Smart wheelchair for disable people

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Abstract

Physically disable people are neglected in every step of their life. Even if they have ability to do much more they cannot express themselves due to the disability. May be their disability to move or walk like normal people cannot be cured sometimes. But we can give a try to reduce the problems. Technology came this far not for only normal peoples. It also opened new opportunities for the people with disabilities. This project focuses on building a smart wheelchair that can be controlled by the hand movement of the user using IoT technology. This wheelchair can move forward, right and left based on the command given to the system by the user. As well as if in anytime user face any kind of problem or difficulty or critical situation and need someone emergency then simple tap on the sensor will activate an emergency SMS to given emergency contacts. This project will reduce the complexity of movement and make life easier for disable people by opening new opportunities in his/her life.

Declaration

The research work entitled "**Smart wheelchair for disable people**" has been carried out in the Department of Computer Science and Engineering, Jahangirnagar University is original and conforms the regulations of this University.

I understand the University's policy on plagiarism and declare that no part of this project has been copied from other sources or been previously submitted elsewhere for the award of any degree or diploma.

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Chapter 1

Introduction

1.1 Overview

Present technology and IoT is making our daily life much easier than before. Using this technology it is possible to create and develop new things which will help people who need this most. This project focuses disable people who depend on other people to move from one place to another place. The presented project is an IoT based smart wheel chair which can identify hand movement using gesture or 3D hand movement recognition technology. Motion gesture technology is a very popular sensor right now and it has a very large implementation on different field of IoT. By integrating this gesture technology with general wheel chair it is possible to help disable people in many ways to perform their general daily basis works. This combined project will bring a revolution in the medical sector due to its easy use and simple instructions.

Disable people are mostly neglected and everyone think them as burden to society most of the time only because they cannot move their own. This can be solved using this proposed motion gesture based wheel chair technology.

Regular wheel chair have many limitations and do not have integration with technology. On the other hand they require another person's assistance to move it or the user need physical force to operate this. But somehow if the user need to move one place to another place it is quite challenging for him if he or she do not have that much strength to move the wheelchair or he do not have fingers in his hand or there is no one else to assist them.

But after implementation of this technology people will be able to move their wheelchair with simple sweep of their hand, so that they will be able to move one place to another without any external help. They will not even need physical strength to move the wheel chair. Not only this, this project will also unlock some other features like, they will be able to contact their family members, police station, hospital or any number that is inserted into the system based on user requirement from any place in the earth using the gesture sensor. The user can execute the command without even touching the device. So in short, this project will open new opportunities for the disable people and things will be much easier for them.

To operate this wheel chair user will not need any technological knowledge or education, because instructions are simple and easy. This project is to demonstrate that gesture sensing can be used to effectively translate hand gestures into computer interpreted signals. To complete this project

required components are - Raspberry Pi, Skywriter HAT, Battery, Motor, general wheel chair, Arduino Mega, GSM and some other regular hardware and tools.

1.2 Motivation

Bangladesh is a very small country of Asia but the population is very high which is more than 167 million [http://www.worldometers.info/world-population/bangladesh-population/]. Among this large population almost estimated 16 million people with disabilities living this country. From the report of BSS among total population people have physical disability is around 5.5%. Age group 5 to 9 have average 0.33%, age group 10 to 19 have 0.37%, age group 20 to 29 have 0.35%, 30 to 39 have 0.42%, 40 to 49 have 0.63%, 50 to 59 have 0.97% and age group 60 to 69 have 1.52% disable people among total population in percent [http://203.112.218.65:8008/WebTestApplication/userfiles/Image/PopMonographs/disabilityFinal.pdf]. Though disable people are getting support from the government, but those are very limited for most of the people. Even people of urban areas don't even know about their facilities provided by government.

Among all kind of disabilities, disability of movement is very common and highest number of people have physical disability. Most of the time due to limitation of movement physically disabled people cannot get back to their work and become neglected because they require support for almost everything. Traditional movement support tools have limitations and also may require support of others. Though automated wheel chair is available to the market, but they are very costly. Therefore service of this kind of supportive machine are also limited to the elite people. Poor country like Bangladesh, where most of the people don't have enough money to buy costly device to make their life easy, depends on cheap things.

From that perspective the idea of making a smart wheelchair for physically disable people came to our mind. The main focus of this project is to develop an embedded hand gesture based smart wheel chair in low cost. The project have the feature of movement and also combines a feature for emergency situations which is an alert system. The movement of the wheel chair is dependent to the hand movement of the user and a simple but specific signal will trigger an alert system where the developed system sill send text message to seek attention during and emergency situation. This system also can be used for multipurpose like, emergency signal sending, making an emergency phone call, smart home control using home automation, and monitoring disable people or user. The main target of this project is turning the disable people productive again for the society. So that they become confident again to do anything.

1.3 Objective

The main objective of this project is providing a smart solution for disable people to make them less dependent. Using this project they will be able to perform daily things much more independently than before. In an IoT or embedded system project many things can be implemented but first and most important things must come first in this project. Therefore considering different perspective objective of this project are-

- ✓ To make a smart wheel chair using hand gesture technology.
- ✓ To control the wheel chair without physical support.
- ✓ To make a system for emergency signal generation.
- ✓ To provide support disable people to move independently.
- ✓ To expand the benefits of technology to general people.

In the primary level of the development the system will have few features like moving forward, backward, left and right. On the other hand system will have text messaging feature for emergency situation. Later on the system can be upgraded by adding object detection system, fire alert, and so on. This motion gesture technology can also be implemented in other different sectors for long range development plan.

Our main objective is to make the disabled people less dependent on their daily works. Considering that few sectors of this project are-

- Target people: disabled population (paralyzed in lower limb, or old age home residents).
- Target device: Technology specified wheel chair using motion gesture.
- Target features: wheel chair movement, sending emergency alert to few pre-defined contacts.

Chapter 2

Background study

2.1 Introduction

Bangladesh is a very small and as well as a very poor country. Most of the people in this country do not have enough amount of money for their living because of the earning rate which is below average. As most of them do not have enough wealth for living, therefore they are not interested to medical treatments. Sometimes due to their avoidance simple medical issues become critical and people suffer a lot.

In the case of disable people, this things are much worst. Because people consider and treat a disable people as he is such a burden to everyone and good for nothing. Though people who cannot walk, but have physical fitness to work, do not get a job to do. The reason behind it that people think he/she will need help to move or come to work, even without support he will not be able to come to work. So why should I hire this person? On the other hand, even people have disability of movement think they cannot do anything because they cannot move or walk.

But this is not the actual thing. People having different types of disability are not actually good for nothing. Because may be someone cannot walk, but he or she have good programming skills, may be someone cannot see, but have the talent to sing. So disabilities are not actually disabilities. Everyone have their own potentials and can be helpful to society if they get the chance.

From that point of view many researchers all over the world are working on making the disable people useful and trying to give them hope, as well as a new life for him and his family. There are different categories of disability among the people. For example-

- Vision Impairment.
- Deaf or hard of hearing.
- Mental health conditions.
- Intellectual disability.
- Acquired brain injury.
- Autism spectrum disorder.
- Physical disability.

Different Researchers are working on different disabilities and trying to find new solutions to overcome them. In this section few of them will be discussed but the physical disability will be

discussed briefly because as mentioned before this research also focuses on physical disability and solution to overcome it.

2.2 Literature Review

For a long time people are trying to use IoT to provide support to world's largest minority people which is people with disability. Though a normal people can utilize the ability of his own to perform daily things but those simple staffs are sometimes difficult for disable people. But IoT can simply break this barrier for disable people and make things easy for them. So researchers are trying to develop IoT products to help disable people and help the society grow.

If we consider disabilities other than physical disability and the research to overcome them we can mention the work of Osama Sohaib, Helen Lu and Walayat Hussain for blind people [1]. Internet is now a day's one of the most important thing which helps us to learn new things and so many things became very easy to do due to internet. Online shopping is one of the benefits of internet, which provide support of shopping without going to the market. Though this is very easy to use for us but on the other side that much complex for a blind person. Osama Sohaib and his team worked on a proposed integrated framework of the IoT and cloud computing for people with disabilities such as sensory (hearing and vision), motor (limited use of hands) and cognitive (language and learning disabilities) impairments in the context of business-to-consumer (B2C) e-commerce context. They concluded that IoT-enabled services offer great potential for success of disabled people in the context of e-commerce. Smart devices are able to work in wireless network environments without the fear of limitations such as access devices or dat a sources with limited power and unreliable connectivity. In particular, we propose an iAccess service to provide the user-driven service modeling process. The cloud based iAccess service will allow disable consumer to compiles a digital shopping list of item(s) using a speech recognition or text, scanning the barcode or using RFID reader through smart device and deliver it to IoT cloud portal. The created list of item(s) is stored and registered in the service repository to be detected in the IoT cloud based service web portal. The IoT service abstracts the service modeling result to deliver to the e-commerce service platform. The web portal will display the required item to the user. Online payment can also be completed using RFID. Such as RFID chips embedded in smart devices or RFID credit cards.

