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Wheelchair controller by eye motion using Emotive Epoc neuroheadset

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Abstract

To be fair in a humane society, Handicapped people need to live more normal life as possible as we can.Adjusting to life with a disability can be a difficult transition..It’s possible to overcome the challenges they face and enjoy a full and fulfilling life as there are many ways to improve their indepence and the sense of empowerment.

In this project,we design a wheelchair controller system which is used for reading eye movement of handicapped people with complete disability. The system will be designed to read the movement of the eye using the helmet which allows the chair to move in the right direction.If something wrong for example, he falls, the system sends an alarm to the patient's relatives. The system will also be able to detect obstacles and change it’s direction left or right .

At the end of the project, we did two things. First, the handicapped people will be able to control the movement of their wheelchair safely using the eye movement.Second, the chair will react and move in the required direction.

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Chapter 1

Introduction

1.1 Overview for the project:

There are many kinds of the wheelchair for the handicapped people, which are based on the use of wheelchair buttons to move them. On the other hand, there are many disabilities that make the patient unable to control his four limbs or even move his head . The system will allow these patients to control their wheelchair. Moreover, the helmet which the patient wears, reads the patient's eye movements to control the chair direction . If something wrong , for example, he falls, the system sends an alarm to the patient's relatives. The system will also be able to detect obstacles and change it's movement .

1.2 Description for the project:

The system, has a wheelchair moves in several directions (right, left ,forward and backward), step by step according to the patient's eye movements which the helmet reads.

The system contains three main components. First, the neuroheadset to capture EEG signal from the user's head . The second, a software application to receive the captured EEG signal from the helmet, converts the signal as a command for the third component, which is the microcontroller that controls the motors to move the wheels of the wheelchair in the required direction.

While moving the chair, the system checks for obstacles on its way in order to avoid them or stop completely.

The alarm system checks if there is a movement for the chair happened out of the system control like the user falls .If so , it makes an alarm voice and sends an message to the patient's close relatives.

The system will have several sensors .The first sensor type examines if there is an obstacle on it's way.The second sensor type is used to have a feedback property to ensure that is moving in the correct direction .The last sensor to check the weight on the chair to detect the falling of the user. In other words ,the system will distinguish between the case that the user moves out of the chair or falls on the ground , by detecting the continuous movement of chair while the weight is reduced or reaches zero.

1.3 Motivation:

I hadn't realised the suffering of the handicapped people, until one of my relatives was exposed to Parkinson's disease .It makes him unable to move his hands, speak and even eat. Moving him from place to another requires a great effort . People who suffer from such disabilities need to use the knowledge and skills in order to help them to have an easier and better living among their families. As a graduaters , this is what prompted us to look at such a project seriously and choose it as our graduation project.

1.4 Objectives:

The main goal is the designing a wheelchair system controller using the eye motions , and that leads the following sub objectives :

1-The system will be able to detect the eye movements.

2-The system will translate the eye movements into the correct directions.

3-The chair will be able to move forward , left , right and back.

4-The system will be able to detect the obstacles and avoid them .

5-The system will detect the falling down from the chair and sends alarms accordingly.

1.5 Importance:

The importance of this project lies in several things:

1- It provides service to the handicapped people.

2-It reduces the burden on their families and those who care for them.

3-It enable the handicapped people to live normal life as possible as they can.

1.6 : Problem Statement:

There are many people with special needs in the community , including people who are completely handicapped or people with disabilities that prevent them from moving their limbs. They are a burden to their families , and do not have the freedom to move . They need a solution that enables them to use their wheelchair to move around easily .We're going to do our project to design a wheelchair that works according to the eye movement, just move it in any direction based on the motion system.

1.6.1 Purpose

Wheelchair is important for handicapped people as it may help patients to get out from their isolation and reduces their feeling that they are a burden on other.

1.6.2 Definition:

Wheelchairs are used by people who have disabilities- despite the development they have had by pressing buttons- they cannot help them well. We try to provide a chair that moves based on the movement of their users' eyes, which is a solution for the problem of the movement disabling.

1.6.4 List of requirements :

1. The system will allow the user to move in several directions (right, left, front and back) step-by-step depending on the movements of the patient's eye movement by the helmet.
2. The neuroheadset reads eye movements to determine directions using a helmet.
3. The system will be able to detect and avoid the obstacles.
4. The system is provided with an alarm system to notify the user's relative when something wrong happened.
5. The system checks any movement of the chair outside the control of the system and make the proper notification using the alarm system.

1.6.5 Expected results:

The system is expected to**:**

1. Control the movement of the chair through eye movement
2. Chair will respond and move in the required direction.
3. Chair will be used safely.

1.7 Overview of the rest of report:

The next chapter "background", contains the theoretical background and Literature review, options (design options for hardware components and design options for software components) and design constraints.

The third chapter "design ", includes a detailed conceptual description for the system (HW and SW), detailed design, schematic diagrams, block diagrams, structural diagrams, and any necessary information about the design.

The fourth chapter "system implementation and validation", includes a description of hardware and software implementation ,implementation issues and challanges ,and testing of hardware and the system.

The fifth chapter "system analysis and discussion" ,include analysis and discussion about the result ,and error rate of the system.

The last chapter"conclusion",include summary of the project ,the main challanges was faced during the implementation ,and many ideas for future works of the project will be improved.

Chapter 2

Background

2 .1 Overview

This chapter provides the theoretical background for our project, a brief description of the design options to be used in the system, design specifications and limitations and also some additional information about the system.

2.2 Theoretical background

ALS-or amyotrophic lateral sclerosis, is a progressive neurodegenerative disease that affects nerve cells in the brain and the spinal cord. A-myo-trophic comes from the Greek language. "A" means no. "Myo" refers to muscle, and "Trophic" means nourishment – "No muscle nourishment." When a muscle has no nourishment, it "atrophies" or wastes away. "Lateral" identifies the areas in a person's spinal cord where portions of the nerve cells that signal and control the muscles are located. As this area degenerates, it leads to scarring or hardening ("sclerosis") in the region.[1]

Based on the latest developments in neuro-technology, Emotiv presents a revolutionary personal interface for human-computer interaction. Emotiv EPOC is a high resolution, multi-channel, wireless neuroheadset. The EPOC uses a set of 14 sensors plus 2 references to tune into electric signals produced by the brain to detect the user's thoughts, feelings and expressions in real time. The EPOC connects wirelessly to PCs running Windows, Linux, or MAC OS X.The Facial Expression detection suite uses the signals measured by the EPOC to interpret player facial expressions in real-time. It provides a natural enhancement to game interaction by allowing game characters to come to life. When a user smiles, their avatar can mimic the expression even before they are aware of their own feelings. Artificial intelligence can now respond to users naturally, in ways only humans have been able to until now.[2]

The Epoc headset reads the brain signals by electrodes, then sends those signals to a laptop by USB receiver.

Emotiv EmoEngine is a logical abstraction exposed by the Emotiv API. EmoEngine communicates with the Emotiv neuroheadset, manages userspecific and application-specific settings, and translates the Emotiv detection results into an EmoState.[10]

Detection a high-level concept that refers to the proprietary algorithms running on the neuroheadset and in Emotiv EmoEngine which, working together, recognize a specific type of facial expression, emotion, or mental state. Detections are organized into three different suites: Expressiv, Affectiv, and Cognitiv.[10]

EmoState is a data structure containing information about the current state of all activated Emotiv detections. This data structure is generated by Emotiv EmoEngine and reported to applications that use the Emotiv API.[10]

Emotiv Control Panel is used to explore the Emotiv detection suites.By default, the Control Panel will automatically connect to the EmoEngine when launched. In this mode, it will automatically discover attached USB receivers and Emotiv neuroheadsets.[10] The control panel it takes the clear signals then convert it to asymbols by emokey in the control panel

2.3 Existing Work

There are various projects that serve the handicapped, as the wheelchair model through electricity is in itself considered an aid for the handicapped, and this chair has been developed with other projects.

1.There is a project called a wheelchair that is controlled via the movement of the HEAD-4 TECH, developed by Anis Al-Qudaihi at the University of TUM in Munich 2017, this project was discovering wheelchair-controlled technologies that are controlled through the movement of the head, and this technology uses smart glasses that connect Via a wireless device with the wheelchair to translate the head movement into orders that the chair complies automatically. This project differs from our project where we work on a system that moves the chair in all directions based on eye movement, as the person with complete paralysis cannot also move the head. However, the user can move his eye, so we helped them move freely. Thus, we use a complete system such as the helmet that monitors eye movement. You send the signal, and the system accordingly moves the chair .. As for they moved the chair based on smart glasses that communicate via a wireless device with the wheelchair to translate the movement of the head, it moves accordingly.[6]

2. Wheelchair Makes the Most of Brain Control :

A robotic wheelchair combines brain control with artificial intelligence to make it easier for people to maneuver it using only their thoughts. The approach, known as “shared control,” could help paralyzed people gain new mobility by turning crude brain signals into more complicated commands.

Mind control: PhD student Michele Tavella operates a wheelchair that uses “shared control” to navigate. Brain signals are translated into simple commands like “forward” or “left”; the chair then steers itself around any obstacles.

The wheelchair, developed by researchers at the Federal Institute of Technology in Lausanne, features software that can take a simple command like “go left” and assess the immediate area to figure out how to follow the command without hitting anything. The software can also understand when the driver wants to navigate to a particular object, like a table. Several technologies allow patients to control computers, prosthetics, and other devices using signals captured from nerves, muscles, or the brain. Electroencephalography (EEG) has emerged as a promising way for paralyzed patients to control computers or wheelchairs. A user needs to wear a skullcap and undergo training for a few hours a day over about five days. Patients control the chair simply by imagining they are moving a part of the body. Thinking of moving the left hand tells the chair to turn left, for example. Commands can also be triggered by specific mental tasks, such as arithmetic.[5]

3. A new wireless device has allowed paralyzed people to drive a wheelchair simply by moving their tongues.

In a clinical trial, people with paralysis of all four limbs, a condition known as tetraplegia, effectively used the tongue-drive system to steer a wheelchair through an obstacle course or operate a computer.

"As of now, paralyzed individuals have very limited options," said study leader Maysam Ghovanloo, an electrical engineer at the Georgia Institute of Technology in Atlanta. The device could give people with severe disabilities greater independence and better quality of life, Ghovanloo told LiveScience.

The tongue-drive system consists of a tiny magnet the size of a lentil, which sits in a titanium barbell tongue piercing. A headset containing wireless sensors measures changes in the magnetic field as wearers moves their tongues; the headset then sends these signals to a smartphone, which converts the tongue position into a command to control a computer cursor or driv wheelchair.[4]

Type / Comparison	**Wheelchair that move based on tongue[4]**	**Wheelchair Makes the Most of Brain Control.[5]**	**Wheelchair moving based on the movement of the head.[6]**
The method used	Drive a wheelchair simply by moving their tongue.	Uses brain indicators .	Head movement.
Working principle	Patients control the chair by moving tooth based on a headset containing wireless sensors measures changes in the magnetic field as wearers moves their tongues.	Patients control the chair simply by imagining they are moving a part of the body. Thinking of moving the left hand tells the chair to turn left.	This technology uses smart glasses that connect Via a wireless device with the wheelchair to translate the head movement into orders that the chair complies automatically.
Difficulties	Difficulty moving the tongue if there has been an accident, the need for more accurate sensors.	Distracted thinking during an accident.	Random head movement due to fatigue, aiming for vision, or for normal targets.

