Chapter 1

Introduction

1.1 Significance

The eyes and their movements are an essential element used to express the desires, emotional states, and needs of people. For those people with major disabilities, the detection of eye movement can be an alternative form of communication. In recent years, considerable effort has been devoted to researching methods that allow the development of robust systems for the detection and monitoring of the eyes. There are many different methods for eye tracking. Several researches are ongoing in finding methods to implement the eye tracking technology with the existing systems. Our project “Smart Wheelchair” does the same. We have tried to use the eye tracking technology in conjunction with an existing system, which is the wheelchair. Our aim here is to move the wheelchair with the movement of our eyes.

A system of this type consists of three main elements: a hardware device for acquiring the necessary signals for controlling the system followed by a software application for data processing, and an output delivering system which gives the results of our inputs. The hardware device acquires the eye movement signals corresponding to the left, right, forward and stop. The software interface uses a script that detects movement of the eyes and sends corresponding signal to our controller which then sends signal to motor driver in order to control the motors. Thus, the wheelchair can be controlled easily with the movement of the eyes helping users with major motor disabilities, but who have intact eye movement.

1.2 Background

Several studies have shown that both children and adults benefit substantially from access to a means of independent mobility, including power wheelchairs, manual wheelchairs, scooters, and walkers. Independent mobility increases vocational and educational opportunities, reduces dependence on caregivers and family members, and promotes feelings of self-reliance. For young children, independent mobility serves as the foundation for much early learning.

For adults, independent mobility is an important aspect of self-esteem and plays a pivotal role in "aging in place." For example, if older people find it increasingly difficult to walk or wheel themselves to the commode, they may do so less often or they may drink less fluid to reduce the frequency of urination. If they become unable to walk or wheel themselves to the commode and help is not routinely available in the home when needed, a move to a more enabling environment (e.g., assisted living) may be necessary. In addition, impaired mobility often results in decreased opportunities to socialize, which leads to social isolation, anxiety, and depression.

While the needs of many individuals with disabilities can be satisfied with traditional manual or powered wheelchairs, a segment of the disabled community finds it difficult or impossible to use wheelchairs independently. These individuals often lack independent mobility and rely on a caregiver to push them in a manual wheelchair.

To accommodate this population, several researchers have used technologies originally developed for mobile robots to create "smart wheelchairs." A smart wheelchair typically consists of either a standard power wheelchair to which a computer and a collection of sensors have been added or a mobile robot base to which a seat has been attached. Smart wheelchairs have been designed that provide navigation assistance to the user in a number of different ways, such as assuring collision-free travel, aiding the performance of specific tasks (e.g., passing through doorways), and autonomously transporting the user between locations.

1.3 Scope

Our Aim is to a design a Smart Wheelchair which will help the person suffering from any physical disabilities to be able to move independently; regardless of anyone's assistance. We also aim to provide aid to those handicapped and physically challenged persons by some sort of mobility which would greatly help them. The person who wants to operate our smart wheelchair system will be able to do so by using movement of his/her eyes to move the wheelchair.

Chapter 2

Literature Review

2.1 History

There were many previous works carried out on electric wheelchairs. A few of them helped us get ideas for our current prototype.

In a 2015 study by author Satish Kumar a low-cost Electrooculogram (EOG) acquisition system that can be used efficiently in Human Machine Interface (HMI) systems has been proposed [1]. This system consists of an Op-Amp based EEG/EOG amplifier circuit and ATMega8 microcontroller for analog to digital conversion and transferring of acquired data to PC. In this system five electrodes are used to acquire eye blinking, horizontal and vertical eye movements. In this system, the signals are first captured using EEG surface electrodes, amplified, filtered and then converted into digital form before stored into PC. The acquired EOG signal provides different eye related activities. Depending upon these eye related activities various systems can be developed to perform different tasks in real world, which provides a degree of independence to the user.

In 2012 Kousik Srathy Sridharan in his thesis work has built a portable system to acquire and analyse electro-oculographic (EOG) signals in real-time [10]. The system contains two subsystems; a hardware sub-system that consists of the filters, amplifiers, data acquisition card and isolation and the software sub-system that contains the program to acquire and analyse the signal and present the results to the observer. In his work, one paradigm records only normal blinks while the other records long blinks and the results showed differences in detection and error rates. The observations made from performance tests at various levels gave satisfactory results and proved the usefulness of the system for sleep state and drowsiness detection.

In 2015 A Saravananet. al, designed a system which incorporates Texas embedded processor, wireless communication solutions and highly-customized analog front ends[11]. As a demonstration of concept, this technology uses instrumentation amplifiers as analog front end and further single supply quad op-amp for analog signal processing in an effective manner.

W S Wijesoma et.al, in 2005 presented a complete system that can be used by people with extremely limited peripheral mobility but having the ability for eye motor coordination [12]. The Electrooculogram signals (EOG) that results from the eye displacement in the orbit of the subject are processed in real time to interpret the information and hence generate appropriate control signals to the assistive device. The effectiveness of the proposed methodology and the algorithms are demonstrated using a mobile robot for a limited vocabulary.

In 2014 Ali Marjan Nejad, Sabalan Daneshvar published a paper which discussed EOG based low-cost real-time wheelchair navigation system for severely disabled people is presented using signal processing techniques, bio-amplifiers and a microcontroller driven servomotor[13]. All the digital signal processing and execution of commands were performed utilizing a microcontroller which drastically reduced the total cost of this project. The servomotor has been synchronized with the computed eye direction resulted from processing the horizontal EOG signal. The speed of the wheelchair was also regulated with the same EOG signal. Performed tests indicated that in 98.5% of trials, subjects could navigate properly.

2.2 Comparison with Existing Implementation

While researching for our project, we found out that most of the studies focused around using EOG (Electro-oculography) technology. But when we personally implemented this technology we noticed that there was a lot of noise that was being captured by the EOG electrodes. Also the signals acquired by the electrodes were only of a few millivolts. Any attempt to amplify these signals would also amplify the noise. This could severely lower the accuracy of eye movement detection.

So, we decided to use a camera. This could help us capture accurate high quality images of the eyes. Then by using various image processing and feature extraction techniques with the help of software we could get the proper position of the eyes. The MATLAB is a very powerful tool which helped us in our project. We found that detection accuracy by this technique was much higher than EOG technique.