In the case of deaf people, researcher Pushpanjali Kumari, Pratibha Goel and S. R. N. Reddy worked on a IoT based wireless alert system for deaf people [2]. In their work they designed and implemented a low cost stand-alone device for deaf people to notify doorbell ringing who live alone in their house. The system is based on Raspberry pi which includes camera, vibrator, wireless GSM and Bluetooth. When the visitor presses the doorbell, captured image is transferred to the wearable device which helps to know the right person at the door or intruder. After transferring image, wearable device vibrates to notify. Also, the message is sent to the owner through GSM. Visitor's image along with the date and time is sent to the server for retrieving information later.

Considering the intellectual disability of people, researcher Sharon Varghese worked on different sensors of IoT to improve intellectual disable people's life style [3]. This article analyses the living environment of Sensory and physically disabled people, then present how IoT can help them to overcome these difficulties. According to them the Internet of thing enables new means of communication between people, things and the environment. By using this technology differently able people can improve their life style to some extend as normal people do. Disability is the consequence of an impairment that may be Physical, Cognitive, Mental, Sensory, and Emotional, Developmental or some combination of the above. It may be right from the birth or may develop during a person's life time.

Autism is a developmental disorder characterized by difficulties with social interaction and communication and by restricted and repetitive behavior. The amount of autistic children are increasing rapidly according to the WHO (World Health Organization). To improve this situation researcher Ardiana Sula and her team implemented and evaluated the performance of a new system based on Internet of Things (IoT) and P2P technology for supporting learning and improving the quality of life for children with Autism Spectrum Disorder (ASD) [4]. Many children with autism are highly interested and motivated by smart devices such as computers and touch screen tablets. These types of assistive technology devices get children with autism to interact, make choices, respond, and tell parents what they are interested, need, think, and maybe even feel. Our proposed system uses JXTA-Overlay platform and Smart Box device to monitor the children and create P2P communication between children, caregivers and therapists. Various visual systems, such as objects, photographs, realistic drawings, line drawings, and written words, can be used with assorted modes of technology, as long as the child can readily comprehend the visual representation. Vocabulary skills, mathematics skills and other life skills can be taught through our proposed system. We evaluated the effect of our system during study sessions of children diagnosed with ASD. The experimental results show that our system teaches new skills to children with ASD and the Smart Box increases the concentration of children during studying.

Till now we have seen different status of research done worldwide on different kind of disability. So now we can make some discussion on physical disability and get some overview of research status on this topic. As we already know that among all kind of disability most of the people are suffering from physical disability. So the research area are also that much large as its sufferers. Considering all aspects and the target of this project, some research work on gesture controlled wheel chair will be discussed now.

Automated hand gesture based wheelchair requires specific hardware implementation and proper programming to implement it successfully. There are several raspberry pi codes and many more hardware connections to execute each command with 1oo% accuracy. The programming was done in python platform. To implement the project successfully we have gone through many papers related to the project.

U. Rajkanna and M.Mathankumar introduced and developed a system which is classified into two basic units. The gesture unit and mobile robot unit. The title of the paper is "Hand Gesture Based Mobile Robot Control Using PIC microcontroller". In that work, the gesture or the movement of the user controls the movement of the mobile robot [5].

Prof. Vishal V. Pande, Nikita S.Ubale Darshana P. Masurkar, Nikita R. Ingole and Pragati proposed a Hand Gesture Based Wheelchair Movement Control for disabled Person Using MEMS. This paper describes about developing a wheel chair control which is useful to the physically disabled person with his hand movement or his hand gesture recognition. They used Acceleration technology to implement the project. The objective of this paper was to implement wheel chair direction control with hand gesture reorganization [6].

Hand Gesture Recognition Using Accelerometer Sensor for Traffic Light Control System was presented by Shirke Swapnali and P.G.Chilveri. In thirpaper, hand gesture recognition was implemented for traffic light control system (TLC). They used Thresholding Algorithm for recognition purpose. Swapnali and Chilveri [7] Sign to Letter Translator System using a Hand Glove was presented by Hanine El Hayek and Jessica Nacouzi and Abdallah Kassem, Mustapha Hamad and Sami El-Murr. This paper proposed a sign to letter translator system using a hand glove. The glove can be used by any deaf and/or mute person. The glove will help them to communicate with people who do not understand sign language [8].

Accelerometer Based Direction Controlled Wheelchair Using Gesture Technology was presented by Manisha Devi1, B.Anil Kumar. This paper presents a model for Gesture controlled user interface (GCUI), and it is also able to identify trends in technology and also application and usability. The paper presents gesture based data glove technique which controls the wheelchair using hand movements [9].

This paper is about Wheel-Chair Control Using Accelerometer Based Gesture Technology. This work presents a novel approach to gesture recognition system using accelerometer sensor. This methods is based on joystick and camera based vision where camera is always tracking the movement of different body parts like face, eye etc [10].

Srinivas Ganapathyraju, Ph.D proposed the thesis paper on Hand Gesture Recognition Using Convexity Hull Defects to control an Industrial Robot. This paper is about a method for hand gesture recognition to control a robot. The robot was a 6 axis industrial robot. The image is acquired by means of a web cam system [11].

Shreedeep Gangopadhyay, Somsubhra Mukherjee & Soumya Chatterjee proposed intelligent gesture controlled wireless wheelchair for the physically handicapped people. In this paper they discussed about an architecture of an intelligent wheelchair working on wireless hand gesture control [12].

Shruti Warad, Vijayalaxmi Hiremath, Preeti Dhandargi, Vishwanath Bharath and P.B.Bhagavati proposed a Speech and flex sensor controlled wheelchair for physically disabled people. This paper is about an intelligent motorized wheelchair for physically handicap person. The project was done by using user speech controlled and flexes sensor technology. The project shows to drive the wheelchair using speech commands like “forward, backward, maximum, stop” etc [13].

2.3 Research Summery

In this research the focus is to build a hand gesture based wheel chair that will be able to move according to users command. The project can be divided into two major parts. They are –

- Hand gesture recognition
- Automatic wheel chair

Hand gesture recognition system will be able to detect any kind of user command based on the users hand movement. Some fixed commands will be pre-given to the system and each command will have particular action for it. When user moves his hand the gesture recognition will try to match the movement pattern with the stored instruction. If any match found action will be performed.

On the other hand automatic wheel chair will be an electronic wheel chair, which is traditional wheel chair but modified to perform the action instructed from the sensor. This particular section will need proper research and development steps as a cycle to improve its effectiveness.

Overall this research is done to reduce the price of smart wheel chairs instead of costly devices available currently. So that people don't have capacity to buy costly devices, can get the chance to use this low price device. This research will reduce the price of the device almost half.

Chapter 3

Requirement Analysis

3.1 Data Flow

In this research based project the data have its own way to flow to be useful to the user. From the very beginning data flow starts with the movement of hand of the user. A sensor named gesture sensor collects the data value through the hand movement or gesture sensing. The sensor is integrated with a Raspberry Pi module where the sensor data is forwarded for matching. Data will be matched with previously trained data set. Every single previously trained data have its own input pattern and every pattern have its own action. So after getting the sensor data Pi module crossmatch the data with training data. If the input data do not match any pattern then it wait for another pattern of hand gesture from the user.

On the other hand if any kind of pattern is found Raspberry Pi module transfer an action signal to the Arduino. Here Arduino and Raspberry Pi module is connected through a wireless network system. When Arduino get the signal from Raspberry Pi it trigger the action to perform. Here the Arduino is connected with two actuators (motors). Depending on the command the Arduino turn on or off both motors.

The data flow Diagram is given below which shows us the work flow of the entire system of the hand gesture based smart wheel chair –