Results	The need for another technique or the use of another organ that is more disciplined than the tongue, which may use it in speech and affect its functioning.	The need for more counseling devices, so that another organ can be used and more effective.	The head is a member that contains many other parts, so its use of involuntary matters is very large, so this cannot be used as a main thing to move the chair.
Differences to our system	Patients control the chair by moving tooth based on a headset containing wireless sensors measures changes in the magnetic field ,while the our project patients control the chir by eye movement based on the headset by reading an EEG signal.	Patients control the chair uses brain indicators and control the chair simply by imagining they are moving a part of the body,while the our project patients control the chir by eye movement based on the headset by reading an EEG signal.	Patients control the chair uses smart glasses that connect Via a wireless device with the wheelchair to translate the movement of the head, it moves accordingly, while the our project patients control the chir by eye movement based on the headset by reading an EEG signal.

Table 2.1: Comparison between other projects that used multiple techniques to move the chair

2.4 Design options:

The project contains two types of components, the first one is hardware component Which shows the overall structure of the design . the other one is software component including what we will program to run the project .

2.4.1 Hardware components

1-Components to reading brain signals:

The simplest way to study brain activity is to cover the head with a helmet, cap or headband dotted with flat metal sensors. These sensors can pick up electricity inside the brain. A device that graphs that activity is called an EEG, short for electroencephalograph.[7]

And this table compares 3 different types of headsets that were manufactured by the same company, so that we can choose the right headset for our project to read the brain signal.

Manufacturer	Emotive Epoc Flex	Emotive insight	Emotive Epoc+

Figure			
Brief description	EPOC Flex from Emotiv is a 32-channel EEG headset system with the highest density and flexibility for researchers. It requires a PRO license and allows best quality. The EPOC flex caps are made of EasyCap material with high wearing comfort and have 72 openings.	Emotional mental training: A mobile EEG headset with five channels so that you can train and get to know your brain even better in the shortest possible time.It also recognizes emotions. Incl. free training software. Strong performance in the segment of brain performance training.	High resolution and portable 14 channel EEG system. Quick and easy to install. You can perform measurements in research applications. Free software included. This model was the breakthrough for Emotiv and is performance leader.
Target groups	Research Development Universities Schools Industry	Neurofeedback- Trainer final consumers	Research, Development Universities Schools Industry People with Handicap
Sensors type	Gel or saline	Semi-dry polymer	saline solution soaked felt
Battery Life	Up to 6 hours	Up to 4 hours	Up to 9 hours
Facial Expressions	Not Available	Blink , Wink Left/Right Furrow (frown) RaiseBrow(surprise) Smile ,Clench Teeth (grimace)	Blink, Smile ,Laugh Wink Left/Right Look Left/Right Furrow (frown) Raise Brow (surprise) Clench Teeth
Main Features	Combines the award winning wireless technology of our EPOC+ Headset with the flexibility and high density afforded by more traditional EEG head cap system.	EMOTIV INSIGHT 5-channel mobile EEG boasts advanced electronics that fully optimized to produce clean ,robust signals any time ,anywhere .	Hi-performance wireless gives users total range of motion dongle is USB compatible and requires no custom drivers hours of continuous use.

*Tabel 2.2:*Reading brain signals comparison

Decision :

We chose Emotive Epoc+ to read brain signals ,Because it has advantages compared to others ,as it is high resolution and easy to install and the battery is better.[8]

2- Obstacle avoidance:

There are several sensors that can used , the comparison can be shown in table 2.3:

Type / Comparison	IR sensors	Ultrasonic sensors
Detection distance	2 -30cm	2cm-450cm
Sensor angle	35 degrees	Not more than 15 degrees
Working Voltage	3-5V DC	5V(DC)
The shape		

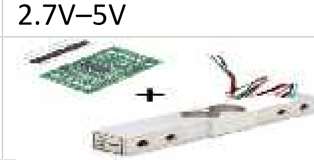
Tabel 2.3:Comparison between IR sensors and Ultrasonic sensors

The chosen sensor:

We choose the Ultrasonic sensor to check obstacles in the patient's path to avoid them and change direction or stop the chair .This sensor is more reliable and accurate ,and cheaper than IR . [9]

3- weight sensor:

There are various sensors that can be used to measure the weight in a wheelchair, the comparison can be shown in table 2.4 :

Type / Comparison	**CHENBO Load Cell Weight Sensor**	**Degraw Load Cell Weight Sensor**
Manufacturing material	Aluminum	Aluminum
maintenance costs	0-5kg .	0-5kg (0-11 lb).
Programming	No programming needed	Use with arduino
Voltage	5-10V DC	2.7V–5V
the shape		

Tabel 2.4:Load Cell comparison

The chosen sensor:

We chose CHENBO Weight Sensor To monitor the weight on the chair, if the weight becomes zero, an alarm must be sent.this sensor is cheaper and easier to use than Degraw.[10]

HX711 module is a Load Cell Amplifier breakout board for the HX711 IC that allows you to easily read load cells to measure weight. This module uses 24 high precision A/D converter chip HX711.

4-Motor Controller:

There are many types of motors that can be used in our project to drive wheels, the comparison is shown in the table 2.5.

Type / Comparison	stepper motor	DC Motor
Brushes	Steppers have no brushes, and are limited only by the life of the bearings.	DC Motors have brushes with a finite lifetime.
Nature of loop	operates in Closed loop	operates in Closed loop
Controlling	Easily controlled with microprocessors	is not easy
Motion and displacement	Its motion is incremental and resolution is limited to the size of the step.	They have continuous displacement and can be controlled accurately.
Response time	Response time is slow	faster response time
Effect of Overloading	Stepper motor can be slipped if overloaded and the error cannot be detected.	If an overload occurs, it can be detected
The shape		

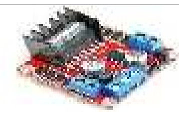
Tabel 2.5: Comparison between Stepper motor and DC motor

Decision :

We chose DC motor , because, faster response time and more accurate compared with stepper motor. [11]

5-Motor Driver :

Motor driver receives signals from the microprocessor and eventually, it transmits the converted signal to the motors.There is several motor driver that can be used in our project , the comparison can be shown in table 2.6 :

Specification	L293N	L298N
		
Voltage	Upto 14 v	Upto 7v -24v
Current	Upto 2A	Upto 2A
Type	Speed Controller	Speed Controller
Compatible Motors	-BO motors -Basic gear motors (for Certain applications)	-BO motors -Basic gear motors (for Certain applications)
Interface	-Micro-Controllers such as Arduino. -Other TTL serial inputs.	-Micro-Controllers such as Arduino. -Other TTL serial inputs.

Tabel 2.6 : Comparison between two types of Motor Drivers

Decision : we choose the L298N Motor Driver because it has a wider range of Voltage.

6-Microcontroller:

Type / **Comparison**	**Raspberry Pi**	**Arduino**
Cost	It is expensive	It is available for low cost.
Storage	Did not have storage on board. It provides an SD card port.	Can provide onboard storage.
battery pack	It is difficult to power using a battery pack.	Arduino can be powered using a battery pack.
I/O pins	20 I/O pins	8 I/O
The shape		

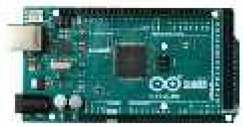
Tabel 2.7: Comparison between Resberry pi and Arduino

Decision :

We chose arduino ,because is less expensive and consumes much less power than raspberry pi.

7- Arduino:

Type / Comparison	**Arduino Mega**	**Arduino UNO**
Microcontroller	ATmega2560	ATmega328.
Operating Voltage	5V	5V

Digital I/O Pins	54 (of which 14 provide PWM output)	14 (of which 6 provide PWM output)
Clock Speed	16 MHz	16 MHz
Analog Input Pins	6	16
The shape		

Tabel 2.8: Comparison between Arduino Mega and Arduino UNO

Decision :

We need 22 pins to connect all the hardware components to the microcontroller . so chose arduino MEGA 8-bit board with 54 digital pins, 16 analog inputs, and 4 serial ports. because it has good proessing speed easy to use and has the largest number of pins that we need in order to connect it to other modules. [12]

7-Buzzer :

Type / Comparison	**Piezo Buzzer**	**Magnetic Buzzer**
Start method	Piezo - electric effect	Electromagnetic effect
Size	Big (10-50mm)	Small (6-25mm)
Resonant Frequency	High (2-6KHz)	low (1-3KHz)
Operating voltage	High (9-24V)	Low (1.5-12V)
Sound level	Louder (85-120dB)	Lower (70-95dB)
Current consumption	Low (5-20mA)	high(35-60mA)

Tabel 2.9 : Comparison between Piezo Buzzer and magnetic Buzzer

Decision :

We chose Piezo Buzzer because it is available in various types and sizes to suit the requirements.

8-Rotary Encoder:

We need the Rotary Encoder to measure the angle of the wheels to know the direction or the linear position of them ,to ensure that wheels are moving. The comparison can be shown in table 2.9 :

Type / Comparison	**Absolute Encoder**	**Incremental Encoder**

Measurement	measure either angular or linear positions of the shaft and convert them into digital or pulse signals	measure either angular or linear positions of the shaft and convert them into digital or pulse signals
Cost Efficiency	costs twice as much as the incremental encoders.	More cost-effective and less complex than an absolute encoder
Complexity	More complex	less complex than an absolute encoder
Degree of measurement	Both sensors can measure one 360 deg. from a starting position.	displacement in turn or across

Tabel 2.10 : Comparison between Absolute Encoder and Incremental Encoder

Decision :

We chose incremental encoder because ,it can measure either angular or linear positions of the shaft and convert them into digital or pulse signals . Incremental encoders are typically simpler to use and cheaper than absolute encoders.And they are good enough for simple pulse counting or frequency monitoring applications such as speed, direction, and position monitoring.

A quadrature encoder is an incremental encoder with 2 out-of-phase output channels used in many general automation applications where sensing the direction of movement is required [14].

9-trackers:

Type / Comparison	**Bluetooth trackers**	**GPS trackers**
Range	Close range	Unlimited range
Price	Less expensive	more expensive
Battery	Low consumption	substantial battery consumption

Tabel 2.11: Comparison between Bluetooth trackers and GPS trackers

Decision :

Although the Bluetooth features seem more, our choice is GPS tracker is ideal for larger, open spaces. It will give you real time information about the item’s exact location.

SIMCom presents an ultra compact and reliable wireless module-SIM900. This is a complete Quad-band GSM/GPRS module in a SMT type and designed with a very powerful single-chip processor integrating AMR926EJ-S core, allowing you to benefit from small dimensions and cost-effective solutions. Featuring an industry-standard interface, the SIM900 delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. With a tiny configuration of 24mm x 24mm x 3 mm, SIM900 can fit almost all the space requirements in your M2M applications, especially for slim and compact demands of design.[3]

2.4.2-Software component:

1-Arduino:

Is a cross platform that is written in the programming language Java. It is used to write and upload programs to the Arduino board. its flexible and easy to use .

