchair.
[7]

Powered standing wheelchair

This consists of a DC battery-powered electric motor drive system installed at the frame's base. The speed of these motors is regulated by the remote control system, which allows the wheelchair to go forward, backward, and sideways. On lifting the user, linear actuators and revolute motors (mounted at the back of the chair) are used to produce the required torque or control input signal from the remote control system to transform the shape of the wheelchair frame from seated to standing posture and vice versa . The user is extended from a sitting position to a full standing position. The user's legs are locked and support the weight of the body at full extension. A hydraulic lift is used to complete the motion with elevation times ranging from 3 to 60 seconds (1.4) [7]

Figure 1.4: Electric powered standing wheelchair.
[7]

1.3.4 Stair climbing wheel chair

A Stair-climbing wheelchair has a pair of track assemblies that can be placed in an operative drive mode to propel the wheelchair along ascending and descending paths of travel relative to an obstacle Such as a Stairway, curb, or the like. Each track assembly includes a guide member with rollers at opposite ends thereof carrying an endless cleated belt. The guide member is arched between its end Sections thereby permitting the endless belt

to deflect upwardly between the rollers when the endless belt engages an obstacle Such as a Step, curb or the like. This permits a Smooth gradual tran sition of the wheelchair onto and/or off the top step of a Staircase. Preferably, each track assembly also includes an inclined tail Section having a separate endless cleated belt. The track assemblies can also be utilized in connection with remote control and/or unmanned motorized vehicles.[8]
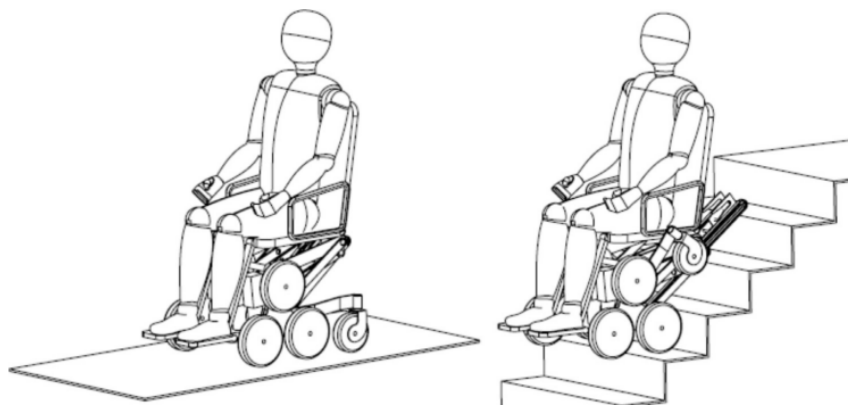
Figure 1.5: Wheelchair configurations for movement on flat ground and on stair. [9].

1.4 Various techniques used in wheelchair control

With the advancement of research in the field of wheelchair, many methods have been used in Out of all the methodologies, HCI Human Computer Interface and HMI Human Machine Interface is the latest and most effective techniques. In user interface systems, both bio-signals and non-bio-signals are used as a medium of control. These interfaces have been focused on direct assistance with a user sitting in a wheelchair. This section shows an association between the human body and some of the existing recognition methods. [10]

1.4.1 EEG and ECG based interface

A Brain-Computer Interface (BCI) is a system that can collect the ECG/EEG signal, re-trieve features from it, understand the user's intent, and control electronic devices. Several research groups are using electro-biological signals as a communication route between a person's brain and electronic components. Figure 1.6 illustrates un example of BCI inter-face. A BCI based on a programmable system-on-chip using Steady-State Visual Evoked Potentials via a Bluetooth interface has been proposed in [11]. The proposed system can help people with Amyotrophic Lateral Sclerosis (ALS) to more easily control their electric wheelchairs. To select different directions and force the wheelchair to move ahead, turn right or left, the user only has to gaze a flickering target with specific frequencies. Cao et al. in [12] propose a new hybrid BCI system that combines Steady-State Visual Evoked Potentials and motor imagery-based bio-signals to control synchronously wheelchair speed

and direction. In this system, the imageries of left and right hand movements are used to adjust the direction of the wheelchair .[10]

Figure 1.6: Example of Brain Computer Interface.
[10]

To keep the wheelchair moving straight, the state without mental activities has been deciphered. Similarly, under current conditions, the Steady-State Visual Evoked Potentials elicited by a glittering specific button were employed to speed up or slow down the wheelchair. Another technique in [13] proposes a bilateral teleoperation system in order to allow people with lower extremity and upper limb impairments to overcome locomotion difficulties. The person receives visual feedback from the wheelchair movement and sends position-speed commands generated by electromyogram signals through Emotiv EPOC headphone. The required speed is determined by the person's unwillingness to move the wheelchair. [10]

1.4.2   Sip and Puff based interface

The Sip-and-Puff (SnP) technology is a method used to send signals to a device using air pressure by "inhaling" and "exhaling" into a straw mounted on the wheelchair to execute the four basic commands that drive the chair. This method is mainly used by people who do not have the use of their hands. This is usually a type of control interfaces for easy navigation. Figure 1.7 illustrates the principle. [10]

Figure 1.7: Sip and Puff based interface.
[10]

Certain interfaces generate analog signals according to the variation of the air pressure applied to it. Others generate digital signals as a function of the generated command which may be either a sip or a puff. This interface enables two switches which are naturally open. The first is closed when the driver makes a puff blowing and the second is closed when a sip is effectuated.[10] A digital signal is generated by a series of sips

and puffs, which is processed by a controller to securely propel the wheelchair in the desired direction. Voice-activated user interface For the first time, severely impaired people with normal speech have used a speech recognition-based interface. The aim was to promote the independence by which speech recognition was used to convert human speech signals into effective actions . The first voice-activated wheelchair was created in the rehabilitation medicine field in New York at the end of the 1970s. The availability of this low-cost technology has been utilised in many other smart chair projects as the reliability of voice recognition systems has grown over the last few years. A noise-sensitive voice recognition technique used to a voice-activated wheelchair was proposed by Sasou and Kojima. Rather than using a headset placed near the user's mouth, they employ a set of microphones mounted on the chair. The precision gained is fairly comparable to that of the headset approach, but it has the advantage of eliminating circumstances when the user must alter the position of the headset.[10]

1.4.3 Tongue based interface

People with severe motor disabilities can move more readily and quickly thanks to the natural properties of the tongue muscle than they can with typical assistive technologies like SnP. TDS, a novel interface, was published in the journal "Science Translational Medicine" , and it demonstrates a promising notion.[10]
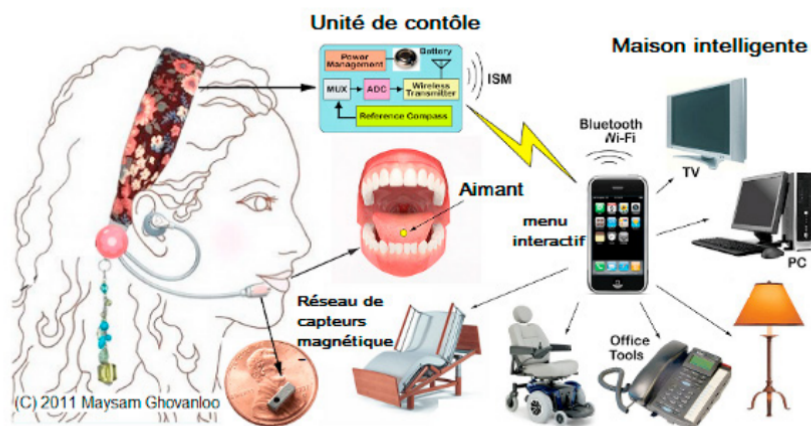
Figure 1.8: Example of tongue based interface.
[10]

The equipment, as indicated in Figure 1.8 is composed of a small magnet installed inside the piercing, an orthodontic splint of magnetic sensors and a headset to collect the information provided by the rest of the equipment. The movements and positions of the tongue are detected thanks to the magnetic field produced by the magnet. They are then picked up by the headset which transmits the information to a connected smartphone. The whole is then transmitted to the wheelchair or to a computer that executes the corresponding command. [10]

1.4.4 Touchscreen based interface

A touchscreen offers an integrated version of both the user display and the physical device (to interact with the machine). Its benefits are the simplicity of usage and the reliability, when compared to other interfaces such as voice recognizers. Depending on the user laterality, the screen is mounted on the wheelchair table and tipped to the right-hand side or left-hand side to keep the user's frontal view free/unobstructed. By touching on the screen, the user have the possibility to select intermediate targets to operate the wheelchair or stop it at any given time. Hence, the screen displays information on the vehicle's current evaluation of the environment and also supplementary information needed for command selection. Indeed, based on this information, the user chooses commands or options by instantly touching the screen, following a given operation protocol. Video based systems can be used to recognize various types of human face movements. Some works used video to capture the facial expressions, gaze, position and orientation of the patient's head to create interfaces able to control a wheelchair.[10]

1.4.5 Head movements based interface

Here on this method, head movements are transformed into cursor movements, to recognize the position of the head using the data provided by internal gyroscopes from the Epoc headset. In order to translate head position into wheelchair commands, the control system must align with several steps. First, the position of the head must be calibrated. For this, the patient must maintain a fixed head until the end which is indicated by a feedback (in the graphical interface) and a beep. Second, a calibration of the thresholds of directions must be carried out. Thus, eight threshold values are fixed: two for each direction. To set these values, the system requires the user to slightly lean his head to a intended direction and then to return to the initial position, after the user shall increase the angle of leaning of the same direction and then return to the initial position.At each change of position, the values of the "x" and "y" position of the head will be delivered to the system. Once the threshold values are set, the system triggers the translation of head movements into commands. To ensure the user safety, the stability of the system and the material, the authors chose to return to reset state after each head movement. [10]

1.5 Draw backs of presently available wheelchair

The main purpose of the human-wheelchair interface is to allow the user to control the wheelchair mobility with the least effort and with more robustness and safety. When the patient is in serious conditions, special tools may be needed. In addition, smart wheelchairs can have additional technologies and facilities that require a more advanced interface. However, there are many weaknesses in these new sophisticated interfaces. Some of them are described in Table 1.1.[10]