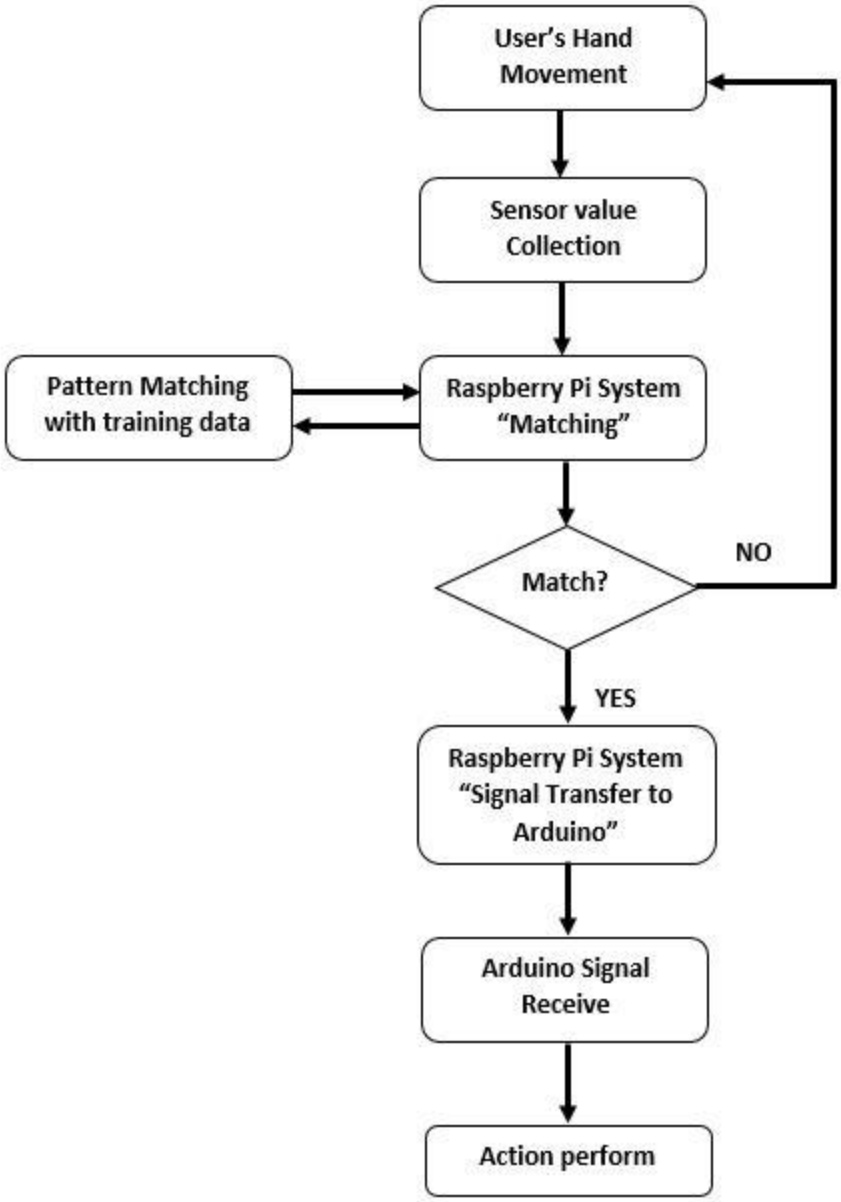

Fig 3.1: Data flow of the system

3.2 Technical Specification

This IoT based project contains different type of sensors, systems and actuators. Sensors will collect data from the environment, system will process the data interact with environment and provide instructions to the actuators. Actuators will perform the task according to the command from the system.

Based on the impact on the project components can be divided into two categories major and necessity based on their importance. Some major components are –

- Hand Gesture – Skywriter HAT
- GSM
- Bluetooth
- Raspberry Pi 3
- Arduino Mega
- Wheel Chair
- MY6812 24V DC motor
- 12V Battery

3.2.1 Hand Gesture – Skywriter HAT

Gesture recognition can be said as a way adopted by computers to understand human body language or specific gesture. It builds a communication or bridge between machines and humans. As any bodily movement is defined as gestures, thus when a machine get to recognize the movement from a certain movement from human body it is called gesture recognition by that machine.

Gesture recognition enables humans to communicate with the machine (HMI) and it is also used to interact naturally without any particular mechanical devices. The "motion gesture" technology is very useful and developed in many sectors of modern science. The gesture in computer science and language technology deals with the goal of interpreting human gestures with the help of mathematical algorithms. Motion gestures can originate or recognized from any bodily motion or state of any position but commonly originate from the face or hand.

The main functionality of gesture recognition technology is any user can use simple gestures to control or interact with devices without physically touching the device. So, in short Gesture recognition is the mathematical interpretation of a human motion recognized by a device.

Skywriter HAT is the main gesture sensing interface of this project. HAT stands for Hardware attached on Top. It is a perfectly developed module for Raspberry pi. Thats why it is highly compatible with Raspberry pi. Skywriter HAT can sense and generate full 3D position of data and gesture information. It uses 4 layer PCB for providing best type of performance.

Skywriter HAT is used to sense things floating in the air over it. It can detect swipes and motion of human hand with X, Y & Z positions. The HAT is interfaced with Raspberry Pi. Its range is up to 5cm. IT is compatible with python library. Skywriter HAT comes with fully assembled and is a great platform to work on. Skywriter HAT uses electrical near-field and 3D sensing to generate positional data and detect common gestures like flicks, sweeps and taps.

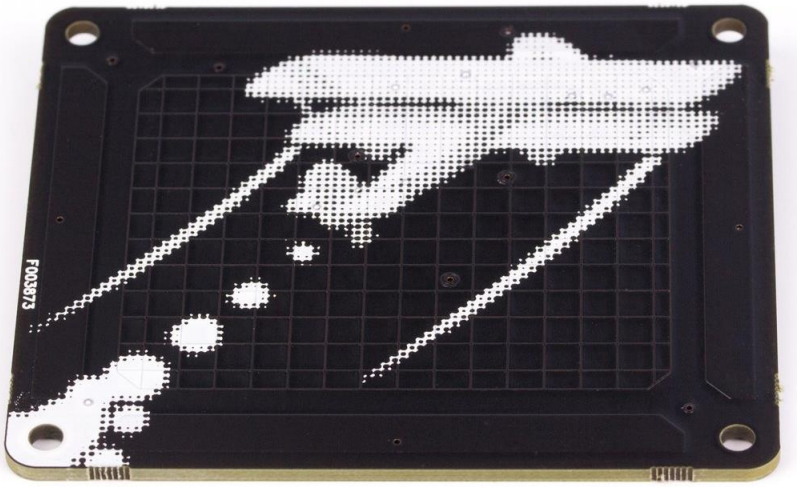

Fig 3.2: Hand Gesture – Skywriter HAT

3.2.2 GSM

GSM stands for Global System for Mobile Communications. It is developed by the European Telecommunications Standards Institute. GSM can be described as a digital, circuit switched network which is optimized for full duplex voice telephony. This technology has been expanded over time for including data communications. GSM was developed as a secure wireless system.

For this project, we used SIMCOM 800L core board as a GSM module. SIM800L is a nice module and cost effective GSM breakout board. We set it up with Arduino and sent simple text messages from the raspberry pi via gestures. The library can be used to perform more operations like making calls etc.

Fig 3.3: GSM Module

3.2.3 Bluetooth

Bluetooth is another wireless technology standard which is used for exchanging data over short distances. Bluetooth was developed by Bluetooth Special Interest Group. In general, its physical range is typically less than 10 m. It can perform within the area range up to 100 m (330 ft.).

There are several remote control technologies which are used to communicate and control the devices remotely. Some of them are adopted to make the device work perfectly as our requirement. Among them we have used Bluetooth in association with raspberry pi and we used GSM module to communicate over phone.

3.2.4 Raspberry Pi 3

The Raspberry Pi is a single-board microcomputer. It was developed in the United Kingdom by the Raspberry Pi Foundation. It was mainly developed to promote the basic computer science knowledge in developing countries. The main purpose of using raspberry pi in this project is it is so available in Bangladesh and it is compatible with the sensor skywriter HAT. HAT stands for Hardware Attached on Top. So, we used the raspberry pi to attach the gesture sensing interface. Using raspberry pi we can have the opportunity to use a single board computer for our project. Raspberry pi supports a wide range of modules to work with. It is very cost effective. We used Raspberry pi to make our prototype device easily.

Fig 3.4: Raspberry Pi 3

3.2.5 Arduino Mega

The Arduino Mega is a microcontroller board based on the ATmega1280 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila [14].

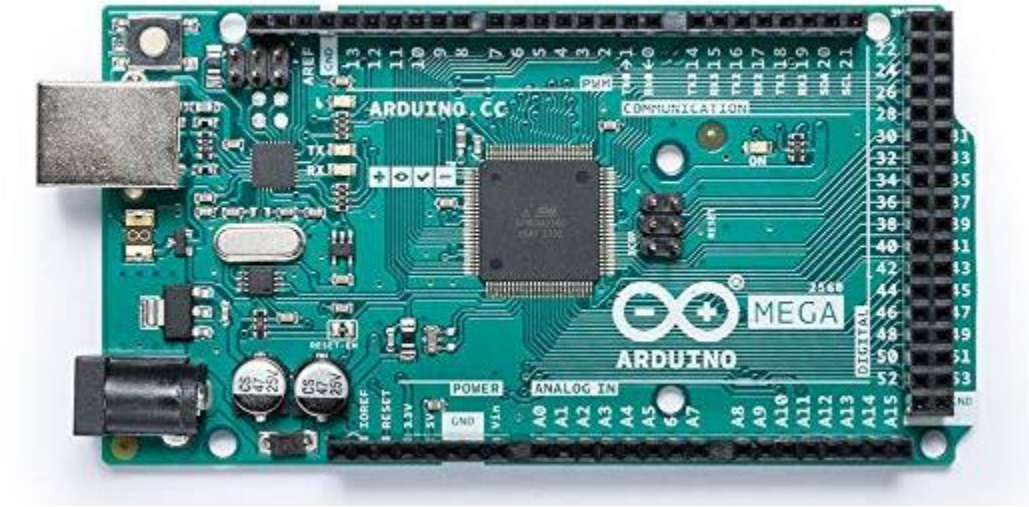

Fig 3.5: Arduino Mega

3.2.6 Wheelchair

Wheelchair, any seating surface (e.g., a chair) that has wheels affixed to it in order to help an individual move from one place to another. Wheelchairs range from large, bulky, manually powered models to high-tech electric-powered models that can climb stairs. The modern standard wheelchair design is based on the so-called cross-frame design that was introduced in 1932 by disabled American mining engineer Herbert A. Everest and American mechanical engineer Harry C. Jennings. Together, Everest and Jennings patented the cross-frame wheelchair, which uses a cross brace to attach the two sides of the chair, allowing it to be folded when not in use. They later formed Everest & Jennings, Inc., which subsequently became one of the world's major wheelchair manufacturers [15].