2-SDK:

A software development toolkit (SDK) is a set of software tools and programs provided by hardware and software vendors that developers can use to build applications for specific platforms. These providers make their SDKs available to help developers easily integrate their apps with their services.[13]

3-EmoKey:

Tool to translate EmoState into signals that emulate traditional input devices (such as keyboard).[10]

4-Control panel :

"Emotiv Epoc" control panel show cases the capabilities of the "Emotiv Epoc" Neuroheadset to decipher brain signals

The control panel has been divided into three categories: Expressive Suite (facial expression), Affective Suite (subjec- tive emotional responses) and the Cognitive Suite (intentional thoughts). We will only use the: intentional thoughts in our project.

5-EmoEngine:

Communicates with the Emotiv neuroheadset, manages user specific and application-specific settings, and translates the Emotiv detection results into an EmoState.

6-EmoState:

A data structure containing information about the current state of all activated Emotiv detections. This data structure is generated by Emotiv EmoEngine and reported to applications that use the Emotiv API.[10]

7-Alaram Software:

When the weight is suddenly reduce to zero this software sends to the relative a notification.

8-API application :

Written by visual basic language used for sending the key strockes written by emokey software to arduino so it can be as a link between epoc and the wheelchair(contains the microcontroller).

2.5 Design constraints:

1- As the system is a prototype, a doll will be placed on the chair with a predefined weight, so when we picked it up while the chair is moving, the system will assume that the user falls down the chair. Therefore, the chair with an adult on it will have some predefined weight, and the simple motors will not be enough. A user will wear the helmet and moves the prototype of the chair while he is not on it.
2- There should be a specific time interval between each command so as the signals interpreted correctly, and no interferences will occur .

3-Limitaion of ultrasonic sensor:

a- Sensing accuracy affected by soft materials:

Objects covered in a very soft fabric absorb more sound waves making it hard for the sensor to see the target.

b- Not designed for underwater use.

4-The road along it should be smooth and with no slopes, to protect the patient from falling.

5- The system considered all roads are straight and no downhill roads are used.

6- Special places must be provided for the chair to walk on instead of going up the stairs, if these palaces are not available ,the staris are considered as an obastacl and the user can not move forward.

7- For going up and down stairs , Elevators are required .

2.6 Chapter Summary:

In this chapter we talked about previous projects to control a wheelchair in different ways,then we talked about the components of the system (Hardware &Software),and choose the Appropriate components for our project by comparing available components based on quality,price and mechanism, and finally we determined system limitations and problems may faced the user.

Chapter 3
System Design

3.1 Overview:

This chapter discusses the conceptual design of the system, it shows the system requirement analysis, a block diagram of the system, structural diagram, flow chart, detailed design, schematic diagrams.

3.2 Detailed system description:

Epoc reads brain signals then sends to the Emotiv SDK , the signals recieved by the usb recievers attached to the PC where the Emotiv SDk installed .

Then EmoEngine translates the Emotiv detection results into an EmoState . After that EmoKey translates EmoStates into KeyStrokes . API reads these KeyStrokes then send it to Arduino software. Each symbol has a special indication, so we can control the movement of the wheelchair by these different symbols.

According to these symbols , the microcontroller will respond by sending the approbriate command to the motors to move in the requisted direction.

The microcontroller is connected to many sensors for feedback to enhance the effecency of the system .The first sensor type is the Ultrasonic sensor . Ultrasonic uses sound waves (echolocation) to measure how far away the wheelchair is from an object.There will be four sensors , each of them is located in a specific side in the wheelchair (left , right , forward and backward) . If an object has detected in the way , the microcontroller will stop the motors .The second sensor type is the load cell weight sensor .When a sudden decrease in weight to zero occured , the microcontroller will play the buzzer and send an alarm message to the user's relatives (the buzzer and the SIM GPS are connected to the microcontroller).The third type sensor is the quadrature encoder , we use it to measure the angle of the wheels to know the direction or the linear position of them ,to ensure that wheels are moving . We need four encoders , one for each wheel or motor , to know the moving direction of each wheel (forward or backward). According to the speed of each sensor we decide if the chair is moving left , right , forward or backward .If the wheels are not moving in the right direction , then the microcontroller will send a command to the motors to stop , then resend the previous command.

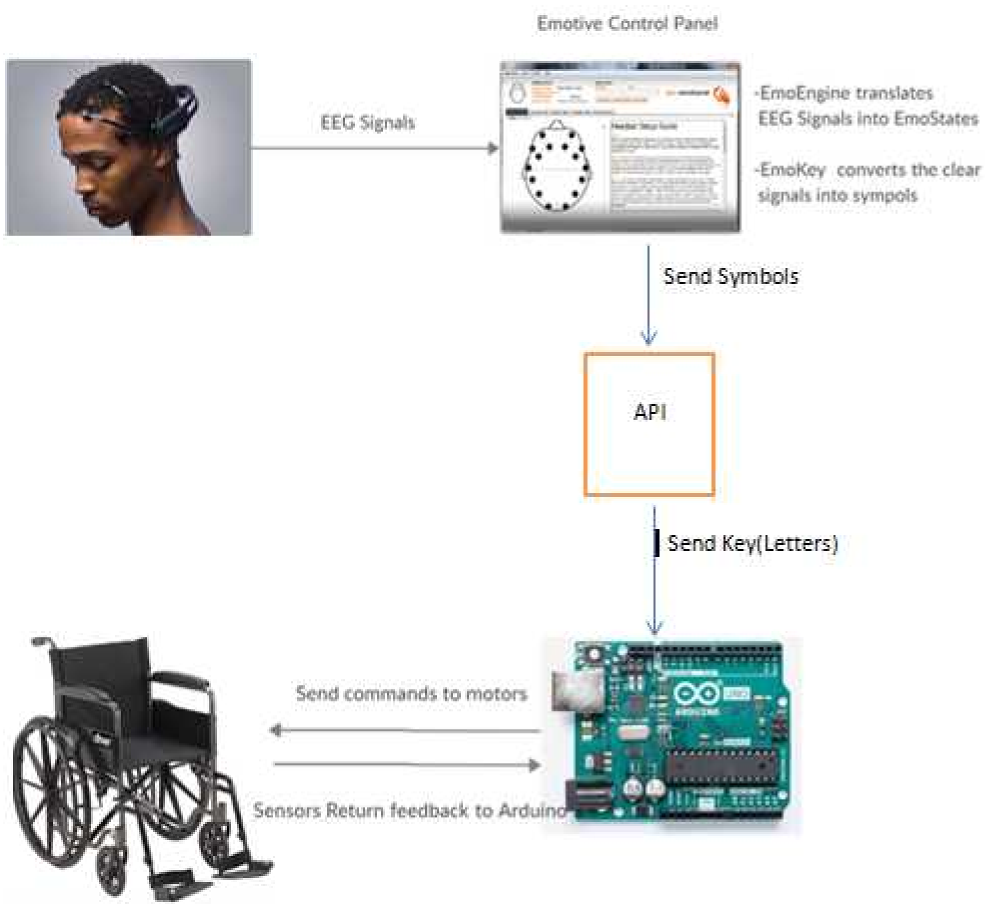


Figure 3.1 :genrela Block Diagram of the system

3.3 System Components

3.3.1 Hardware Components:

The first part from our system is to connect the Emotive Epoc neuroheadset to the microcontroller using Bluetooth technology . The other part is to connect the microcontroller to the rest of system's components . System's components include :

1- Ultrasonic sensor with Arduino mega:

Ultrasonic uses sound waves (echolocation) to measure how far away you are from an object. If an object or an obstacle has detected by this sensor . the microcontroller will send a command to the motors to stop moving the wheels.

The Ultrasonic sensor has four terminals - +5V, Trigger, Echo, and GND connected as follows

Connect the +5V pin to +5v on your Arduino board.

Connect Trigger to digital pin 7 on your Arduino board.

Connect Echo to digital pin 6 on your Arduino board.

Connect GND with GND on Arduino.

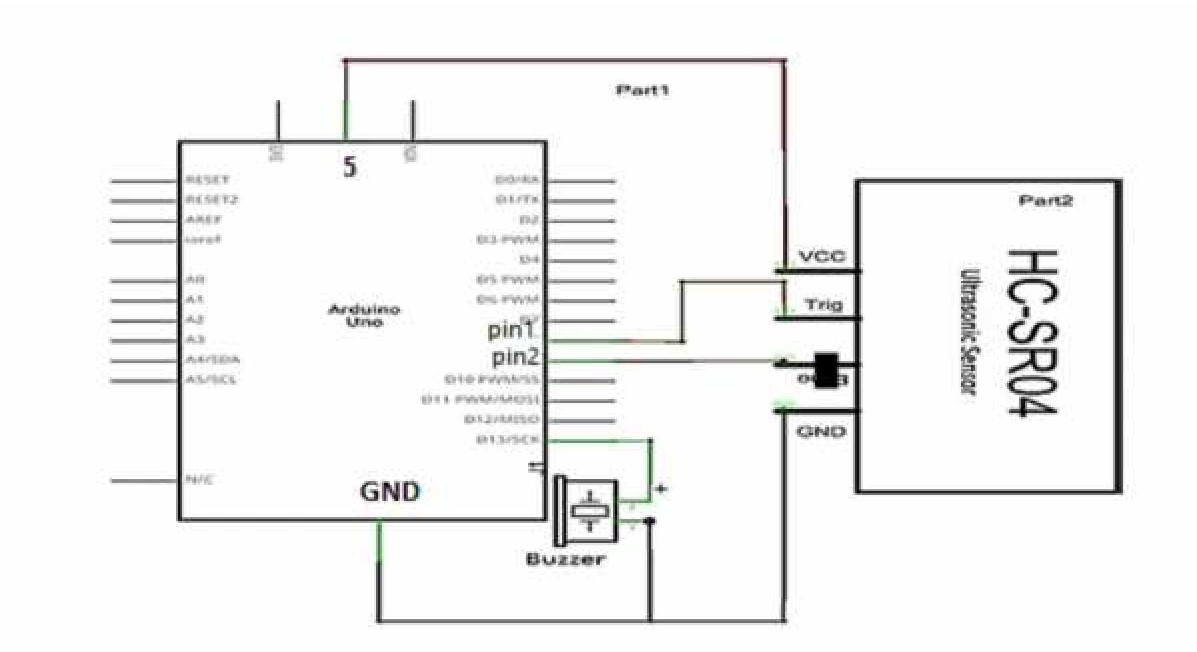


Figure 3.2: Schematic diagram for HC-SR04

2- Load Cell with Arduino mega:

This sensor reads the weight over the chair , by converting the pressure into an electrical signal that can be measured and standardized. As the force applied to the load cell increases, the electrical signal changes proportionally. the microcontroller will continuously read this sensor . if the force is suddenly decreases to zero , the microcontroller will send an order to the motors to stop .

Connect load cell pins to the instrumentation amplifier as shown in the schematic diagram.

RED : Excitation +

WHITE : Signal +

GREEN : Signal –

BLACK : Excitation –

The Resistor 10Ω connected between pin 8 & 9 is responsible for Gain of INA 125 instrumentation amplifier, the output is taken combined from Vo and Sense (Pin 10 & 11) and it is fed into Arduino analog pin A0. Here the need of power supply for load cell and instrumentation amplifier solved by Arduino power pins.