Also acquiring the EOG electrodes is quite hard as it is not easily available. These electrodes are costly as well. Applying these electrodes around a person's eyes is always a time taking task and the sticky side of electrodes wears off after two-three removals. So, a lot of these sticky connectors are required making the implementation of EOG very costly. On the other hand, using a camera is very much easy and also highly accurate. It is also very easily available and comparatively cheap.

2.3 Problem Definition

After studying all the papers and doing some research we can finally state our problem definition which is to:

- Build a system which can be easily used by people with any physical disabilities.
- Build a cost-effective system with less complexity.
- Build a system that is easy to use by persons who do not have much technical knowledge.
- Build a system whose maintenance and configuration is as intuitive as possible.

Chapter 3

System Requirement and Analysis

3.1 Camera

The camera used in our project is a Logitech C310 HD Webcam. Being two ways adjustable and having a field of view of 60°, we can fix the camera according to the angle that we want. The main purpose of our camera is to capture the close up image of our eye. Equipped with a maximum resolution of 720p at 30 frames per second we can easily obtain high quality images. It allows easy and fast video calling in high definition which helps us in real time eye tracking. The Logitech HD Webcam C310 is a universal USB web camera that has been designed to work with any computer that has a USB port. It is designed to work with a 1.1 port, but for better speed and quality, a USB 2.0 port is recommended. Through our research and by using it firsthand, we found that Logitech HD Webcam C310 users find this webcam very easy to use and user friendly. Once the Logitech software is installed on your computer, you will find step-by-step registration prompts to help you get it ready to use. Logitech HD Webcam C310 makes an excellent option for anyone shopping for a high-quality, affordable aftermarket Webcam. The Logitech Webcam software acts as a central hub for controlling the basic functionality of the Web camera, in addition to some extra features. The main menu offers the option to take a quick snapshot, view a gallery of archived pictures, or make a video call using a number of preinstalled apps: Logitech Vid HD is its proprietary video chatting software, but there's also Gmail Voice and Video chat, Skype, Windows Live Messenger, and Windows Live Movie maker, with a convenient "Get More Apps" button in the right corner that takes you to even more applications.

Fig 3.1: Logitech C310 HD Webcam

3.2 Arduino Uno

3.2.1 Description

The Arduino UNO is an open-source microcontroller board based on the microcontroller and developed by Arduino. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under a creative commons Attribution ShareAlike license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards and the reference model for the Arduino platform. The ATmega328 on the Arduino Uno comes pre-programmed with a bootloader that allows uploading new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol. The Uno also differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

3.2.2 Features

- Microcontroller: ATmega328
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz

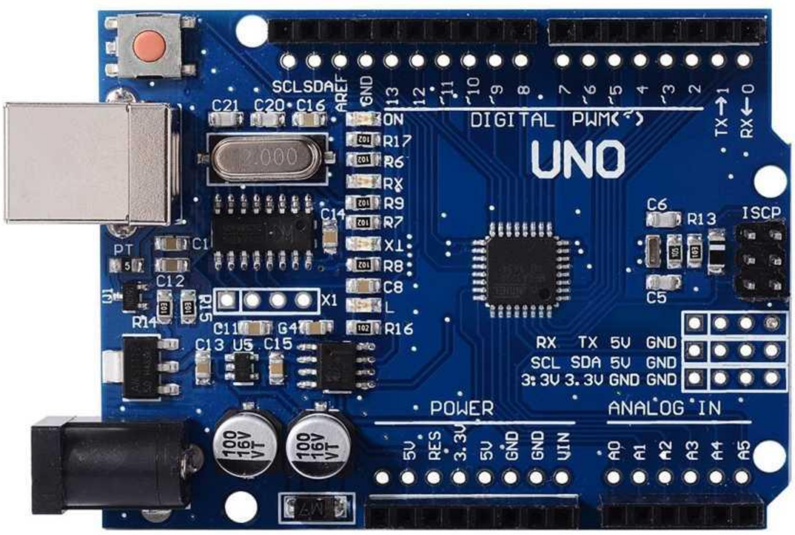

Fig 3.2: Arduino Uno

3.2.3 Pin Description

Table 3.1: Pin description of Arduino Uno

Pin Category	**Pin Name**	**Details**
Power	Vin, 3.3V, 5V, GND	Vin: Input voltage to Arduino when using an external power source. 5V: Regulated power supply used to power microcontroller and other components on the board. 3.3V: 3.3V supply generated by on-board voltage regulator. Maximum current draw is 50mA. GND: ground pins.
Reset	Reset	Resets the microcontroller.
Analog Pins	A0 – A5	Used to provide analog input in the range of 0-5V
Input/Output Pins	Digital Pins 0 - 13	Can be used as input or output pins.
Serial	0(Rx), 1(Tx)	Used to receive and transmit TTL serial data.
External Interrupts	2, 3	To trigger an interrupt.
PWM	3, 5, 6, 9, 11	Provides 8-bit PWM output.

SPI	10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK)	Used for SPI communication.
Inbuilt LED	13	To turn on the inbuilt LED.
TWI	A4 (SDA), A5 (SCA)	Used for TWI communication.
AREF	AREF	To provide reference voltage for input voltage.

3.3 DC Motor

The Square GearBox Motor is mechanically commutated DC electric motor which simply means that these motors equip Gearboxes for providing a great balance between torque-speed as per your requirement. So, Square GearBox Motor is a simple DC motor of 6000RPM (Base Motor RPM) which features a heavy-duty metal gearbox. This Square gearbox DC motor is a very high torque motor which should be used to make big robots or robotized platform. The motor will run at 60 RPM when powered with 12V DC supply. It produces the massive torque of 16 kg-cm at 60 RPM. The motor shaft is made up of good quality Engineering steel with nickel plating to handle high Torsion Stress. The shaft of the motor equips metal bushes which makes these DC gear motors Shaft wear resistant. The Square GearBox Motor's shaft is the D-type shaft which ensures strong and safe coupling. The Square GearBox Motor is very easy to use and available in standard size. Their wide application areas include Robot Development, centralized air conditioning valve, amusement equipment, coin refund devices, grill, oven, peristaltic pumps, atm bank automatic system, medical equipment, office equipment, household appliances, automatic actuator, and many other Industrial applications.