Fig 3.6: Wheelchair

3.2.7 MY6812 24V DC Motor

Popular as a scooter motor or general application motor. Extremely durable and reliable. Commonly found in 24V scooters or even small kiddies carts and it's also been a proven motor in robotics! There are a few different versions of this motor with the earlier versions having a body length between 97-100mm. It just depends on what revision of the motor you get. The newer versions of this motor are shorter than the original, though the face mounting is the same as is the design of the motor (the only changes are in the core winding and magnets).

Some of these were also available with a 2 screw face fixture, but the 3 screw face plate is more common and more widely used (as well as being more secure). The ones we sell are the 100W version, though a 150w version is also available (and we may stock it at some point in the future) as these really are a low cost reliable motor.

Fig 3.7: MY6812 24V DC Motor

3.3 Modification Requirement

Even after collecting all the necessary components, it is not enough to complete the project. Because though some component are enough in their actual shape as Raspberry Pi 3, sensor, Arduino etc. But some components need modification to make the project run. For example the wheel chair have its own compact design. But it has no option for complete the project without modification. On the other hand the motor do not have any direct communication with the wheelchair or wheel chair cannot be moved using it. Therefore considering that it can be said that the true complexity of this project lies on the hardware modification, which is wheelchair and its necessary setup.

3.4 Modification challenge

The main challenge in this project is to modify the wheel of the wheel chair. This wheel do not have any extra part other than the wheel, so that connection with the motor became tough. So this wheel or part of the wheel may be need to be changed to complete the project. On the other hand the motor have its own gear type shape. But this is not enough to drag the wheel of the wheelchair. According to the research study, this motor may also need to be modified. So the full setup of the wheelchair need proper study to redesign and make it fully functional.

Chapter 4

Design and Implementation Methodology

4.1 Introduction

Basically this hand gesture based smart wheelchair is a very complex system and without proper research development is quite difficult. Because the hardware itself needs proper modification to make it useful to the system. Configuring the wheelchair is one of the biggest difficulties in this project.

Gesture Recognition System needs to be integrated with the wheel chair with proper power management. The connection should be placed via Bluetooth communication between raspberry pi and a smart phone. So that one can easily make a phone call just by waving their hand and also can do more with just a sweep. Based on different commands generated by gesture recognition unit the main controller will give commands to the wheel chair to move on a direction or pass the commands to a smart phone. One of the major goals of the research is that the instrument developed should be endorsed and marketed by both local entrepreneur and government bodies with the help of local people.

As our proposed embedded device in wheelchair is solely planned to be used by disable person, so it can be a new business sector which can claim price of the finished product market wise. They can earn by manufacturing the product. Besides, by making it available for public use, there is also a scope for making the device in industrial level which ultimately contributes to generate local income.

4.2 Functional Design Discussion

In this project, we applied the motion gestures for the physically disadvantaged people. Our aim is to develop an embedded hand gesture-based device which will attached with electric wheelchair; using the micro-controller; along with the power controlled Raspberry Pi -3, and a sensor called "Skywriter HAT". The sensor will be communicating with the Raspberry Pi when the user sweeps his/her hand over the sensor. For specific waving patterns after gesture recognition, the device will execute specific operations or commands according to the users' need.

It is particularly useful and designed to speech and hearing handicapped people, paralyzed people who are unable to walk or move both of their hands or even it can be used by the special disable children. This proposed device can secure the quick contact with the police stations, nearby hospitals and also can make emergency calls to their family and friends. It can let them to monitor and control the household devices or office management very efficiently without even touching the device or actual physical labor. In Bangladesh, we need a standard solution where disable people can ask emergency helps whenever they need to be without the direct intervention of others. The final product of this project is able to help out these people to lead their life easily than they have never before. It is an essential gadget to a good number of disable people or in the regular life of a special child.

4.3 Implementation

The implementation of this research can be divided into two parts based on the hardware configuration and the systems own data flow. They are – hand gesture recognition system and automated wheelchair. In this system these two major parts works independently, though for full functional system communication between them is very important. Both of this systems will require its own power source. If one of them fail to operate the other part will remain active but the system will not work. For example if the hand gesture recognition system is not working properly and is unable to take input from user then this particular part will remain disabled, but the automated wheelchair will still be waiting for signal establishment and input from the previous system. Therefore now this major two parts implementation will be discussed briefly to clarify its construction in the system.

4.3.1 Hand Gesture Recognition System

The very first part of this project is the hand gesture recognition system. This system will be able to recognize hand gesture from the user. Basically this device will simply read movement in a 3D base. This is not mandatory to have fingers in user's hand, so that physical damage will not effect this system at all.

This system requires a sensor that will be able to detect gesture. So that Skywriter HAT is perfect for this project. The Skywriter is a gesture controller built around the MGC3130, a 3D gesture recognition and tracking controller chip. It uses near-field sensing to locate the position of your hand in the air at a range of 5cm. The board can also detect touch input to a number of positions on its surface. The skywriter HAT has some strong benefits like, it has electrical near-field 3D/gesture sensing, 4-layer PCB for best sensing performance, it is compatible with Raspberry Pi so it easy to use and it comes fully assembled so that simple plug and play is possible for this device.

The Raspberry Pi is directly connected to the Skywriter HAT. Simple design of the sensor fits easily to the Raspberry Pi. But if the user want to just few features of Raspberry Pi they will need to connect some ports with the Raspberry Pi for sure.

Skywriter	Raspberry Pi
GND	GND
TRFR	GPIO 27
RESET	GPIO 17
SCL	GPIO 3 / SCL
SDA	GPIO 2 / SDA
VCC	3V

Table 4.1: Port connection between raspberry pi and Skywriter HAT

This 3D interface can sense things floating in the air over it using detect swipes and the motion of user's hand with X, Y and Z positions. Skywriter HAT uses electrical near-field 3D sensing to generate positional data and detect common gestures like flicks and taps. Along with a neat hardware solution, the team have invested a great deal of time producing a Python API (application programming interface) for both Python 3 and 2.7, installable via the Pip package manager.

In this part of the system the Raspberry Pi is the center of the total control. We already know that the skywriter HAT is connected with it and also the GPS is communicating with the outer world with the help of Raspberry Pi. Figure given below is describing the components of Raspberry Pi.

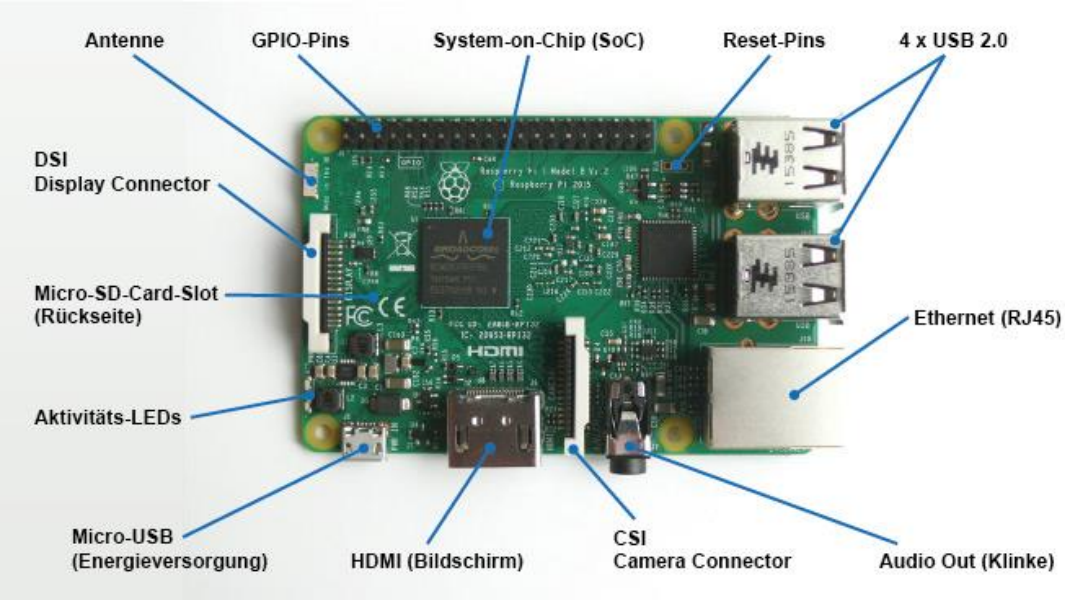

Figure 4.1: Components of Raspberry Pi

The hardware description of Raspberry Pi which is shown in Figure 4.1 consists of the GPIO pin, SD slot, USB port and Micro USB connector. The GPIO pins are used for serial communication for interfacing GSM and GPS etc. It uses 16GB SD for installing the Raspberry Pi OS and for storage. The USB port is used for connecting keyboard, mouse, dongle and pen drive. The power supply is given through USB connector.

The GSM module was developed as a digital system using time division multiple access (TDMA) technique for communication purpose. A GSM digitizes and reduces the data, then sends it down through a channel with two different streams of client data, each in its own particular time slot. The digital system has an ability to carry 64 kbps to 120 Mbps of data rates.