HMIs	The shortcomings
BCI (EEG, EMG)	- Relatively low signal noise ratio. - A limited frequency range. - Complex treatment of EEG, EOG or EMG signals. - An error rate between 30 % and 40 % - Research has shown that this technique can lead to cerebral tumors.
SnP	- Inhaling and exhaling is tiring. - The tubes must always be clean.
Voice recognition	- Noise can cause recognition errors. - Slow and tiring.
Tongue movements	- Lack of the device stabilization on the head. - Not comfortable.
Head movements	- Possible accidents when the user intuitively turns his head to look around him

Table 1.1: The schortcomings of HMIs.
[10]

BCI has major deficiencies in signal processing as it has a relatively low signal-to-noise ratio and A very limited range of frequency and topographic resolution. In addition, the technique makes The system more complex because it demands complex processing of EEG/ EOG/ EMG signals and one or more microprocessors dedicated to control the wheelchair. Also, the EEG interface has a fault rate. Between 30 % and 40 %, which requires merging it with other techniques. In consequence, the system will become increasingly complex and costly. Moreover, researches and studies have demonstrated and proved that such interface can lead to brain tumours. In this instance, the wheelchair is not safe for patients.[10]

That this type of interface has, we should not neglect that expiring and inspiring a long time will be exhausting Even for people with a normal respiratory system. Tongue based interface represents a real advance to improve the life quality of impaired people. A majority of people suffering from neurological diseases or spinal marrow lesions are still able to move their tongue, which is a voluntary muscle. For HMI based on voice recognition, efficiency in many situations, it still seems to be defective when the surrounding environment is very noisy. Many other situations include cases in which the voice of the user does not match the training data, or when the user cannot attain appropriate speaker adaptation. [10]

1.6   Future scope of wheelchair

We suggest a novel method of controlling a wheelchair using the eyes for the sake of our research. In the following chapters, we'll go above more features and techniques.

1.7   Conclusion

This chapter presents a summary of current state-of-the-art wheelchairs. Different strategies are accessible to function and control the wheel, instrument of the wheelchair. A few of the working methods of wheelchairs have been clarified and gave a comparison between them.

Chapter 2

Arduino board

2.1 Introduction

To build an embedded system project, the engineer or the person needs many electronic components to be used, and to facilitate the task. We used The Arduino as a solution to help so that it is considered a good component in terms of cost, time and size. In this

chapter we talk about general information of Arduino, we start with Talking about the beginning of the Arduino and Overview, as we get to know the Architecture and Board Types Finally, we talk about Arduino UNO into two-part Hardware, Software, Features and advantages.

2.2 What is Arduino

Arduino is an open-source hardware and software platform designed for computer programmers, industrial artists, professionals and those interested in developing interactive devices and applications specific to an interactive development environment.

Arduino can receive input signals from various sensors and inputs. By controlling light sources, motors, or other actuators, Arduino can change the surrounding environment. Programs for the microcontroller on the Arduino board are written in Arduino's programming language (based on "Wiring" - an open source framework for microcontrollers) and run in the Arduino development environment (based on "Processing" - an open source programming language and integrated development environment). Arduino is able to run independently or communicate with software running on a computer (for instance, Flash, Processing and MaxMSP).[14]

2.3 The Birth of Arduino

Arduino started in a small picturesque town in northern Italy as as a project for students at the Interaction Design Institute Ivrea. Members of Arduino's core development team were Massimo Banzi, David Cuartielles, Tom Igoe, Gianluca Martino, David Mellis and Nicholas Zambetti.

Massimo Banzi's students often complained that they couldn't find a cheap and easy-to-use microcontroller. In the winter of 2005, Banzi mentioned this issue while talking with David Cuartielles, a Spanish chip engineer who was a visiting scholar to Massimo's university. They decided to design their own circuit board and brought Banzi's student David Mellis into this project to design the programming language for their board. Mellis finished the source code within two days. It took them another three days to etch the circuit board. They named it Arduino. [14]

2.4   Arduino Architecture

Basically, the processor of the Arduino board is based on the Harvard architecture,where the program code and program data use separate memory. It consists of two separate memories, program memory and data memory. In this architecture, the data is stored in data memory whereas the code is stored in the flash program memory. [15]
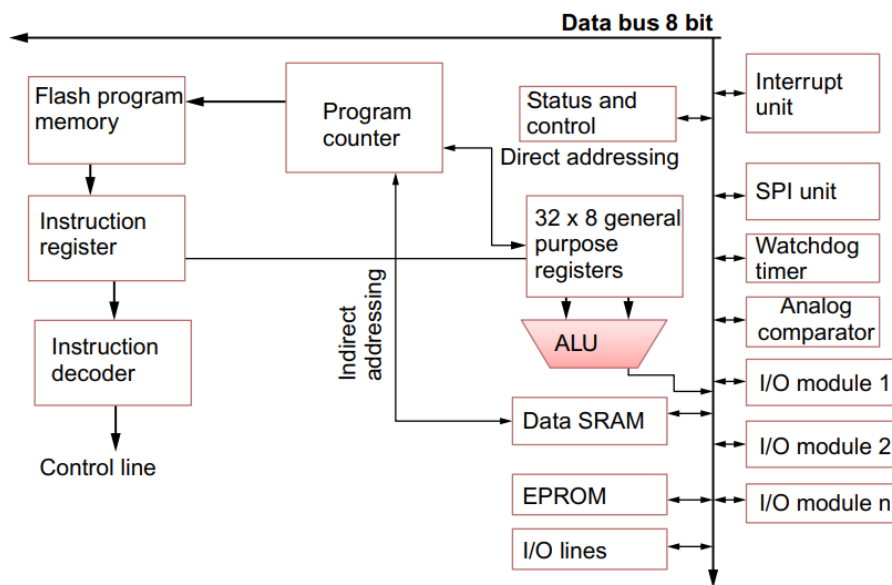
Figure 2.1: Arduino architecture.
[15]

2.5   Board Types

Various kinds of Arduino boards are available depending on different microcontrollers used. However, all Arduino boards have one thing in common: they are programed through the Arduino IDE.

The differences are based on the number of inputs and outputs (the number of sensors, LEDs, and buttons you can use on a single board), speed, operating voltage, form factor etc. Some boards are designed to be embedded and have no programming interface (hardware). Some can run directly from a 3.7V battery, others need at least 5V.[16]

Here is a list of different Arduino boards available in (2.1 ,2.2 ,2.3)

Board Name	Operating Volt	Clock Speed	Digital i/o	Analog Inputs	PWM	UART	Programming Interface
Arduino Uno R3	5V	16MHz	14	6	6	1	USB via ATMega16U2
Arduino Uno R3 SMD	5V	16MHz	14	6	6	1	USB via ATMega16U2
Red Board	5V	16MHz	14	6	6	1	USB via FTDI
Arduino Pro 3.3v/8 MHz	3.3V	8MHz	14	6	6	1	FTDI-Compatible Header
Arduino Pro 5V/	5V	16MHz	14	6	6	1	FTDI-Compatible Header
Arduino mini 05	5V	16MHz	14	8	6	1	FTDI-Compatible Header
Arduino Pro mini 3.3v/8mhz	3.3V	8MHz	14	8	6	1	FTDI-Compatible
Header Arduino Pro mini 5v/16mhz	5V	16MHz	14	8	6	1	FTDI-Compatible Header
Arduino Ethernet	5V	16MHz	14	6	6	1	FTDI-Compatible Header
Arduino Fio	3.3V	8MHz	14	8	6	1	FTDI-Compatible Header
LilyPad Arduino 328 main board	3.3V	8MHz	14	6	6	1	FTDI-Compatible Header

Table 2.1: Arduino boards based on ATMEGA328 microcontroller.
[16]

Board Name	Operating Volt	Clock Speed	Digital i/o	Analog Inputs	PWM	UART	Programming Interface
Arduino Leonardo	5V	16MHz	20	12	7	1	Native USB
Pro micro 5V/16MHz	5V	16MHz	14	6	6	1	Native USB
Pro micro 3.3V/8MHz	5V	16MHz	14	6	6	1	Native USB
LilyPad Arduino USB	3.3V	8MHz	14	6	6	1	Native USB

Table 2.2: Arduino boards based on ATMEGA32u4 microcontroller.
[16]

Board Name	Operating Volt	Clock Speed	Digital i/o	Analog Inputs	PWM	UART	Programming Interface
Arduino Mega 2560 R3	5V	16MHz	54	16	14	4	USB via ATMega16U2B
Mega Pro 3.3V	3.3V	8MHz	54	16	14	4	FTDI-Compatible Header
Mega Pro 5V	5V	16MHz	54	16	14	4	FTDI-Compatible Header
Mega Pro Mini 3.3V	3.3V	8MHz	54	16	14	4	FTDI-Compatible Header

Table 2.3: Arduino boards based on ATMEGA2560 microcontroller.
[16]

2.6 Arduino Uno Board Description

In this element, we explain the Arduino Uno because is a low-cost, flexible, and easy-to-use programmable open-source microcontroller board .An Arduino Uno Board can be classified into two parts [16].

2.6.1 Hardware

The Arduino board hardware consists of many components that combine to make it work, but we are going to discuss the main component on the board such as follows:
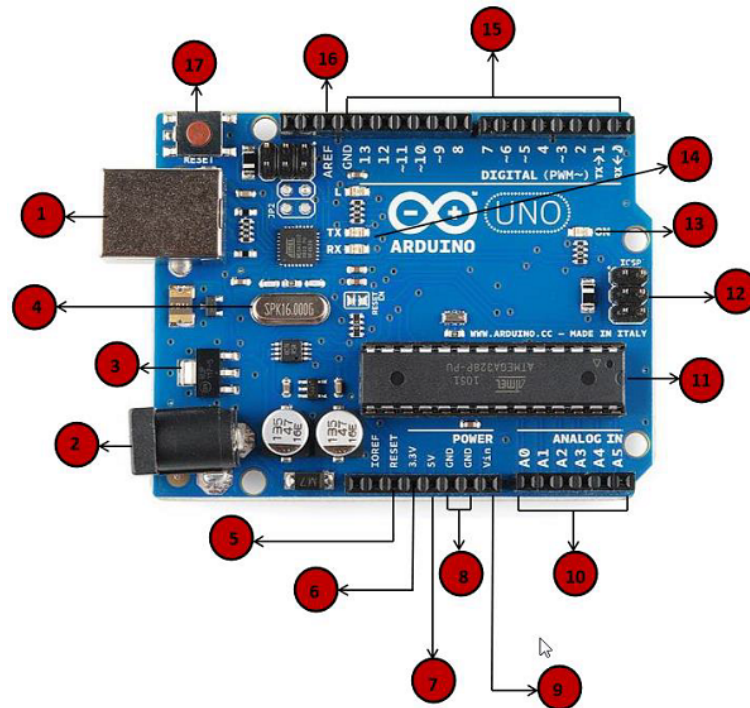

Figure 2.2: board description.
[17]

- Power USB Arduino board can be powered by using the USB cable from your computer. All you need to do is connect the USB cable to the USB connection (1).