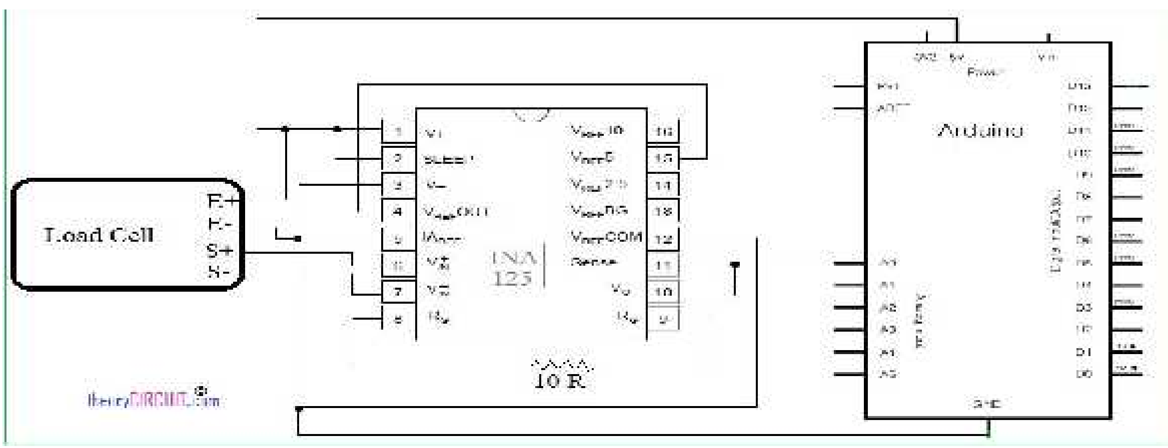


Figure 3.3 : Schematic diagram for load cell

3- DC Motor control with rotary encoder and Arduino mega:

The DC motor is used to move the wheels of the wheelchair if the microcontroller has ordered to.The rotary encoder measure either angular or linear positions of the shaft and convert them into digital or pulse signals , we use it to measure the angle of the wheels to know the direction or the linear position of them , then compare the current command send from the microcontroller to the wheels with the signal or direction written from the rotary encoder .if the wheels are not moving in the right direction , then the microcontroller will send a command to the motors to stop , then resend the previous command.

The rotary encoder has 5 pins: GND, + (+5V or 3.3V), SW (push button), DT (pin B) and CLK (pin A).

GND : The Ground connection.
+V :The VCC or positive supply voltage, usually 3.3 or 5-volts.
SW : The pushbutton switch output. When the shaft is depressed this goes to ground level.
DT : The Output A connection.
CLK : The output B connection.

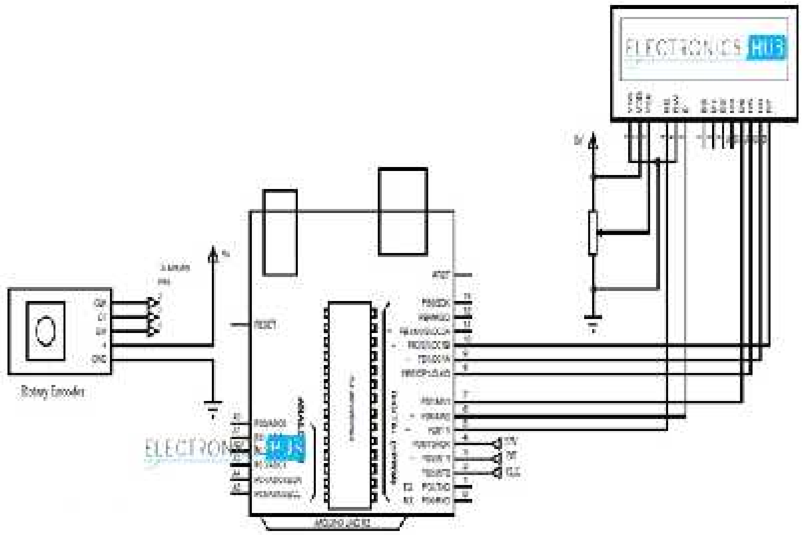


Figure 3.4: Schematic diagram for DC Motor control with rotary encoder and Arduino

4- Buzzer with Arduino mega :

We use the buzzer in our system by connecting it to the microcontroller for two purposes .The first is to indicate that the has fallen , and the second is to indicate the user that there is an obstacle in the way .

The Buzzer has 2 pins, one pin connects to the input pin of the Arduino and another pin connects to GND of Arduino as shown in the schematic diagram in Figure 3.5

Pin 1:input pin of the arduino

Pin 2:GND

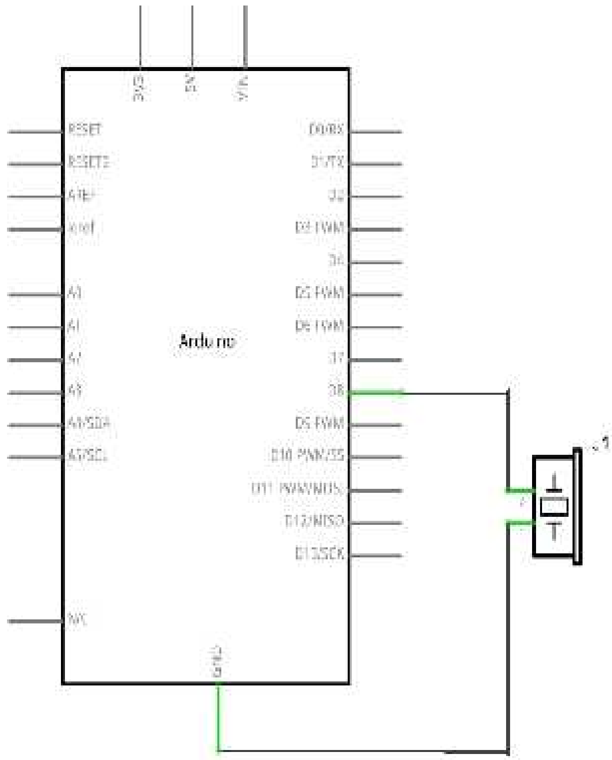


Figure 3.5 : Schematic diagram for Buzzer

5- SIM900 GSM/GPRS/GPS with Arduino mega :

The GPS technology is used in our system to send an alarm message to the user's relative when he falls over the floor . This message include the location of the user.

The RX Pin of SIM808 module connects to TX Pin of the Arduino. Similarly, the TX Pin of SIM808 module should connect to RX Pin of Arduino.

The GND Pin of SIM808 Module connects to GND Pin of the Arduino.

The 5V Pin of SIM808 Module connects to 5V Pin of the Arduino board as shown in the schematic diagram in Figure 3.6.

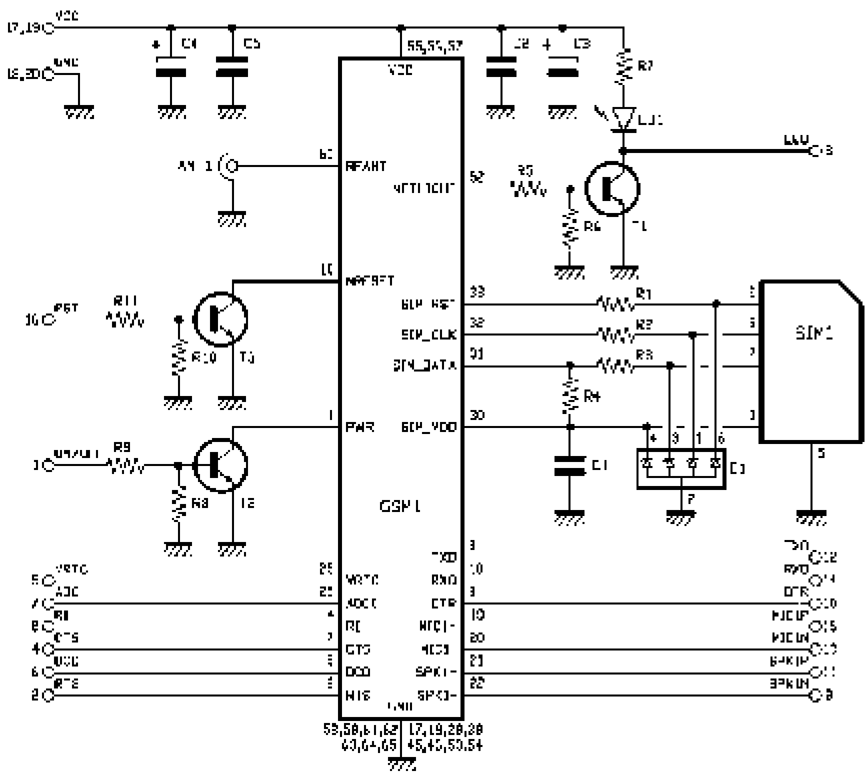


Figure 3.6: Schematic diagram of SIM900

3.3.2 Software Components:

The emotive epoc + headset in our system reads the brain waves as an EEG signals , that expresses the movement of the user's eye.

The EEG signals sends to the Emotive EmoEngine which is part from the Emotive SDK . control panel in the PC takes the EmoStates from Emotive EmoEngine and to the convert it into sympols that microcontroller will understand ,then send to the microcontroller. According to the symol received , the microcontroller sends an order or a command to the motors to move the wheels in the required direction. . Herein, the microcontroller checks if the wheels are moving in the right direction using rotary encoder technology.

If yes , the microcontroller will wait for a specific time period to read the next keystroke or EEG signal .

If no ,then the microcontroller will stop the wheels and resend the command .

The alarm system consists of two parts . The first part checks if there is an obstacle on the way , and will play or start the buzzer if yes . The second is to keep tracking the change of weight on the chair . if it suddenly goes to zero then the buzzer will play and a message will send to user's relative using the GPS technology.

Symbol	Action	Reaction
R	Looks Right	Move right
L	Looks Left	Move left
F	Right Wink	Move forward
B	Left Wink	Move backward
S	Blink	Stop

Table 3.1 : The meanings of the symbols in the flowchart.