3.3.1 Features

- Rated Voltage: 12V
- RPM (at12v): 50
- No load current: 220mA
- Load Current: 1.3A
- Stall Current: 4.8A
- Full Stall Load Torque: 30.59 kgcm

3.3.2 Description

Here we have used two square geared motor rated for torque of 3.5 Nm. The DC motor works over a fair range of voltage. The higher the input voltage more is the RPM (rotations per minute) of the motor. For example, if the motor works in the range of 6-12V, it will have the least RPM at 6V and maximum at 12 V.

In terms of voltage, we can put the equation as:

RPM= K1 * V, where,

K1= induced voltage constant

V=voltage applied

The working of the gears is very interesting to know. It can be explained by the principle of conservation of angular momentum. The gear having smaller radius will cover more RPM than the one with larger radius. However, the larger gear will give more torque to the smaller gear than vice versa. The comparison of angular velocity between input gear (the one that transfers energy) to output gear gives the gear ratio. When multiple gears are connected together, conservation of energy is also followed. The direction in which the other gear rotates is always the opposite of the gear adjacent to it.

In any DC motor, RPM and torque are inversely proportional. Hence the gear having more torque will provide a lesser RPM and converse. In a geared DC motor, the concept of pulse width modulation is applied. The equations detailing the working and torque transfer of gears are shown below:

$T_{in}\omega_{in} = T_{out}\omega_{out}$

where,

T_{in} = input torque by the driver gear

ω_{in} = angular speed of the driver gear

T_{out} = output torque by the driven gear

ω_{out} = angular speed of the driven gear

In a geared DC motor, the gear connecting the motor and the gearhead is quite small, hence it transfers more speed to the larger teeth part of the gear head and makes it rotate. The larger part of the gear further turns the smaller duplex part. The small duplex part receives the torque but not the speed from its predecessor which it transfers to larger part of other gear and so on. The third gear’s duplex part has more teeth than others and hence it transfers more torque to the gear that is connected to the shaft.

Fig 3.3: Square Geared DC Motor

3.4 Power Supply

The power supply which we are using for our project is Extech 382260: 80W Switching Mode DC Power Supply. The 382260 features 4-Digit LED displays, front/rear output terminals and remote sensing for accurate applied voltage at load point. This power supply has three selectable output ranges that perform like three power supplies in one: 0 to 16V/0 to 5A; 0 to 27V/0 to 3A; 0 to 36V/0 to 2.2A. Being a compact and lightweight unit, it provides easy portability and is ideal for tight workbenches with limited space.

3.4.1 Specification

- Voltage Output (3 ranges): 0.10 to 16.40V / 0.10 to 27.60V / 0.10 to 36.80V
- Current Output (3 ranges): 0.100 to 5.100A / 0.100 to 3.100A / 0.100 to 2.300A
- Basic accuracy: ±1%
- Ripple & Noise: <30mVpp
- Line Regulation: <4mV
- Load Regulation: <20mV
- Display Dual 4-digit LED displays
- Power: 90-264VAC; 47-63Hz
- Dimensions: 13 x 5 x 2" (330 x 127 x 53.5mm)
- Weight: 4.2lbs (1.9kg)

Fig 3.4: Extech 382260: 80W Switching Mode DC Power Supply

3.5 Wheelchair

The wheelchair basically consists of two mechanical frames which are bolted together. The bottom frame supports the wheels of our project. The wheel used as a front wheel is a cluster wheel. Welded to the frame is a metallic plate which supports the motors on the left and right sides of the bottom frame respectively. Two bearing housings are bolted on each of the metallic plates through the bottom frame.

The upper frame supports the seat of our project. The seat is made of two wooden ply. One ply forms the bottom seat while the other forms the back rest. The bottom seating ply is of dimension 410x400mm with a thickness of 10mm. The back resting ply is of dimensions 410x500mm with a thickness of 10mm. The back resting ply is bolted on the upper frame and the bottom seating ply is bolted to the bottom frame through the upper frame.

On both the sides, the respective shafts of the motors which are of 8mm diameter are attached to a rod of 15mm diameter through a tapping of 4mm diameter of screw. These rods then pass through their respective bearing housings towards the gear spoke on either side where they are welded. The spoke drives another smaller gear spoke with the help of a chain. The smaller gear spoke is attached on the axis of the wheel. Thus when the larger spoke rotates, it also rotates the smaller spoke with the help of chain which eventually rotates the wheel on each side.

3.6 Motor Driver

The motor driver basically acts as an interface between the Arduino and the motors. Since the 5V signals coming from Arduino are not enough to drive the 12V motors, the use of motor driver becomes necessary. The circuit of the driver consists of eight IRF540 N-channel MOSFETs which are capable of handling 20V 24A and operating at a temperature of 175°C. Also used in the drivers are four BC547B transistors which effectively handle the switching operation. Signals coming from the Arduino decide whether the motors will rotate clockwise or anticlockwise. The driver has four input pin which receives four control signals from the Arduino (two for each motor). The polarity of the 12V given to a motor is decided by the two control signals received at the motor driver from Arduino. If 10 is received the motor rotates clockwise and if 01 is received the motor rotates in an anticlockwise direction. If 11 or 00 is received the motor stops.

3.7 MATLAB

MATLAB (*matrix laboratory*) is a multi-paradigm numerical computing environment and proprietary programming language developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include:

- Math and computation
- Algorithm development
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics
- Application development, including Graphical User Interface building

The MATLAB system consists of five main parts:

The MATLAB language: This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create complete large and complex application programs.

The MATLAB working environment: This is the set of tools and facilities that you work with as the MATLAB user or programmer. It includes facilities for managing the variables in your workspace and importing and exporting data. It also includes tools for developing, managing, debugging, and profiling M-files, MATLAB's applications.

The MATLAB Graphical User Interface (GUI): This is the MATLAB graphics system. It includes high-level commands for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level commands that allow you to fully customize the appearance of graphics as well as to build complete Graphical User Interfaces on your MATLAB applications.

The MATLAB mathematical function library: This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigenvalues, Bessel functions, and fast Fourier transforms.

The MATLAB Application Program Interface (API): This is a library that allows you to write C and Fortran programs that interact with MATLAB. It include facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.

MATLAB also features a family of application-specific solutions called toolboxes. These toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others. For our project we used the image acquisition and image processing toolboxes. With these we could apply the algorithm which could detect and subsequently generate the corresponding signals according to the position of the eye.