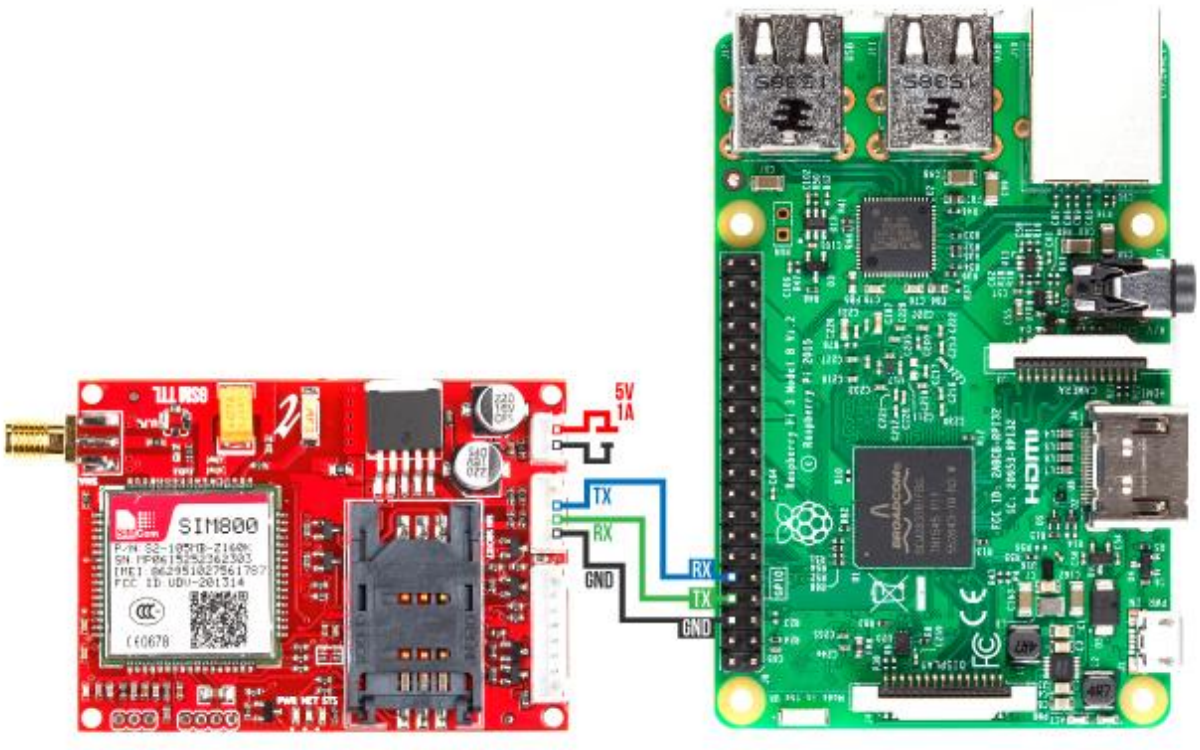

Figure 4.2: Connection circuit diagram of Raspberry Pi and GSM Module

GSM module have total 5 pins and between them 2 pin works as TX and RX which is data receive and transfer. There is also 2 ground pins and 1 five volt power pin in the module. The GSM module have a SIM card slot where we inserted a SIM card and used it as a communication device. The Raspberry Pi will be able to send data through this device to any mobile.

Till now we have discussed about the structure or communication between the hardware devices in this part of the project. Now it is time to explain how those devices are working as one. The figure given below shows the framework of the system.

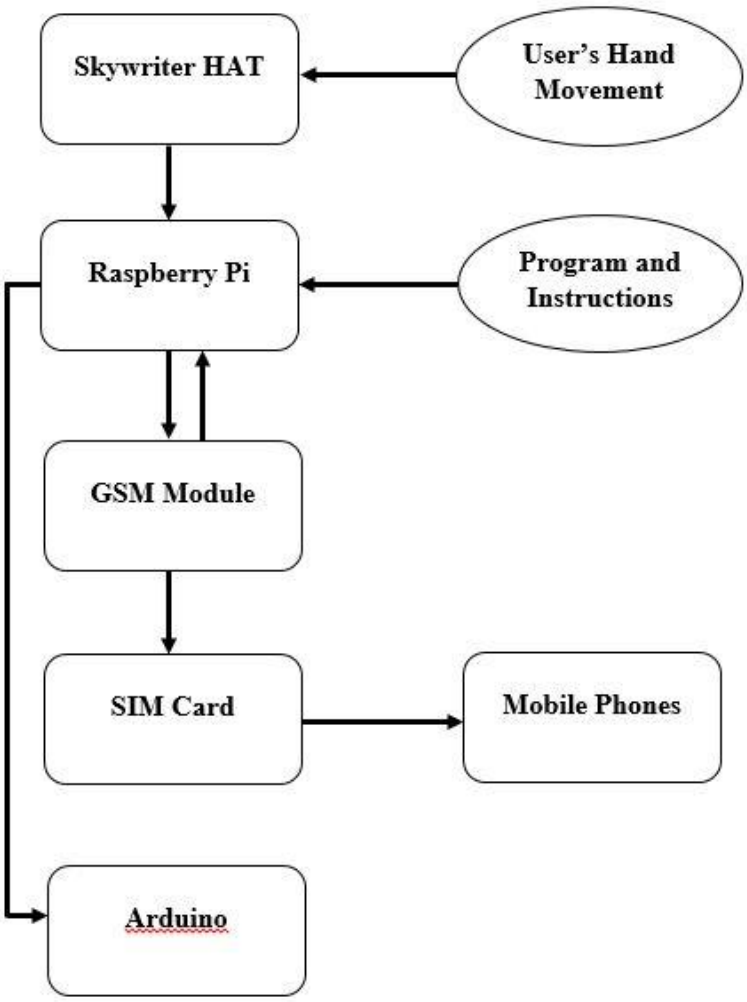

Figure 4.3: Hand Gesture system framework

Here if we consider the working process of this system, first of all the system will take input from the user through the Skywrite HAT. Basically here the user is the rider of the wheelchair. When a movement is received it will sent to the Raspberry Pi immediately.

Raspberry Pi will match the received signal pattern with its previously defined library. Developer need to train the system with predefined data. In this case the predefined data will be the hand movement. Every type of hand movement will mean an instruction for the wheelchair. Therefore the data pattern will need to be corresponded with a specific action.

In this project the system is trained with 4 types of instructions. They are –

1. Move Forward
2. Move right
3. Move left
4. Send SMS (Emergency Text)

So after getting the input from the user Raspberry Pi will match the input signal with the training set and send the action signal to the Arduino to perform the task in the Wheelchair. If pattern match is not found then the system will wait for the next signal.

On the other hand for the given instruction double tap to the skywriter will active an emergency signal and send it to the Raspberry pi. Then Pi will activate the GSM module and request for sending emergency text. Raspberry Pi will contain emergency contact list and as well as emergency text. So the raspberry pi will provide those information to the GSM. Later GSM will send text messages to mobile phones to respond immediately for the emergency of the user.

4.3.2 Automated Wheelchair

Automated wheelchair is the second part of the project. This section of the project combines the action receiving and action performing part. User will provide instruction to the gesture sensing device and Raspberry Pi will forward the action to this part of the hardware to complete the task. Some of the main devices used in this part are the wheelchair, motor, Arduino mega and a Bluetooth device.

In this project Arduino itself do not have the ability to connect to the Raspberry Pi for internal communication and signal transfer. Therefor a communication device is needed most importantly. So I used Bluetooth device to establish the internal communication network.

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila. The Mega 2560 board can be programmed with the Arduino Software (IDE).

The Mega 2560 can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and V in pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM.

Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode(),digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50 k ohm. A maximum of 40mA is the value that must not be exceeded to avoid permanent damage to the microcontroller. The Mega 2560 has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analogReference() function.

In order to connect the Bluetooth nodes to the Raspberry Pi, we need to ensure that we have the BLE addresses for each node. Another alternative would be to name each device and then conduct a scan for specific keywords, but that is a much more complicated problem that can be explored once the user has a basic understanding of the Bluepy protocol and BLE behavior. To acquire the Bluetooth address of each BLE device, you will need to connect the TX/RX pins of the HM-10 to the TX/RX of the Arduino Mega board.

Pin	Description
State	can be connected to the Arduino Input in order to know the state of the connection. Paired or disconnected.
Rx	Receive Pin of the module. It is recommended to use a voltage divider as shown in the hookup.
Tx	Can be connected directly to the Arduino Rx Pin
GND	connected to GND pin of Arduino
5v	This breakout board has a internal 3.3v regulator on board.
EN	Enables or Disables the module. Rarely Used.