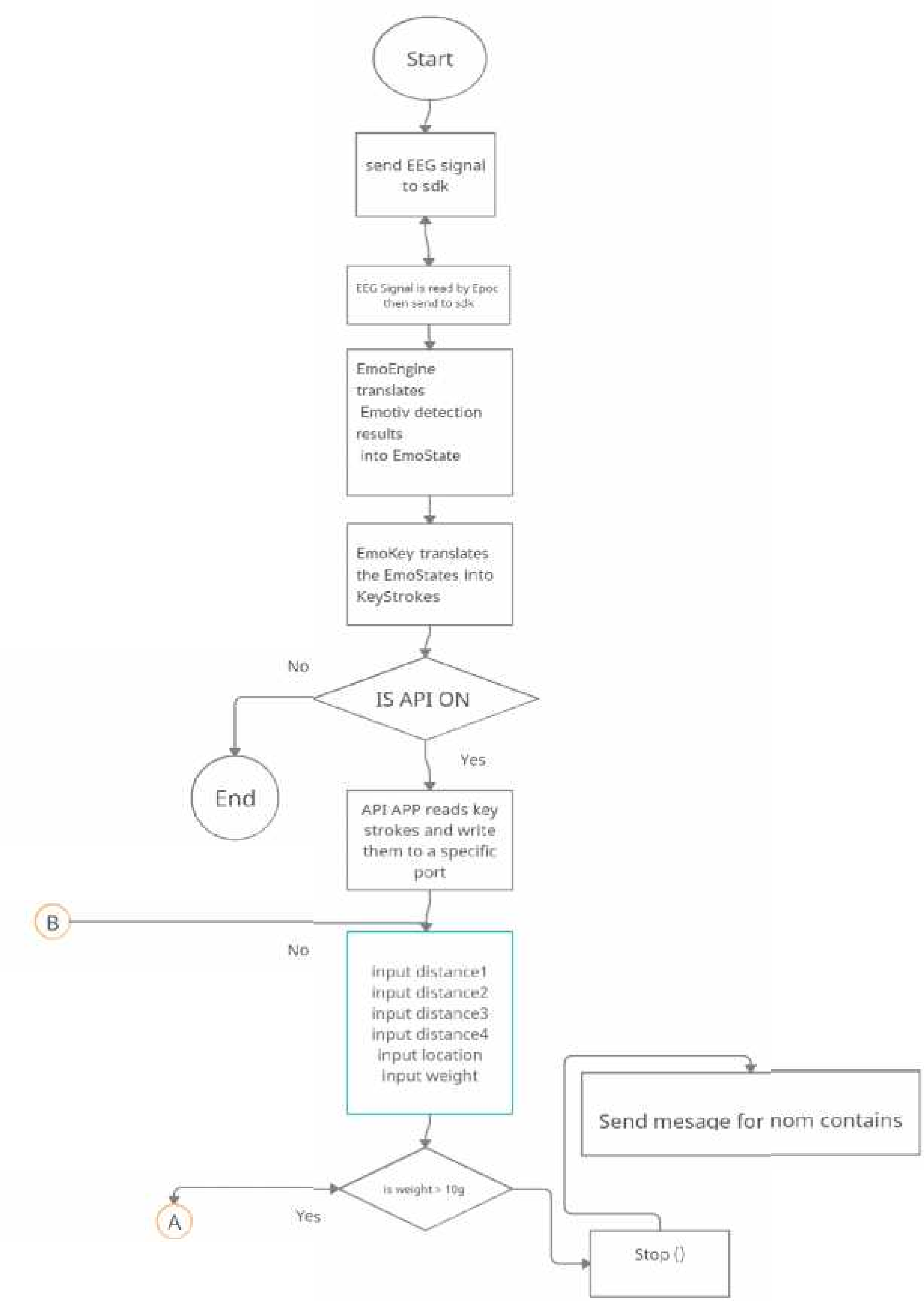


Figure 3.7 :Flow chart of system Software

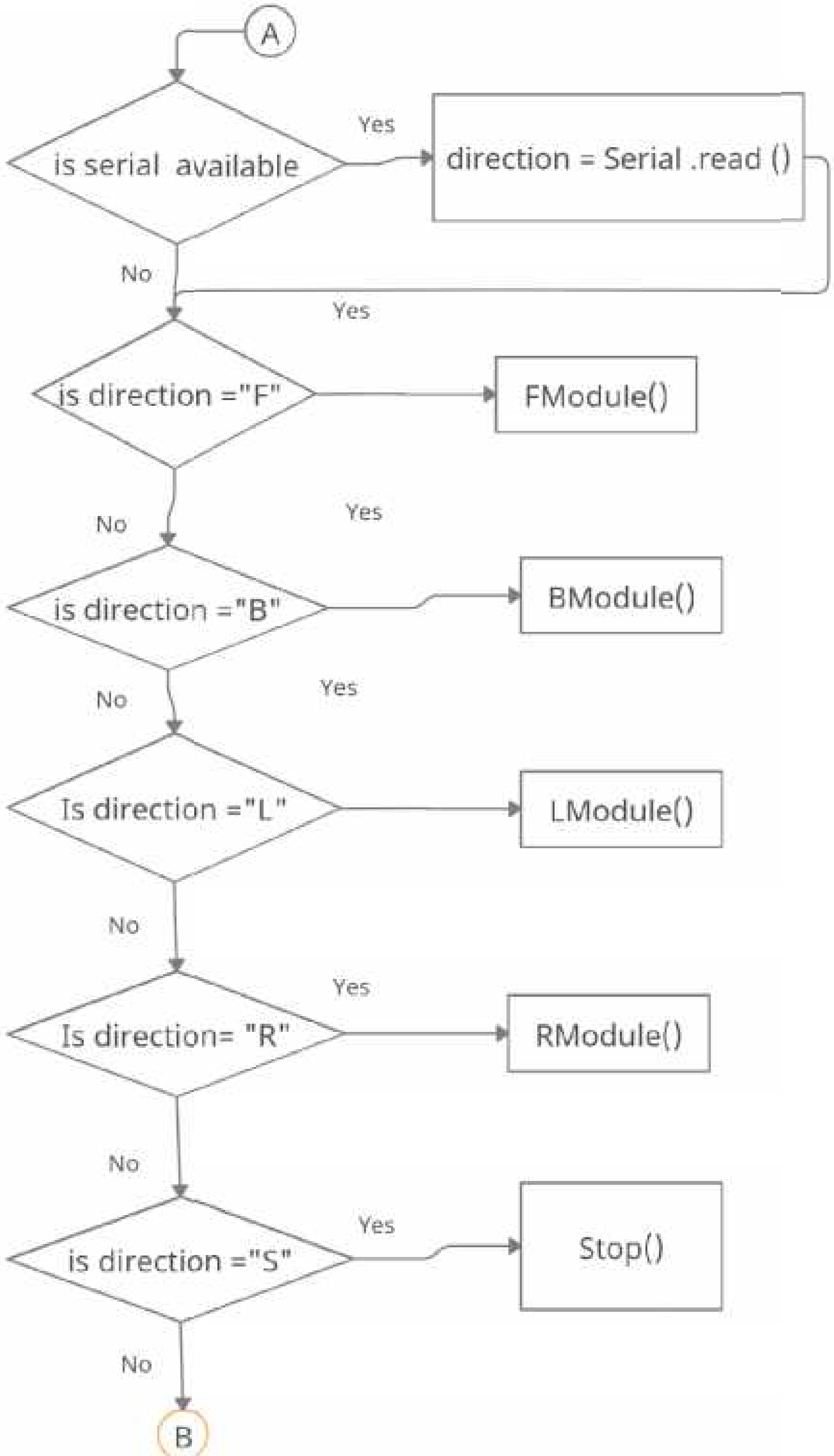
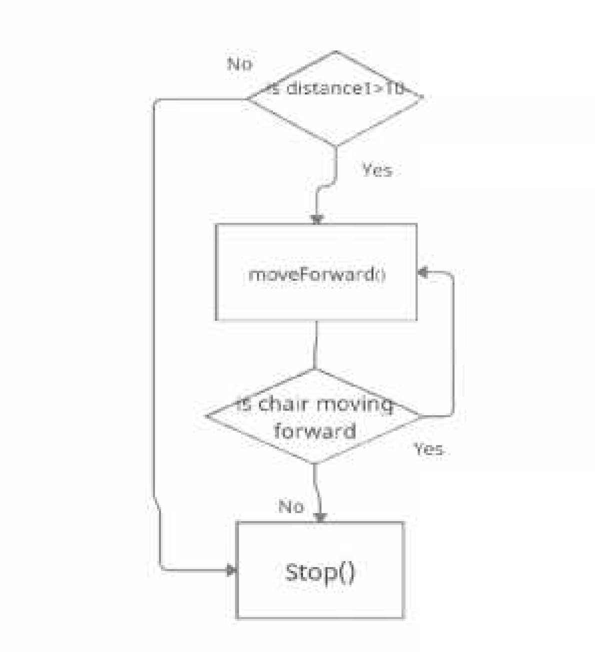
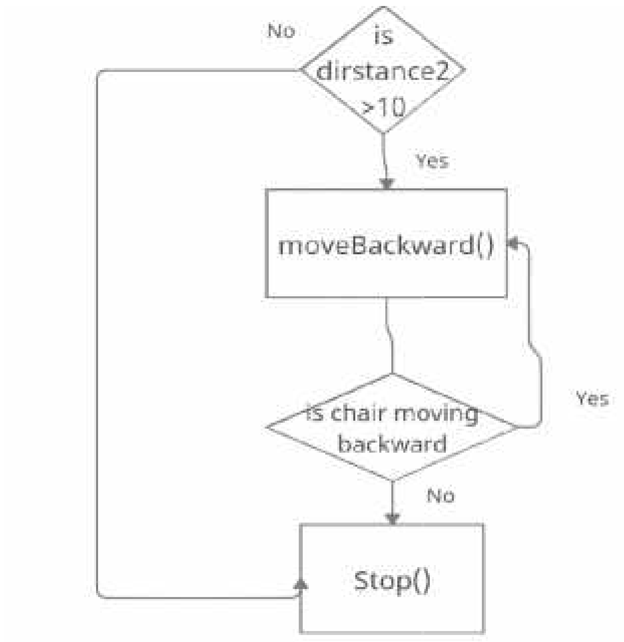


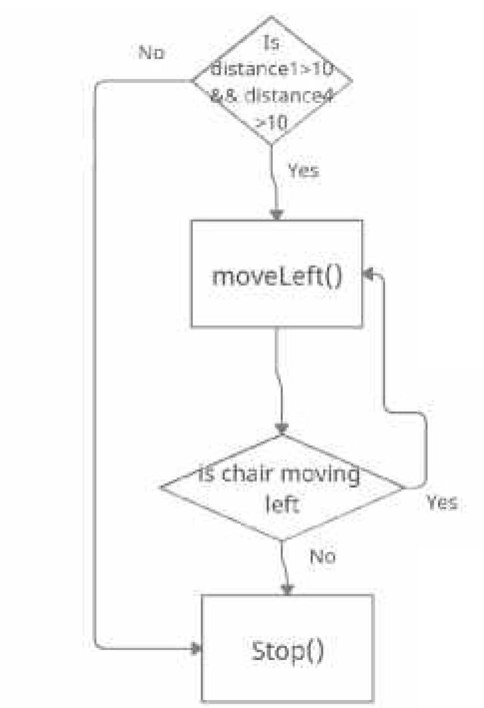
Figure 3.7 :Flow chart of system Software



