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# Design of an Eye Gaze Tracking System for Motorized Wheelchair Control

# تصميم نظام تتبع بالعين للتحكم في كراسي العجلات الآلية

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# الآية

بسم الله الرحمن الرحيم

قال تعالى

( قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا ۖ إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ )

صدق الله العظيم

سورة البقرة الاية 32

# DEDICATION

*To those who live to combat ignorance, build ideas; make glory to raise the nation.*

*I dedicate this modest effort.*

# ACKNOWLEDGMENT

**Thanks be to God, before and after, characterized the human mind and distinguished it.**

**In a private quotation, I raise my deep and sincere thanks to Dr. Alaa Eldien Awouda, the words stand astonishingly since the humble Dr. Alaa has been pushing me with unlimited efforts, support and assistance.**

**Of course, our thanks to my family and all contributors who help me to complete this work in forms of idea, opinions, words and guidance.**

**I wish you a shining future based on health, progress and fruitful career.**

**Praise is to God before and after.**

# ABSTRAC

Motorized wheelchairs are designed to aid paraplegics. Unfortunately, these cannot be used by persons with higher degree of impairment, such as quadriplegics, they cannot move any of the body parts, the eye muscles one of the few parts that still function well. Medical devices designed to help them are very complicated, rare and expensive. A microcontroller system that enables motorized wheelchair control by eye gaze is presented. In this research three IR emitters and sensors are used to track the eye gaze. IR emitter will transmit the light over iris and reflected light will be received by IR sensors. Depending upon the intensity of reflected light falling on the sensors, the controller will understand the user intention of wheelchair movement. Now controller will take the decision of moving the wheelchair forward, left, right or backward as long as IR sensors receives the directions information from the user. The system idea simulated using Proteus software and implemented in a simple prototype; a motorized toy car instead of the wheelchair to symbolize it. Also the infrared radiation effects on the eye are discussed. This system enables the patient to move freely and independently.

# المستخلص

صممت الكراسي المتحركة الكهربائية لمساعدة المصابين بالشلل النصفي. ولسوء الحظ، هذه الكراسي لا يمكن استخدامها من قبل الأشخاص الذين يعانون من درجة عالية من الإعاقة، مثل الشلل الرباعي، حيث أنهم لا يمكنهم تحريك أي من أجزاء الجسم، عضلات العين واحدة من الأجزاء القليلة التي لا تزال تعمل بشكل جيد لديهم. الأجهزة الطبية المصممة لمساعدتهم معقدة للغاية ونادرة ومكلفة. يقدم البحث نظام تحكم يتيح التحكم بالكراسي المتحركة الكهربائية عن طريق نظرة العين. في هذا البحث تم استخدام ثلاثة أجهزة إرسال واستشعار للأشعة تحت الحمراء لتتبع نظرة العين. يقوم باعث الأشعة تحت الحمراء بنقل الضوء على قزحية العين وينعكس الضوء حيث يتم استقبال هذه الأشعة المنعكسة على أجهزة الاستشعار. اعتماداً على شدة الضوء المنعكس الساقط على أجهزة الاستشعار، فإن وحدة التحكم ستميز حركة الكرسي التي يريدها المستخدم. الآن وحدة التحكم ستميز حركة الكرسي المقصودة من المستخدم سواء كانت امامية، اليسار، اليمين أو الخلف طالما أن أجهزة استشعار الأشعة تحت الحمراء تتلقى معلومات الاتجاهات من عين المستخدم. تمت محاكاة فكرة النظام باستخدام برنامج بروتوس وتنفيذها في نموذج بسيط؛ لعبة السيارات الآلية بدلا من كرسي العجلات كنموذج مصغر له. تمت مناقشة آثار الأشعة تحت الحمراء على العين أيضاً . هذا النظام يتيح للمريض التحرك بحرية واستقلالية.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| AC | Alternating Current |
| ADC | Analog to Digital Converter |
| CIE | International Commission on Illumination |
| CMOS | complementary metal-oxide-semiconductor |
| COGAIN | Communication by Gaze Interaction |
| DC | Direct Current |
| EEG | Electroencephalography |
| EMG | Electromyography |
| EOG | Electrooculography |
| HCI | Human Computer Interaction |
| HMI | Human Machin Interaction |
| IC | Integrated Circuit |
| IEC | International Electrotechnical Commission |
| IR | Infrared Radiation |
| LED | Light Emitting Diode |
| RISC | Reduced instruction set computing |
| SCI | Spinal Cord Injury |
| TC | Technical Committee |

# LIST OF SYMBOLS

| | |
|---|---|
| $\theta$ | Half Angle |
| ° | Degree (angle) |
| WC | Width of Coverage |
| D | Distance |
| P | Power in watts |
| m | Mass in kilo-newton |
| kN | kilo-Newton |
| t | Time in seconds |
| v | Velocity in m/s |
| $S_n$ | Sensor |
| $M_n$ | Motor |
| $R_V$ | Variable Resistor |
| $V_{sn}$ | Sensor output voltage |

# CHAPTER ONE

# INTRODUCTION

# Chapter One

# Introduction

## 1.1 Preface

Intelligent wheelchairs have been developed for a long time to support paralyzed people with several disability levels. In many cases, the eye muscles of paralyzed people are one of the few controllable muscles that still function well. Therefore, using the eye gaze as an interface for paralyzed or physically disabled people has been of interest. To make lives of those people simple and by simpler we mean self-reliant, which will thereby reinstate their confidence and their happiness. The particular project is useful for the patients where they can move their wheelchair in their own directions, without any third party’s help or support.

## 1.2 Problem Statement

Those who suffering Tetraplegia cannot drive the wheelchair manually, even with a joystick, because the lack of the physical ability to control the movement. The eyeball of these people is one of the few controllable parts that still function well. Effective usage of eye movements as a communication technique in user-to-machine interfaces can find place here.

## 1.3 Proposed Solution

Designing a real-time eye-gaze tracking system using IR sensors to control wheelchair movement, in this eye tracking based technology, three Infrared (IR) sensor modules are mounted on an eye frame to trace the movement of the iris. Based on the position of iris the wheelchair will move left, right, forward, backward and stop when the eyes closed.

## 1.4 Aim and Objectives

The main objective of this research is to design of eye gaze tracking system for motorized wheelchair. To achieve this aim

1. A control system for wheelchair will be proposed using IR sensors.
2. The proposed control system will be simulated using virtual system modeling and circuit simulation application (Proteus).
3. Prototype of the proposed system which symbolized the wheelchair will be done.

With the help of iris movement tracking system the idea of providing a low cost, less hardware complex embedded system that helps the physically challenged people to move freely and independently inside their houses.

## 1.5 Methodology

In this eye tracking based technology, three Proximity Infrared (IR) sensor modules are mounted on an eye frame to trace the movement of the iris. Since, IR sensors detect only white objects; a unique sequence of digital bits is generated corresponding to each eye movement. These signals are then processed via a microcontroller IC to control the motors of the wheelchair by sending control signals to the motor driver. The idea is simulated using Proteus and implemented on a simple prototype.

## 1.6 Research Outlines

In general the thesis will be divided into five chapters.

Chapter One introduction, states the problem, proposed solutions and methodology.

Chapter Two describes the background required to understand the proposed system and some examples of other systems.

Chapter Three gives an overview of the system design and describes certain decisions made when designing the system.

Chapter Four provides a step by step implementation of the system. Describes and discusses the results obtained from the system.

Chapter Five outlines the conclusions drawn from this research and identifies possible extensions of this project.

# CHAPTER TWO

# LITERATURE REVIEW

# Chapter Two

# Literature Review

## 2.1 Introduction

Spinal Cord Injury (SCI) is a medically complex and life disrupting condition. It happens for a wide variety of reasons. Injuries due to trauma are the most common. There are many other reasons, Include infection, stroke, tumour, inflammation, and several congenital causes. Each of these causes will produce a differing pattern of nerve damage, resulting in differing patterns of sensory loss and paralysis. The main types of paralysis are Paraplegia (The legs and possibly the trunk may be entirely or incompletely paralyzed. The arms are not affected. The trunk will be affected according to the level of spinal cord injury) and Quadriplegia or Tetraplegia (Usually result in paralysis of all four limbs). Tetraplegia is more debilitating than Paraplegia. However, there are cases where hand and arm movement is possible[1]. The type and extent of paralysis will determine the impact it has on a person's quality of life and day-to-day activities. For example, a person with Paraplegia will usually be able to lead a relatively independent and active life, using a wheelchair to carry out their daily activities, but a person with Tetraplegia/Quadriplegia will need a great deal of support. However, we have to help a person live as independently as possible.

Wheelchair is commercially available, It’s one of the most commonly used assistive devices for enhancing personal mobility, which is a precondition for enjoying human rights and living in dignity and assists people with disabilities to become more productive members of their communities. Manual wheelchairs are designed for people with good upper body strength. Electric wheelchairs are designed for people with poor upper body muscle strength or paralysis in all four limbs. For many people, an appropriate, well-designed and well-fitted wheelchair can be the first step towards inclusion and participation in society. When the need is not met, people with disabilities are isolated and do not have access to the same opportunities as others within their own communities. Providing wheelchairs that are fit for the purpose not only enhances mobility but begins a process of opening up a world of education, work and social life[2].

An electric-powered wheelchair is a wheelchair that is moved via the means of an electric motor and navigational controls as an interface between the paralyzed person and the wheelchair's motors. Wheelchair generally requires considerable skill to operate, In order to take care for different disabilities; various kinds of interface have been developed for powered wheelchair control which is based on Human Machine Interaction techniques; such as joystick control, head control, sip-puff control and etc. Many people with disabilities do not have the ability to control powered wheelchair using the above mentioned interfaces and people with disability with Tetraplegia cannot drive the wheelchair manually, even with a joystick, so the requirement for designing a sophisticated model of a wheelchair control system today is useful for these people.

Ever since humans started to build tools, there was interaction between the humans and the machines (Human Machine Interaction HMI). This interaction has evolved over time. Human Machine Interaction describes how we as humans interact with machines, and machine defines as any mechanical or electrical device that transmits or modifies energy to perform or assist in the performance of human tasks. After the advent of small low cost, low power microcomputers, which propelled electronics forward that has allowed us to open the door to such varying HMI technology. [3]

The eyeballs of the paralyzed person with Tetraplegia are one of the few controllable parts that still function well which paves the idea for the design of the system in this project. Eyes can be used as an interface between paralyzed person and the powered wheelchair by tracking the eye gaze directions. In the end of this chapter I will present some background knowledge required for the creation of a gaze tracking system and the decisions that had taken for choosing the adequate components for the system design.

## 2.2 Human Machine Interaction (HMI)

New technologies driven by digitalization and artificial intelligence are changing the way humans interact with machines. After the advent of small low cost, low power microcomputers, HMI propelled electronics forward and allowed us to open the door to varying HMI technologies. Next-generation devices and machines will be more sophisticated, ensuring an even higher degree of collaboration.

Human Machine Interaction (HMI) has the most general definitions; the point where the human can tell the machine what to do[4]. describes the interaction and communication between human users and machine, dynamic technical system, via a human-machine interface[5]. HMI Sometimes called as Man-Machine Interaction or Interfacing, concept of Human-Computer Interaction/Interfacing (HCI) was automatically represented with the emerging of computer, or more generally machine, itself [6]. The basic goal of HMI is to improve the interaction between users and make computers more usable and receptive to the user's need.

Functionality and usability is the basic arguments presents the main terms that should be considered in the design of HMI. Functionality of a system is defined by the set of services that it provides to its users. However, the value of functionality is visible only when it becomes possible to be efficiently utilized by the user. The second term is usability, usability of a system is the range and degree by which the system can be used efficiently and adequately to accomplish certain goals for certain users.

Human-Machine interaction can be achieved by different technologies, they can be divided into three categories; visual based HMI, audio based HMI, and sensor based HMI.

In the Visual based interaction the hardware which is used in usually is the camera, therefore the visual based technologies does not usually require the user to physically touch anything; simple hand motions and gestures can easily be used to interact with the device, which allows it to become a very effective public interface. Research areas in this section can be divided to the Facial Expression Analysis, Gesture Recognition, Body Movement Tracking and Eye Gaze Tracking [3, 6].

Audio based interaction uses human speech or some other voice for interaction between man and machine which deals with information acquired by audio signal, the information gathered from audio signal can be more trustable, helpful, and is a unique provider of information. The goal of voice based interaction is to accurately recognize every person voice with minimal error, no matter how different you may sound. Some of the main research areas in this section are Speech Recognition, Speaker Recognition, Musical Interaction, Auditory Emotion Analysis and Human-Made Noise/Sign Detection (Gasp, Sigh, Laugh, Cry, etc.)[4, 6].

The sensor based interaction is a combination of variety of areas with a wide range of applications. The commonality of these different areas is that at least one physical sensor is used between user and machine to provide the interaction these sensors can be very primitive or very sophisticated such as joysticks, motion tracking sensors, taste/smell sensors, pressure sensors, haptic sensors mouse and keyboard, and pen-based interaction. All of these sensors is considered under the non-biological signal based sensors.

Another type is the biological signal based sensors which is used in the bionic based technologies. Bionic technology is a combination of biology, robotics and computer science, and can be seen as any technology that uses or monitors the biological aspects of the body, in order to perform a function. You can have bionic eyes, ears, legs, arms, toes, feet and hands. In order to use biological signals we need to gather useful information from our bodies, which is done via electrodes. All the biological signal based techniques originated from medical practices, EEG was used to measure the brain for conditions such as sleep deprivation, and insomnia etc..., EMG and EOG are used to check if the muscles and the nerves are working correctly. Biological signal technology has much future potential, from helping the disabled regain their lost independency to interacting with our environment. This is one area that could really enhance how we interact with technology and seamlessly integrate it into our lives. [3, 4, 6]

All HMI technologies which are mentioned here can be used to improve the capacity of the movement of individuals with motor dysfunctions to control powered wheelchairs navigation. By these methods, the user with disability will find it comfortable for indoor navigation and does not need an external aid. Infrared sensors are one of the simplest interaction technologies which can find place here.

## 2.3 Infrared Technology

Infrared radiation is the portion of electromagnetic spectrum having wavelengths longer than visible light wavelengths, but smaller than microwaves as shown in figure 2.1, Infrared waves are invisible to human eyes, the region IR sensor roughly from 0.75µm to 1000 µm is the infrared region. The wavelengths of these regions and their applications are shown below.

Near infrared region — 750 nm to 1400 nm — IR sensors, fiber optic
Mid infrared region — 1400 nm to 3000 nm — Heat sensing
Far infrared region — 3000 nm to 1 mm — Thermal imaging

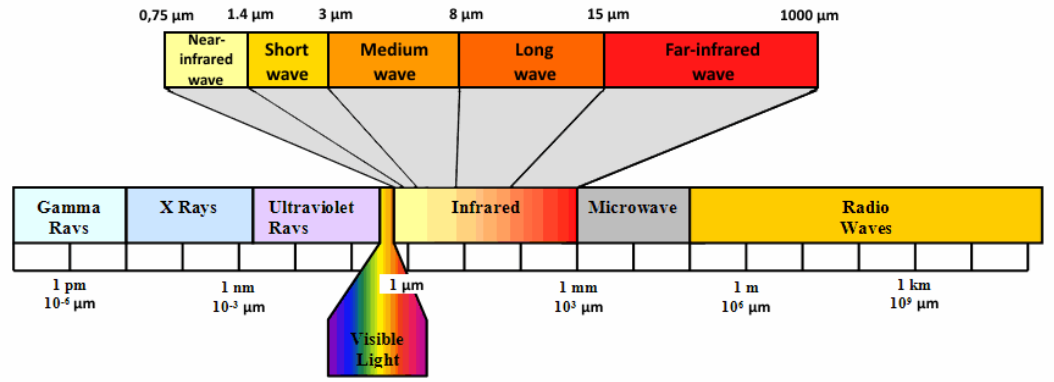


Figure 2. 1 Spectrum Frequencies Ranges

An infrared sensor emits and/or detects infrared radiation to sense its surroundings.