Figure 4.4: Bluetooth module pin description

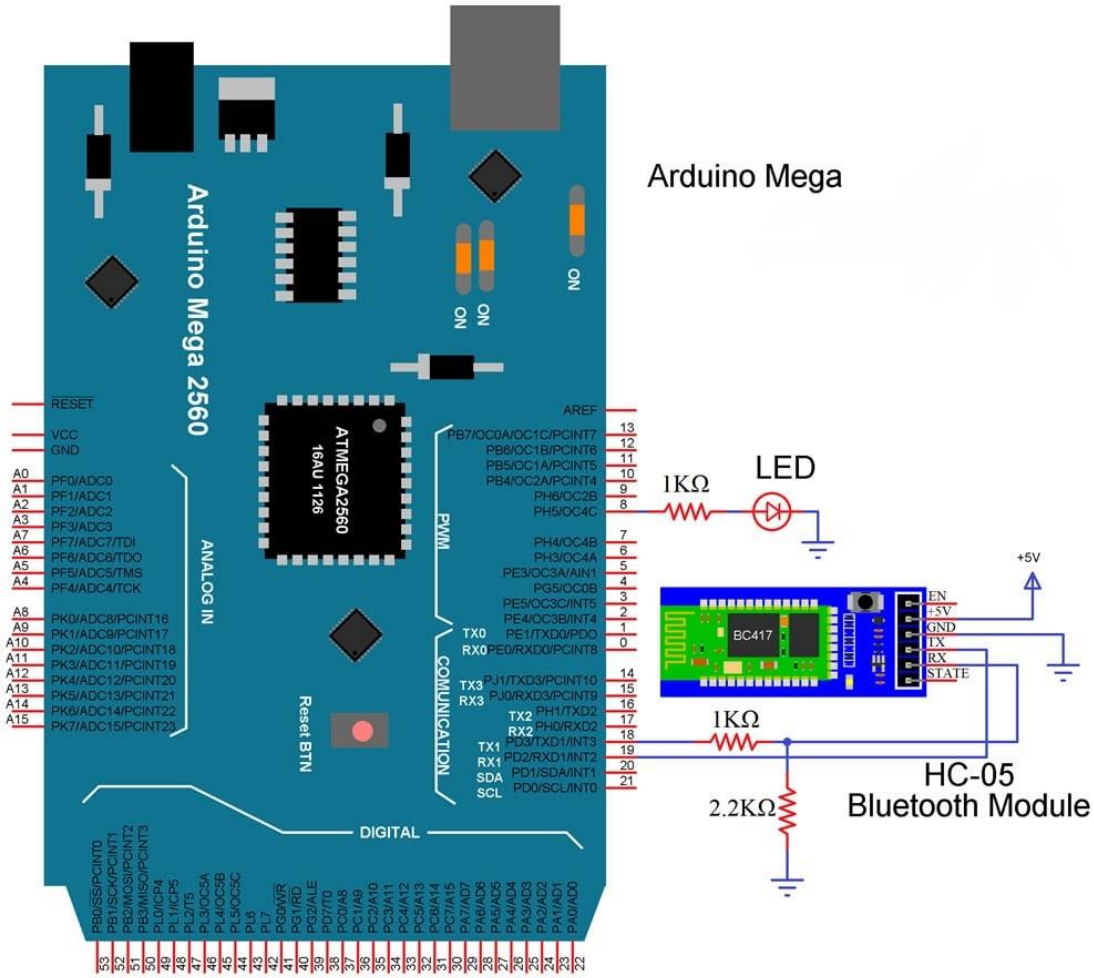

Figure 4.5: Arduino Mega and Bluetooth Connection

The Bluetooth module will be able to collect data from the Raspberry Pi and the data will be forwarded to the Arduino Mega.

In this project I used a 24v DC motor and the motor model is MY6812. Popular as a scooter motor or general application motor. Extremely durable and reliable. Commonly found in 24V scooters or even small kiddies carts and it is also been a proven motor in robotics! There are a few different versions of this motor with the earlier versions having a body length between 97-100mm. It just depends on what revision of the motor you get. The newer versions of this motor are shorter than the original, though the face mounting is the same as is the design of the motor.

Some of these were also available with a 2 screw face fixture, but the 3 screw face plate is more common and more widely used. The ones we sell are the 100W version, though a 150w version is also available as these really are a low cost reliable motor.

The belt drive has the belt sprocket fitted to an 8mm d-cut shaft that is held together with a circlip and some type of filler glue to stop any movement of the sprocket onto the shaft. The way we remove these is to brace the back of the shaft on the motor and tap the top sprocket to break the

beading of the glue, then use two screwdrivers or similar to remove the sprocket. It is also possible to brace underneath the sprocket and tap the shaft to push the pulley off that way.

But to control this motor a motor driver is required. Therefor I used BTS7960 (IBT-2) motor driver in this project. The BTS7960 is a fully integrated high current H bridge module for motor drive applications. Interfacing to a microcontroller is made easy by the integrated driver IC which features logic level inputs, diagnosis with current sense, slew rate adjustment, dead time generation and protection against over temperature, over voltage, under voltage, overcurrent and short circuit. The BTS7960 provides a cost optimized solution for protected high current PWM motor drives with very low board space consumption.
The input voltage of BTS7960 is 6v to 27v DC connection. There is 8 pins in this motor driver. Their function and description is given below-

Pin NO	Function	Description
1	RPWM	Forward Level or PWM signal, Active High
2	LPWM	Reverse Level or PWM signal, Active High
3	R_EN	Forward Drive Enable Input, Active High/ Low Disable
4	L_EN	Reverse Drive Enable Input, Active High/Low Disable
5	R_IS	Forward Drive, Side current alarm output
6	L_IS	Reverse Drive, Side current alarm output
7	Vcc	+5V Power Supply microcontroller
8	GND	Ground Power Supply microcontroller

Table 4.2: BTS7960 motor driver pin description

There is another 4 pins in this motor driver for Motor Power Supply and Output Pin Assignment. The figure is given below-

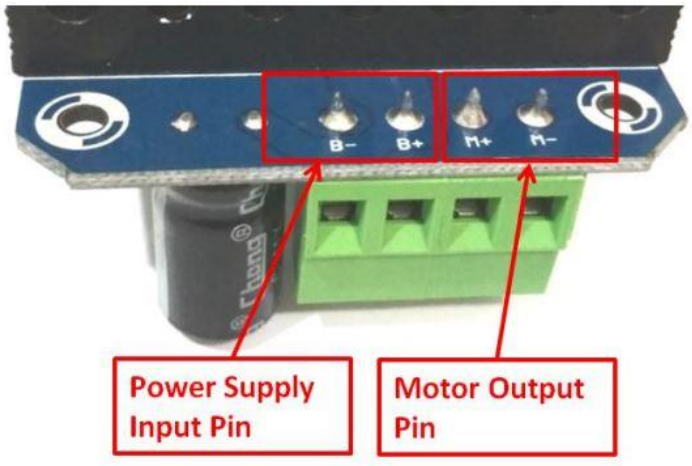

Figure 4.6: Motor Power Supply & Output Pin Assignment

Below is the circuit connection using BTS7960 high power driver to control one DC motor with Arduino board. The potentiometer allows the control of motor speed and rotation direction of the motor.

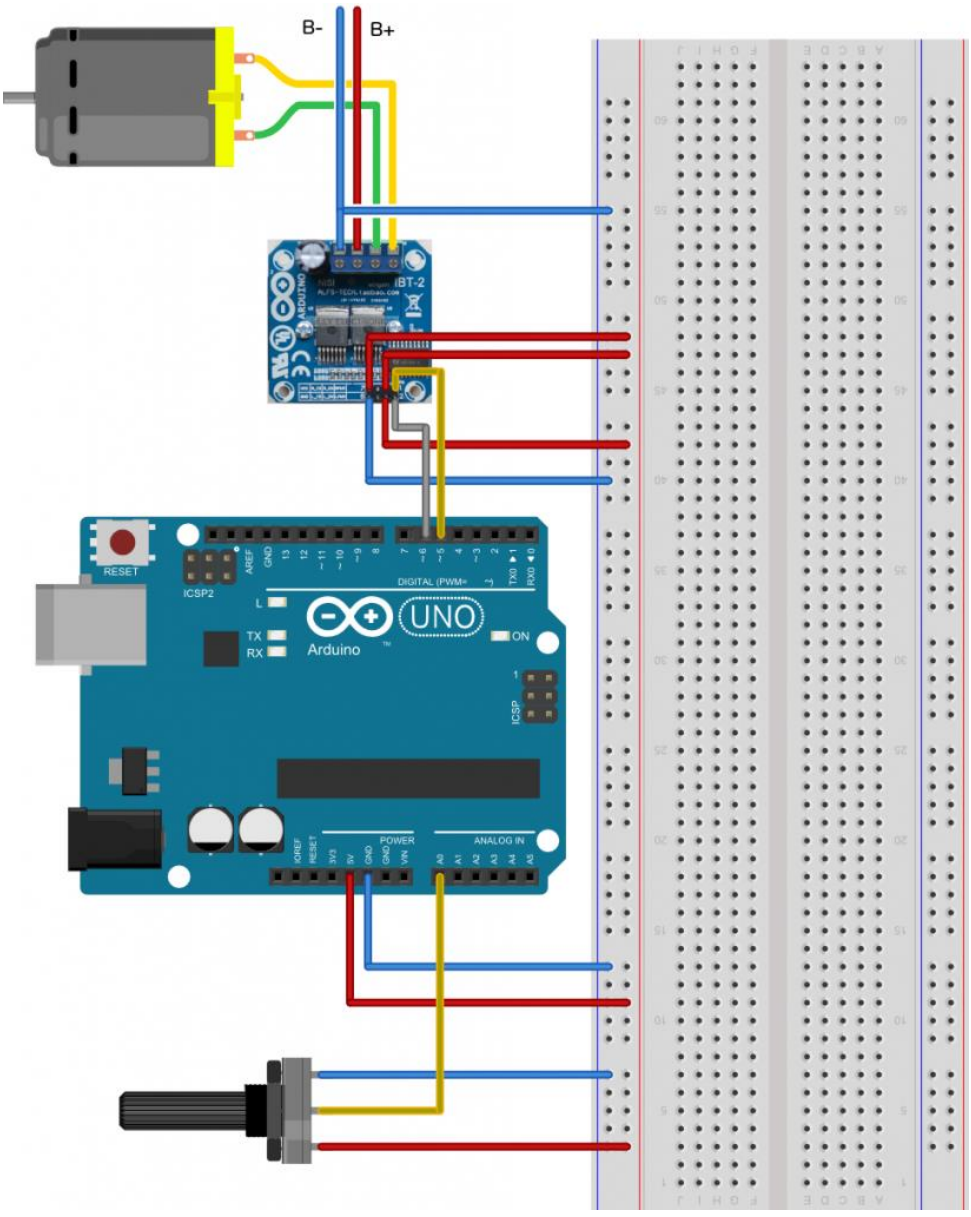

Figure 4.7: Circuit Diagram for BTS7960 with Arduino and Motor

The motor in project requires 24v power to run. Therefor I used 2 12v battery for each motor so that I can provide enough power to the motor. On the other hand the wheelchair needed some modifications to prepare it for the project. We changed the regular hub of the wheelchair into both sided rare hub. Moreover the side partition of the wheelchair is removed and instead of that a steel plate was installed to the wheelchair. This partition will contain the motor of the wheelchair, hand gesture system and the Arduino mega setup with all its necessary components. The battery setup will be placed under the wheelchair.