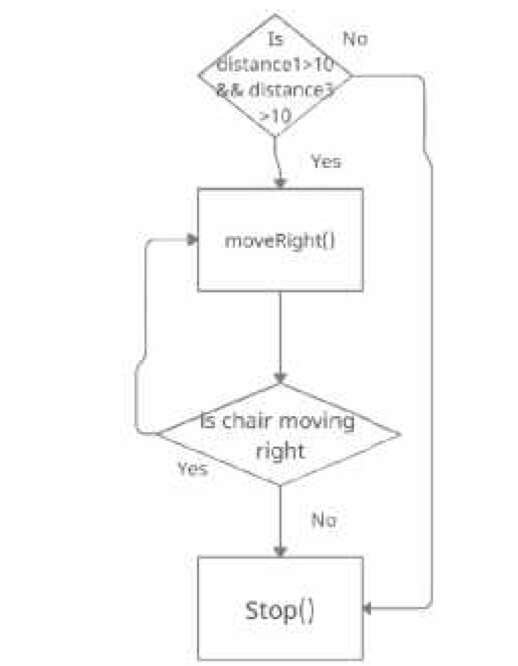
FModule



Bmodule



Lmodule



RModule

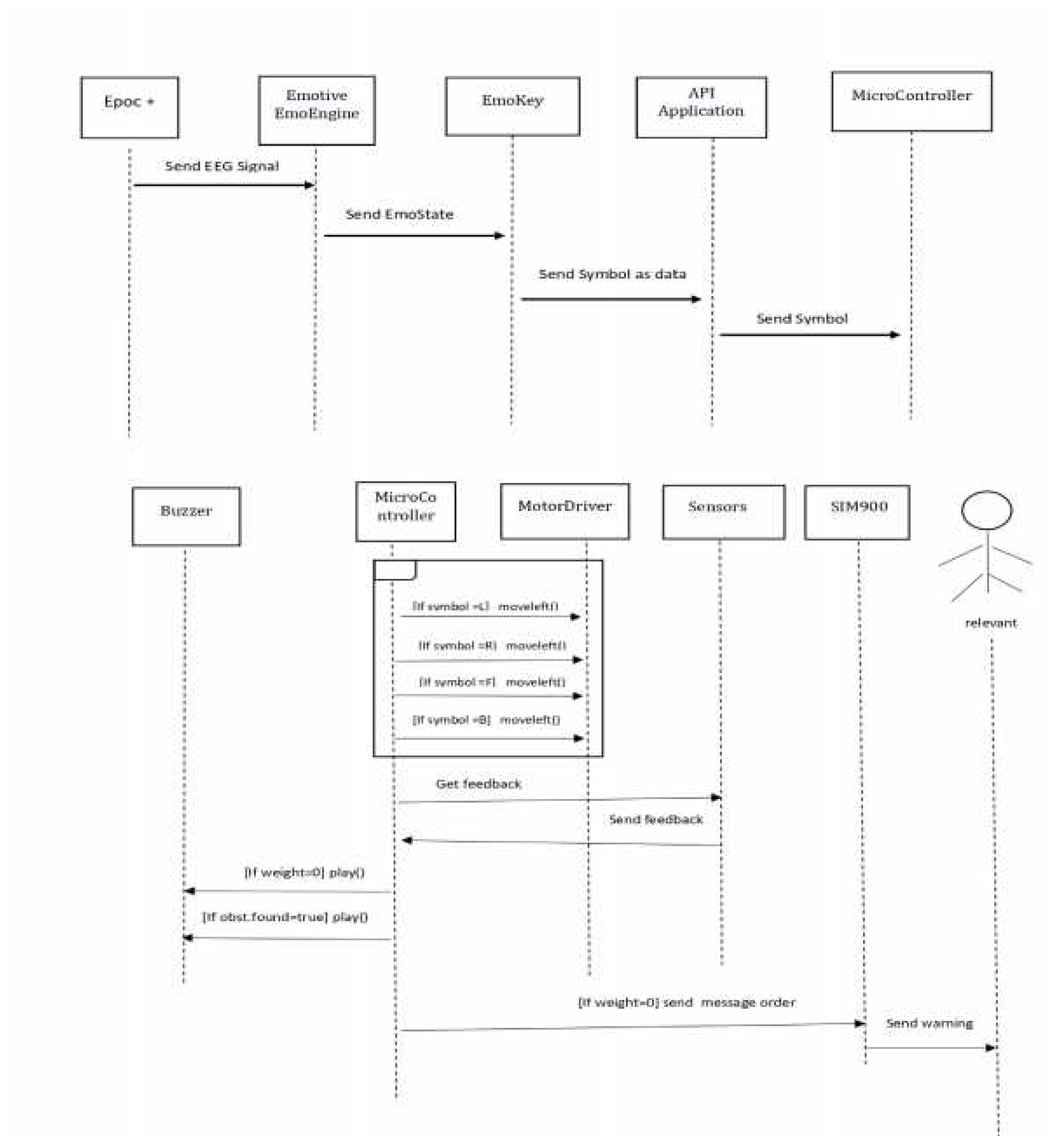


Figure 3.8 : Sequence diagram of the system

Chapter 4

System Implementation and Validation

4.1 Overview

This chapter introduces first the description of the implementation,it's issues, and the challenges ,then description for the different methods to validate the system and their results.

4.2 Description of the implementation

This section will give information about the hardware and software implementations which are done through our project:

4.2.1 Software implementation

-Emotiv SDk

When we started using Emotiv SDk, we noticed that not all sensors located in the neuroheadset were active , so each time were 3 sensors at least were black , which means that there was no signal recieved from these sensors.

We used some of the facial expressions and some of cognitiv to emphasize the 4 directions plus stop command.

- Arduino Software (Arduino IDE):

The code of all hardware components and sensors interfaces are written through many functions and libraries.We needed to download TinyGps and softwareseril libraries for SIM900 and Gps in order to detect location , send message to the relative and Hx711 library for load cell to measure weight.

-API:

To send the key that emphasize the direction to the Arduino code.We wrote API program using visual basic language. This program containes textbox. When EmoKey write a character on this textbox as a key strockes our program will send this character to arduino code on a specific port.

4.2.2 Hardware implementation

Starting with Arduino mega 2560. We connect the other system components well as follows:

1.Ultrasonic sensors: We connect Arduino mega 2560 with four ultrasonic sensors, to compute distances and directions. The first two ultrasonic sensor uses analog pins in the microcontroller, we put it in front and back of the wheelchair. Another two ultrasonic use digital pins on the microcontroller, we placed it in the Left and the Right of the robot.

Result:

The four ultrasonic sensors enable the robot to avoid obstacles and prevent collisions of an object for the Front, back, Left and Right sides of the robot.

2. DC motors: We connect Arduino mega 2560 with four DC motors with encoder. Each of them connected to wheel. We connect each two DC motors to one L298N motor driver as interfcae between the DC motors and the Arduino microcontroller.

Result:

DC motors connected to wheels enables the wheelchair to move in four directions (left ,right ,forward, backward) and get feedback for the right direction.

3.Load Cell: We connect Arduino Mega 2560 with Load Cell to measure the weight over the chair .

Result :

Knowing the weight over the wheelchair enables us to detect if the user fall over .

4.SIM900A GSM: We connect Arduino Mega 2560 with SIM900A to send message to the user's relatives containing the user's position.

Result :

Using Load Cell enables our system to achieve safety , by sending message to the user's relatives containing the user's position when he falls over.

5.NEO-6M GPS: We connect Arduino Mega 2560 with NEO-6M-GPS to return the location of the user.

Result :

When the user fall over ,SIM900 sends a message contains the location of the user.

6.Buzzer: We connect Arduino Mega 2560 With Buzzer to play as an indiction for danger.

Result :

Using buzzer enables us to indicate the user's relatives if he falls over. And indicates the user that there is an obstacle in the way.

7.Quadrature encoder: We connect Arduino Mega 2560 to quadrature encoder to read the wheels speed and the direction of moving(forward or backward).

Result :

Qudrature encoder enables us to know the direction of moving (forward, backward, left or right) as feed back to check if the wheelchair is moving in the required direction .

4.3 Implementation Issues and challenges

4.3.1 Hardware Issues and challenges

During the course of the project implementation, we faced many obstacles and had to take several issues to reach to the most suitable design of the system and reach the best properties related to the project's aims. We summarize these issues and results as follows:

1-Encoder&Motor:

We faced a problem with encoder and difficulty with code to get feedback.

2.GPS :

We faced a serious problem with the GPS location, we used SIM900 module because the GPS is working indoor, we tried the module in our home ,the GPS coordinates was appearing, but it doesn't work in our University.

The solution: After several unsuccessful attempts to get the GPS coordinates in the university ,we decided to send a fixed location through the message.

3.Weight sensor:

We faced a problem with weight sensor, because we should put it in certin way to make it stick and read correctly.

4.3.2 Software Issues and challenges

Many issues were faced during system implementation, such as:

1-Traning :

As a result of not using the epoc for a long time, the sensor was exposed to rust, and the brain signal was not read until after it was cleaned well.

4.4 System Validation and Testing:

4.4.1 Hardware testing

1. **Motors test:**
At first, we tested the motors with DC motor driver and connect it directly with Arduino mega as shown in figure 4.1, to make the wheelchair move Forward, Backward, Left and Right.then test encoder to get feedback.

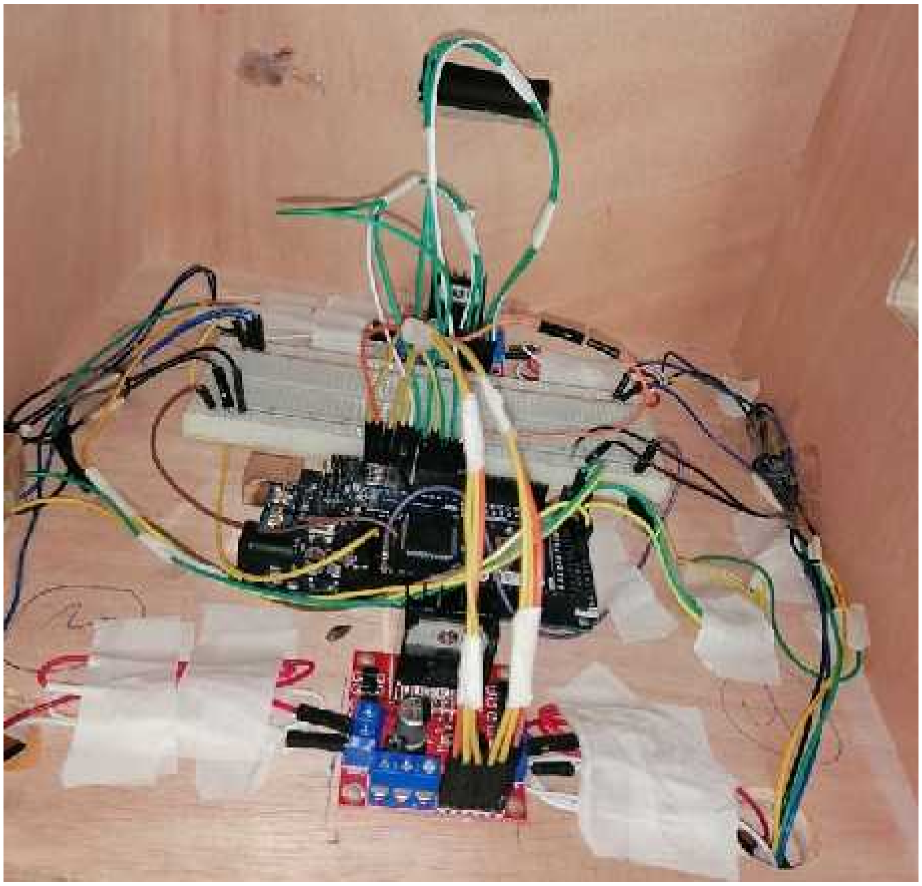


Figure 4. 1 : Test Motor with motor driver

2.Weight sensor testing:

To test user weight that load cell measure , we connect it with Arduino Mega 2560 as shown in figure 4.2. The weight of load cell printed on the serial as shown in Figure 4.3, and if become zero the buzzer will be on.