The working of any Infrared sensor is governed by three laws Planck’s Radiation law, Stephen – Boltzmann law and Wien’s Displacement law.

Planck’s law states that “every object emits radiation at a temperature not equal to 00K”. Stephen – Boltzmann law states that “at all wavelengths, the total energy emitted by a black body is proportional to the fourth power of the absolute temperature”. According to Wien’s Displacement law, “the radiation curve of a black body for different temperatures will reach its peak at a wavelength inversely proportional to the temperature”.

The basic concept of an Infrared Sensor which is used as obstacle detector is to transmit an infrared signal, this infrared signal bounces from the surface of an object and the signal is received at the infrared receiver.

### 2.3.1 Types of IR Sensors

Infrared sensors can be passive or active. Passive infrared sensors are basically Infrared detectors. Passive infrared sensors detect the infrared radiations from outer source. When an object is in a field of view of a sensor it provides a reading based on a thermal input. It does not generate any infrared.

Active infrared sensors consist of two elements infrared source and infrared detector. Infrared sources include an LED or infrared laser diode. Infrared detectors include photodiodes or phototransistors. The energy emitted by the infrared source is reflected by an object and falls on the infrared detector. During the process of detection, the radiation is altered, between process of emission and receiving, by object of interest. The alteration of radiation causes change in received radiation in the receiver.

This property is used to generate desired output with help of associated electronic circuit.

### 2.3.2 Principle of IR Operation

The principle of an IR sensor working as an Object Detection Sensor can be explained using the following figure 2.2. An IR sensor consists of an IR LED and an IR Photodiode.

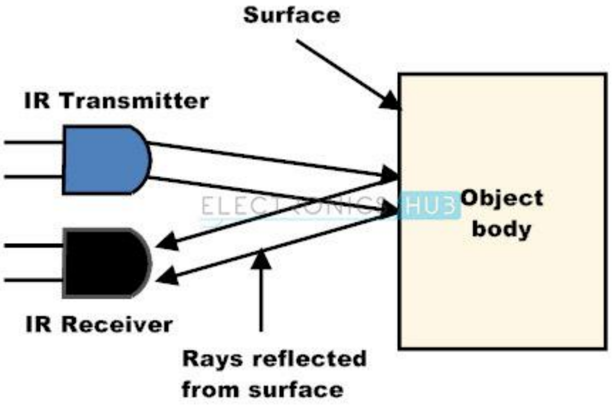


Figure 2. 2 Active IR Sensor for Object Detection

When the IR transmitter emits radiation, it reaches the object and some of the radiation reflects back to the IR receiver. Based on the intensity of the reception by the IR receiver, the output of the sensor is defined.

### 2.3.3 Distinguishing Between Black and White Colors

It is universal that black color absorbs the entire radiation incident on it and white color reflects the entire radiation incident on it. Based on this principle, the second positioning of the sensor couple can be made. The IR

LED and the photodiode are placed side by side. When the IR transmitter emits infrared radiation, since there is no direct line of contact between the transmitter and receiver, the emitted radiation must reflect back to the photodiode after hitting any object. The surface of the object can be divided into two types' reflective surface and non-reflective surface (figure 2.3). If the surface of the object is reflective in nature i.e. it is white or other light color, most of the radiation incident on it will get reflected back and reaches the photodiode. Depending on the intensity of the radiation reflected back, current flows in the photodiode.

If the surface of the object is non-reflective in nature i.e. it is black or other dark color, it absorbs almost all the radiation incident on it. As there is no reflected radiation, there is no radiation incident on the photodiode and the resistance of the photodiode remains higher allowing no current to flow. This situation is similar to there being no object at all.

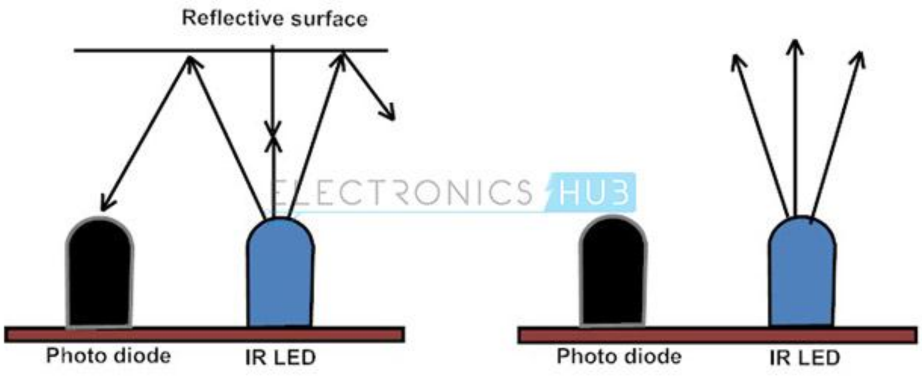


Figure 2. 3 Reflective Surface and non-Reflective Surface

The positioning and enclosing of the IR transmitter and Receiver is very important. Both the transmitter and the receiver must be placed at a certain angle, so that the detection of an object happens properly. This angle is the directivity of the sensor which is +/- 45 degrees. The directivity is shown in figure 2.4.

In order to avoid reflections from surrounding objects other than the object, both the IR transmitter and the IR receiver must be enclosed properly. Generally the enclosure is made of plastic and is painted with black color.

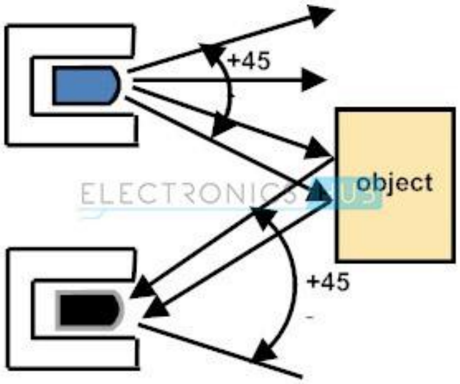


Figure 2. 4 IR Transmitter and Receiver Positioning

The eyes of a person with disability like Tetraplegia as in our case here, are function well and he can move them freely, the sclera and the iris has different colors (dark color and white respectively), which can be recognized using IR sensors to move the wheelchair depending on the iris position.

## 2.4 Eye Gaze Tracking Using Infrared Radiation

In gaze tracking system which is aimed to track the focus of the user's vision. It’s necessary to be able to track the patient’s eye, when we use the IR reflection based system for wheelchair movement. For this objective more information on the relevant biology and behavior of the eye is required to know all the effects that may cause damage to any part of the eye structure due to infrared radiation exposure.

### 2.4.1 Human Eye Structure

To accurately track the gaze of a person it is vital to know the basics of how the human eye works. This requires acknowledge of the structure of the eye, as shown below in figure 2.5.

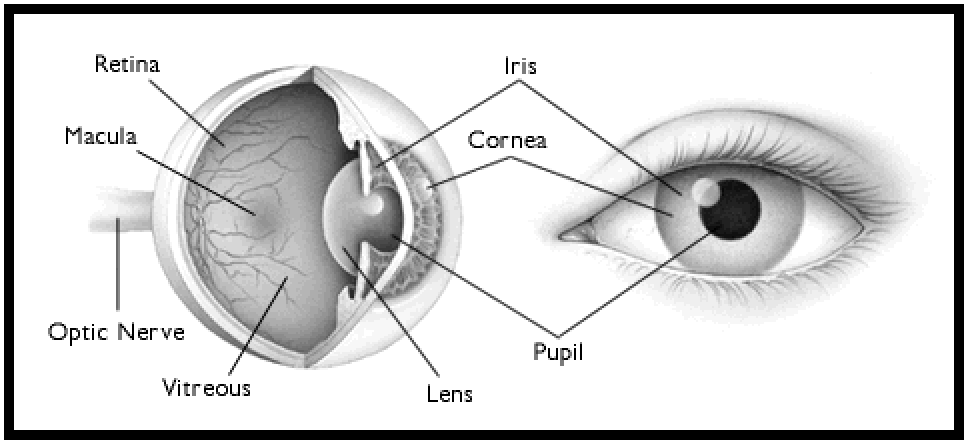


Figure 2. 5 Basic Eye Structure

The eye is a complex optical system which collects light from the surrounding environment, regulates its intensity through a diaphragm, focuses it through an adjustable assembly of lenses to form an image, converts this image into a set of electrical signals, and transmits these signals to the brain through complex neural pathways that connect the eye via the optic nerve to the visual cortex and other areas of the brain[7].

Light waves from an object (such as a tree) enter the eye first through the cornea, which is the clear front window of the eye. The cornea transmits and focuses light into the eye. The light then progresses through the pupil, the dark center in the middle of the iris. The pupil determines how much light is let into the eye. It changes sizes to accommodate for the amount of light that is available. Initially, the light waves are bent or converged first by the cornea, and then further by the crystalline lens the transparent structure inside the eye that focuses light rays onto the retina. At retina, the image becomes reversed (turned backwards) and inverted (turned upside-down). The light continues through the vitreous humor, the clear, jelly-like substance that fills the middle of the eye, and then, ideally, backs to a clear focus on the retina, behind the vitreous. The small central area of the retina is the macula, which is a small area in the retina that contains special light-sensitive cells. The macula allows us to see fine details clearly. Within the layers of the retina, light impulses are changed into electrical signals. Then they are sent through the optic nerve, the nerve connects the eye to the brain. And carries the impulses formed by the retina to the brain, which interprets them as images. [7, 8]

### 2.4.2 Infrared Radiation Effects On Eye

Light cause biological damage through both temperature effects due to absorbed energy and through photochemical reactions. The chief mode of damage depends on the wavelength of the light and on the tissue being exposed. The damage is believed to be due principally to temperature effects, and the critical organ is the eye. Somehow the eye is well adapted to protect itself against overly intense broadband optical radiation (ultraviolet, visible and infrared radiant energy). And because most IR LEDs are emitting in the 800 nm to 960 nm range which will be used in this project as a source signal to control the wheelchair movement, we have to put the disabled person's eye safety under consideration, thus because most of this radiation within these wavelengths causes a thermal retina hazard and thermal injury risk of the cornea and possible delayed effects on the lens of the eye (cataractognesis).

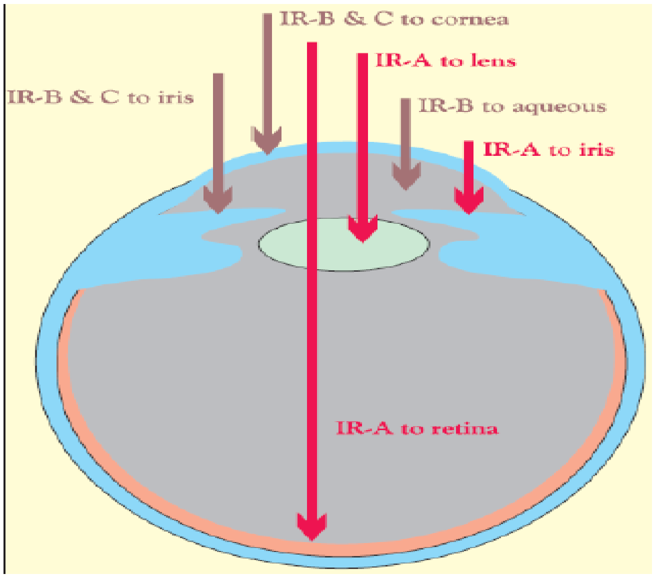


Figure 2. 6 Infrared Radiation Absorbed by the Ocular Tissues

### 2.4.3 Eye Safety of IR LED's

There are several standards and guidelines for safe infrared radiation exposure, The current standards are IEC 60825-1 [9], IEC 62471 [10], and European Directive 2006/25/EC [11]. In general the IEC 60825-1 is more restrictive in case of the thermal retinal hazard; the cornea/lens limits with the given conditions can be found only in IEC 62471 and in the European Directive 2006/25/EC. In the past IR LEDs were classified by the simplified method according IEC 60825-1 comparing the maximum intensity emitted under absolute maximum rating conditions. When the intensity was above that limit, the source size had to be taken into account. All these standards tested under 1000 seconds for the infrared exposure time to the eyes, It’s not clear enough to know if that exposure for longer time is harmful or not.

There are a group of five authors and nine contributors from Technische Universität Dresden, a public university in Dresden, Germany, introduced a report which describes the use of infrared light in eye tracking equipment, reviews current standards and guidelines regarding safe exposure to infrared light, and outlines the steps being taken by Communication by Gaze Interaction (COGAIN) to ensure the safety of both current and future hardware. Their motivation was to address the lack of clarity in the standards literature as regards long term daily exposure, in order to provide a clear safety protocol for developers and users alike.[12]

They concludes that the prototype Infrared eye tracker devices and the LED emitters employed in several systems tested in Brussels do not pose a potential hazard to the eye based upon current safety standards when used under realistic viewing conditions. Even when fixating on the LED for many minutes, the exposure would not exceed the applicable limits. LEDs are radiance limited and cannot produce exposure levels at the retina that even approach the levels that are known to cause retinal thermal injury. Currently, only short-wavelength blue-violet emitters clearly exceed the more restrictive photochemical hazard limits at wavelengths shorter than 550 nm. In other words, the infrared LEDs would have to emit far more power to pose a serious acute hazard to the retina. This is theoretically impossible for current LEDs.

Although the LED and lamp sources tested clearly pose no hazard to the eye for brief periods of viewing of some minutes—or even hours—when applied against current national and international ocular exposure limits for infrared optical radiation, there remains a question that should be addressed by an expert committee on whether the limits are truly adequately conservative for chronic daily exposure of the eye for decades. It is not clear whether any of the standards, which vary in their stringency, can be directly applied to the eye tracking situation of gaze based communication.

Also they states questions to be addressed by a CIE (International Commission on Illumination) technical committee (TC) to review the currently relevant standards and consider if the infrared exposure levels in current standards can be safely applied to the case of ongoing, day-long exposure. Furthermore, the TC should provide guidance on standardized techniques for measurement and hazard analysis for the range of eye-tracking systems and how to apply safety criteria.

### 2.4.4 Finding the eye using infrared reflection

Sclera and iris are the two main fragments of due to color intensity. The different color intensities are reflected from this portion, mostly the sclera is of white color and iris is having darker color such as black, brown and dark bluish for all human being. The different colors reflect the different light with different wavelength. The human eye is spherical shape, it is possible to get reflected light intensity for predefined portion of eye and perform moving phenomenon by gesture of eye wings.

It has been found that the average size of the iris is 11.8 mm with the majority of population falling between 10.2 mm and 13.0 mm. The average axial length along the visual axis is 24 mm. It was found that the accurate detection of the eyeball movements can be achieved by using three proximity IR sensor modules, Sill43 Infrared sensor has been chosen here.

## 2.5 Si1143 Infrared Sensor

The Si1143 is an active optical reflectance proximity detector and ambient light sensor. The chip outline spans 2x2 mm it is approximately 63 times smaller than the U.S. dime. Figure 2.7 below shows a size comparison to a dime.

Figure 2. 7 Size Comparison of Si1143 Chip to a Dime

The sensor features low power consumption with average current consumption of 9 μA and a low standby current of less than 500 nA. It has three independent LED drivers with pulse widths of 25.6 μs and each driver can be adjusted to a variable current drive setting. It operates up to 128 klux which is the equivalent to direct sunlight and it has a high reflectance sensitivity of less than 1 μW/cm$^2$. When compared with other proximity sensors such as OSRAM SFH 7743 Digital Proximity Detector or TAOS TSL2572 Light-to-Digital Converter as shown in Table 2.1, the Si1143 outperforms in terms of power consumption, range in luminance, number of channels, and current driving capacity.

Table 2. 1 Performance Comparison between Three Different Infrared Sensors

| **Sensor** | **Current During Active Mode (μA)** | **Current During Standby Mode (μA)** | **Maximum Measurable Illuminance (lx)** | **Number of Measurement Channels** | **Maximum Current of Pulsed LED (mA)** |
|---|---|---|---|---|---|
| Sill43 | 9 | 0.5 | 128,000 | 3 | 359 |
| SFH 7743 | 45 | N/A | 1000 | 1 | 60 |
| TSL2572 | 200 | 90 | 60,000 | 2 | N/A |

Before IR LED is turned on, the Si1143 makes a measurement of the ambient infrared light alone. When IR LED is turned on, it makes a second measurement that captures both the target reflectance and the ambient infrared light. Both measurements are digitized to a count value through the internal analog to digital converter (ADC). The Si1143 subtracts these two values to report only the target reflectance in its output register.