In this part of the project, automated wheelchair system follows a step by step to process the instructions. First of all the Arduino mega receives the signal from the Raspberry Pi through the Bluetooth module. Then Arduino mega will pick an action from its action list. For example for the action ‘start’ it will start moving forward. The motor will roll a chain and the other end of the chain will be connected to the wheelchairs wheel. The motor driver will control the voltage of the motor from the battery and as well as the speed of the motor. For the instruction start, the motor will start rolling on both side at same speed. If the user moves his hand from right to left, the Pi will consider it as move left command. Than it will pass the information to the Arduino. The Arduino will command the left motor’s driver to stop but on the right side to role. So the wheelchair will move to the left. Same will happen for move to the right side command. The Arduino will turn off the right motor and start the left motor. So the wheelchair will move to the right side.

4.4 Result Discussion

This system was successfully implemented on a prototype. In there instead of a wheelchair the prototype was a small car. The prototype could move forward, backward, right and left. On the other hand, the prototype could communicate with a mobile phone successfully with the help of the GSM module.

In this following picture we can see the raspberry pi 3 and there is a skywriter HAT attached on top of the raspberry. We used a USB cable to supply the power for the raspberry pi. The skywriter HAT sensor is attached right on to the raspberry pi. As it senses the gesture performed above the surface of the sensor, the python code inside the Raspberry pi becomes active to execute the specific operation predefined for that gesture.

There is a GSM module connected to the raspberry pi via some jumper wires. There is also a SIM card inside the slot of the GSM module. Which makes the call or send messages to a phone in any location. GSM module needs to have a power supply of up to 2 amp at a time to execute an operation. But, the Raspberry pi cannot supply the continuous power via the Vcc of Raspberry pi. So, we need to have a 2 amp power supply immediately to the GSM module when we input a gesture to make a call or sending a message.

To solve this problem, we used a capacitor to attach the GSM module to the Raspberry Pi. So that the capacitor can store the current for the immediate supply to the GSM module. When the device gets an input gesture to execute the operation via GSM module, the capacitor is the one who makes the on demand supply of the power to execute the command.

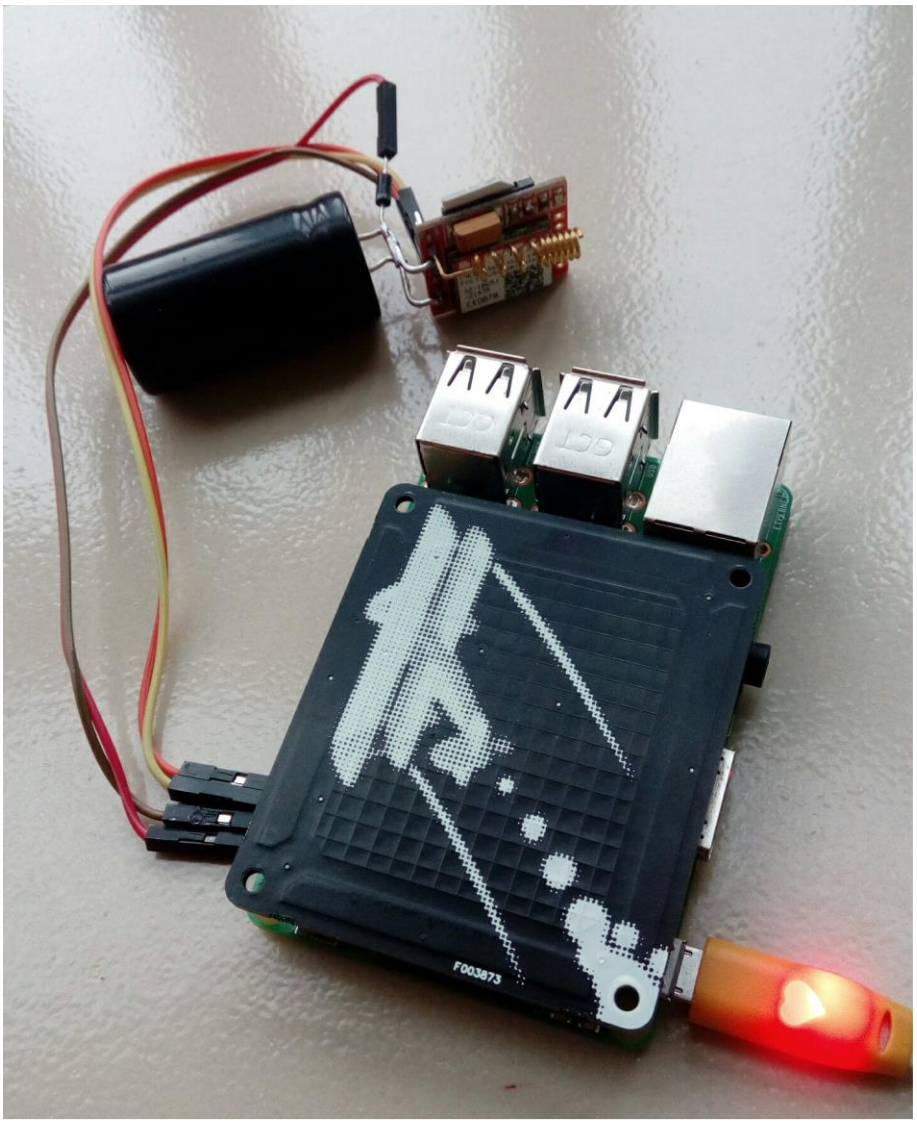

Figure 4.8: Hand Gesture System

As I mentioned before this project was successfully able to send movement instructions to the wheelchair prototype. On the other hand emergency message through the GSM was also fully functional.

On the other hand the wheelchair prototype which is an Arduino controlled car is also functional and working well during test. I tried to control the wheels of this Arduino controlled car as I can control the wheels of the wheelchair as the same way. I used a 11.1V battery for the power supply to the motor controller and the Arduino as well.

The battery also provides the power for the Bluetooth module. The Bluetooth module communicates between the Raspberry pi and the motor controller via the Arduino. The range of this Bluetooth module will select the range the raspberry should be in between that range.

I used motor driver to control the encoder motors of the wheels. I controlled the wheels in four ways. When both of the wheels are stop, the car or the wheelchair remains stop. I implemented this action by a sweep from north to south. When the sensor gets a sweep from south to north, it executes the command to start the wheelchair. The wheels start to rotate with the same speed. Sample picture of the prototype is given below-

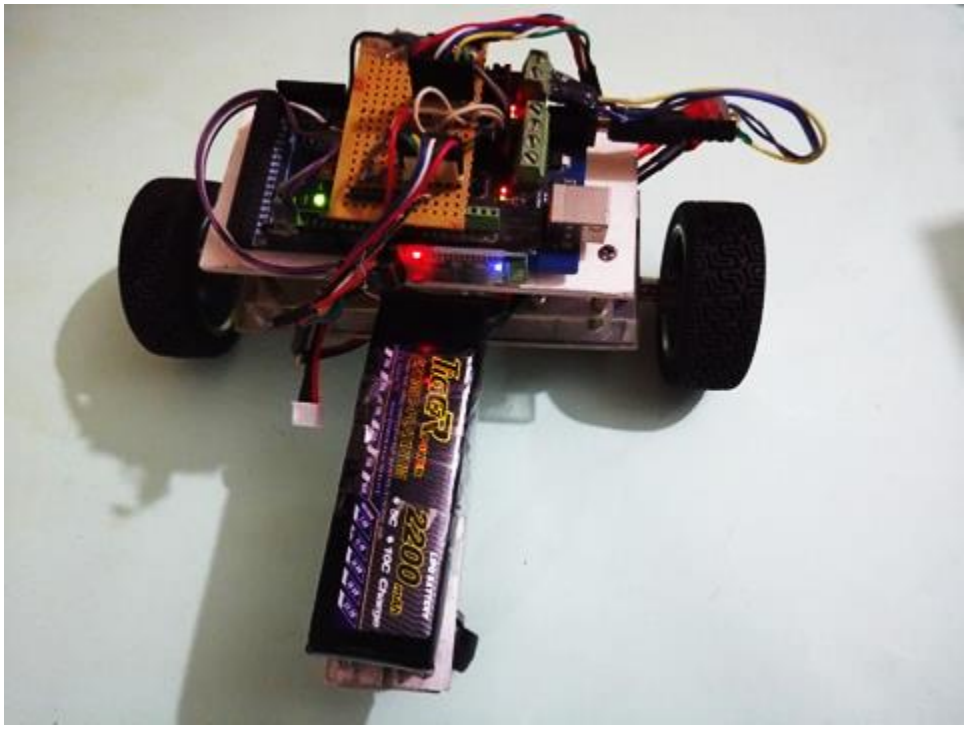

Figure 4.9: Prototype Car

If we consider the final outcome of the project which is modified wheelchair with gesture control, the main modification happened to the wheels. General types of wheels of a wheelchair do not have the capacity to attach a gear to it for being controlled by the motor. So I needed to change the hub of the wheelchair with cycle's rare hub. Even not every kind of hub is going to work, only 28 spoke per wheel rare hub will do the work. Finally I was able to configure the wheel.