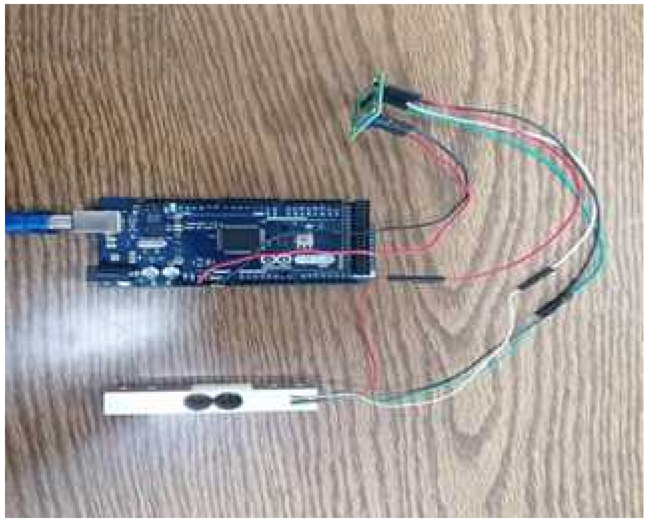


Figure 4. 2 : Test wheight sensor

Figure4.3: Result of weight sensor

3-Ultrasonic sensor testing:

To test the distance that Ultrasonic sensor measure, we connect it with Arduino Mega2560 as shown in Figure 4.4.The distances of Ultrasonic sensor printed on the serial as shown in figure 4.5.

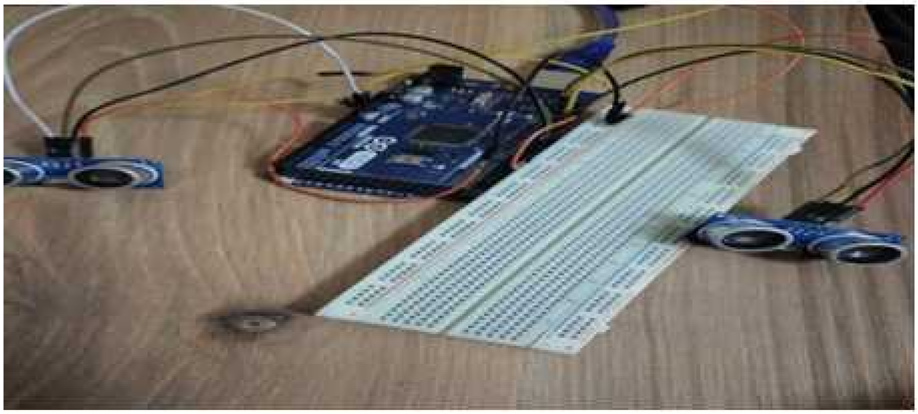


Figure 4. 4:Test Ultrasonic sensor

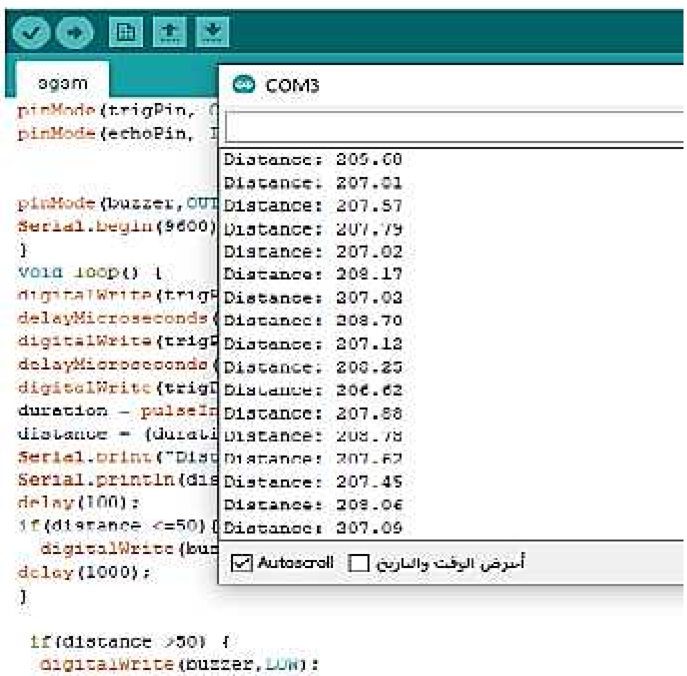


Figure 4. 5: Result for Ultrasonic sensor in serial

4.SIM900 GSM/GPRS/GPS module testing:

To test the SIM900, we connected it with Arduino Mega 2560 as shown in figure 4.6. The SIM900 sends a message to the relative as shown in figure 4.7.

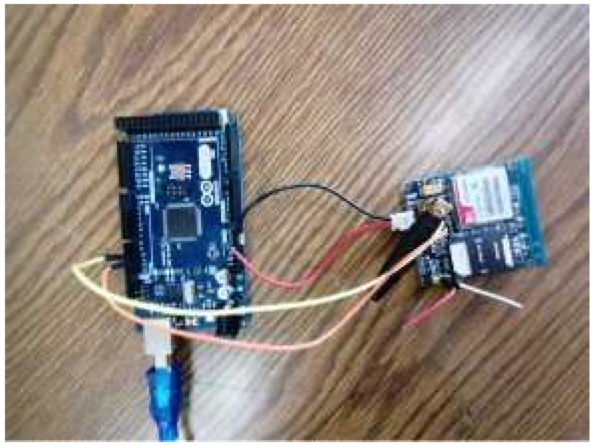


Figure 4.6:Test for SIM900 GSM/GPRS/GPS module

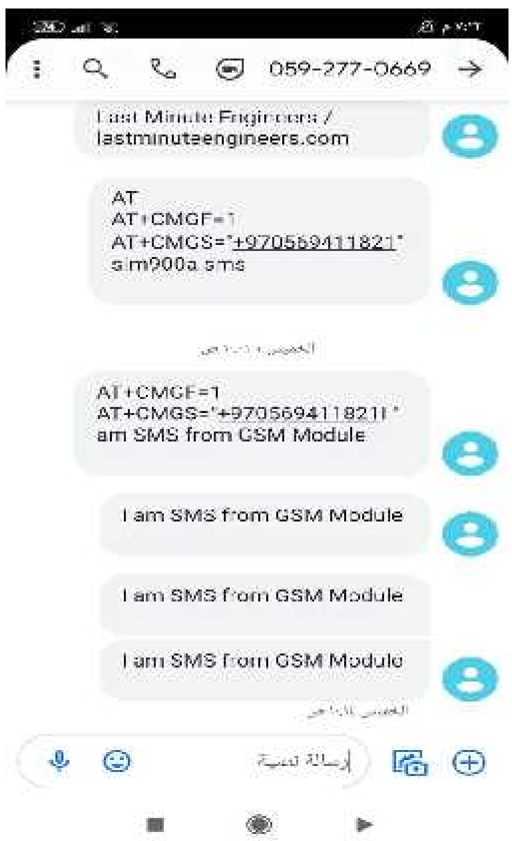


Figure 4.7: message sent by sim900

5. GPS:

To test GPS, we connected it with Arduino Mega 2560 as shown in figure 4.8.The GPS detects the location of the user ,then this data is sent by SIM900 to the relative.

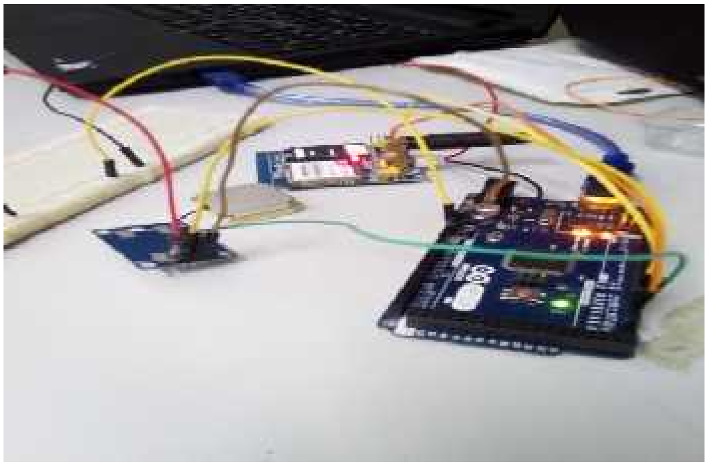


Figure 4.8: Test for GPS

6. Buzzer testing:

To test the buzzer we connect it with Aduino Mega 2560. The buzzer runs with load cell when weight becomes zero and with ultrasonic to avoid obstacles as shown in figure 4.9.

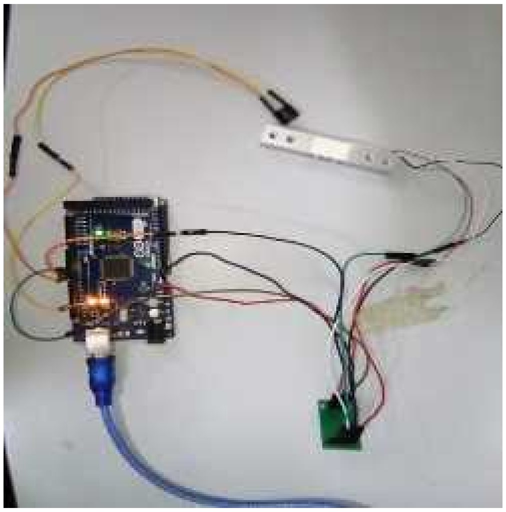


Figure 4.9:Test for Buzzer

4.4.2 System Testing:

A. Obstacle avoidance Test:

The first function to test the wheelchair was obstacle avoidance. We designed and implemented the obstacle avoidance function of the system based on four ultrasonic sensors (Front ,back ,right and left).

We write a code for obstacle avoidance , The details of this code :

1. If the measured distance value of front and back ultrasonic sensor is smaller than 10 cm, the buzzer will run to alert the user then the wheelchair will stop. Then user changes direction to be in a free place.
2. If the measured distance value of right or left ultrasonic sensor is smaller than 10 cm, the buzzer will run to alert the user then the wheelchair will stop. Then user changes direction to be in free place.

- Results:

We tested the Obstacle avoidance implementation while the user was navigating through the environment. The user was able to avoid itself from collision with the static and dynamic objects while moving and change its direction to a path where there is no obstacles.

B. Weight testing:

To check the weight, we installed the sensor on the chair and put a weight on it to give a reading, and when the weight is removed, the reading becomes zero and buzzer running then sends message contains GPS location via SIM 900.

-Result:

Buzzer response to the reading and the message sent when weight becomes zero ,but load cell must be located in a certain way.