## 2.6 IR LED Selection

For ideal detection of eye movement, the IR LED needs a half angle of an IR LED that covers a good portion of the eye. The half-angle is defined as the angle where the radiant intensity has dropped 50% from its max value (in the axial direction) measured with respect to the IR LED's center emission line as shown in Figure 2.8. An IR LED with a narrow half-angle would mean that it concentrates most of its power in a small region of space.

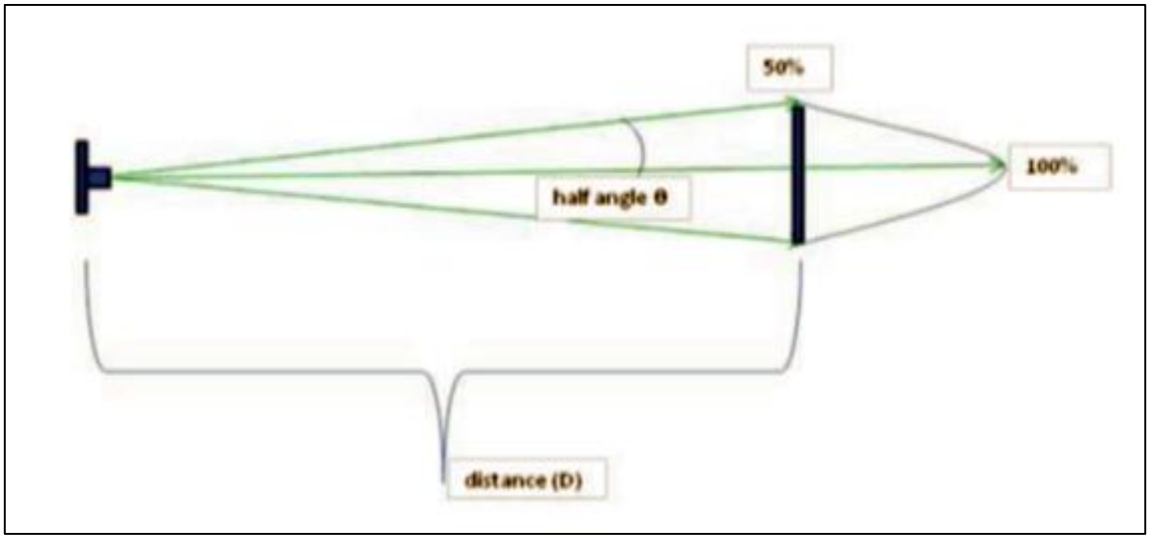


Figure 2. 8 IR LED Radiant Intensity vs. Half-Angle

Given the distance from the frame to the eye and the height from the frame of the glasses to the center of the lenses (or center of the eyes), figure

2.9 shows how the infrared LED will shine light on the eye. For ideal use of the infrared LED, the half angle should cover the entire eye. , the half angle can be calculated using basic trigonometry as per Equation (1).

$$\theta = tan^{-1}({}^{WC}/_{D}) \qquad (1)$$

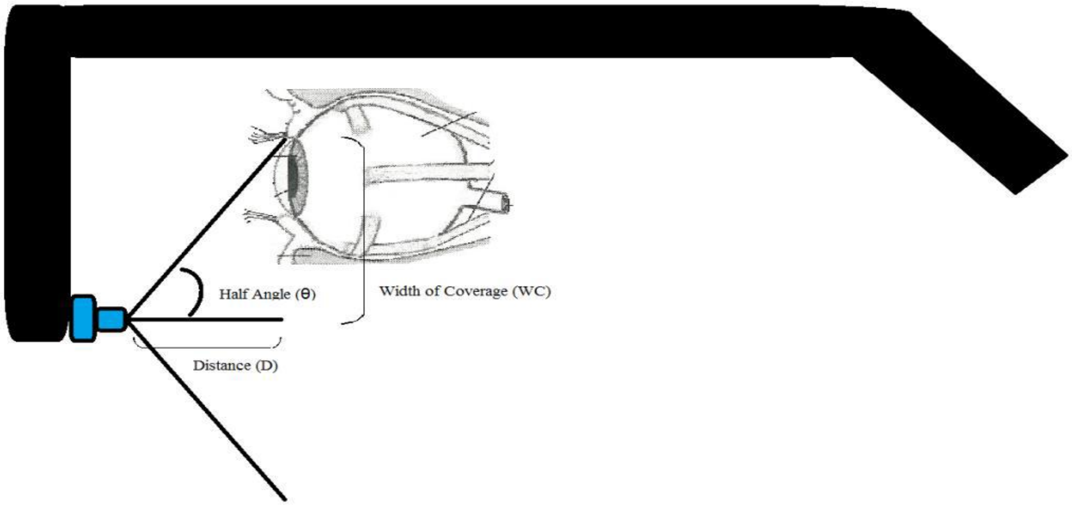


Figure 2. 9 Infrared LED Emission on the Eye

With approximate values of 1 cm for the distance and 1.18 cm for the Width of Coverage, the Half Angle θ would be calculated to be around 50°.

Another important consideration in choosing the IR LED's radiant intensity is to know the minimum irradiance level needed at the sensor. Radiant intensity is the measurement of radiant flux per unity solid angle from a point light source and is expressed in watts per steradian. It is equivalent to power density, in the sense of measuring the amount of power in a given area.

Since the OSRAM SFH 4056 is one of the few IR LEDs that is small in size and can handle the Si1143's max current drive setting, this IR LED was chosen.

## 2.7 ATmega 16 Microcontroller

The ATmega16 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega16 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed.

ATmega16 has 16 KB programmable flash memory, static RAM of 1 KB and EEPROM of 512 Bytes. The endurance cycle of flash memory and EEPROM is 10,000 and 100,000, respectively.

ATmega16 is a 40 pin microcontroller. There are 32 I/O (input/output) lines which are divided into four 8-bit ports designated as PORTA, PORTB, PORTC and PORTD.

ATmega16 has various in-built peripherals like USART, ADC, Analog Comparator, SPI, JTAG etc. Each I/O pin has an alternative task related to in-built peripherals. Refer to appendix B to show the pin description of ATmega16.

ATmega16 microcontroller is preferred because the presence of an inbuilt ADC circuit in the IC makes the circuit simpler, see figure 2.10. This device is extremely cost-effective as well as efficient.

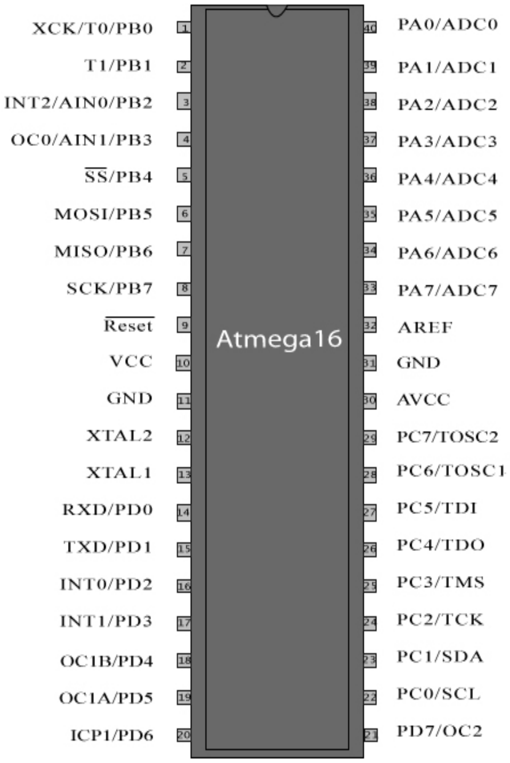


Figure 2. 10 Scheme of ATmega 16 Microcontroller

## 2.8 DC Motor

A direct current or DC motor converts electrical energy into mechanical energy. It is one of two basic types of motors; the other type is the alternating current or AC motor. Among DC motors, there are shunt-wound, series-wound, compound-wound and permanent magnet motors.

A DC motor consists of a stator, an armature, a rotor and a commutator with brushes. Opposite polarity between the two magnetic fields inside the motor cause it to turn, show figure 2.11.

DC motors are the simplest type of motor and are used in household appliances, such as electric razors, and in electric windows in cars.

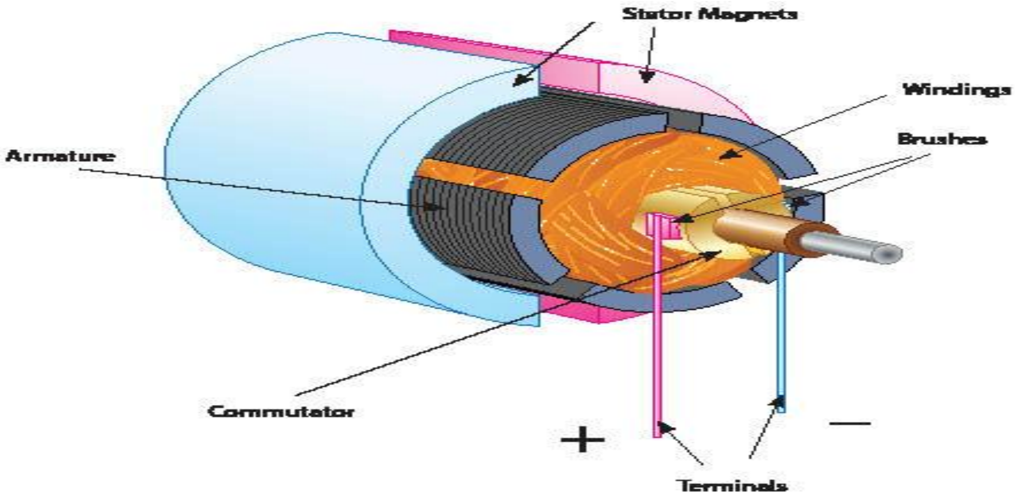


Figure 2. 11 DC Motor Structure

### 2.8.1 Basic DC Motor Operation

A DC motor is equipped with magnets, either permanent magnets or electromagnetic windings, which produce a magnetic field. When current passes through the armature, also known as the coil or wire, placed between the north and south poles of the magnet, the field generated by the armature interacts with the field from the magnet and applies torque. In a DC motor, the magnet forms the stator, the armature is placed on the rotor and a commutator switches the current flow from one coil to the other. The commutator connects the stationary power source to the armature through the use of brushes or conductive rods. Furthermore, DC motors operate at a fixed speed for a fixed voltage and there is no slip.

### 2.8.2 DC Motor Selection

Motors must accelerate loads while overcoming system friction and gravity without overheating. To select the appropriate motor, we must know the main purpose of its use, in our case this will be used to move the chair wheels to carry the person with disability where he wants.

There are two separate issues here. The maximum weight your motor will be able to drive depends on its torque. The rate at which your motor can accelerate the weight depends on its power. The torque of the motor can be increased or decreased by running it through a gearbox, so in principle you could pull as big a weight as you want as long as you use a very low gear (and therefore accelerate the weight slowly).

The rate of pulling is easier to be precise about. If you pull a mass through a distance in a time the power required is:

$$P = \frac{md}{t}$$

Where:

**P** is the power (watt)

**m** is the mass (kN)

**d** distance (m)

**t** time (sec)

Or putting it another way, if you pull the mass at a velocity **v** the power is:

$$P = mv$$

(Because v = d/t).

So to take an example of a 200kg weight, to pull this at a speed of 0.2 m/s would require a power:

$$P = \frac{200}{101.971621} \times 0.2 \cong 400\ kW$$

Where: 1 kilo-Newton = 101.971621 kilograms-force.

Once I have decided how much power the motor must put out, I face the torque/speed tradeoff. By figuring out what torque/speed I need at the wheels, but that will usually be much too slow and too high torque for a reasonable motor to produce directly. As a result, there will be some gearing between the wheel shaft and the motor shaft. Since gearing is in there anyway, we have to pick a good motor and then design the gear ratio accordingly, not the other way around, and the gearing will likely be custom designed anyway.

## 2.9 L293D Motor Driver

L293D is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal. This higher current signal is used to drive the motors.

L293D contains two inbuilt H-bridge driver circuits. In its common mode of operation, two DC motors can be driven simultaneously, both in forward and reverse direction. The motor operations of two motors can be controlled by input logic at pins 2 & 7 and 10 & 15. Input logic 00 or 11 will stop the corresponding motor. Logic 01 and 10 will rotate it in clockwise and anticlockwise directions, respectively.

Enable pins 1 and 9 (corresponding to the two motors) must be high for motors to start operating. When an enable input is high, the associated driver gets enabled. As a result, the outputs become active and work in phase with their inputs. Similarly, when the enable input is low, that driver is disabled, and their outputs are off and in the high-impedance state.

Since DC motors require more current than the microcontroller pin can generate, we use this motor drivers as current amplifiers. L293D is a 16 pin microcontroller which allows DC motors to rotate in either direction. The maximum voltage supply is 36 volts.

Figure 2.12 shown the scheme of the motor driver the input pins receive control signal from the microcontroller and depends on the truth table illustrated in table 2.2 the DC motors rotates.

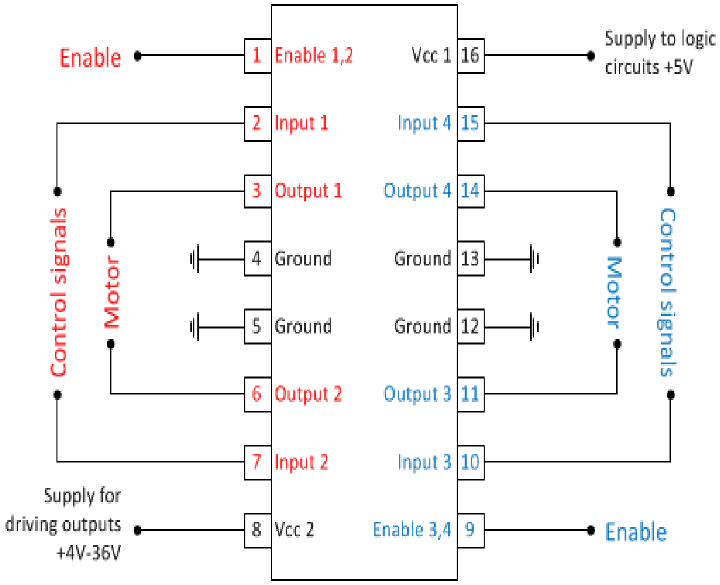


Figure 2. 12 Scheme of Motor Driver L293D

Table 2. 2 DC Motor Control Using L293D Motor Driver

| **Input** | | | | **Output** | |
|---|---|---|---|---|---|
| **Input 1** | **Input 2** | **Input 3** | **Input 4** | **Left Motor** | **Right Motor** |
| 0 | 1 | 0 | 1 | On Forward | On Forward |
| 0 | 0 | 0 | 1 | Off | On Forward |
| 0 | 1 | 0 | 0 | On Forward | Off |
| 1 | 0 | 0 | 1 | On Reserved | On Forward |
| 0 | 1 | 1 | 0 | On Forward | On Reserved |
| 1 | 0 | 1 | 0 | On Reserved | On Reserved |
| 0 | 0 | 0 | 0 | Off | Off |

## 2.10 Related Works

Patients who have extremely restriction in term of mobility have a certain ways of controlling wheelchairs movement. Out of all the methodologies, HMI is most effective technique.

In user interface systems both bio-signals and non-bio-signals are used as a medium of control.

The bio-signal based approach is used for completely paralyzed patients who can only use their bio-signals as the only resource to control. There are several methods of using biological signals such as using brain signal by Electroencephalography (EEG), muscle signal by Electromyography (EMG) and eye muscle by using Electrooculography (EOG). The bio signal waveform of EEG, EOG and EMG are gathered using electrodes, amplified and filtered before it can be processed, to classify the mode operation of the signal of the wheelchair, signal processing tools and training tools are used. The processing signal will be feed to the electrical wheelchair an again through the microcontroller and motor driver. The bio signal based devices require more training for patients and provide less accuracy than non-bio-signals based devices which provide high accuracy.[13]

Non-bio-signal based techniques which make use of joystick control, sip-n-puff control, Voice recognition, eye movement tracking.