- Power (Barrel Jack) Arduino boards can be powered directly from the AC mains power supply by connecting it to the Barrel Jack (2).

- Voltage Regulator The function of the voltage regulator is to control the voltage given to the Arduino board and stabilize the DC voltages used by the processor and other elements.

- Crystal Oscillator The crystal oscillator helps Arduino in dealing with time issues. How does Arduino calculate time? The answer is, by using the crystal oscillator. The number printed on top of the Arduino crystal is 16.000H9H. It tells us that the frequency is 16,000,000 Hertz or 16 MHz.

- Arduino Reset You can reset your Arduino board, i.e., start your program from the beginning. You can reset the UNO board in two ways. First, by using the reset button (17) on the board. Second, you can connect an external reset button to the Arduino pin labelled RESET (5).

- Pins (3.3, 5, GND, Vin)

- 3.3V (6) Supply 3.3 output volt

- 5V (7) Supply 5 output volt

- Most of the components used with Arduino board works fine with 3.3 volt and 5 volt.

- GND (Ground) There are several GND pins on the Arduino, any of which can be used to ground your circuit.

- Vin This pin also can be used to power the Arduino board from an external power source, like AC mains power supply.

- (10) Analog pins The Arduino UNO board has six analog input pins A0 through A5. These pins can read the signal from an analog sensor like the humidity sensor or temperature sensor and convert it into a digital value that can be read by the microprocessor.

- Main microcontroller Each Arduino board has its own microcontroller (11). You can assume it as the brain of your board. The main IC (integrated circuit) on the Arduino is slightly different from board to board. The microcontrollers are usually of the ATMEL Company. You must know what IC your board has before loading up a new program from the Arduino IDE. This information is available on the top of the IC. For more details about the IC construction and functions, you can refer to the data sheet.

- ICSP pin Mostly, ICSP (12) is an AVR, a tiny programming header for the Arduino consisting of MOSI, MISO, SCK, RESET, VCC, and GND. It is often referred to as an SPI (Serial Peripheral Interface), which could be considered as an "expansion" of the output. Actually, you are slaving the output device to the master of the SPI bus.

- Power LED indicator (13) This LED should light up when you plug your Arduino into a power source to indicate that your board is powered up correctly. If this light does not turn on, then there is something wrong with the connection.

- TX and RX LEDs (14,15) On your board, you will find two labels: TX (transmit) and RX (receive). They appear in two places on the Arduino UNO board. First, at the digital pins 0 and 1, to indicate the pins responsible for serial communication. Second, the TX and RX led . The TX led flashes with different speed while sending the serial data. The speed of flashing depends on the baud rate used by the board. RX flashes during the receiving process.

- Digital I/O The Arduino UNO board has 14 digital I/O pins (15) (of which 6 provide PWM (Pulse Width Modulation) output. These pins can be configured to work as input digital pins to read logic values (0 or 1) or as digital output pins to drive different modules like LEDs, relays, etc. The pins labeled " " can be used to generate PWM.

- AREF AREF stands for Analog Reference. used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins (16) [17] .

2.6.2 Software(The Arduino IDE)

The software is a set of instructions that informs the hardware of what to do and how to do it. The Arduino IDE (Integrated Development Environment) is divided into three main parts: [18]
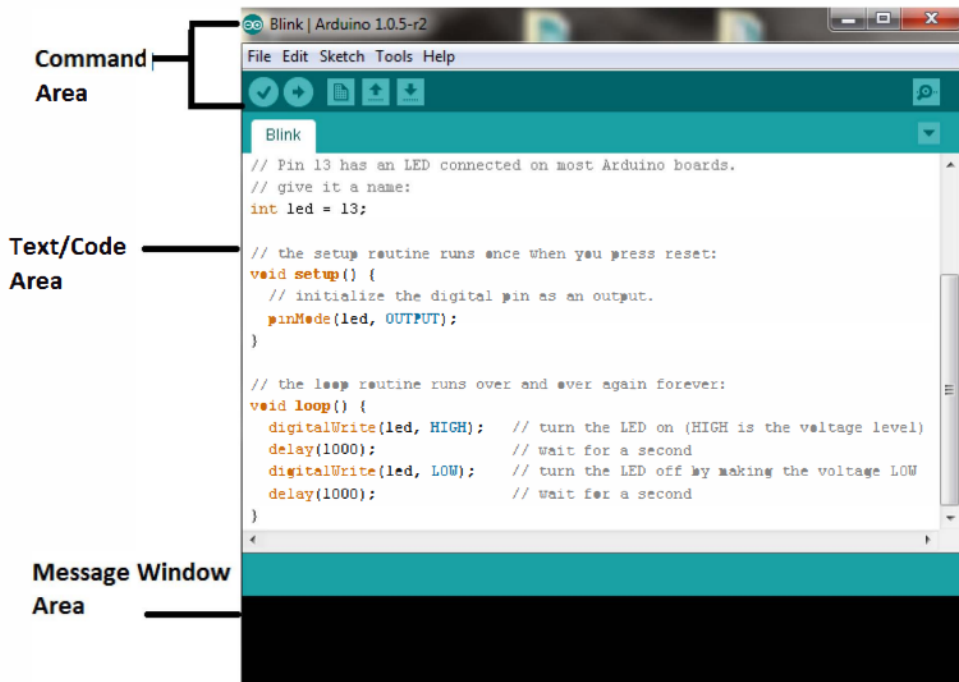

Figure 2.3: Labelled IDE.
[18]

Conunand Area

This is the area where you have the menu items such as File, Edit,Sketch, Tools, Help and Icons like Verify Icon for verification, Upload Icon for up loading your progarrmne, New, Open, Save and Serial Monitor used for sending and receiving of data between the arduino and the IDE.[18]

Text Area

This is where you write your code which uses a simplified version of C++ programming language that makes it easier to write your programme, which is also called a sketch. When writing your code there are mainly two important parts :[18]

- The setup function: Before the setup you need to intialize the variables you intend again.Here is an example..

Algorithm 1: void setup

---

1 void setup () { This where you write your code which will run once.}

- Loop routine: This is the loop that runs or execute your main code over and over again.Here is an example ...

Algorithm 2: void loop

---

1 void loop() { This is where your main code is written, to run repeatedly. }

Message Window Area

This shows message from the IDE in the black area, mostly on varification on your code.[18]

2.7   advantages of Arduino

- It is inexpensive

- It comes with an open source hardware feature which enables users to develop their own kit using already available one as a reference source.

- The Arduino software is compatible with all types of operating systems like Windows, Linux, and Macintosh etc.

- It also comes with open source software feature which enables experienced software developers to use the Arduino code to merge with the existing programming language libraries and can be extended and modified.

- It is easy to use for beginners.

- We can develop an Arduino based project which can be completely stand alone or projects which involve direct communication with the software loaded in the computer.

- It comes with an easy provision of connecting with the CPU of the computer using serial communication over USB as it contains built in power and reset circuitry [19].

2.8 Conclusion

In this chapter, we examined the two most important hardware and software parts of Arduino.

- Open-source hardware.

- Open-source software.

We use Arduino UNO because Cheap and Compatible with the computer, It is a features of Arduino in the creation of the project.

Chapter 3

Computer Vision

3.1 Introduction

Computer Vision uses many processes and applications to solve some problems related to images, such as extracting some information or improving the image. In this chapter, Firstly, we discuss about the image formation and representation, and we talk about important tow type image binary and grayscale, secondly the explanation of the image Gradient is considered to be the basics of the Histogram of Oriented Gradients. We used the HOG method for detection, face and SVM for classification, must know face landmark 68 to detection eyes from the face using Dlib Finally, Knowing the method or equation in determining eye blink.

3.2 Definition

Computer Vision is the process whereby a machine, usually a digital computer, automatically processes an image and reports "what is in the image." That is, it recognizes the content of the image. For example, the content may be a machined part, and the objective may be not only to locate the part but to inspect it as well. We can divide the entire process of Image Processing into Low-Level Image Processing and High-Level Image Processing. If we interpret these processes from signal and systems perspective, it is more clear to describe their difference and similarity from the format of input/output of the system. [20]
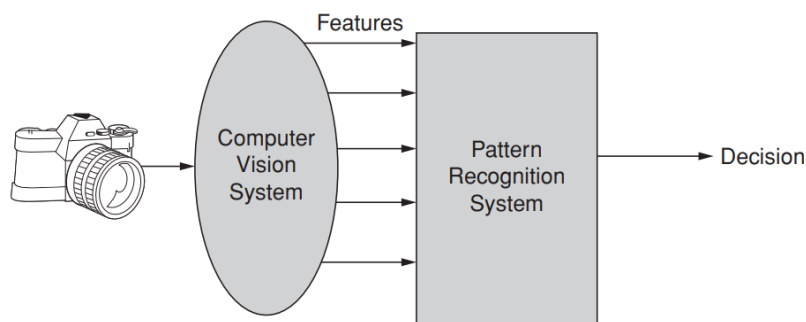
Figure 3.1: A Computer Vision system accepts an input that is an image and produces a number of measurements extracted from the image. These measurements are called features and are provided to a pattern recognition system that makes a decision about the object or objects being imaged.