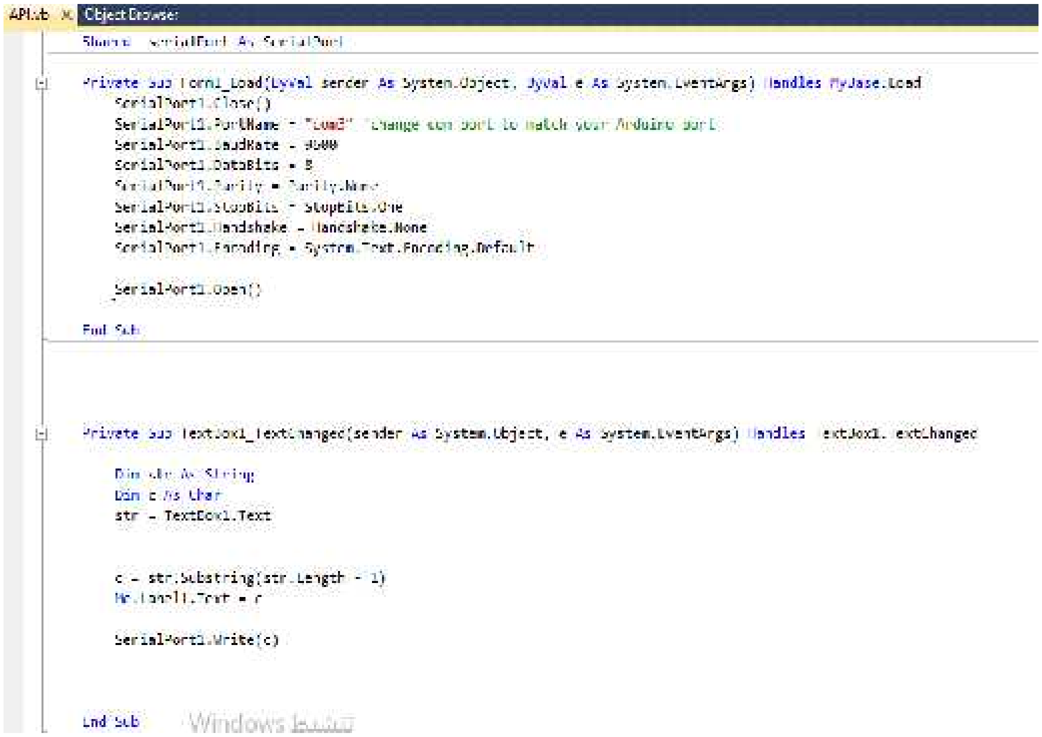
Emotive Epoc test :

To check if the Emotiv Epoc runs correctly we tested it on a person who did a different facial expressions so we checked that the avatar in the emotive control panel is simulating the person facial expressions. Then we use API that reads the key strokes EmoKey generates and send it to Arduino, so Arduino code will control the motors to move in a specific direction according to the key received from API.

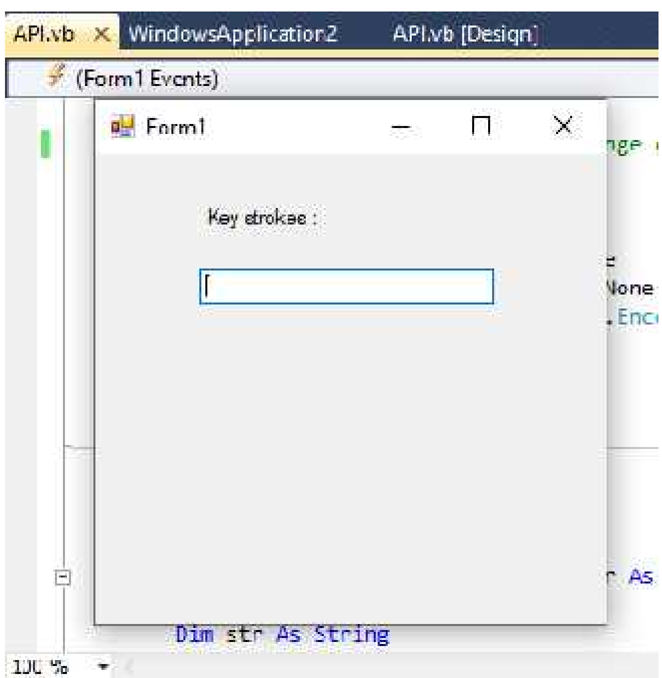
Result:

1-The system is able to detect the eye movements.

2-The system translates the eye movements into the right directions.



4.10:API Code



4.11: API Design

4.5 Implementation Results:

By the end of the implementation process ,we combined all the components with each other to get the Wheelchair controller by eye motion . We fixed the loadcell , SIM900 and GPS above of the chair, ultrasonic sensor (front, back, left and right of the chair) and we connected the Arduino, L298D motor Driver and the DC motor with encoder on the bottom inside the chair . The final connection of the system is shown in figure 4.12.

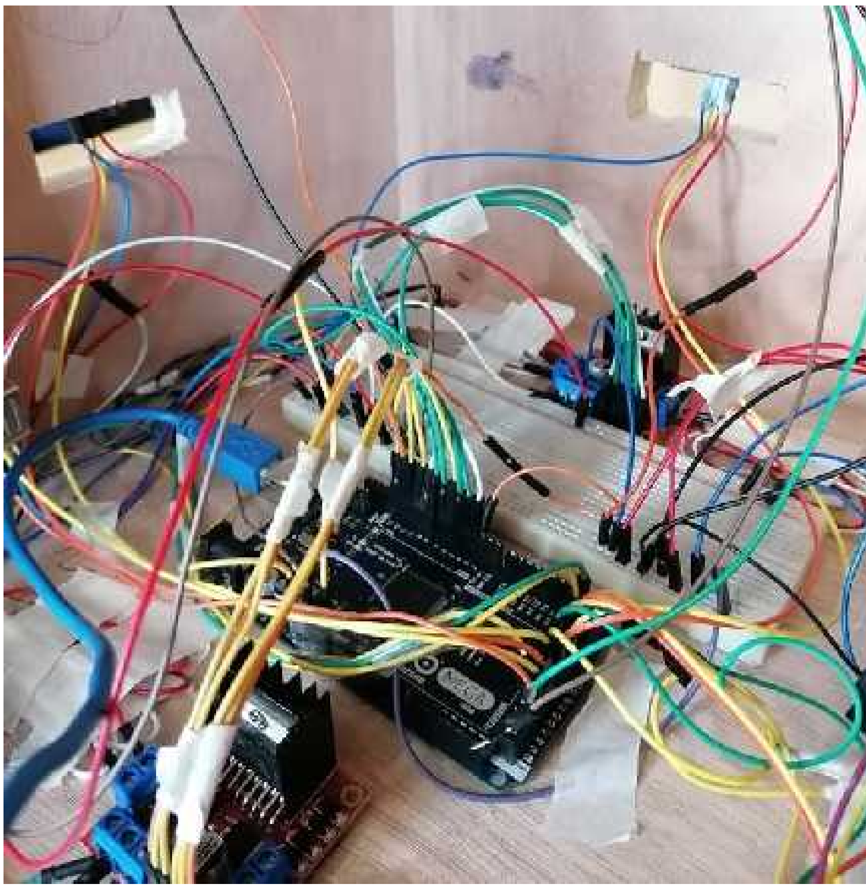


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Figure 4.12:Test for all sysytem

Chapter 5

System analysis and Discussion

6.1 Overview

This chapter introduces analysis and discussion about the results and error rate of the system.

6.2 System analysis

Epoc reads brain waves as EEG signals and send it to Emotiv SDK. Emokey is responsible for translating these signals after processing into key strokes. API application is responsible for reading these keystrokes and sends them to Arduino. According to this, we tested this part of system including Epoc and Arduino is responding correctly to eye movement. We used 4 leds, each led emphasize a done direction. So we checked that arduino turns on the right led.

We put the wheelchair in a room inside the house shown in figure 5.1, and run the code to move the wheelchair in the required direction (right, left, forward, backward) and while it was moving, it detected the obstacles by the sensor that was placed.

Figure 5.1: Testing wheelchair

5.3 Analysis and discussion about the results

5.3.1 Motor with encoder result

For the motor with encoder test discussions, use an API application that reads the key strokes that EmoKey generates and send it to Arduino. Then arduino reads that key from the port to control motor movement. Such that L means left direction, R means right direction, F means forward and B means backward. Then wheelchair moves to the requierd direction and return feedback by encoder.

5.3.2 Obstacle avoidance result

For the obstacle avoidance test discussions, an environment which contains four obstacles was established shown in figure 5.2. In obstacle avoidance test it was observed that the obstacle avoidance structure and algorithm of the system could satisfy requirements of the safty Wheelchair. The performance of the robot was tested eight times in the established test environment and the result record in Table 5.1.

Figure 5.2: Obstacle avoidance for the Robot

5.3.3 loadcell Result

For the load cell test discussions, a weight was placed on the wheelchair,and by the load cell the weight was reading when the weight is removed the reading becomes zero. Then buzzer turns on, and a message is sent to the relative.

5.4 Error Rate in the system

The wheelchair must be safe and move in the required direction. Therefore, we tested the system several times, where a certain character was sent from the API, and accordingly the chair moves and during its movement the system works as a hole. Starting from turn on a buzzer in the event of obstacles detected to avoid it or in the event of a fallover from the wheelchair, as well as sending the message Which contains the location of the patient.

Table 5.1:Test results for the system

	1 st Test	2nd Test	3 rd Test	4 th Test	5 th Test	6 th Test	7 th Test	8 th Test
Move in required direction	Success	Success	Success	Success	Fall	Fall	Success	Success
Obstacle avoidance	Success	Success	Success	Success	Success	Success	Success	Success
Loadcell	Success	Success	Success	Success	Success	Success	Success	Success
Whole system(moto r ,obstacle avoidance ,load cell)	Success	Success	Success	Fall	Fall	Success	Success	Success

According to records in the table, we calculated the success rate of the system. Firstly, the success rate when the robot move in the required direction was 75%. Secondly, we calculated the success rate of the system obstacle avoidance. It was 100%. Then we calculated the success rate of the system when reading a weight by the load cell, and it was 100%. Finally we calculated the success rate of the whole system when it obstacle avoidance, detects weight, etc, it was 75%. So, the total success rate for all the system was 75 % and the total error rate was 25%.

Success Rate = summation of success rate / number of experiment times.

Error Rate = summation of Error rate / number of experiment times

Chapter 6

Conclusion

6.1 Summary

This project is to design and produce a Wheelchair controller by eye motion using Emotive Epoc neuroheadset . At this level, hardware components, software tools and design are explained. Movement of the wheelchair are tested and results are discussed. Despite the implementation issues, wheelchair passed the function tests successfully. It detect the obstacle , weight over the wheelchair ,and send a message to the user's relative with a fixed location and turn on a buzzer.

According to our system's objectives, we achieve these results :

1-The system is able to detect the eye movements.

2-The system translates the eye movements into the correct directions,and the feedback feature gureantee the correct movement.

3-The chair is able to move forward , left , right and back.

4-The system is able to detect the obstacles and avoid them .

5-The system detects the falling down from the chair and sends alarms accordingly.

6.2 Challanges :

We faced many challenges that impeded the progress of the project and prevented its performance from being in its best case. These are the most important ones:

1. Our biggest challenge was in dealing with the Epoc. As the quality of the sensors was poor, so the signal we received was weak, which led to unread some movements such as looking to the right and to the left. Another problem that we faced while dealing with Epoc as a part of whole system. It takes a while until we understand how Emokey works. Then we became able to transmit the signal as symbol from Emotive SDK to Arduino.

2. We faced a problem with GSM moduel. It was not always sent a message. And we faced a problem with gps because it cant read a location inside the door so we put a fixed location .

3. The loadcell is a sesnsitive sensor so after using it for many times, it stoped reading weight. So we bought a new load cell sensor with higher range.

4. The battery problem was that it did not give the current required to operate the motor. As we can’t use the projects lab , we take a long time to know this problem. We ran the motor on the power supply in the laboratory, then brought a new battery.

6.3 Recommendations and future work :

1. As our project is a model, can carry only a doll or a baby less than 10 kg, we recommend to make it a real wheelchair so an adult person can use it. This would be a more practical implementation of the project.

2. To implement the previous recommendation , we advice to use more powerful motors with bigger wheels. So it needs battery with higher Ampier hour. Also you need a load cell with higher range , or simply use start-stop button switch insted of it to know if there is an object over the chair or not . You may need more ultrasonic sensors.As the model is bigger but ultrasonic range will not be enough to cover the around area .

3. We recommend to use wifi insted of GPS . We choosed GPS to cover all areas even remote area , but practically wifi is more realable .

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