The joystick based control navigation is a method uses joystick as an interface between the user and the wheelchair. To be able to use this, the user must have some motor skills to operate the joystick. So this wheelchair can be of great benefit for a paraplegic person i.e., a person with disability only in hind limbs or region lower to hip. But a person with complete disability to move his limbs can't use joystick wheelchairs.[14, 15]

The sip and puff systems is a method of sending signals to a device using air pressure. The signals are converted by “sipping”, or inhaling and “puffing”, or exhaling into a tube. Sharp sips and puffs can be used to change the speed and direction of the wheelchair. Steering is accomplished by lower-level sips and puffs. In this system the patient does not need to produce accurate and tiring driving motions and makes the individual feel independent. The main problem with this mode of control is the range in breathing capability across the spectrum of consumers. The system is calibrated to respond to hard and soft puffs and sips and for individuals that have problems controlling their breathing, achieving the hard puffs or sips with consistency can be difficult.[16]

The voice recognition system is employed to the wheelchair control system for triggering and controlling all its movements integrates a microcontroller, microphone, voice recognition processor, motor control interface board to move it. The users simply speaking to the wheelchair microphone. The spoken words are linked to the voice recognition processor to detect word spoken and then determine the corresponding output command to drive the left and right motors. In order to recognize the spoken words, the voice recognition processor must be trained with the word spoken out by the user who is going to operate the wheelchair. The main problem with this method is that many people have difficulty with speech recognition software in general, because speech recognition varies due to many reasons including accent, volume, speed, pronunciation, articulation, roughness, nasality and pitch, and. Furthermore, speech is distorted by a background noise, echoes, and electrical characteristics that cannot always be recognized and filtered out by the system.[17, 18]

In human eye controlled navigation technique, usually webcams are used to read the human eye, to detect its movements and to control the wheelchair. The camera based eye tracking methods for wheelchairs are based on image processing techniques thus it is not only tedious to work with images but also it is very costly. One of the major disadvantages of this system is the camera will not work in night. [19, 20]

The potential and efficiency of previously developed systems that mentioned above found to be inconvenient as they served either limited usability or non-affordability. After multiple regression analyses, the proposed design will be designed as a cost effective system where the patients can move their wheelchair freely, without any third party's help or support.

# CHAPTER THREE

# METHODOLOGY

# Chapter Three

# Methodology

## 3.1 System Design

As shown in Figure 3.1, the system consists of three major modules first one is the infrared sensors/emitters, second one is the control module and third one is the motor driver. The sensors will sense the infrared radiation that reflected from the iris and sclera and send values to the control module. Control module converts analog data into digital, defines these values and send the appropriate signals to the motor driver. The flow chart in figure 3.2 shows an overview of the control process.

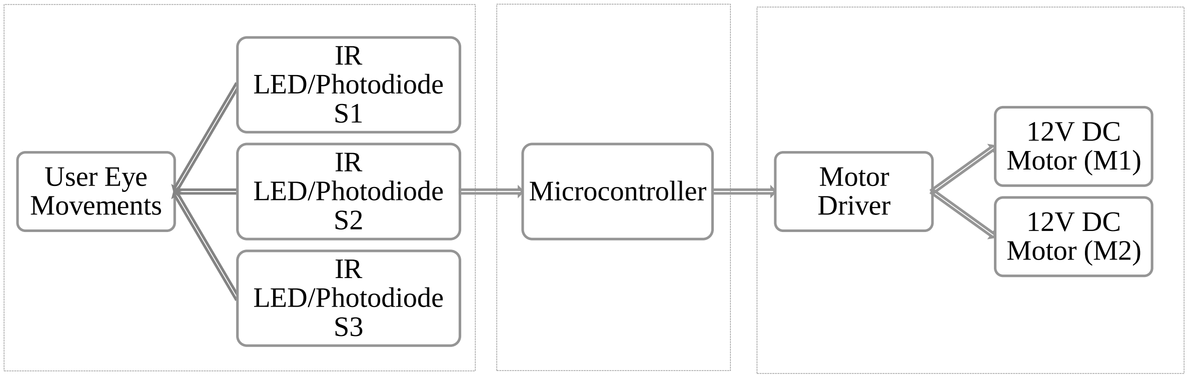


Figure 3. 1 Block Diagram of the Proposed Model

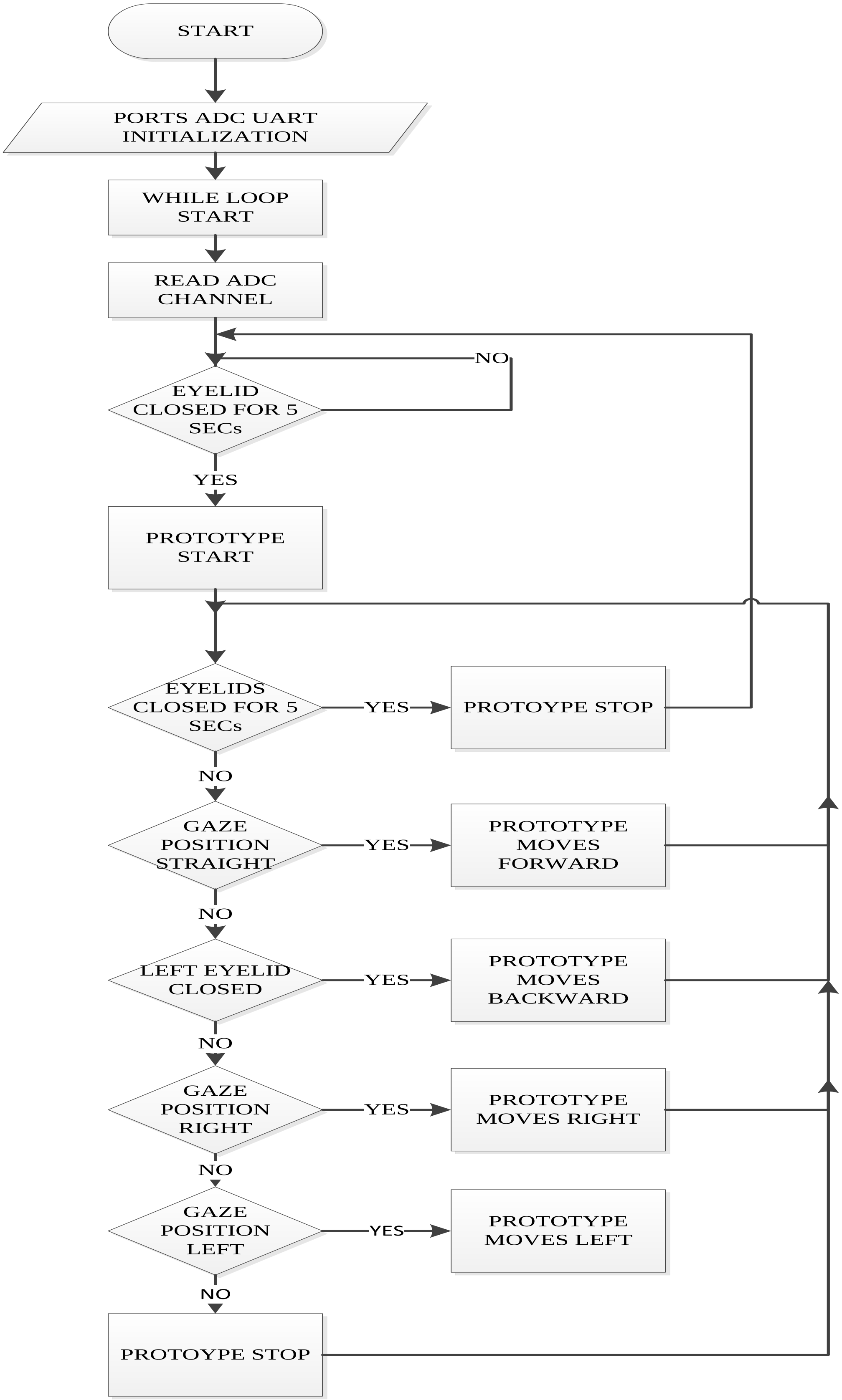


Figure 3. 2 An Overview of the System Control Process

## 3.2 IR Sensors Module

In this proposed design, an eye mounted frame has been developed as shown in Figure 3.3.

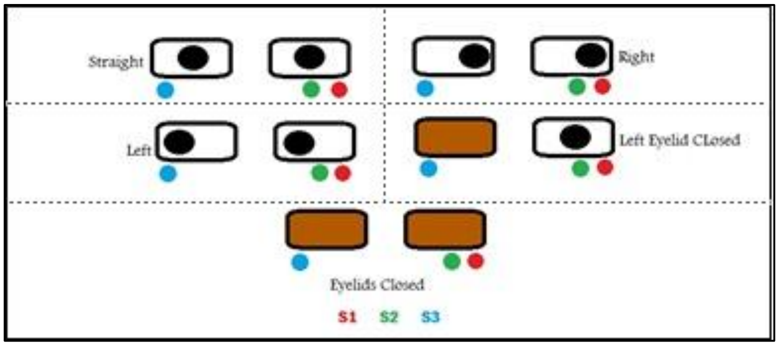


Figure 3. 3 IR Module Positioning on the Frame

Three of IR LED/sensor pairs (OSRAM SFH 4056/Sill43) have been drilled into the frame. IR LEDs modules emit a continuous beam of IR rays. Whenever the sclera comes in front of the receiver (Sill43), these rays are reflected back and captured. When faced with the iris most of the IR rays are absorbed by the surface and very low light intensity captured. A user has to look extreme left and extreme right to enable the wheelchair motion in either direction. When the gaze of the user is straight, the motion of the wheelchair is forward. Closing of the eyelids for a span of five seconds has been used to initiate and stop motion alternately. And closing the left eyelid has been used to rotate the wheelchair backward. By using a timer delay of 5 seconds it has been ensured that the normal blinking of a user (12-13 times in a minute) doesn't interfere with the working of the program as the average blink time is 0.3 to 0.4 seconds. The reflected signal is largest when it reflected from sclera, smallest when it reflected from iris and medium when it reflected from closed eyes, the following chart (figure 3.4) represents the reflected light intensity (voltages level) of the sensors. The signals after being received by the IR sensors are then fed to the Atmega-16 microcontroller.

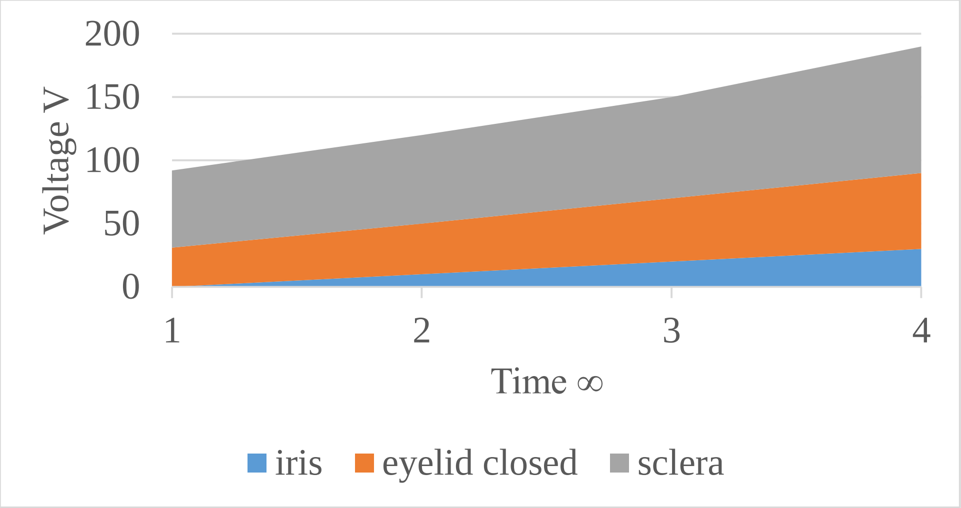


Figure 3. 4Voltage Levels Received By the Sensors

## 3.3 Control Module

Microcontroller has three phases:

1. Reading: the microcontroller reads the input values from the input ports ($ADC_n$).
2. Recognition: the microcontroller recognizes the input values from the stored program to know which action should be taken.
3. Action: the microcontroller takes actions by sending signals to the output ports ($PD_n$).

Here sensors are connected to Port A in the microcontroller and this port is configured as ADC; $S_1$ is connected to $ADC_0$, $S_2$ to $ADC_1$, and $S_3$ to $ADC_2$. The motor driver is connected to Port D, $PD_2$ and $PD_3$ which are linked with Channel 1 in the motor driver, and $PD_4$ and $PD_5$ with Channel 2.

The raw signals are picked by three IR sensor modules, $S_1$, $S_2$ and $S_3$. These signals are amplified and then sent to the ADC channels of ATmega16 where they get converted to digital form.

The microcontroller is programmed using BASIC Language (see Appendix A) to perform the control tasks after reading the voltage levels of the three signals that has been received from the sensors, the program has been stored in the program memory. The output values are sent to the motor driver.

## 3.4 Motor Driver Module

Both of the channels of the motor driver have interfaced with the microcontroller as

Channel 1= ($PD_2$ to $IN_{1,}$ $PD_3$ to $IN_2$)

Channel 2 = ($PD_4$ to $IN_3$, $PD_5$ to $IN_4$)

The motor driver receives the control signal from the microcontroller and performs this value to rotate the DC motors.

## 3.5 Circuit Design

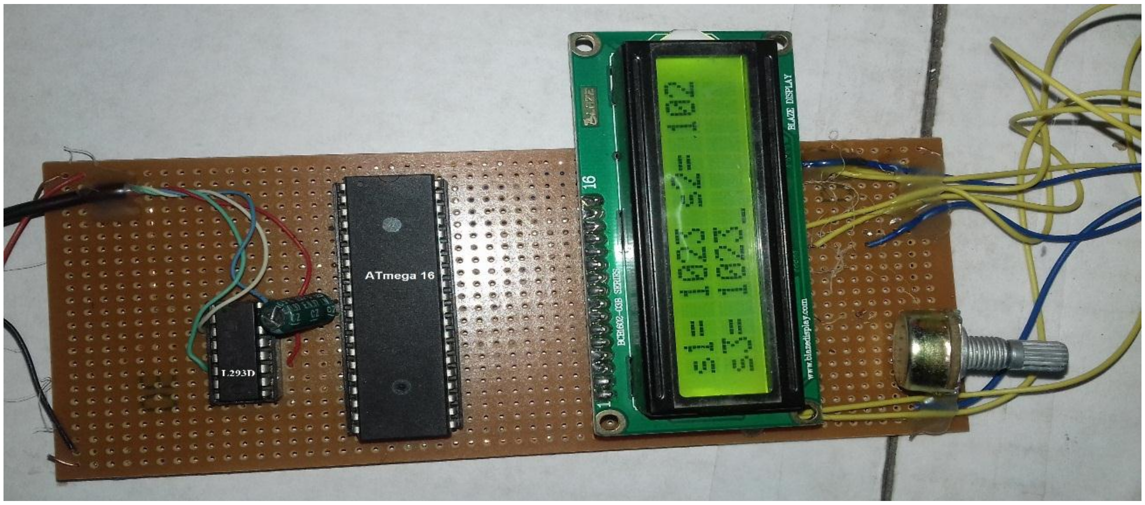


Figure 3. 5Actual Photograph of the Circuit Design

Figure 3. 6  Sensors Positioning on the Frame

The above pictures are photographed from the actual implementation for the system, in figure 3.5 the circuit illustrated the connection of microcontroller (ATmega 16) and the motor driver (L293D), in figure 3.6 the sensors modules are illustrated, $S_1$, $S_3$ are focusing in the middle of the eyes and $S_2$ is focusing to the right edge of the left eye. When the patient looks straight $S_2$ read the reflected light from sclera and $S_1$,$S_3$ read the reflected light from the iris, The sensors are connected to the microcontroller and the microcontroller interfaced to the motor drive which is control the motors of the car. The following figure illustrated the final actual design of the system.