[20]

3.3   Image formation and representation

3.3.1   Image formation

In modeling any image formation process, geometric primitives and transformations are crucial to project 3-D geometric features into 2-D features. However, apart from geometric features, image formation also depends on discrete color and intensity values. It needs to know the lighting of the environment, camera optics, sensor properties, etc. Therefore, while talking about image formation in Computer Vision, the article will be focussing on photometric image formation. [21]

Photometric Image Formation [21]

Fig. 1 gives a simple explanation of image formation. The light from a source is reflected on a particular surface. A part of that reflected light goes through an image plane that reaches a sensor plane via optics.
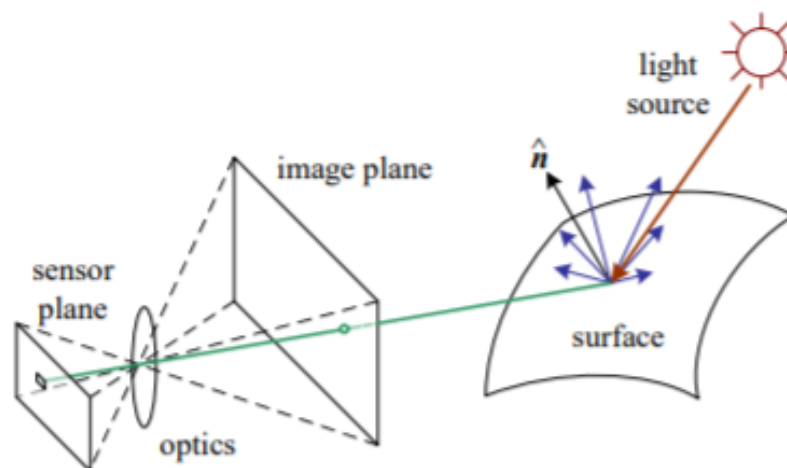

Figure 3.2: Photometric Image Formation.
[21]

Image sensing Pipeline (The digital camera) [21]

The light originates from multiple light sources, gets reflected on multiple surfaces, and finally enters the camera where the photons are converted into the (R, G, B) values that we see while looking at a digital image.

3.3.2   Image Représentations

In this section, several ways to represent the information in an image are discussed. These representations include: functional, linear, probabilistic, and graphical representations. Note that in a digital image, the first dimension is columns and the second is rows. In a

3D digital image, the dimensions are columns, rows, and frames .[21] Some representations:

Linear Representations (A Vector)[21]

We can unwind the image into a vector, making vector-matrix operations very convenient in such a representation. Another linear representation that will prove to be very important is that of the shape matrix. The simplest way to represent the image is in the form of a matrix. Image as a function

Image as a function [21]

An image can also be represented as a function. An image (grayscale) can be thought of as a function that takes in a pixel coordinate and gives the intensity at that pixel. It can be written as function f: $^2 \rightarrow$ that outputs the intensity at any input point (x,y). The value of intensity can be between 0 to 255 or 0 to 1 if values are normalized.
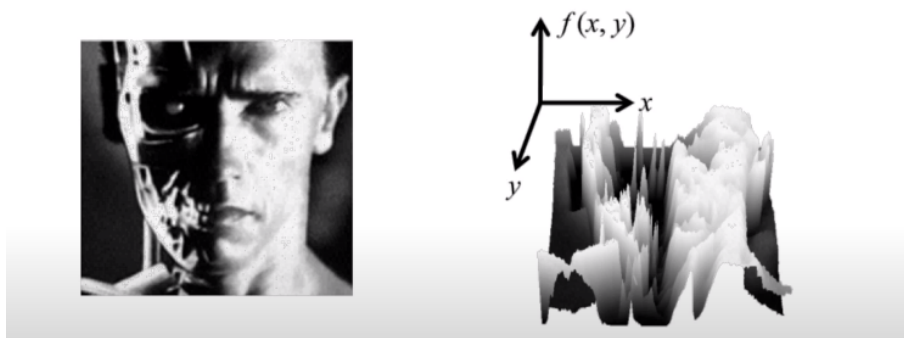

Figure 3.3: An image represented as a function.
[21]

3.4   Binary Image

It is an image with the purpose of having two different potential standards for every pixel. Two colors were utilized for the creation of the binary illustration, represented as black and white, and among these two colors can be utilized. The color utilized for any item in the illustration is the middle color at the same time as the rest of illustration is the surroundings. [22]

3.5   Gray-scale images

Grayscale images are monochrome images, Means they have only one color. Grayscale images do not contain any information about color. Each pixel determines available different grey levels.

A normal grayscale image contains 8 bits/pixel data, which has 256 different grey levels. In medical images and astronomy, 12 or 16 bits/pixel images are used [22].

Figure 3.4: Examples of gray-scale image.
[22]

3.6   segmentation

This process is used to split a picture into regions or categories, which matches. Two different objects or parts of objects. Every pixel in an image is allocated to one of a number of these categories. There are three general approaches to segmentation, termed thresholding, edge-based methods and region-based methods.

3.7   Image gradient

An image gradient is a directional change in the intensity or color in an image. The gradient of the image is one of the fundamental building blocks in image processing. Image gradients can be used to extract information from images. Are created from the

original image (generally by convolving with a filter, one of the simplest being the Sobel filter) for this purpose. Each pixel of a gradient image measures the change in intensity of that same point in the original image, in a given direction. To get the full range of direction, gradient images in the x and y directions are computed. [23]
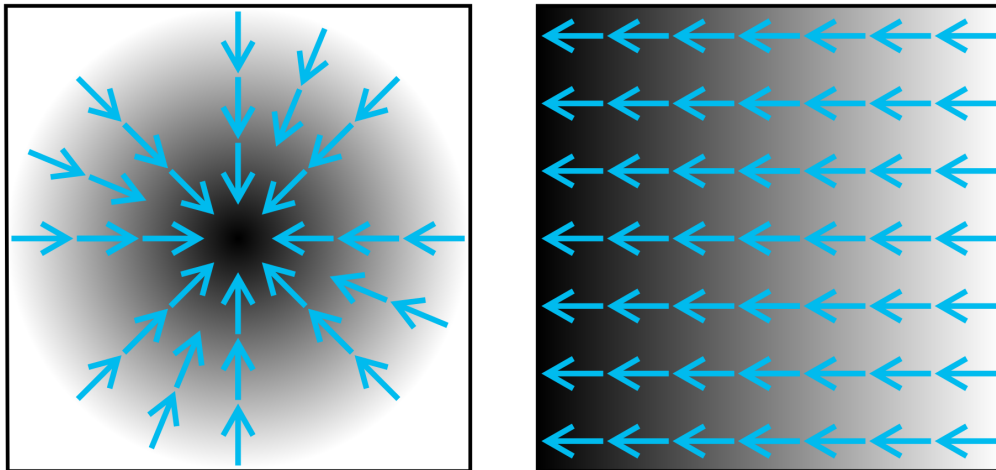
Figure 3.5: Two types of gradients, with blue arrows to indicate the direction of the gradient. Dark areas indicate higher values.

[23]

3.8   What is OpenCV ?

OpenCV is a huge open-source library for computer vision, machine learning, and image processing. OpenCV supports a wide variety of programming languages like Python, C++, Java, etc. It can process images and videos to identify objects, faces, or even the handwriting of a human. When it is integrated with various libraries (Dlib , Numpy ...). [24]

Figure 3.6: OpenCV logo.

[24]

3.9   Face detection

Face detection is the task of detecting face in a photo or video There is many method to detect face one of them is HOG + SVM based OpenCV.
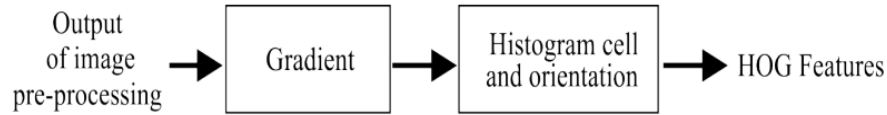
Figure 3.7: Stages on the HOG method .

3.9.1 Histogram of Oriented Gradients

The Histogram of Oriented Gradients method has been widely used for face detection
. Dalal et al presented their supplementary work on pedestrian detection that is based
on the idea that the edge directions or the intensity of the gradient distribution contains
important information. Consequently, the shape and the appearance of a local object can
be easily defined. [25] (HOG) method allows the histogram to be easily calculated. In
fact, every key point owns a generated HOG feature. The neighboring area of each one
is divided into small blocks called cells. A local 1-D histogram of gradient directions is
compiled for the pixels within each cell. Consequently, the descriptor is the combination
of all these histograms. The gradient vector is calculated as follows:

$$G_x(x,y) = H(x+1,y) - H(x-1,y) \tag{3.1}$$

$$G_y(x,y) = H(x,y+1) - H(x,y-1) \tag{3.2}$$

The horizontal gradient of the image pixel $Gx(x,y)$ and the vertical gradient $Gy(x,y)$ are
presented in equation 3.1 and 3.2. The gradient amplitude and direction of the pixel
(x,y) are respectively presented in equation 3.3 and 3.4.

$$G(x,y) = \sqrt{G_x(x,y)^2 + G_y(x,y)^2} \tag{3.3}$$

$$a(x,y) = \tan^{-1}(\frac{G_x(x,y)}{G_y(x,y)}) \tag{3.4}$$

The given frame is divided into either rectangular or circular regions of size $N*N$
pixels, called cells. Furthermore, gradient feature vectors are computed for each cell in
Fig.3.8. These gradient feature vectors are then added to obtain the feature vector for a
single frame.

Finally, all gradient feature vectors extracted from different images are concatenated
to obtain one long vector which is the HOG feature vector. The later will be used as
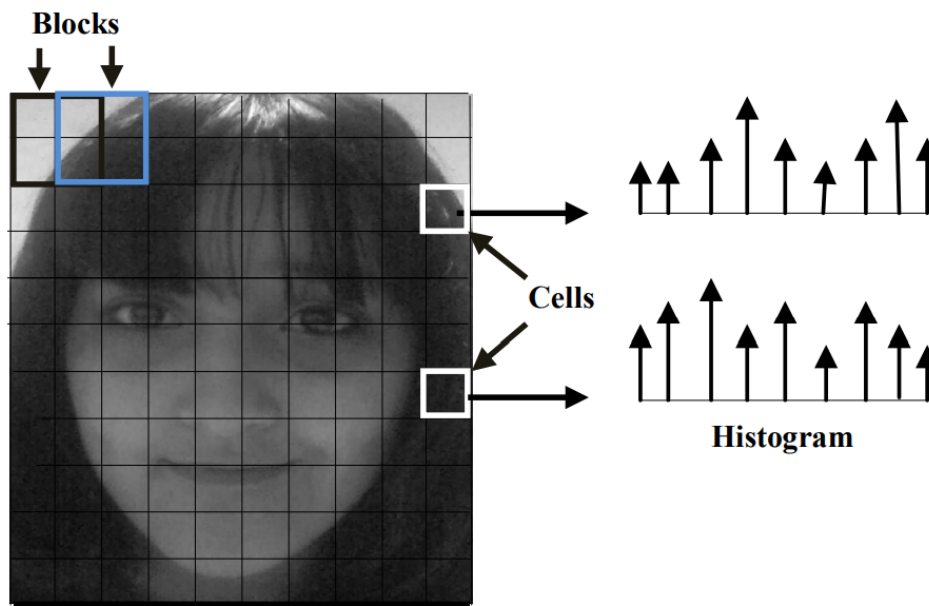input to SVM classifier. [25]

Figure 3.8: Hog feature extraction.
[25].