Additionally to extend the capabilities of MATLAB and gain additional functionality for specific tasks and application, one can use add-ons. These add-ons are especially helpful when we want to interface third party hardware with MATLAB. For our project we used Image Acquisition Toolbox Support Package for OS Generic Video Interface which helped us to interface our Logitech HD Webcam C310 with the MATLAB. The second add-on which we used for our project was MATLAB Support Package for Arduino Hardware which as the name suggests is used by MATLAB to communicate with the Arduino board connected to the computer.

3.8 EAGLE

EAGLE stands for Easily Applicable Graphical Layout Editor. It is a software application developed by CadSoft Computer GmbH. EAGLE is a scriptable electronic design automation (EDA) application with schematic capture, printed circuit board (PCB) layout, auto-router and computer-aided manufacturing (CAM) features. PCB design in EAGLE is a two-step process. First you design your schematic, then you lay out a PCB based on that schematic. EAGLE's board and schematic editors work hand-in-hand. A well-designed schematic is critical to the overall PCB design process. It will help you catch errors before the board is fabricated, and it will help you debug a board when something doesn't work. The first version of this software was released in 1988.

3.9 Laptop

The laptop which we used for our project is Acer Predator Helios 300. Since MATLAB is a very resource demanding software a very powerful machine is required to run the software smoothly without any lag. Acer introduced the Predator series in the year 2008. This series is known to have high-end configurations aimed especially for high performance.

3.9.1 Features

- **Operating System:** Windows 10 Home Edition
- **Processor:** Intel® Core™ i7-8750H processor Hexa-core 2.20 GHz
- **Graphics:** NVIDIA® GeForce® GTX 1050 Ti with 4GB Dedicated Memory
- **Screen:** 39.6 cm (15.6") Full HD (1920 x 1080) 16:9 IPS
- **Memory:** 8 GB, DDR4 SDRAM
- **Storage:** 1TB HDD, 128GB SSD

Chapter 4

Methodology

4.1 Block Diagram

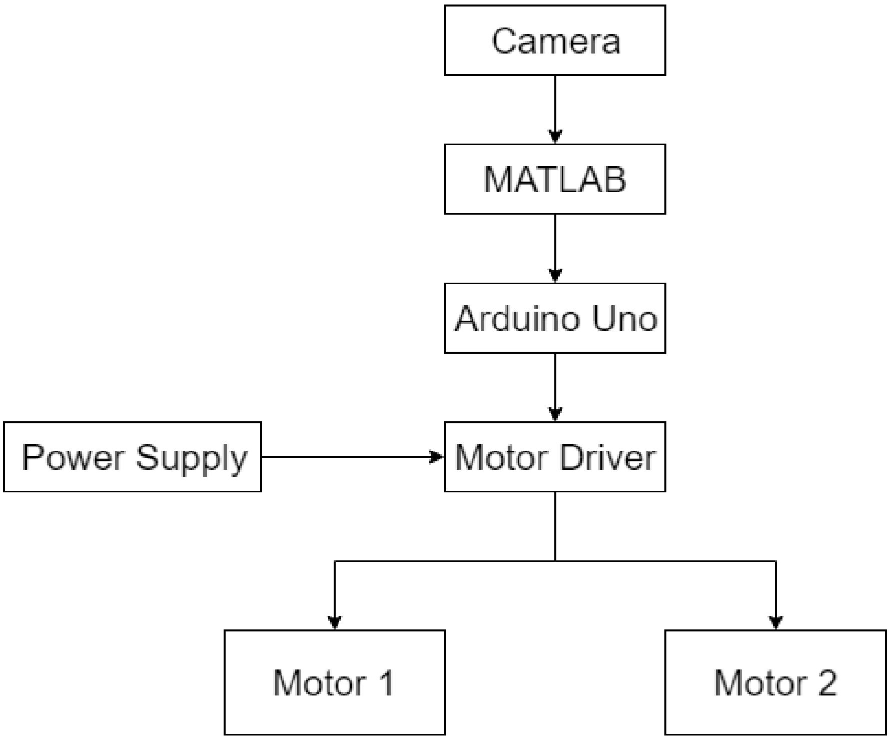

Fig 4.1: Block Diagram of Smart Wheelchair

4.2 Working

The system initiates when we run the program. At the start MATLAB establishes connection with Arduino and the webcam respectively. Immediately after this the cascade object detector is initialized which uses Viola-Jones Algorithm to detect people's faces, noses, eyes, mouth, or upper body. Since our project uses the movement of the eyes we define the object detector to recognize pair of eyes only. Four images indicating, ‘Right’, ‘Left’, ‘Straight’ and ’No face’ are also defined. Now that everything is defined our system can finally work.

A snapshot is taken of a person facing the laptop screen with the help of webcam. This image is flipped sideways in order to obtain a mirror image of the person’s face. Several image processing algorithms like colour to grayscale, intensity adjustment and Contrast-limited adaptive histogram equalization are performed on this flipped image.

Now, the Cascade Object Detector and the flipped processed image are stepped. This helps MATLAB to recognize the pair of eyes (which we defined earlier) from the flipped processed image. All the eye pairs present in the image are recognized but we need only one pair and that too of the person sitting closest to the laptop screen. Since the eye pair of the person sitting close to the laptop will be biggest, our code considers the biggest eye pair and discards all other eye pairs.

We now have obtained the eye pair of the required person who will be controlling our wheelchair. We can discard one eye from the eye pair as eye movement can be determined with one eye. So we divide the eye pair into half. Next, with the help of Hough Transform we detect circles in our image of the eye. Here we can pre-configure several parameters like the sensitivity of the detection, object polarity and radius of the circle to be detected. The iris of the human eye being perfect circle gets easily recognized by Hough Transform. The location of the detected circle is recorded.

Depending on the position of the circle one of the three signals are generated. Those three signals are Left, Right and Straight. If the eye is looking at left direction the circle detecting the iris will be positioned at left of the image, indicating the left direction chosen by the user to move his wheelchair. We can easily define and tune the range that will indicate the left direction. The same is done for right too. For indicating straight direction we have kept the range of position of the circle around the center. Also if no eye pair is detected we display the image “No Face”.