Figure 3. 7Actual Photograph of the Proposed System

# CHAPTER FOUR

# RESULTS AND DISCUSSION

# Chapter Four

# Results and Discussion

## 4.1 System Simulation

To simulate the control circuit I use a virtual system modeling and circuit simulation application (Proteus), we cannot exactly simulate IR sensors in Proteus. but we can make use of switches or variable resistors, to simulate this scenario we have to use the variable resistors that’s because the photodiode has analog output and variable resistors allow us to change the resistance during simulation runtime, so I use 3 variable resistors ($RV_n$) 1KΩ, these VR’s interfaced with the microcontroller to port A which is configured as ADC ports, the microcontroller converts the received signal to digital values, the converted values is segmented to five groups and depends on these values the microcontroller takes actions and send signals to the motor driver. The simulation circuit diagram illustrated in the following figure 4.1

All cases of the received values have been illustrated in more details below.

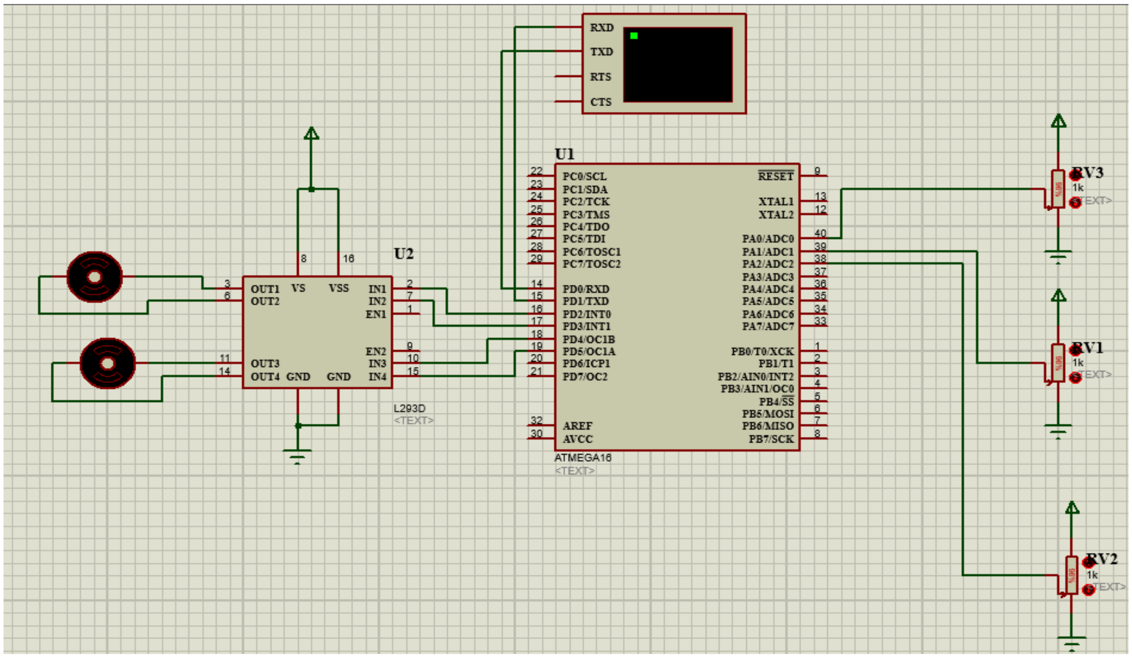
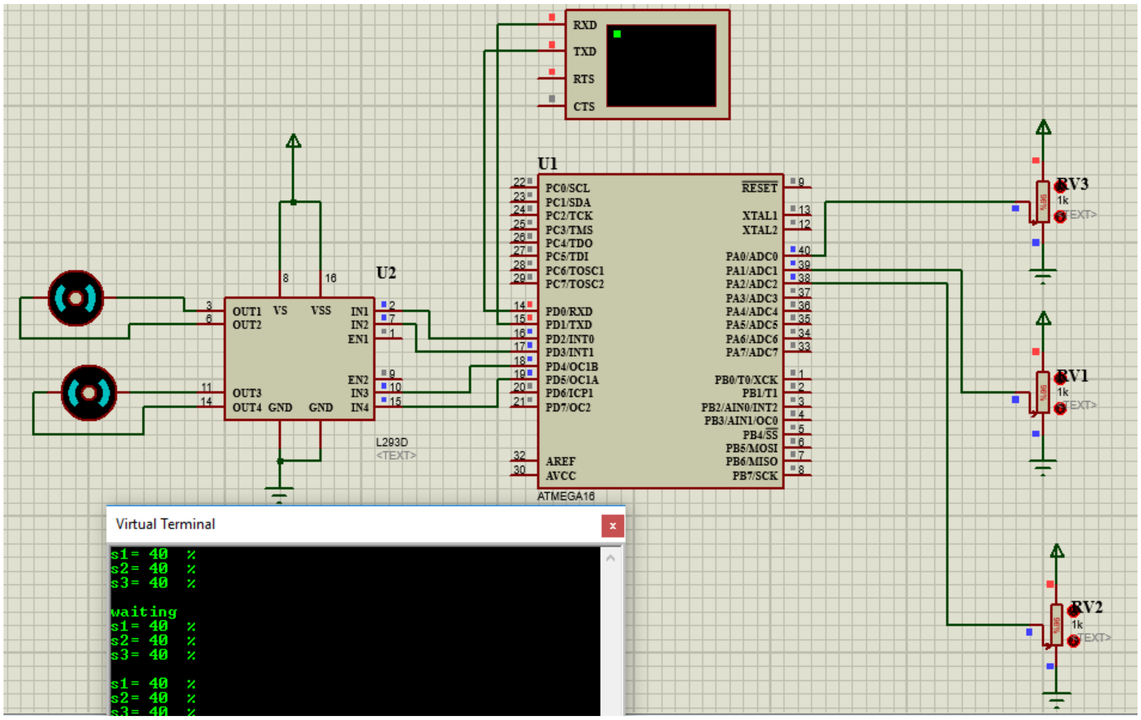


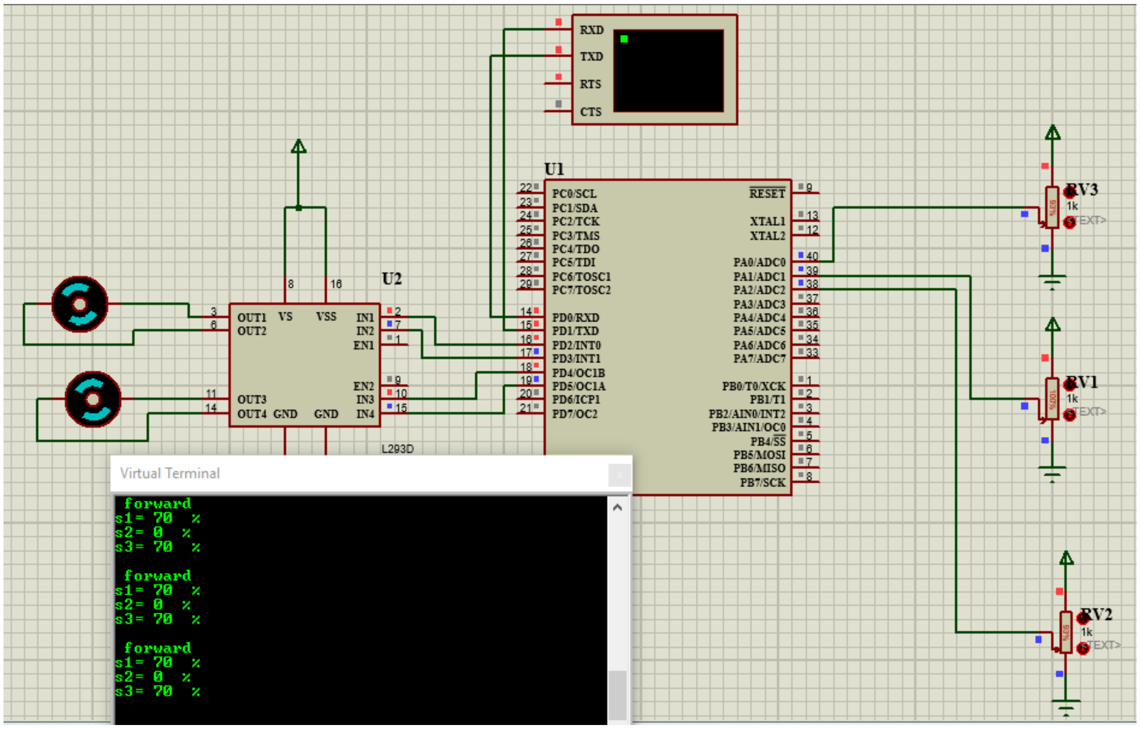
Figure 4. 1Simulation Circuit Diagram



```
s1= 40  %
s2= 40  %
s3= 40  %

waiting
s1= 40  %
s2= 40  %
s3= 40  %

s1= 40  %
s2= 40  %
s3= 40  %
```

Figure 4. 2 Idle Status

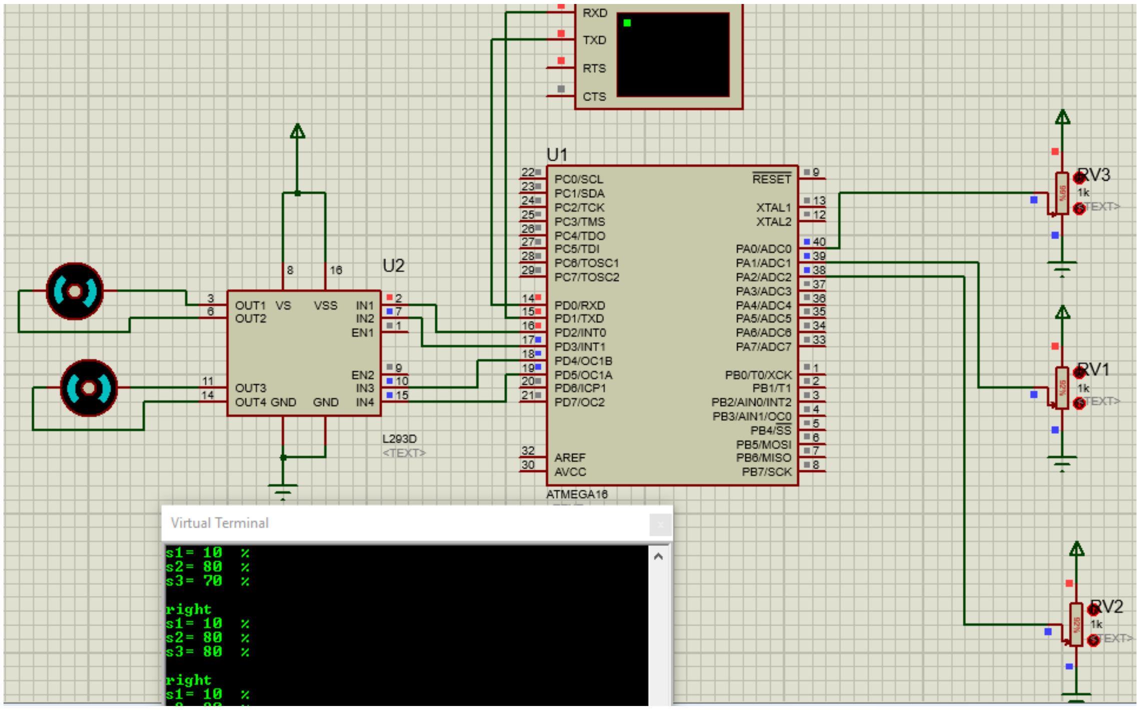
Case 1: Idle status (figure 4.2), ($RV_1$,$RV_2$,$RV_3$= 31~60), the system waiting for changing the inputs (close the eyes for 5sec) to start the movement.



```
forward
s1= 70  %
s2= 0  %
s3= 70  %

forward
s1= 70  %
s2= 0  %
s3= 70  %

forward
s1= 70  %
s2= 0  %
s3= 70  %
```

Figure 4. 3 Forward Status

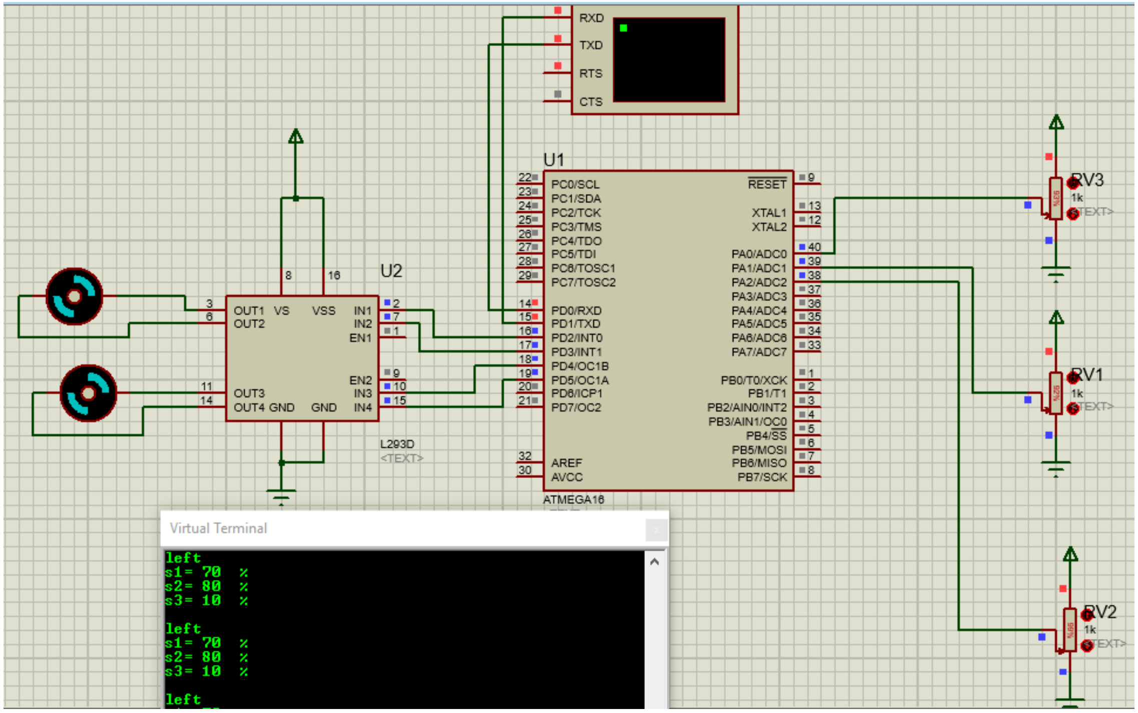
Case 2: Forward Status (figure 4.3), ($RV_1$,$RV_3$= 61~100 and ,$RV_2$= 0~30) when the input signals in this range the microcontroller send signals to the motor driver to move the DC motors forward.



```
s1= 10  %
s2= 80  %
s3= 70  %

right
s1= 10  %
s2= 80  %
s3= 80  %

right
s1= 10  %
```