3.9.2   Support Vector Machine (SVM) Classifier

SVM is a supervised models associated with respect to learning algorithm and mainly used for analyzing the data for regression and classification . SVM works by looking the best decision boundary located between the two classes boundary. The decision boundary is chosen to be the one for which the margin is maximized and the margin is the shortest distance from the decision boundary. [26]
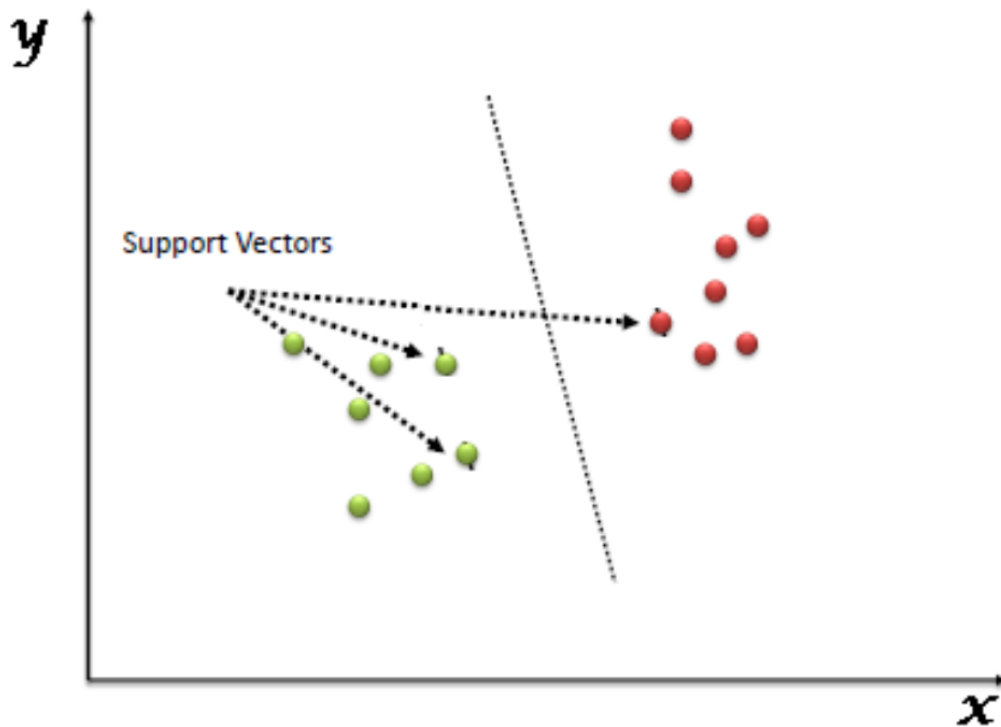
Figure 3.9: Support Vectore.
[27]

3.10 Facial Landmarks Detection

Facial landmark functions as a sign for part of the face. Commonly used key points are the angle of the eye, the tip of the nose, the angle of the nose, the corner of the mouth, the endpoint of the eyebrow arc the outline of the ear, and the chin.

The process continues with posing and projecting faces, in order to deal with faces that are in different directions or angles. Face landmark evaluation method is used to complete the following task. This is a machine learning algorithm that can detect 68 particular human face landmarks on a face image, as shown in Figure 3.10.Following the identification of face landmarks, we can determine the position of the eyes feature in an image, allowing us to simply rotate, scale, and shear the image to ensure that the eyes features are in the image's center, making the next phase much easier. [28]

Figure 3.10: The 68 specific human face landmarks.
[28]

3.11 Eye detection

Right Eye Points = 36–41, Left Eye Points = 42–47 are the 68 coordinates indices depicted in Fig. 3.10. Identifying facial landmark points using Dlib's 68 After we've found the location of a face in an image, we need to fill in the rectangle with points. This annotation is part of the 68-point iBUG 300-W dataset, which is used to train the Dlib face landmark predictor [29]. Then, using *np.array*, we isolate an eye to create a frame without the rest of the face.

3.12 Eye blink detection

Eye Aspect Ratio is proposed by the Czech Technical University [30]. It is a scalar quantity obtained by detecting a face from an image, finding the Euclidean distance of the corresponding eye coordinates, and substituting it into the following formula.

$$EAR = \frac{\parallel P_2 - P_6 \parallel + \parallel P_3 - P_5 \parallel}{2 \parallel P_1 - P_4 \parallel} \qquad (3.5)$$

where p1, . . ., p6 are the 2D landmark locations, depicted in Fig. 3.5 . When the eye is open, the value is almost constant, but it approaches zero when the eye is closed.

35

This value does not depend on head posture or distance, and there are small individual differences when the eyes are open. Since eye blinking is performed by both eyes synchronously, the EAR of both eyes is averaged. Due to the simplicity of the calculation formula, it has excellent real-time performance and shows high robustness. [31]
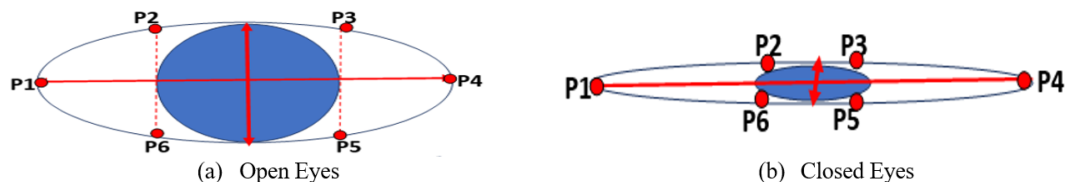

Figure 3.11: The examples of open eyes and closed eyes with facial landmarks (P1-P6). [29]

3.13 Eye pupil extraction

3.13.1 Bilateral filter

first , we filter the captured eye image, and because of the problem of the edges of the eye, the best filtering technique in this process is the Bilateral filter. A bilateral filter is a non-linear, edge-preserving, and noise-reducing smoothing filter for images. It replaces the intensity of each pixel with a weighted average of intensity values from nearby pixels.[32]

3.13.2 Threshold

We considered how to distinguish the foreground from the background and discovered several options using Convert grayscale image to a binary image. With the help of the **cv2.Threshold** function, we threshold, worked out the optimal way to conduct this operation.

3.13.3 Erosion and Dilation

There would still be some joining broken sections of an object after thresholding the image. As a result, two Morphological operators are used: erosion and dilation. First, we dilate the image with the **cv2.dilate** method. After dilatation, we use the method **cv2.erode** to erode the image. A pixel in the original image, whether white or black, will be regarded white only if all of the pixels under the kernel are white otherwise, it will be set to zero.

3.13.4 pupil detection

The final step is pupil detection, which is accomplished by utilizing the function:

cv.findContours(),to find the contours.

3.14   Eye Pupil Tracking

We utilize **cv2.moments** to find the centers of the eye pupil for eye motion tracking, and it is represented in a parameter (x,y) as shown in the fig.3.12.
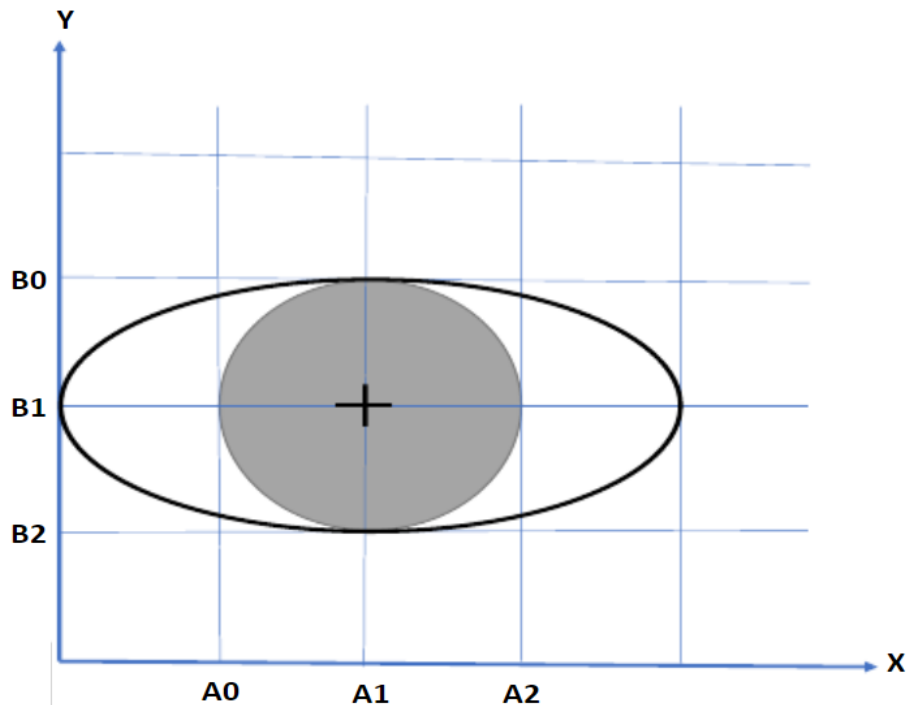

Figure 3.12: Coordinate system of Pupil Movement.
[33]

The eye pupil position denoted as a coordinate point (A1, B1), has been calculated as,[33]

$$A1 = \frac{(A0 + A2)}{2} \tag{3.6}$$

$$B1 = \frac{(B0 + B2)}{2} \tag{3.7}$$

The pupil moves according to an equation that we put in the range between 1 and 0. So that we limit the The horizontal ratio between 0.4 and 0.70

When pupil direct to right the horizontal ratio must be < 0.5

When pupil direct to left the horizontal ratio must be > 0.7

When pupil in the middle range must be 0.7 >the horizontal ratio < 0.5

3.15   Conclusion

In this chapter, we found that the computer vision is important, because give image information at the lowest price from sensors. We learned some of the methods used to

determine the face and eyes through algorithms and equations using OpenCV, It makes it easier for us to progress in the project.