Next modification needed to set the motor to the wheelchair. For that I attached a steel plate on the both side of the wheelchair. The motor was placed on the steel plate tightly so that it can pull the wheel easily. All other components will be placed beside the motor including the Raspberry Pi and the Arduino mega. Figure given below is my modified wheelchair –

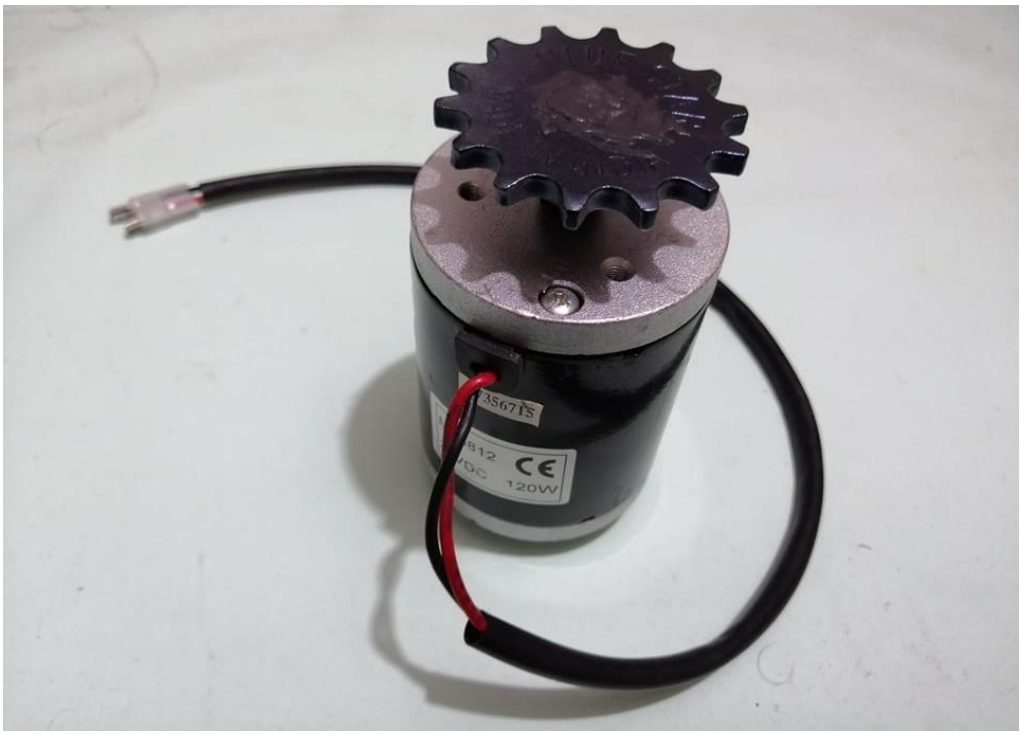

Figure 4.10: Modified wheelchair's Motor

Figure 4.11: Modified Wheelchair's Wheel

Chapter 5

Conclusion & Future Work

5.1 Conclusion

Hand gesture based wheelchair will be an effective tool in a handicapped one's life. The final device is able to make them less dependent in their life. In this era of fastest growing technology, we are enjoying luxury in our life while there are a considerable amount of population who still need our help to do the simplest works in their daily life. We are thinking about helping disabled persons in our own possible way. We have successfully implemented the required applications with this gesture controlled wheelchair. It will be able to support the features mentioned before in real time applications.

Traditional smart wheelchair's cost more than 85000 BDT which is a very big amount for this country where most of the people are not rich enough to effort this. On the other hand this simple project of mine is going to cost less than half of the price. Though this is not yet so cheap, but it will definitely help a lot of people. At the very beginning if there will be less comfort on those wheelchairs but with time and proper research and development this simple design wheels chairs may also be very comfortable for the people.

At the end it can be said that disability is definitely a very strong disadvantage, but not the end of our life. Some disabilities cannot be cured, but we can make some comfort among many discomfort. This is the era of technology, where every day new discoveries are happening. So if we don't focus on the people who actually need it there is no value of those discoveries and smart technologies. IoT can solve many problems of disable people, we just need to focus on those problems and think about finding solution. This will bring the smile of happiness to those disable people, as well as they will again be able to be productive to our society. May be helping one person will make the whole family happy.

So let's take it seriously and work for the disable people, not only to help them or make them smile, but also to make this world a better place. IoT is for everyone and IoT research and development will help us grow faster and give us strength to fight against our major problems in this beautiful world.

5.2 Future Scope

After successful implementation of this project some other IoT features can be added to this project like live monitoring of temperature, oxygen or other different types of gas level, or different smart security features, etc. The comfort of this wheelchair also need proper study and research. Because users of this wheelchair will use this thing for a long time so making it simple will help them to use it for a long time.

On the other hand, in long term process the field of implementation will be increased in a wider range. Then we will think about implementing the motion gesture technology in hospitals, police stations, smart homes, corporate buildings and all sorts of emergency sectors. In future this project can be expanded using more numbers of gestures to apply and implement more actions or features to the wheelchair. Range of communication can be developed to make it effective in a wider area coverage.

References

1. Osama Sohaib, Helen Lu and Walayat Hussain, “Internet of Things (IoT) in E-commerce: For people with disabilities”, 12th IEEE Conference on Industrial Electronics and Applications, DOI: 10.1109/ICIEA.2017.8282881, Siem Reap, Cambodia, June 2017.
2. Pushpanjali Kumari, Pratibha Goel and S. R. N. Reddy, “PiCam: IoT Based Wireless Alert System for Deaf and Hard of Hearing”, 21st Annual International Conference on Advanced Computing and Communications (ADCOM), DOI: 10.1109/ADCOM.2015.14, United States, September 2015.
3. Sharon Varghese, “Application of IoT to improve the life style of differently abled people”, IOSR Journal of Computer Engineering, PP 29-34, e-ISSN: 2278-0661,p-ISSN: 2278-8727, 2015.
4. Ardiana Sula, Evjola Spaho, Keita Matsuo, Leonard Barolli, Rozeta Miho, Fatos Xhafa, “An IoT-Based System for Supporting Children with Autism Spectrum Disorder”, Eighth International Conference on Broadband and Wireless Computing, Communication and Applications, DOI: 10.1109/BWCCA.2013.51, Compiegne, France, October 2013.
5. U. Rajkanna, K. Gunasekaran, and M. Mathankumar. Hand gesture based mobile robot control using pic microcontroller. IEEE, 2015. URL https://en.wikipedia.org/wiki/Gesture_recognition.
6. P. V. V. Pande and N. S.Ubale. Hand gesture based wheelchair movement control for disabled person using mems. Int. Journal of Engineering Research and Applications www.ijera.com, 2014.
7. S. Swapnali and P. Chilveri. Hand gesture recognition using accelerometer sensor for traffic light control system. IEEE, 2014.
8. P. C. p.p., M. K. S.B, and M. K. A.A. A hand gesture based wheelchair for physically handicapped person with emergency alert system. IRJET, 2016.
9. M. Devi and B. Kumar, Accelerometer based direction controlled wheelchair using gesture technology. International Journal of Scientific Engineering and Technology, 8:1065–1070, 2014.
10. M. MAZO and F. J.RODRIGUEZ. Wheelchair for physically disabled people with voice, ultrasonic and infrared sensor control. International Journal of Scientific Engineering and Technology, 2015.
11. S. Ganapathyraju. Hand gesture recognition using convexity hull defects to control an industrial robot. IEEE, 2014.
12. S. GANGOPADHYAY, S. MUKHERJEE, and S. CHATTERJEE. Intelligent gesture controlled wireless wheelchair for the physically handicapped. International Journal of Electrical, Electronics and Data Communication, ISSN: 2320 - 2084, 2013.
13. A. P. S and P. Rohitha. U.M. Microcontroller based hand gesture recognition system using flex sensor for disabled people. International Journal of Computer Applications, 2015.
14. “Arduino Mega”, https://www.arduino.cc/en/Main/arduinoBoardMega/.
15. Carmen P. DiGiovine, “Wheelchair”, https://www.britannica.com/topic/wheelchair.