Figure 4. 4 Right Status

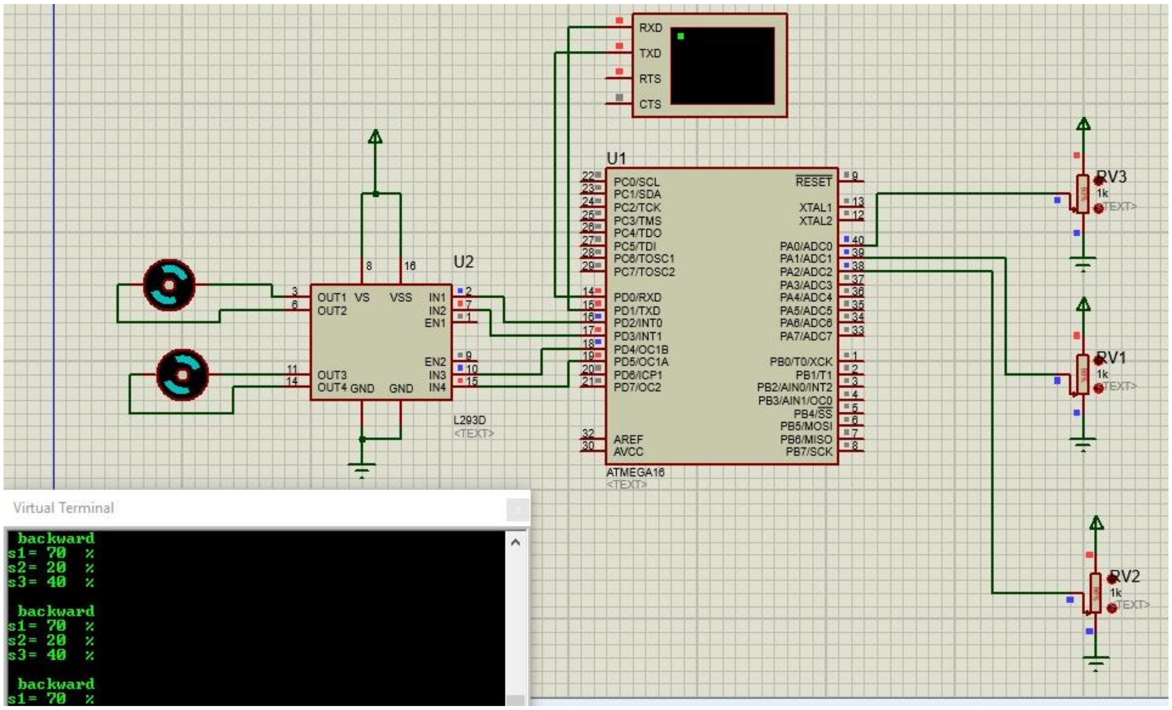
Case 3: Right Status (figure 4.4), ($RV_2$,$RV_3$= 61~100 and ,$RV_1$= 0~30) when the input signals in this range the microcontroller send signals to the motor driver to move the DC motors right.



```
left
s1= 70  %
s2= 80  %
s3= 10  %

left
s1= 70  %
s2= 80  %
s3= 10  %

left
```

Figure 4. 5 Left Status

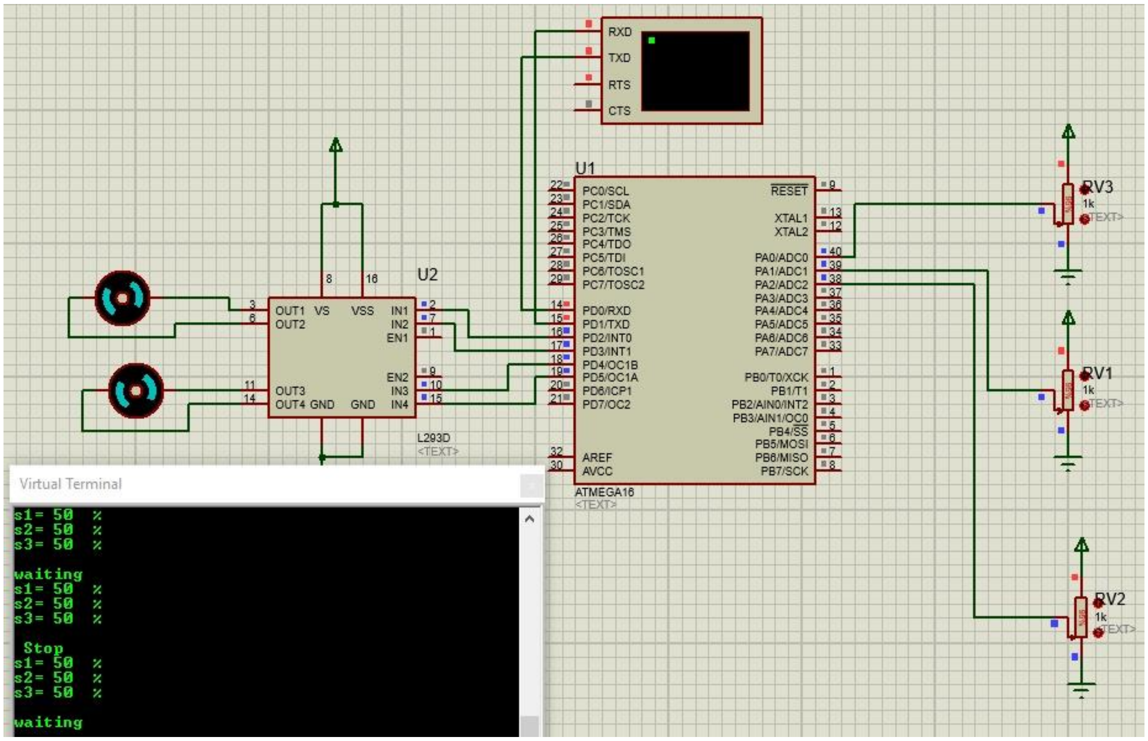
Case 4: Left Status (figure 4.5), ($RV_1$,$RV_2$= 61~100 and ,$RV_3$= 0~30) when the input signals in this range the microcontroller send signals to the motor driver to move the DC motors left.



```
 backward
s1= 70  %
s2= 20  %
s3= 40  %

 backward
s1= 70  %
s2= 20  %
s3= 40  %

 backward
s1= 70  %
```

Figure 4. 6 Backward Status

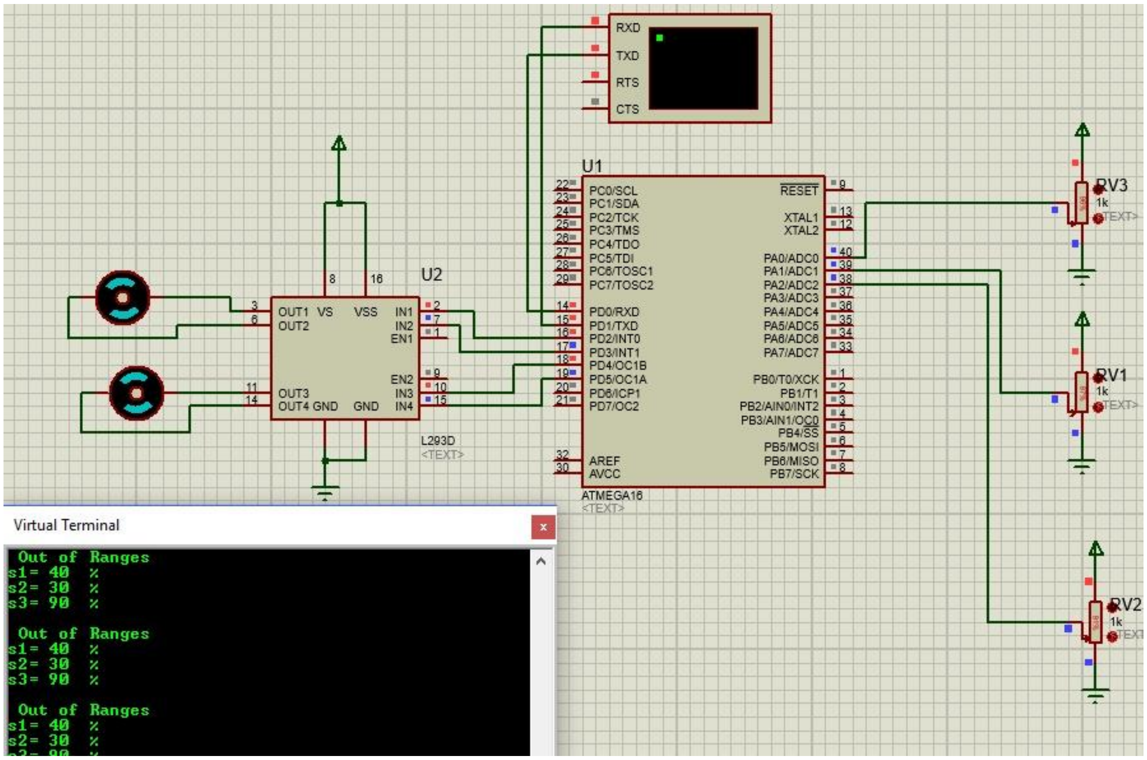
Case 5: Backward Status (figure 4.6), ($RV_1$= 61~100, $RV_2$= 0~30 and, RV3= 31~60) when the input signals in this range the microcontroller send signals to the motor driver to move the DC motors backward.



```
s1= 50  %
s2= 50  %
s3= 50  %

waiting
s1= 50  %
s2= 50  %
s3= 50  %

 Stop
s1= 50  %
s2= 50  %
s3= 50  %

waiting
```

Figure 4. 7 Stop Status

Case 6: Stop Status (figure 4.7), ($RV_1$,$RV_2$,$RV_3$= 31~60) when the input signals in this range the microcontroller send signals to the motor driver to stop the DC motors movement.



```
 Out of Ranges
s1= 40  %
s2= 30  %
s3= 90  %

 Out of Ranges
s1= 40  %
s2= 30  %
s3= 90  %

 Out of Ranges
s1= 40  %
s2= 30  %
```

Figure 4. 8 Out of Ranges Status

Case 7: Out of Ranges Status (figure 4.8), When the input signals are out of all the mentioned ranges  the microcontroller send signals to the motor driver to stop the DC motors.

## 4.2 Hardware Implementation

The sensors output in the idle condition is 1023 which is the highest value, and it reached to 0 in the case of white object recognition. The output signal of the sensors is cached by microcontroller and depends of the received values the microcontroller take an action and send control signal to the motor driver to move the motors. All cases of the received values have been illustrated in more details below.

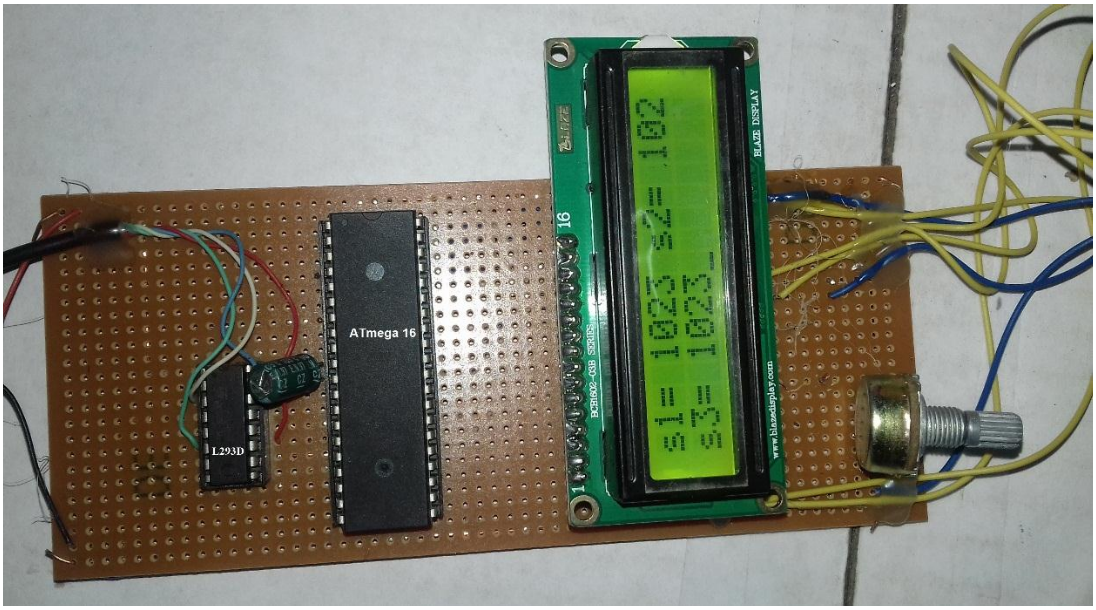


Figure 4. 9 Idle Status - Hardware Implementation

Case 1: Idle status (figure 4.9), ($S_1$, $S_2$, $S_3$= 1023), the system waiting for changing the inputs to start the movement.

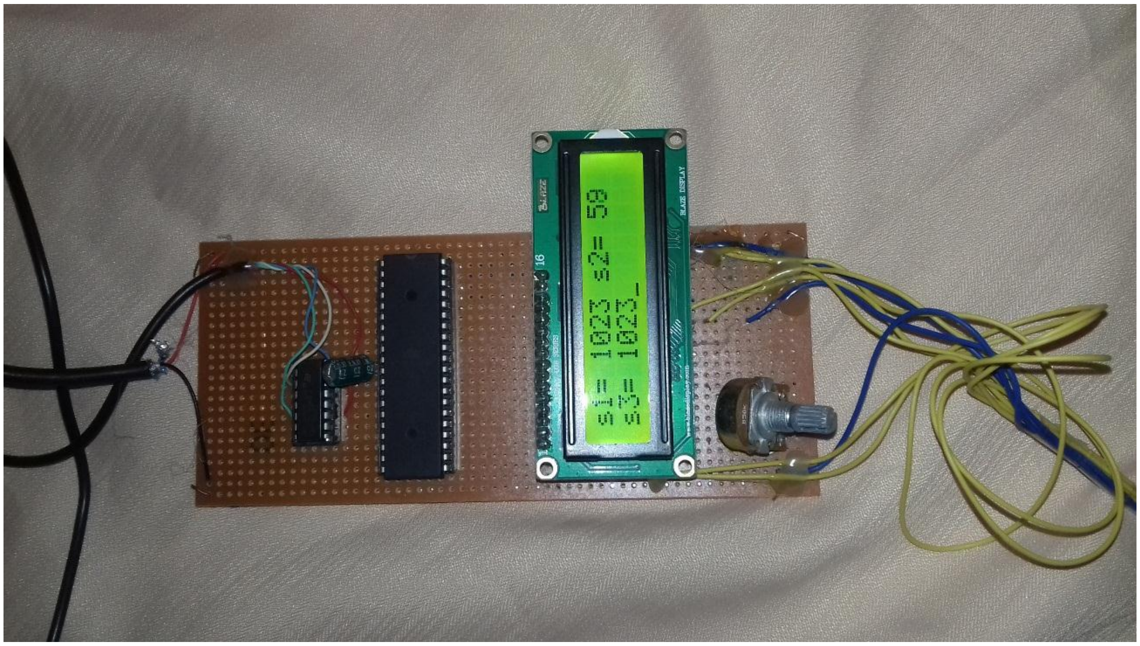


Figure 4. 10 Forward Status -Hardware Implementation

Case 2: Forward Status (figure 4.10), ($S_1$,$S_3$ $\geq$ 500 and ,$S_2$ $\leq$ 70) when the input signals in this range the microcontroller send signals to the motor driver to move the DC motors forward.

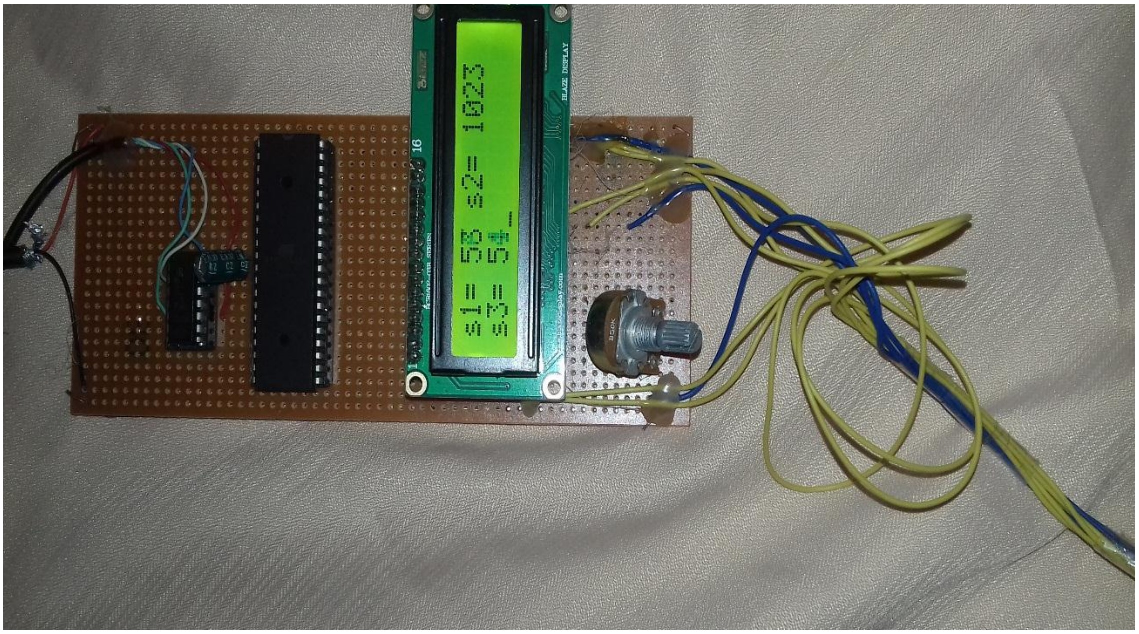


Figure 4. 11 Right Status -Hardware Implementation

Case 3: Right Status (figure 4.11), ($S_1$,$S_3 \leq 70$ and ,$S_2 \geq 500$) when the input signals in this range the microcontroller send signals to the motor driver to move the DC motors right.