Chapter 4

Conception and Realization

4.1 Introduction

In this chapter, we will talk about the design of a wheelchair using Arduino and a laptop (OpenCV). The chapter is divided into two sections: hard and soft. In the hard segment, we will discuss the components of the chair, such as wheels, L298N, DC motor, and Arduino Uno. We'll speak about how to install OpenCV on a laptop, learn the algorithms for eye detection and pupil movement, and then pass the data to Arduino in the second section, the soft part.

4.2 Hard part

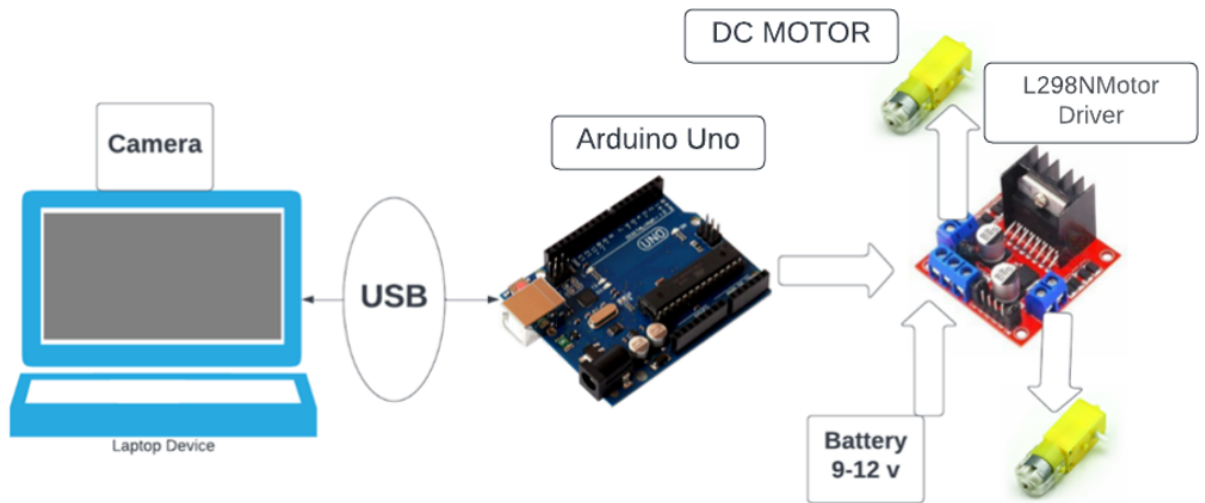### 4.2.1 System block diagram

Figure 4.1: System block diagram .

This diagram block shows a group of components used in the chair's installation, including an Arduino and L928N motor driver, two DC motors, and a laptop with a camera. We connect two DC motors to the L928N motor driver, which are controlled by pins on the Arduino board; we'll go over how to connect them later.We power the L298N by connecting the power supply to the screw on the L298N labeled "12V". The "5V" pin is a 5V output that can be used to power the Arduino. We installed the wheels in the two motors and assembled all of the components on a board that serves as the chair's base. We also use an USB cable to connect a laptop to the Arduino board.

The hard part works through steps that can be divided into : First, the laptop camera is placed in front of the user's face so as to record a video with eyes clear, after image analysis and information extraction, the a laptop sends the eye motion information to the Arduino via a USB cable. The Arduino controls the wheels of the chair (left , right and forward) via the H-bridge.

4.2.2 A laptop

We used a laptop in that project, and there are a lot of benefits to that:

- It has an internal camera.

- Easy to transport by the user.

- It is compatible with Arduino environment and OpenCV

- Response speed (realtime).

4.2.3 L298N DC Motor Driver Module

We used the L298N Motor Driver because it is the easiest and cheapest to control DC motors. It can control both the speed and rotation direction of two DC motors.
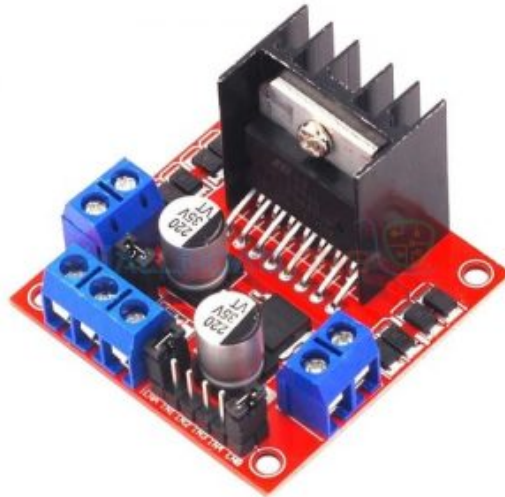
Figure 4.2: L298N DC Motor Driver.

L298N Motor Driver Module Pinout

VCC	supplies power for the motor.
GND	common ground pin.
5V	supplies power for L298N .
ENA	control speed of Motor A.
IN1 & IN2	control spinning direction of Motor A .
IN3 & IN4	control spinning direction of Motor B.
ENB	control speed of B .
OUT1 & OUT2	connected to Motor A.
OUT3 & OUT4	connected to Motor B.

Table 4.1: L298N Motor Driver Module Pinout.

The ENA and ENB speed control pins are used to turn on/off the motors and control their speed. The spinning direction of the motor can be controlled by applying logic HIGH (5V) or logic LOW (Ground) to these inputs. When turning right, the IN1 and IN2 pins control the spinning direction of motor A, while turning left, the IN3 and IN4 pins control the spinning direction of motor B.

The spinning direction of tow motors blow:

Input1	Input2	Input3	Input4	Spinning Direction
High(1)	Low(0)	High(1)	Low(0)	Forward
Low(0)	High(1)	Low(0)	High(1)	Backward
Low(0)	High(1)	High(1)	High(1)	Stop
Low(0)	Low(0)	Low(0)	Low(0)	Stop

Table 4.2: The spinning direction of tow motors.

To move in a specific direction, you must stop one motor and start another. For example, if you want to go right, you must stop the right motor and start the left motor, and vice versa if you want to go left depicted in table 4.3.

Input1	Input2	Input3	Input4	Direction
Low(0)	Low(0)	High(1)	Low(0)	Right
High(1)	Low(0)	Low(0)	Low(0)	Left

Table 4.3: Direction of Movement of the tow motors.

4.2.4   Motor DC

We used two DC motors as shown in the picture :

Figure 4.3: gearmotor .

Specifications

-

- Motor Voltage: 3 - 12 V.

- Motor Current: 70 mA (typical) - 250 mA (max).

- Speed: up to 170 RPM .

- Torque: up to 0.8 Kg.

- Gear Ration: 1:48.

- Package Contents.

- 1 Geared Motor.

- 1 Whee.

4.2.5   Arduino UNO board

We used Arduino Uno as is compatible and cheap and easier to connect with a laptop through USB cable.

Arduino Uno specification

- Microcontroller: ATmega328P

- Operating Voltage: 5V

- Input Voltage (recommended): 7-12V

- Inout Voltage (limit): 6-20V

- Digital I/O Pins: 14 (of which 6 provide PWM output)

- PWM Digital I/O Pins: 6

- Analog Input Pins: 6

- DC Current per I/O Pin: 20 mA

- DC current for 3.3V Pin: 50 mA

- Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader

- SRAM: 2 KB (ATmega328P)

- EEPROM: 1 KB (ATmega328P)

- Clock Speed: 16 MHz

- Weight: 25 g

4.2.6   The hardware prototype

Assemble the components such that the L298N Module and the DC motors are connected as shown in the table.

DC Motor	L298N Motor Driver	
Motor A	Terminal 1	Output 1
	Terminal 2	Output 2
Motor B	Terminal 1	Output 3
	Terminal 2	Output 4

Table 4.4: The connection of the motor driver with the two DC motors.

PINs connect the Arduino to the L298N motor driver, while USB connects the computer to the Arduino. The prototype of the device is shown in the following figure:
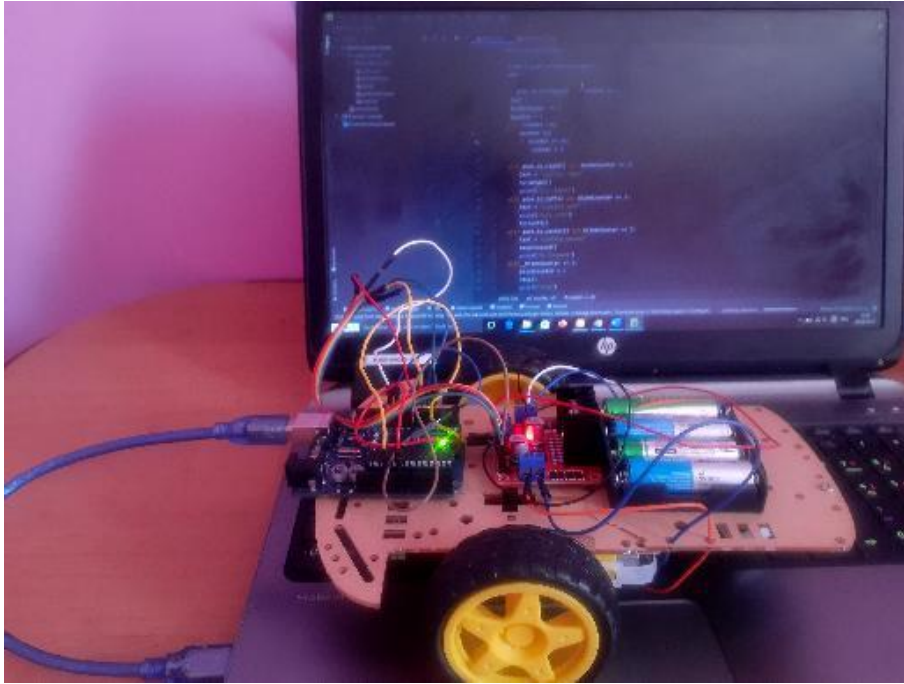
Figure 4.4: The prototype of the device.