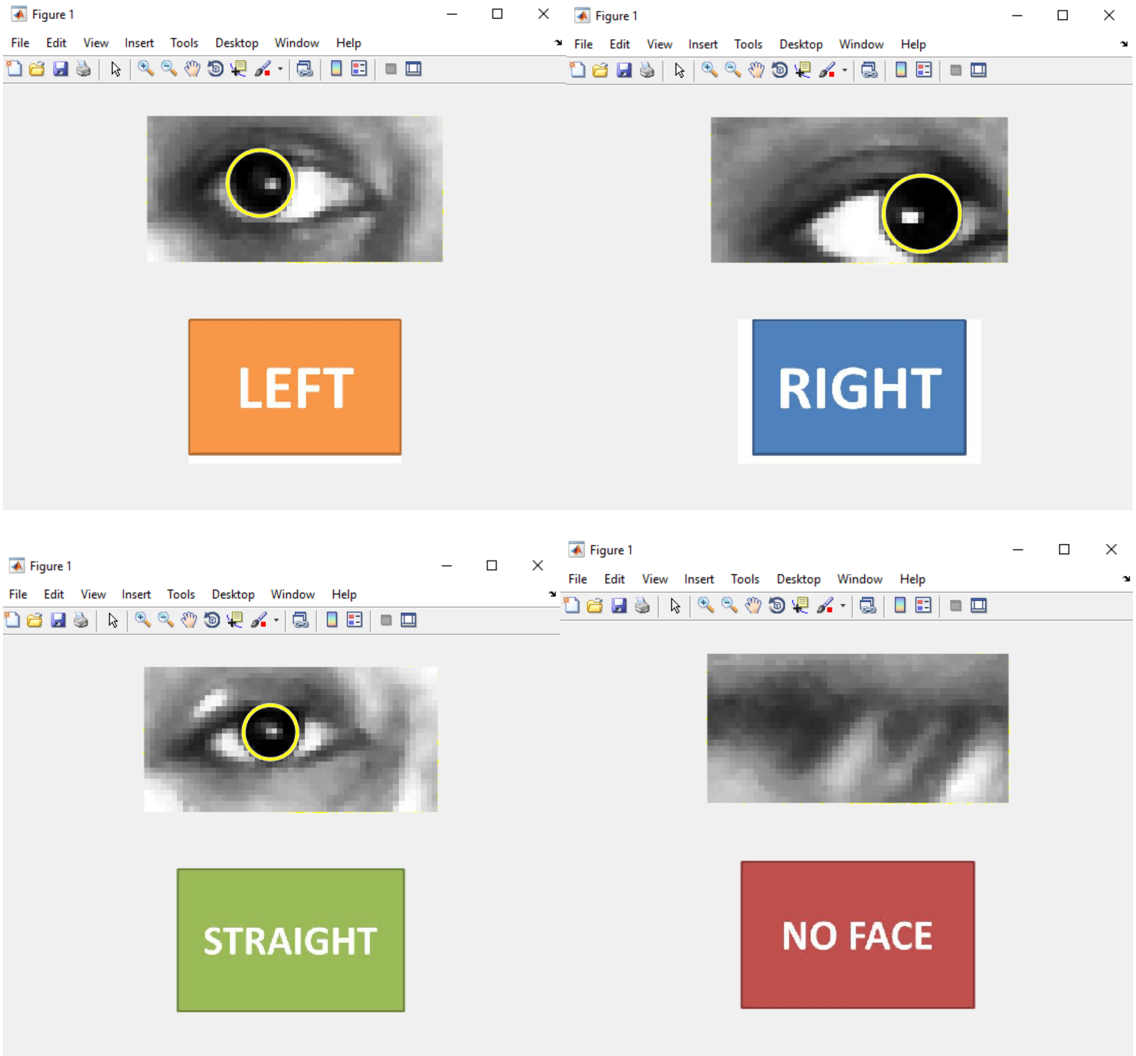

Fig 4.2: Snapshots of Recognized Eye Movements in MATLAB

Subsequently, control signals, corresponding to Left, Right and Straight are generated on the Arduino connected to the laptop. Each of the three indicated direction generates four signals at the digital pins of the Arduino. Two of these four signals control the direction of rotation of one motor while remaining two control the direction of rotation of another motor. These control signals are given through Arduino to the motor driver. Thus Arduino acts as an interface between MATLAB and the Motor Driver.

Table 4.1: Control Signal Truth Table

CONTROL SIGNAL	OUTPUT
00	Motor stops
01	Motor rotates in reverse direction
10	Motor rotates in forward direction
11	motor stops

If control signals 10 is provided the motor rotates in forward direction. If control signals 01 is provided to a motor it rotates in reverse direction. If control signals 00 or 11 are provided, the motor does not rotate.

For the Left direction the right motor rotates in forward direction and the left motor rotates in reverse direction. For the Right direction exact opposite action takes place. The right motor rotates in reverse direction and the left motor rotates in forward direction. For straight direction both the motors rotate in forward direction.

These motor require 12V to operate and as the signals coming from the Arduino are of only 5V we use a motor driver. This motor driver uses an external 12V supply to rotate the motors and control signals coming from Arduino act as direction control of the rotation.

The shafts of these motors are connected to a gear spoke on each side respectively. This spoke drives a smaller spoke that is attached on the axis of the wheel with a help of a chain. So, in short, the shaft of the motor rotates in a specific direction moving the larger gear spoke which in-turn rotates the smaller spoke rotating the wheel itself. Now next snapshot is captured and the process keeps on repeating again and again producing output at the motors according to the eye movement thus moving the wheelchair. The process stops when we stop the code execution in MATLAB.