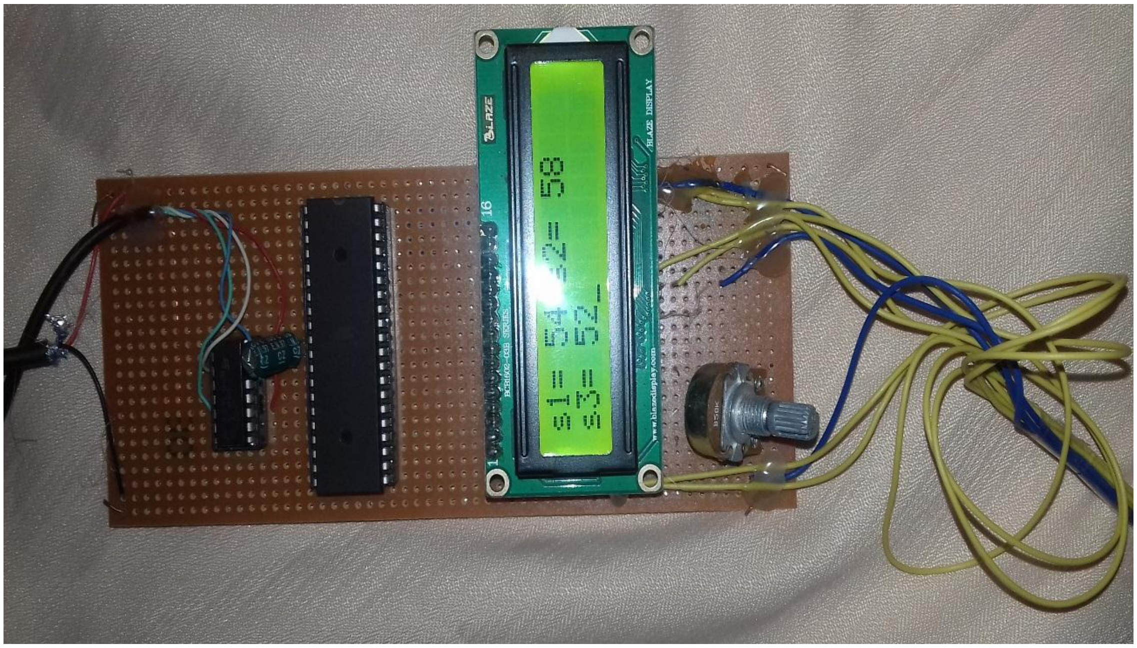


Figure 4. 12 Left Status -Hardware Implementation

Case 4: Left Status (figure 4.12), ($S_1,S_2,S_3 \leq 70$) when the input signals in this range the microcontroller send signals to the motor driver to move the DC motors left.

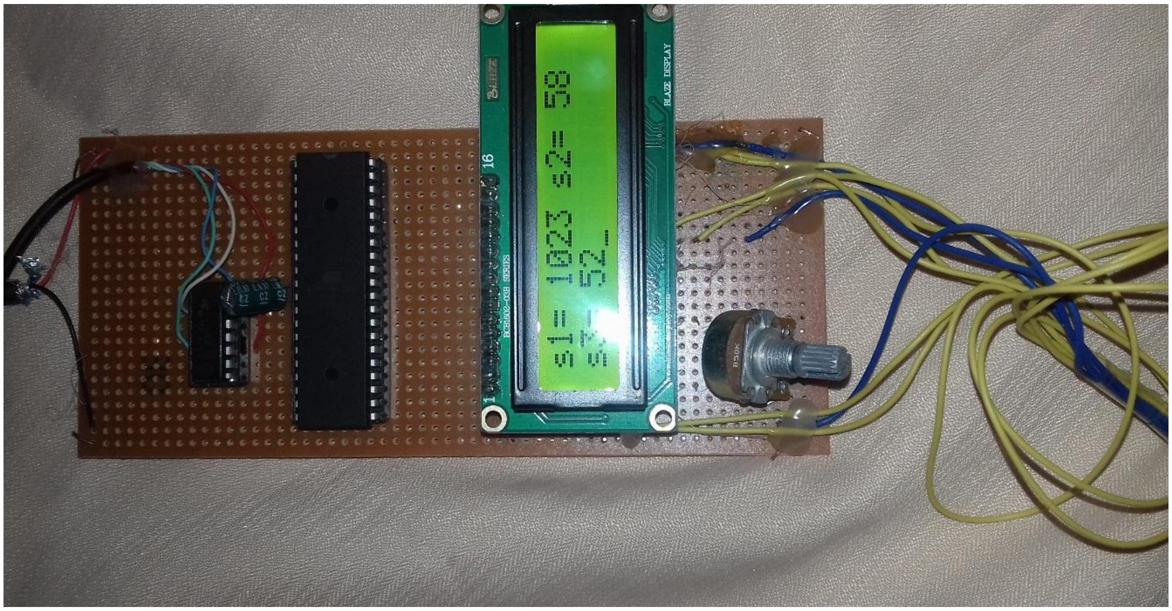


Figure 4. 13 Backward Status -Hardware Implementation

Case 5: Backward Status (figure 4.13), ($S_1 \geq 500$, $S_2$, $S_3 \leq 70$) when the input signals in this range the microcontroller send signals to the motor driver to move the DC motors backward.

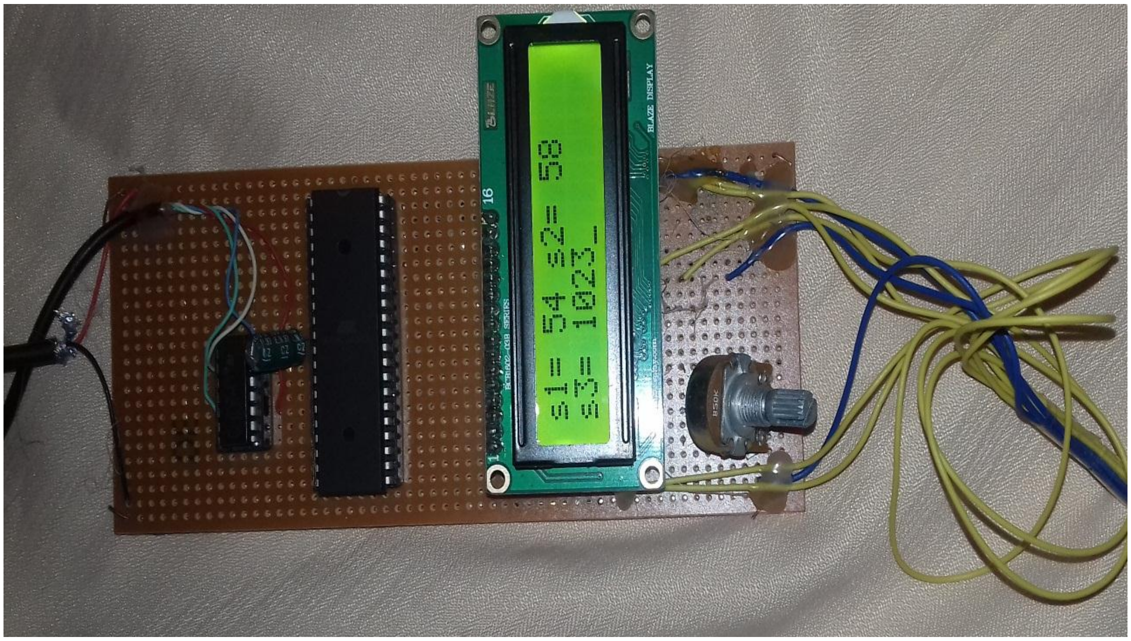


Figure 4. 14 Stop Status -Hardware Implementation

Case 6: Stop Status (figure 4.14), ($S_1$,$S_2$ $\leq$ 70 $S_3$ $\geq$ 500) when the input signals in this range the microcontroller send signals to the motor driver to stop the DC motors movement.

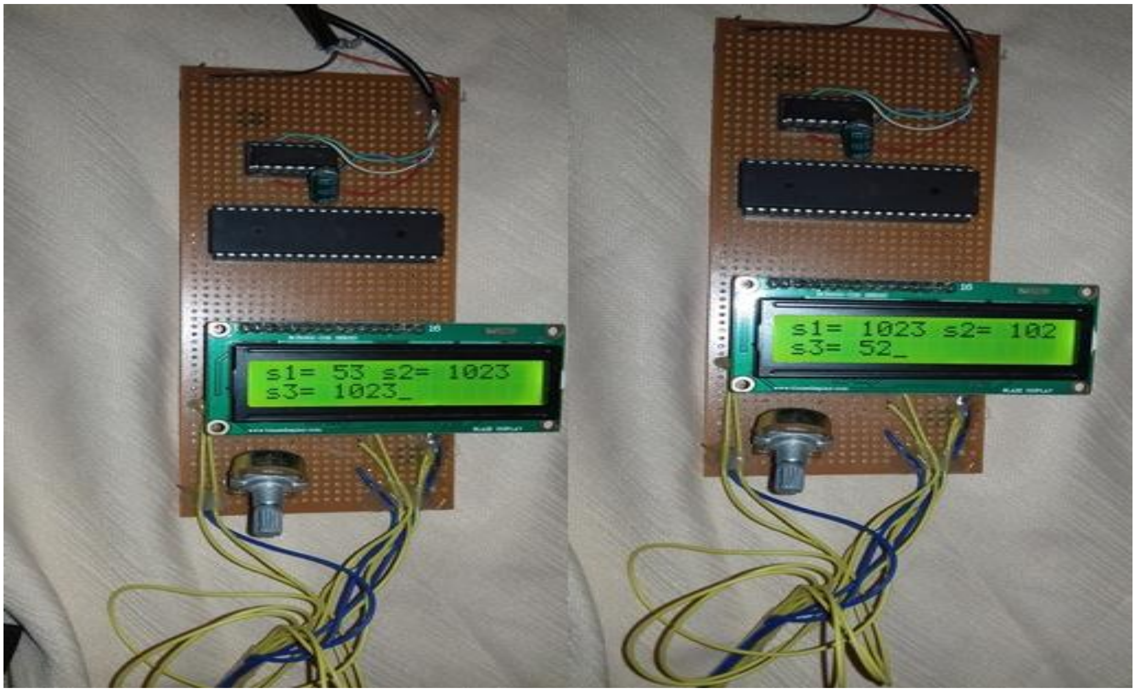


Figure 4. 15 Out of Ranges Status -Hardware Implementation

Case 7: Out of Ranges Status (figure 4.15), When the input signals are out of all the mentioned ranges  the microcontroller send signals to the motor driver to stop the DC motors.

## 4.3 Results and Discussions

The results of the simulation and the hardware implementation will be discussed in this section, I have to refer to the actual implementation for the system where it’s defer from the proposed one, the sensors module that used in the hardware is not the recommended and the proposed one. And that not considered important because the idea is not affected.

The simulation results are summarized in table 4.3. And the hardware results are summarized in table 4.4.

### 4.2.1 Simulation Results

Table 4.1 illustrated the microcontroller phases, reading phase, recognizing phase and the action phase.

Table 4. 1 Microcontroller Phases

| | **Reading** | | | **Recognition** | **Action** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Input (Analog)** | | | **Operation** | **Output (Digital)** | | | |
| | **ADC$_3$** | **ADC$_2$** | **ADC$_1$** | | **PD$_2$** | **PD$_3$** | **PD$_4$** | **PD$_5$** |
| **Voltage Level (V)** | 31~60 | 31~60 | 31~60 | Eyelids Closed for 5 seconds | 0 | 0 | 0 | 0 |
| | 61~100 | 0~30 | 61~100 | Iris Detected in the Middle by S2 | 0 | 1 | 0 | 1 |
| | 61~100 | 61~100 | 0~30 | Iris Detected in the Right by S1 | 0 | 0 | 0 | 1 |
| | 0~30 | 61~100 | 61~100 | Iris Detected in the Left by S3 | 0 | 1 | 0 | 0 |
| | 31~60 | 0~30 | 61~100 | Left Eyelid Closed | 1 | 0 | 1 | 0 |
| | Other | Other | Other | - | 0 | 0 | 0 | 0 |

The control signals that sent from the microcontroller to the motor drive is one of the three pairs; 00, 01 or 10. 00 means the motor driver will not send signals to the motor, 01 means the motor will send a signal to the motor to move forward and 10 means the motor will move backward. If we want the wheelchair moves forward the microcontroller will send 01 signal for both channels, if the move is backward the microcontroller will send 10. To move right the right motor have to be stopped and the left motor moves forward, and to move in the left direction the left motor will be stopped and the right one will move forward as illustrated in the following table (table 4.2).

Table 4. 2 Motor Movements Table

| **Input** | | | | **Output** | | | | **Module Rotation** |
|---|---|---|---|---|---|---|---|---|
| **IN$_4$** | **IN$_3$** | **IN$_2$** | **IN$_1$** | **OUT$_4$** | **OUT$_3$** | **OUT$_2$** | **OUT$_1$** | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Stop |
| 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | Straight |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | Right |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | Left |
| 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | Reversed |

Table 4. 3 Summary of The Simulation Results

| **Voltage Level** | | | **Motor Driver Input** | | | | **Motor Driver Output** | | | | **Operation** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **M2** | | **M1** | | **M2** | | **M1** | | |
| **RV$_3$** | **RV$_2$** | **RV$_1$** | **IN$_4$** | **IN$_3$** | **IN$_2$** | **IN$_1$** | **OUT$_4$** | **OUT$_3$** | **OUT$_2$** | **OUT$_1$** | |
| 31~60 | 31~60 | 31~60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Stop |
| 0~30 | 61~100 | 61~100 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | Left movement |
| 61~100 | 61~100 | 0~30 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | Right movement |
| 61~100 | 0~30 | 61~100 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | Straight movement |
| 31~60 | 31~60 | 31~60 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | Reversed movement |

### 4.2.2 Experimental Results

Table 4.4 illustrated the microcontroller phases, reading phase, recognizing phase and the action phase in the actual implemented design for the system. Table 4.5 summarized the experimental results which illustrated the analog signals received from sensors by the microcontroller, the control signals that sent to the motor driver, and the control signals that sent by the motor driver to the dc motors to move the car in the specified direction.