4.3   Soft part

4.3.1   Install OpenCV and Arduino IDE

To begin, we must install OpenCV-Python on a laptop. Run the following command in Windows using cmd:

pip installs opencv-python

Then run the following command to install the numpy-Dlib library:

pip installs dlib

pip install numpy

Install the Arduino IDE We can download several versions of the Arduino IDE from the Arduino Official Website's Download page. We choose software that is compatible with the Windows operating system.
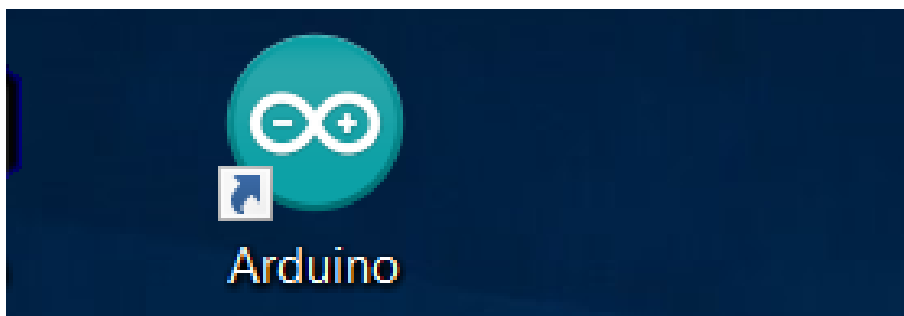

Figure 4.5: Arduino icon in windows .

We use StandarFirmata is a software library that allows Arduino devices to communicate with a laptop using the Firmata protocol.
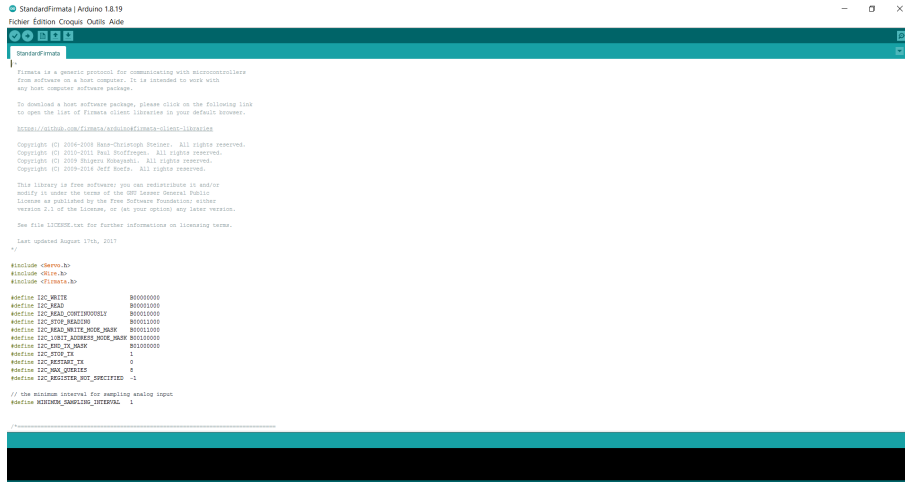

Figure 4.6: standarFirmata library.

4.3.2   System start/stop

Since the system of the wheelchair needs to start and stop, patients with complete paralysis or those who have spinal cord injuries are unable to move their limbs or even their heads. We therefore proposed a solution that involves blinking the eye using the algorithm that we discussed in the third chapter.

We used an algorithm on eye blinks so that when the eye blinks three times in the range of 4-7 seconds, the cart system moves in accordance with the movement of the eye, and when the eye blinks three times in the range of 4-7 seconds, the wheelchair stops .

4.3.3   Face detection

To capture the face, we use the

Algorithm 3:   Face detection.
1 dlib.get frontal face detector()

algorithm, which is based on the dlib library and uses HOG+SVM, as mentioned in Chapter Three.

Figure 4.7: Face detection using dlib library.

4.3.4   Flow charts

We use Opencv for easy of detection, and tracking eye pupil, then control the direction of the chair. We will explain how does the systems work through the flow charts.
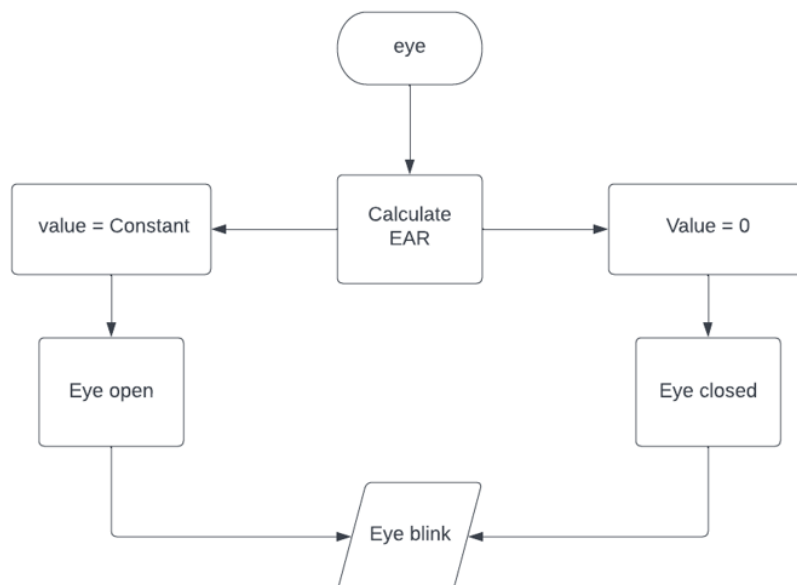

Figure 4.8: Flow chart Eye blink.
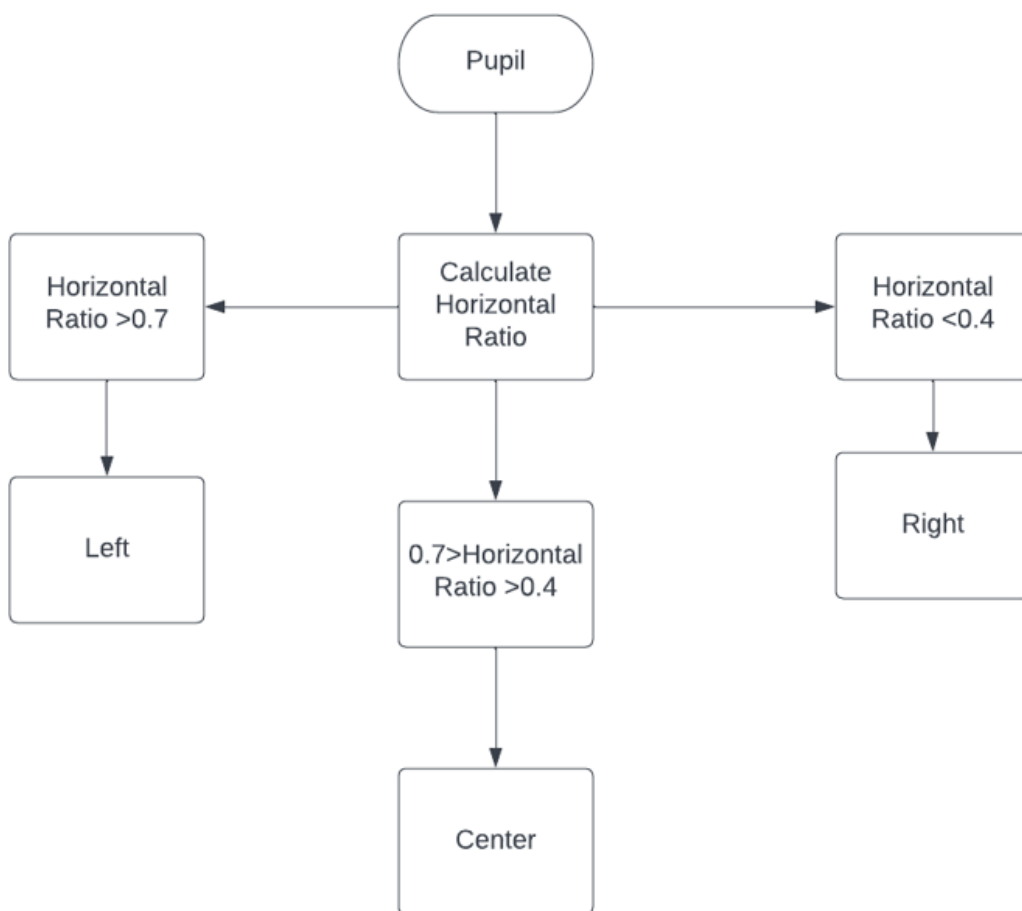
Figure 4.9: Diagram Eye Pupil Extract