4.3 Circuit Diagram

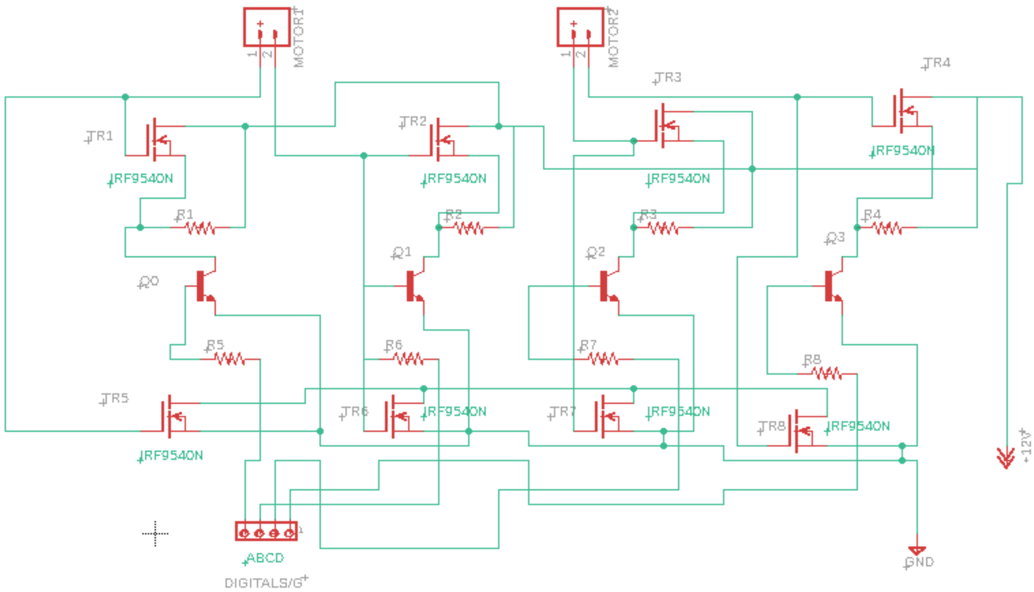

Fig 4.3: Circuit Diagram for Motor Driver

4.4 PCB Layout

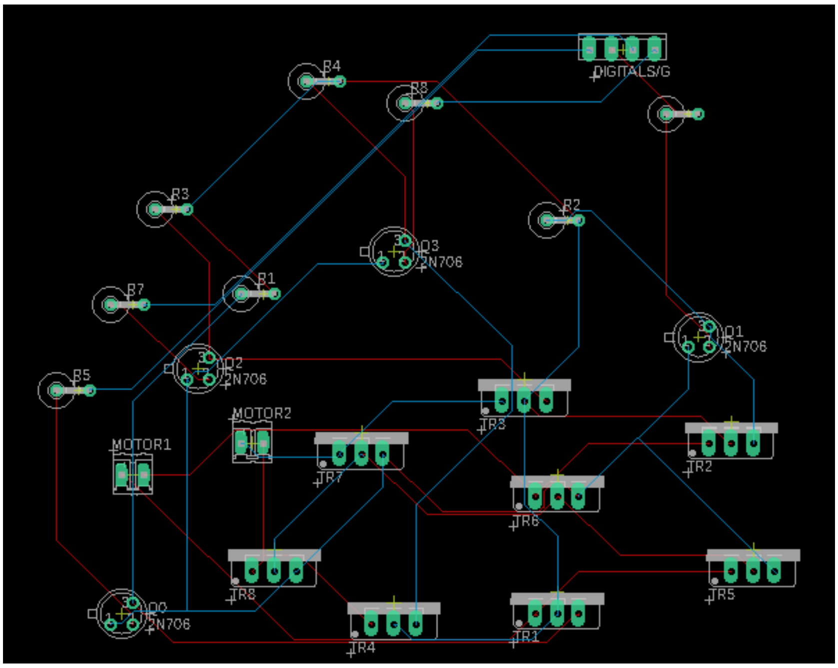

Fig 4.4: PCB Layout for Motor Driver

Chapter 5

Hardware and Software Implementation

5.1 Hardware Implementation

Webcam: The Webcam is connected to the laptop via USB port. MATLAB recognizes this Webcam and initializes at the start of our program. The webcam gets the supply necessary for it to work through the USB port.

Arduino Uno: Like Webcam the Arduino Uno is also connected to the laptop via USB port. Control signals corresponding to the recognized eye movement are generated on the digital pins of the Arduino Uno board through MATLAB programming. We can easily configure which Arduino pin will will generate the output with the help of MATLAB. We have assigned Arduino pins, “D5” and ”D6” for the controlling of left motor and pins “D9” and “D10” for controlling the right motor. The arduino Uno is also powered through USB connection.

Motor Driver: Digital control signals coming from Arduino are given to the control input of the motor driver. Pins “D5” and “D6” of the Arduino Uno board are connected to pins “A” and “B” of the motor driver respectively. This will control the left motor eventually controlling the left wheel. Pins “D9” and “D10” of the Arduino Uno board are connected to pins “C” and “D” of the motor driver respectively. This will control the right motor eventually controlling the right wheel. Also connected to the driver is an external power supply which will supply 12V necessary for the motor to work.

External DC Power Supply: The external DC power supply works on 230V/50Hz AC supply. Of the three available ranges which this power supply offers we selected 16V/5A.

The motor draws a lot of current at full load hence we choose this mode. Next, we set the voltage to 12V with the knob provided to control the voltage. Now, with the help of crocodile pins we connect this DC supply to the motor driver.

Motor: The motor works on the 12V supply. Depending on the polarity of this supply it changes the direction of rotation. The shaft of this motor which is of 8mm diameter is attached in a rod of 15mm diameter through a tapping of 4mm diameter of screw. This rod then passes through a bearing housing towards the gear spoke

Gear Spoke: The rod of 15mm diameter coming through the bearing housing is welded to a gear spoke. This spoke drives another smaller gear spoke with the help of a chain. The smaller gear spoke is attached on the axis of the wheel. Thus when the larger spoke rotates, it also rotates the smaller spoke with the help of chain which eventually rotates the wheel.

5.2 Software Implementation

Viola Jones algorithm is the most famous algorithm for face detection. It is framework that is used in real time and the training rate is very high. There are three major ideas in Viola Jones method: the Integral Image, AdaBoost classifier learning and finally the attentional cascade structure.