Table 4. 4 Microcontroller Phases – Hardware Implementation

| | **Reading** | | | **Recognition** | **Action** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Input (Analog)** | | | **Operation** | **Output (Digital)** | | | |
| | **ADC$_3$** | **ADC$_2$** | **ADC$_1$** | | **PD$_2$** | **PD$_3$** | **PD$_4$** | **PD$_5$** |
| **Voltage Level (V)** | 1023 | 1023 | 1023 | Idle status | 0 | 0 | 0 | 0 |
| | $\geq 500$ | $\leq 70$ | $\geq 500$ | Iris Detected in the Middle by $S_1$,$S_3$ | 0 | 1 | 0 | 1 |
| | $\leq 70$ | $\geq 500$ | $\leq 70$ | Iris Detected in the Right by $S_2$ | 0 | 0 | 0 | 1 |
| | $\leq 70$ | $\leq 70$ | $\leq 70$ | Iris Detected in the Left | 0 | 1 | 0 | 0 |
| | $\geq 500$ | $\leq 70$ | $\leq 70$ | Left Eyelid Closed | 1 | 0 | 1 | 0 |
| | Other | Other | Other | - | 0 | 0 | 0 | 0 |

Table 4. 5 Summary of the Experimental Results

| **Voltage Level** | | | **Motor Driver Input** | | | | **Motor Driver Output** | | | | **Operation** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **M2** | | **M1** | | **M2** | | **M1** | | |
| **S$_3$** | **S$_2$** | **S$_1$** | **IN$_3$** | **IN$_2$** | **IN$_1$** | **IN$_0$** | **OUT$_4$** | **OUT$_3$** | **OUT$_2$** | **OUT$_1$** | |
| $\leq 70$ | $\leq 70$ | $\geq 500$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Stop |
| $\leq 70$ | $\leq 70$ | $\leq 70$ | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | Left movement |
| $\leq 70$ | $\geq 500$ | $\leq 70$ | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | Right movement |
| $\geq 500$ | $\leq 70$ | $\geq 500$ | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | Straight movement |
| $\geq 500$ | $\leq 70$ | $\leq 70$ | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | Reversed movement |

ATmega16 has been successfully used to design and test the iris motion controlled wheelchair using IR sensor modules. The outcomes of the variously conducted trials on different persons have been observed and logged to be used in case of future studies. The circuits and control algorithms have been successfully tested using Proteus Professional software. The proposed design is complete and successfully tested.

This system can be implemented in other applications that depend on eye tracking technique once we succeed in eye movement recognition, in games, eye pattern movement lock, cars driving and many other applications.

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATIONS

# Chapter Five
# Conclusion and Recommendations

## 5.1 Conclusion

The system is designed in such a way that it is simple, cost effective and easy to operate so that it aids the physically challenged people. It consists of three IR sensors, microcontroller, motors. The motion of the iris is tracked by the IR sensors. The movement is obtained due to the intensity of the reflected radiation with the help of microcontroller. To make the life of paralytic people independent such a hardware along with the software is a great tool.

However, the drawback with this project is as the wheelchair requires iris movement as input to the controller for its working, a lot of strain is created to the eyes.

## 5.2 Recommendations

To make the system more interact with patient I have to add some additional sensors, in the real time application I can add long range ultrasonic for the sensing of obstacles in a little far distance.

Systems only based on infrared radiation and iris tracking tend to be inaccurate and sensitive to head movement. I have to address this problem.

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# APPENDICES

# APPENDIX A

## Code of Microcontroller Programming- Simulation

```
' Project       : Design of Eye Gaze Tracking System for Motorized
'                  Wheelchair Control Using IR Sensors
' Program name       : noname4.bas
' Author        : Zubaida
' Date created         : 20170409
' Purpose       : Atmega 16 microcontroller programming to read the sensors
'                 output and send values to the motor driver

     $regfile = "m16def.dat"
     $crystal = 8000000
     $baud = 9600
     Config Com1 = Dummy , Synchrone = 0 , Parity = None , Stopbits = 1 , Databits = 8 , Clockpol = 0

     Config Portd.2 = Output                         'm1
     Config Portd.3 = Output                         'm1

     Config Portd.4 = Output                         'm2
     Config Portd.5 = Output                         'm2
     Config Adc = Single , Prescaler = Auto , Reference = Internal '2,56v
```

```
Dim S1 As Word
Dim Ss1 As Word

Dim S2 As Word
Dim Ss2 As Word

Dim S3 As Word
Dim Ss3 As Word

Do
Start1
Gosub Sensor

If Ss1 >= 30 And Ss1 <= 60 And Ss2 >= 30 And Ss2 <= 60 And Ss3 >= 30 And Ss3 <= 60 Then          'waiting
Portd.2 = 0
Portd.3 = 0

Portd.4 = 0
Portd.5 = 0
Print "waiting           "
Waitms 5000

Gosub C
End If
Loop
```

```
Sensor

S1 = Getadc(0)                          'adc=vin*1024/aref
Ss1 = S1 / 2

S2 = Getadc(1)
Ss2 = S2 / 2

S3 = Getadc(2)
Ss3 = S3 / 2

Print "s1= " ; Ss1 ; "  %"
Print "s2= " ; Ss2 ; "  %"
Print "s3= " ; Ss3 ; "  %"

Print "                          "
Waitms 1000
Return

C
Do
Gosub Sensor

If Ss1 >= 31 And Ss1 <= 60 And Ss2 >= 31 And Ss2 <= 60 And Ss3
>= 31 And Ss3 <= 60 Then      'stop
Portd.2 = 0
```

```
Portd.3 = 0

Portd.4 = 0
Portd.5 = 0
Waitms 1
Gosub Start1

Elseif Ss1 >= 61 And Ss1 <= 100 And Ss2 >= 0 And Ss2 <= 30 And
Ss3 >= 61 And Ss3 <= 100 Then       'forward
Portd.2 = 1
Portd.3 = 0

Portd.4 = 1
Portd.5 = 0

Print "forward"

Waitms 100

Elseif Ss1 >= 61 And Ss1 <= 100 And Ss2 >= 0 And Ss2 <= 30 And
Ss3 >= 31 And Ss3 <= 60 Then       'backward

Portd.2 = 0
Portd.3 = 1

Portd.4 = 0
Portd.5 = 1
```

```
Print " Backward"

Waitms 100

Elseif Ss1 >= 61 And Ss1 <= 100 And Ss2 >= 61 And Ss2 <= 100 And Ss3 >= 0 And Ss3 <= 30 Then       'left
Portd.2 = 0
Portd.3 = 0

Portd.4 = 1
Portd.5 = 0

Print "left"

Waitms 1000
Portd.2 = 0
Portd.3 = 0

Portd.4 = 0
Portd.5 = 0
Waitms 10

Elseif Ss1 >= 0 And Ss1 <= 30 And Ss2 >= 61 And Ss2 <= 100 And Ss3 >= 61 And Ss3 <= 100 Then       'right
Portd.2 = 1
Portd.3 = 0
```

```
Portd.4 = 0
Portd.5 = 0

Print "right"

Waitms 1000
Portd.2 = 0
Portd.3 = 0

Portd.4 = 0
Portd.5 = 0
Waitms 10

Else                    'out of ranges
Portd.2 = 0
Portd.3 = 0

Portd.4 = 0
Portd.5 = 0

Print "Out of Ranges"

End If
Loop
Return
```

# Code of Microcontroller Programming – Hardware Implementation

```
$regfile = "m16def.dat"                    ' specify the used micro
$crystal = 8000000                         ' used crystal frequency

Config Lcd = 16 * 2
Config Lcdpin = Pin , Db4 = Portb.3 , Db5 = Portb.4 , Db6 = Portb.5 , Db7 = Portb.6 , E = Portb.2 , Rs = Portb.0

Config Portd.0 = Output                              'motor
Config Portd.1 = Output                              'motor

Config Portd.2 = Output                              'motor
Config Portd.3 = Output                              'motor

'Config Pina.2 = Input                              'ir2

Config Adc = Single , Prescaler = Auto , Reference = Internal

Dim Ir1 As Word
Dim Ir2 As Word

Dim Ir3 As Word
Dim Ir4 As Word

Dim R As Word
```

```
Dim L As Word

Dim T As Word
Dim Tt As Word

R = 400
L = 400
T = 400
Tt = 400
Start Adc
Do
 Ir1 = Getadc(0)
 Ir2 = Getadc(1)
 Ir3 = Getadc(2)
Cls
 Locate 1 , 1
 Lcd "s1= " ; Ir1 ; " s2= " ; Ir2



 Locate 2 , 1
 Lcd "s3= " ; Ir3

 Waitms 200

 If Ir2 <= 70 And Ir1 >= 500 And Ir3 >= 500 Then
 Gosub Forword
 End If
```

```
 If Ir2 <= 70 And Ir1 <= 70 And Ir3 <= 70 Then
 Gosub Left1
 End If



 If Ir2 >= 500 And Ir1 <= 70 And Ir3 <= 70 Then
 Gosub Right1
 End If

  If Ir2 <= 70 And Ir1 >= 500 And Ir3 <= 70 Then
 Gosub Backword
 End If

 If Ir2 <= 70 And Ir1 <= 70 And Ir3 >= 500 Then
  Gosub Stop1
 End If
Loop

Stop1:



Portd.0 = 0
Portd.1 = 0
```

```
Portd.2 = 0
Portd.3 = 0

Waitms Tt

Return

Forword:


Portd.0 = 1
Portd.1 = 0

Portd.2 = 0
Portd.3 = 1

Waitms T

Portd.0 = 0
Portd.1 = 0

Portd.2 = 0
Portd.3 = 0

Waitms Tt

Return
```

```
Backword:

Portd.0 = 0
Portd.1 = 1

Portd.2 = 1
Portd.3 = 0

Waitms T
Portd.0 = 0
Portd.1 = 0

Portd.2 = 0
Portd.3 = 0

Waitms Tt
Return

Right1:


Portd.0 = 1
Portd.1 = 0

Portd.2 = 0
Portd.3 = 0
```

```
Waitms R
Portd.0 = 0
Portd.1 = 0

Portd.2 = 0
Portd.3 = 0

Waitms Tt


Return

Left1:


Portd.0 = 0
Portd.1 = 0

Portd.2 = 0
Portd.3 = 1

Waitms L
Portd.0 = 0
Portd.1 = 0

Portd.2 = 0
```

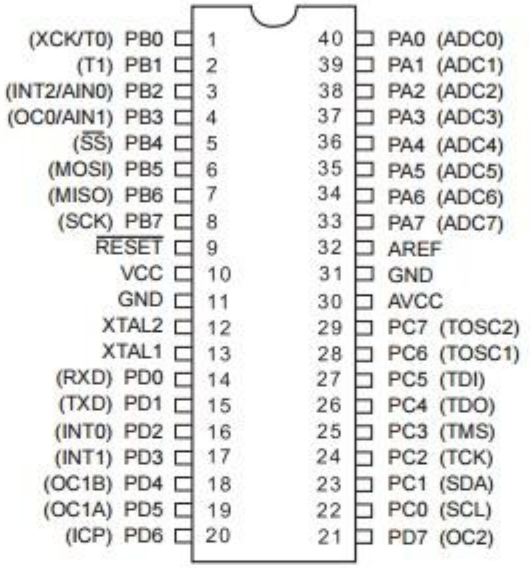
```
Portd.3 = 0

Waitms Tt
Return
```

# APPENDIX B

## ATmega16 Microcontroller Datasheet

ATmega16 8-bit Microcontroller with 16K Bytes in-System Programmable Flash



### Pin Descriptions

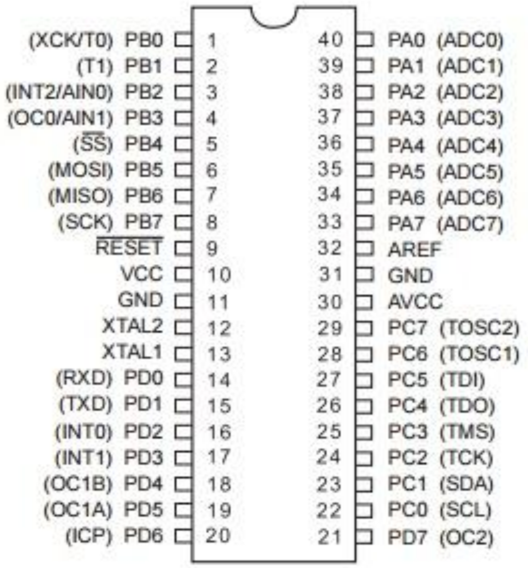
| | |
|---|---|
| VCC | Digital supply voltage. |
| GND | Ground. |
| Port A (PA7..PA0) | Port A serves as the analog inputs to the A/D Converter. Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins |

| | |
|---|---|
| | are tri-stated when a reset condition becomes active, even if the clock is not running. |
| Port B (PB7..PB0) | Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. |
| Port C (PC7..PC0) | Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PC5(TDI), PC3(TMS) and PC2(TCK) will be activated even if a reset occurs |
| Port D (PD7..PD0) | Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not |

| | |
|---|---|
| | running. |
| RESET | Reset Input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The minimum pulse length is given in Table 15 on page 36. Shorter pulses are not guaranteed to generate a reset. |
| XTAL1 | Input to the inverting Oscillator amplifier and input to the internal clock operating circuit. |
| XTAL2 | Output from the inverting Oscillator amplifier. |
| AVCC | AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter. |
| AREF | AREF is the analog reference pin for the A/D Converter. |

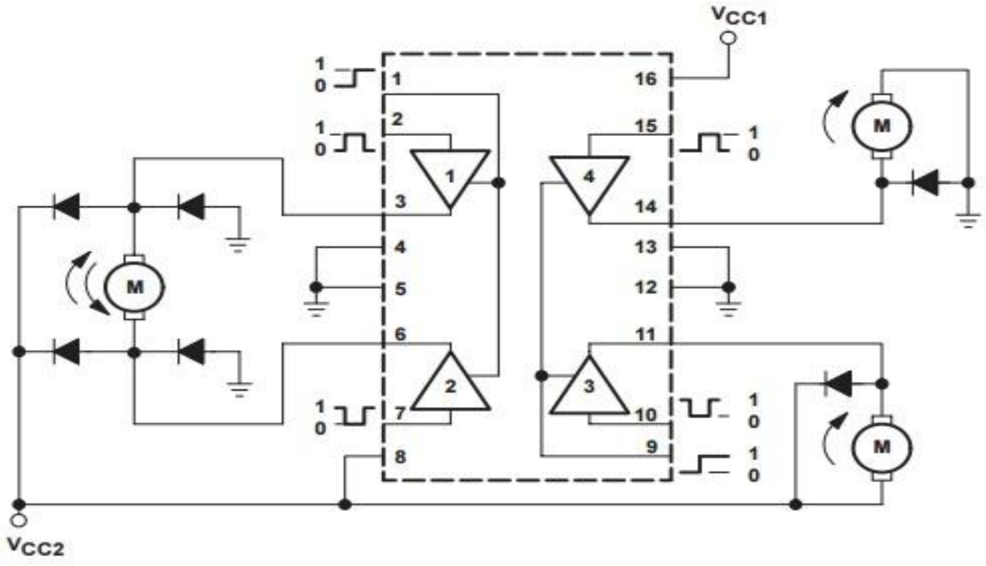
# APPENDIX C

## L293D Quadruple Half-H Driver



- Featuring Unitrode L293 and L293DProducts Now From Texas Instruments
- Wide Supply-Voltage Range: 4.5 V to 36 V
- Separate Input-Logic Supply
- Internal ESD Protection
- Thermal Shutdown
- High-Noise-Immunity Inputs
- Functionally Similar to SGS L293 and SGS L293D
- Output Current 1 A Per Channel (600 mA for L293D)
- Peak Output Current 2 A Per Channel (1.2 A for L293D)
- Output Clamp Diodes for Inductive
- Transient Suppression (L293D)

### Block Diagram



**Pin Descriptions**

| Pin No | Function | Name |
|---|---|---|
| 1 | Enable pin for Motor 1; active high | Enable 1,2 |
| 2 | Input 1 for Motor 1 | Input 1 |
| 3 | Output 1 for Motor 1 | Output 1 |
| 4 | Ground (0V) | Ground |
| 5 | Ground (0V) | Ground |
| 6 | Output 2 for Motor 1 | Output 2 |
| 7 | Input 2 for Motor 1 | Input 2 |
| 8 | Supply voltage for Motors; 9-12V (up to 36V) | Vcc $_2$ |
| 9 | Enable pin for Motor 2; active high | Enable 3,4 |
| 10 | Input 1 for Motor 1 | Input 3 |
| 11 | Output 1 for Motor 1 | Output 3 |
| 12 | Ground (0V) | Ground |
| 13 | Ground (0V) | Ground |
| 14 | Output 2 for Motor 1 | Output 4 |
| 15 | Input2 for Motor 1 | Input 4 |
| 16 | Supply voltage; 5V (up to 36V) | Vcc $_1$ |