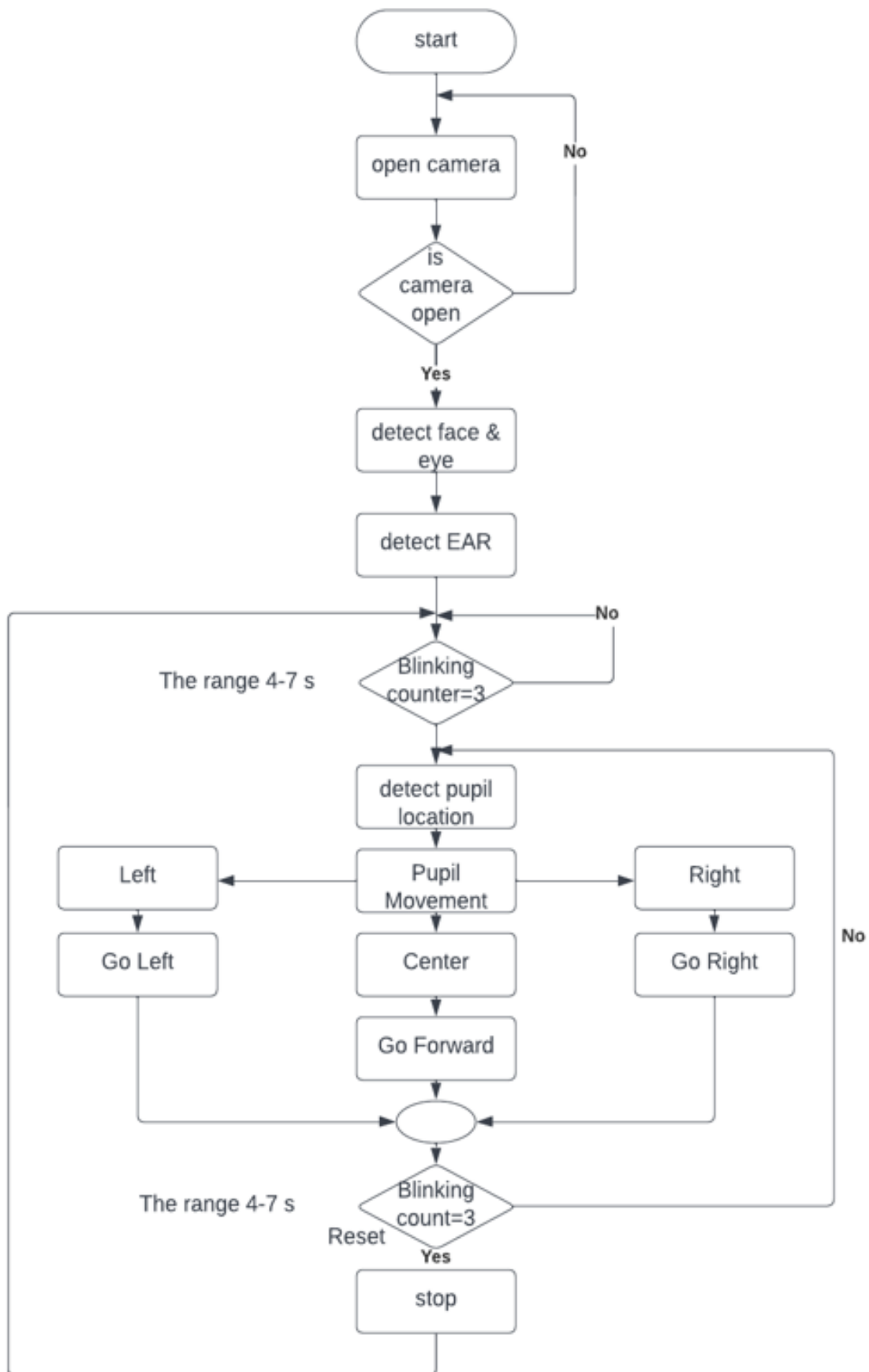Figure 4.10: Flow chart Eyes movement.

Figure 4.11: Flow chart system.

Fig 4.11 represents the flowchart of the overall system, According to the eye blinking and the eye pupil location.

4.3.5 Communication protocol

There are many ways to communicate between Opencv and Arduino, and among these methods is the pyfirmata library, where used to give access to the write and read pins of the Arduino easily.

4.4 Conclusion

In this chapter, we talked about knowing two important parts of the project, which are the soft part and the hard part. In the first part, we used the Arduino as a motor controller under the guidance of OpenCV using a protocol pyfirmata, which in turn uses image processing, as we explained in the second part, i.e. the soft part.

Chapter 5

Results

5.1 Introduction

This section mainly shows the hardware prototype and the experimental results. The system obtains the results of image processing and based on the direction of movement of the center of the Eye pupil, Open CV sends out signals to the to perform the movement of the wheelchair in that corresponding direction.

5.2 The final hardware prototype

Figure 5.1: The final hardware prototype.
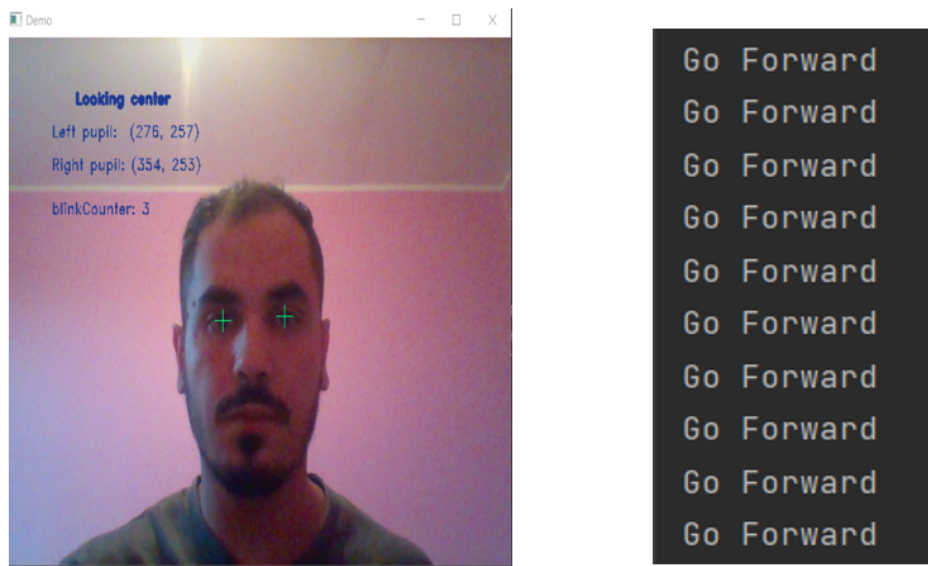
5.3 The experimental results

Figure 5.2: Position of the eye movement (Center), and wheelchair movement according to the position of the Eye movement.
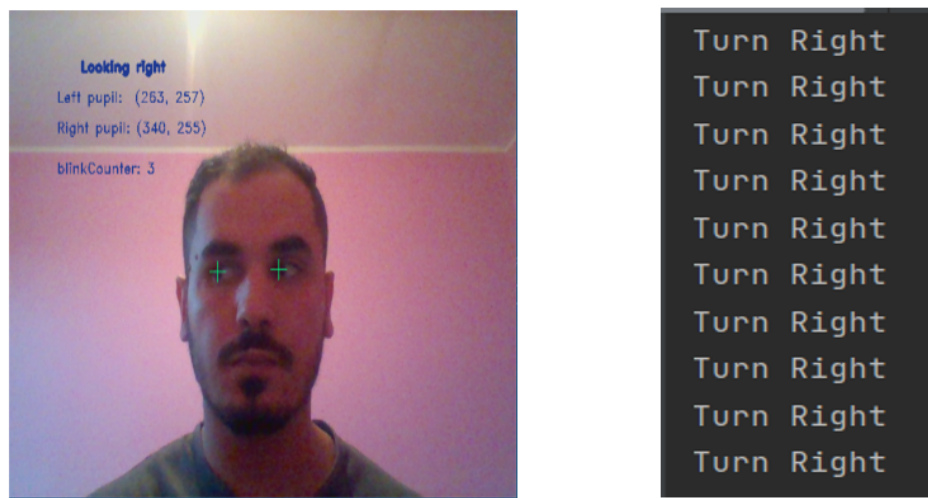

Figure 5.3: Position of the eye movement (Right), and wheelchair movement according to the position of Eye movement.
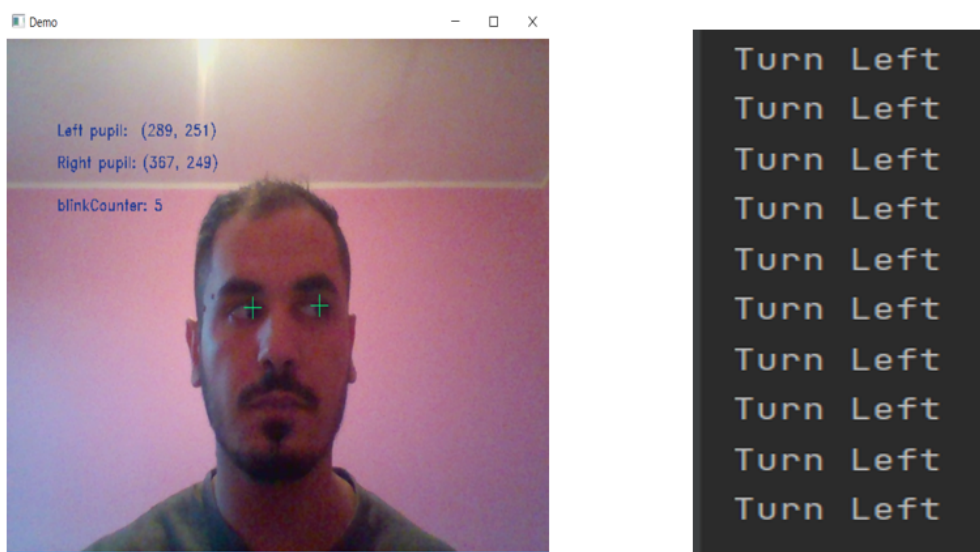
Figure 5.4: Position of the eye movement (Left), and wheelchair movement according to the position of Eye movement.

The following are the performance measurement criteria used in this study: The accuracy was calculated by counting the number of times each user's pupil was detected (1, 2, and 3). 10 for the looking center, 10 for the looking right, 10 for the looking left,and 10 for the blinking eye, as shown in Table 5.1

Result	User 1	User 2	User 3
Looking Center	10/10	10/10	10/10
Looking Right	9/10	8/10	8/10
Looking Left	10/10	10/10	9/10
Blincking eye	8/10	9/10	7/10
Accuracy	92.5%	92.5%	90%

Table 5.1: The calculation of the system performance.

The accuracy rate obtained is 91.6%. This percentage is considered excellent compared to other methods of eye tracking.

5.4 Conclusion

The final shape of the project and the mechanism of action of the chair system were covered in this chapter, as the method utilized by employing Opencv produced excellent results in terms of coordinating the pupil's movement with the chair's movement.

General conclusion

The rapid development led to finding solutions to the problems of mobility of the disabled and the introduction of assistive and distinct technologies for the wheelchair, But it is not easy and convenient. In our project, we wanted to help the category that suffers from complete paralysis by relying on the data of this category (they cannot move their limbs). We concluded that there is a way to control the chair through the eye.

And with the help of image processing algorithms on Opencv and the Arduino board, we were able to create a chair system that can control the chair by eye movement. We used eye blinking to start or stop system, If the eye moves to the right, the wheelchair will move to the right direction, if it moves to the left the wheelchair will move to the left direction, and if the position of the eye pupil remains at the center, then the movement of the wheelchair will be move forward.

Finally, this his method works as hope to a wide range of persons with disabilities, particularly those who are completely paralyzed. Enhance their independence with a simple, practical, and easy-to-use operating system.

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