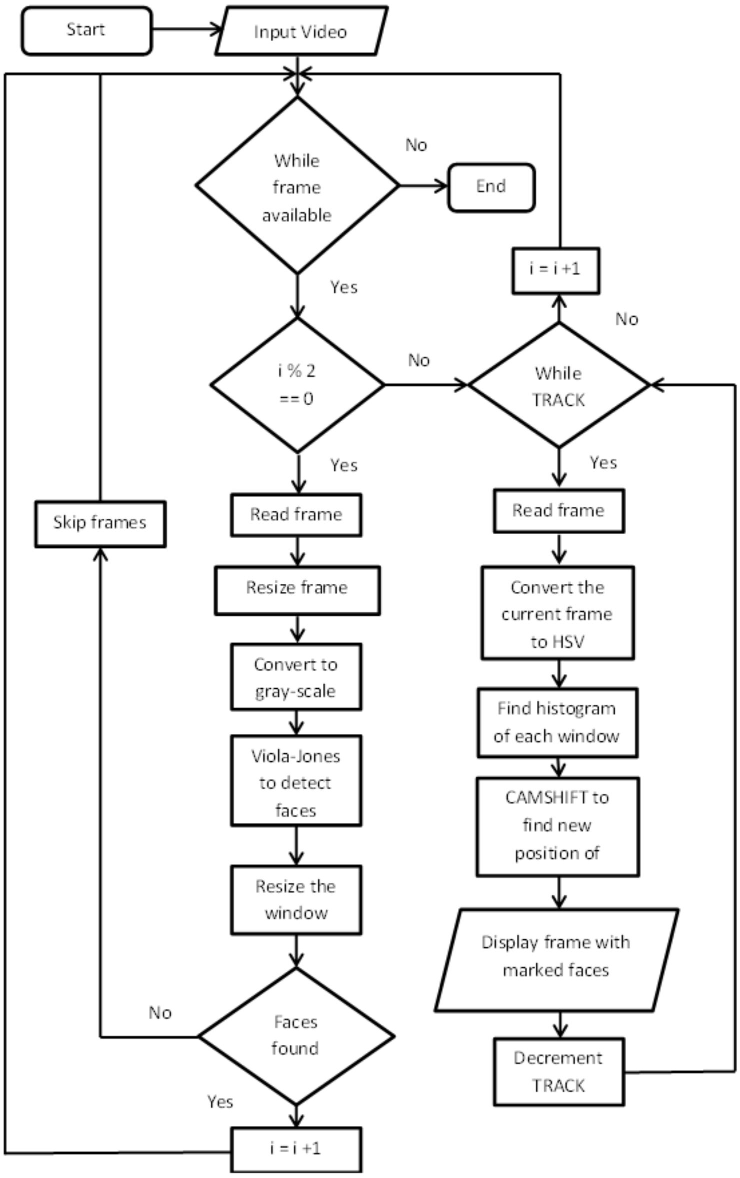

Fig 5.1: Flowchart for Viola-Jones Algorithm

At start the input video is taken from the webcam which will be checked whether frame is available or not. If the video frame is not available, process will stop. If video frame is available, it will be checked whether i is even or not. If i is even, the process of reading and resizing the frame will take place. Then we will convert video frame to gray scale images. Further the Viola-Jones algorithm will help detect faces. Now the window will be resized to find faces. If faces are not found, frame will be skipped and the process will repeat. If face is found, value of i will increment and the process will repeat again.

If i is odd, a new while loop will start. The while loop here executes TRACK. If it is not able to track, i will increment and process will start again. If it is able to TRACK, then it will read frame and convert it into HSV model. Next step is to find histogram of each window. Further Cam will Shift to display new position of face. Now the marked faces will be displayed with frame. Following this TRACK will be decremented. After this, the while loop for TRACK will be implemented again.

Chapter 6

Discussion and Results

The complete development of the project was discussed and this system was divided into the following stages:

- Problem definition stage
- Designing block diagram
- Purchasing of EOG monitor
- Testing EOG monitor
- Designing circuit diagram
- Purchasing of components
- Testing individual components
- PCB designing
- Soldering
- Testing and Troubleshooting
- Developing algorithm in MATLAB
- Testing of code and hardware on a small scale prototype
- Welding and bolting of hardware materials
- Testing and Running

Problem definition stage

This is the very first stage to develop any project. It actually defines the aim and the concept of the project. The aim of **"Smart Wheelchair"** is to design a wheelchair which will move according to the movement of the eyes.

Designing block diagram

At this stage we have categorized the whole system into different individual modules. These modules (block diagrams) will be helpful in understanding the concept and working of the integrated system. It also simplifies the entire debugging and testing process. So the result was the block diagram of the project.

Purchasing of EOG monitor

As there are various techniques to record the eye movement, we initially chose to go with EOG. The EOG monitor was not easily available and after much searching we were finally able to find one online.

Testing EOG monitor

When we were testing the EOG monitor we noticed that there was a lot of noise that was being captured by the EOG electrodes. Also the signals acquired by the electrodes were only of a few millivolts. Any attempt to amplify these signals would also amplify the noise. This could severely lower the accuracy of eye movement detection. Hence we chose to discard the EOG technique and decided to use a camera.

Designing circuit diagram

In this stage a circuit diagram of the motor driver was made showing how the different components will be linked to each other. The circuit diagram is very useful in understanding the real working of the project as it shows how each and every component is connected and working. So the circuit diagram of the project was ready at the end of this stage.

Purchasing parts from the market

After the circuit diagram was made the components that were required to make the project were purchased from the market.

Testing individual components

In this stage all the components were tested that they are working fine before they are implemented. This stage was very much necessary as it would have been difficult to manage if any component would had been found faulty after it was actually implemented.

PCB Designing

The circuit diagram was then drawn on the PCB with permanent marker and then it is dipped in the solution of ferric chloride so that unwanted copper is removed from the PCB, thus leaving components interconnection on the board.

Soldering

After designing the PCB all the components were inserted and soldered. The joint to be soldered is heated with the help of soldering iron. Heat applied should be such that when solder wire is touched to joint, it must melt quickly. The joint and the soldering iron is held such that molten solder should flow smoothly over the joint. When joint is completely covered with molten solder, the soldering iron is removed. The joint is allowed to cool, without any movement.

Testing and Troubleshooting

After soldering each and every component is tested once again. It is required to check that all the components are working fine after implementation is done. If any problem occurs then it is rectified and solved properly.

Developing algorithm in MATLAB

We used MATLAB as it could easily interface with Arduino and the Webcam. We used the cascade object detector present in MATLAB which implements Viola-Jones algorithm. With this we could detect the eye movement and generate control signals corresponding to theses movements which would be sent to the Arduino.

Testing of code and hardware on a small scale prototype

We tested our code with a small hardware prototype using two 5V motors and found out that everything was working perfectly. Now, we were ready to implement this on a large scale.

Welding and bolting of hardware materials

The frame of our wheelchair prototype was made using welding and bolting. This work was done in our college workshop and the necessary assistance and tools were provided by the professors present there.

Testing and Running.

Finally we tested our project for actual working and concluded that our wheelchair system was working successfully without any errors. This was the last and final stage of development of our project.

Chapter 7

Conclusion

We have successfully made an electric wheelchair system whose movement is controlled by the eye movement of the user. Since the wheelchair is motorized there is no physical assistance required to push the wheelchair. The only input required is movement of the eyes which will move the wheelchair. The wheelchair will move straight, turn left or turn right depending on the straight, left or right position of the eyes of the user respectively. People with any kind of physical disabilities can use our smart wheelchair. Only requirement is proper eye movement. Making of this wheelchair is very cheap and the complexity is also very less. Also not much technical knowledge is required to operate this system. Thus a physically disabled person can be self-reliant using our smart wheelchair.

REFERENCES

[1] Satish Kumar, Adyasha Dash, Manoj Kumar Mukul ―Design and Development of Low-Cost EOG Acquisition Circuit for HMI Application‖ 2015 2nd International Conference on Signal Processing and Integrated Networks (SPIN).

[2] Young L. R. and Sheena D: ―Survey of Eye Movement Recording Methods‖, Behavioural Research Methods and Instructions, Volume 7(5), 1975, pp.397–429.

[3] Hansen D. W., Hansen, J. P., Nielsen, M., Johansen, A. S. and Stegmann M. B.: ―Eye Typing using Markov and Active Appearance Models‖, IEEE Workshop on Applications on Computer Vision, Orlando, FL, USA, 2002, pp.32–136.

[4] Gips J., DiMattia P., Curran F.X. and Olivieri P.: ―Using EagleEyes: An Electrodes based Device for Controlling the Computer with Your Eyes to Help People with Special Needs‖, In Klaus, J. et al. (eds.) Interdisciplinary Aspects on Computers Helping People with Special Needs, Vienna, 1996.

[5] S. Venkataramanan, Pranay Prabhat, Shubhodeep Roy Choudhury, Harshal B. Nemade, J.S. Sahambi ―Biomedical Instrumentation based on Electrooculogram (EOG) Signal Processing and Application to a Hospital Alarm System‖ Proceedings of ICISIP – 2005

[6] Jaakko Malmivuo, Robert Plonsey,: ―Bioelectromagnetism-Principles and Applications of Bioelectric and Biomagnetic Fields‖, Oxford University Press,1995, Chapter 28, pp. 437-441.

[7] Zhao Lv, Xiao-Pei Wu, Mi Li, De-Xiang Zhang, ‖Development of a human computer interface system,‖ Health vol. 1, 2009.

[8] Daud, W.M.B.W. Sudirman, R. ; Al Haddad, A., ―Wavelet frequency energy distribution of electrooculogram potential towards vertical and horizontal movement,‖ 2nd international conference on computational intelligence modelling and simulation, September 2010.

[9] Daud, W.M.B.W., Sudirman, R., ―A wavelet approach on energy distribution of eye movement potential towards direction‖, IEEE Symposium on Industrial Electronics & Applications (ISIEA), October 2010.

[10] Kousik Sarathy Sridharan, ―Real-time acquisition and analysis of Electro-oculography signals‖, Masters Thesis, 2012

[11] A Saravanan et al. ,‖Design and implementation of Low power, Cost effective Human Machine Interface by Left and Right Eye Movement Technique‖,978-1-4673-7910-6/15 ©20 15 IEEE

[12] W S Wijesoma et al., ―EOG Based Control of Mobile Assistive Platforms for the Severely Disabled‖, 2005 IEEE International Conference on Robotics and Biomimetics.

[13] Ali Marjaninejad, Sabalan Daneshvar ―A Low-cost Real-time Wheelchair Navigation System Using Electrooculography‖, The 22nd Iranian Conference on Electrical Engineering (ICEE 2014), May 20-22, 2014

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APPENDIX

A

API

Arduino

AtMega

B

Bearing Housing

Bioamplifier

D

DDR4

E

EEPROM

Electro- Oculography

F

FTDI

G

Gear Spoke

GUI

H

HDD

I

IPS

IRF540

M

MATLAB

R

RPM

S

SDRAM

SPI

Square Gearbox Motor

SSD

T

TTL

W

Webcam

Program code

```
clear all
clf('reset');



cam = webcam();
global a
a=arduino('COM3','Uno','Libraries','')

runLoop = true;
detector1 = vision.CascadeObjectDetector('EyePairBig');
right=imread('RIGHT.jpg');
left=imread('LEFT.jpg');
noface=imread('no_face.jpg');
straight=imread('STRAIGHT.jpg');

while runLoop


    videoFrame = snapshot(cam);
    img = flip(videoFrame, 2);

    vid = rgb2gray(img);
    vid = imadjust(vid);
    vid = adapthisteq(vid);

    bboxeyes = step(detector1, vid);

    if ~ isempty(bboxeyes)

            biggest_box_eyes=1;


bboxeyeshalf=[bboxeyes(biggest_box_eyes,1),bboxeyes(biggest_box_eyes,2),bboxeyes(bigge
st_box_eyes,3)/2,bboxeyes(biggest_box_eyes,4)];

            eyesImage = imcrop(vid,bboxeyeshalf(1,:));
            eyesImage = imadjust(eyesImage);
```

```
r = bboxeyeshalf(1,4)/5;
[centers, radii] = imfindcircles(eyesImage, [floor(r-r/4) floor(r+r/2)], 'ObjectPolarity','dark', 'Sensitivity', 0.93);


eyesPositions = centers;

subplot(2,1,1),imshow(eyesImage);
hold on;

viscircles(centers, radii,'EdgeColor','y');

if ~isempty(centers)
  pupil_x=centers(1);
  disL=abs(0-pupil_x);
  disR=abs(bboxeyes(1,3)/3-pupil_x);
  subplot(2,1,2);
  if disL>disR+20
     imshow(right);

     writeDigitalPin(a, 'D5', 0);
     writeDigitalPin(a, 'D6', 1);
     writeDigitalPin(a, 'D9', 1);
     writeDigitalPin(a, 'D10', 0);


  else
     if disR+10>disL
     imshow(left);

     writeDigitalPin(a, 'D5', 1);
     writeDigitalPin(a, 'D6', 0);
     writeDigitalPin(a, 'D9', 0);
     writeDigitalPin(a, 'D10', 1);


     else
       imshow(straight);

     writeDigitalPin(a, 'D5', 0);
     writeDigitalPin(a, 'D6', 1);
     writeDigitalPin(a, 'D9', 0);
```

```
                writeDigitalPin(a, 'D10', 1);

                end
            end

          end
   else
       subplot(2,1,2);
       imshow(noface);

       writeDigitalPin(a, 'D5', 0);
       writeDigitalPin(a, 'D6', 0);
       writeDigitalPin(a, 'D9', 0);
       writeDigitalPin(a, 'D10', 0);
    end




end


clear cam;
```