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An Automated Wheelchair for Physically Challenged People using Hand Gesture and Mobile App

Md. Farhan Razy[1], Sabah Shahnoor Anis[1], Md. Touhiduzzaman Touhid[1], Jia Uddin[2]

[1]BRAC University, Department of Computer Science and Engineering, Mohakhali, Dhaka 1212, Bangladesh
[2]Department of Technology Studies, Endicott College, Woosong University, Daejeon, South Korea
{farhanrazyanik, shahnoor.evana, touhidshuvosb}@gmail.com, jia.uddin@wsu.ac.kr

Abstract

Traditional manual wheelchairs are difficult to use without the help of body strength. This paper presents a model of an automated wheelchair for disabled people. The proposed wheelchair is battery powered and uses an Arduino microcontroller to operate. The device consists of two parts- one is the sender end and another is the receiver end. The sender end records instructions from the user's different hand gestures which are collected using an MPU-6050 gyro accelerometer sensor. The instructions are continuously recorded and sent to the receiver end using an RF transmitter- nRF24101 through an Arduino microcontroller. In the receiver end, the signal is received by an nRF module which is used to control the wheelchair in a plain surface. Additionally, the device contains a Bluetooth module which can be used as a secondary control system so it can be used by a smartphone application. Experimental results demonstrate that the proposed model is functional under normal circumstances with a fast response time which can be very useful for disable people to commute with.

Keywords: *Gesture controlled wheelchair; gyro accelerometer; Arduino microcontroller; RF transmitter; Bluetooth module; mobile application*

1. Introduction

Wheelchairs are needed for physically challenged people of different age groups. 1.825 million Wheelchair users are of the age 65+ years. Besides ageing, other factors are resulting in increased usage of wheelchairs which include genetic disorders, accidents etc. It is evident from a survey that shows an average annual growth rate of 2.5% in the revenue sector of the wheelchair industry from 2009 to 2014. Besides, there are an estimated 3.3 million wheelchair users in the United States alone and about 2,000,000 new wheelchair users joining in yearly; 17.4% of working-age wheelchair users have jobs [1]. Previously, the traditional hand-rowed wheelchairs only had two wheels attached to a chair that had to be controlled manually either by the passenger himself or a third person. A lot of remarkable work has been done in the field of wheelchair technology. However, there is still a huge scope of development. Some patients cannot run the wheelchair with their arms, because they cannot move most of the body parts. This is where the demand for automated wheelchairs arises. In the evolution of intelligent wheelchair system, one of the earliest steps was a system implemented by Connell and Viola, in 1990 in which they set a chair on top of a robot which gave the chair mobility [2]. It could be controlled by the user via a joystick mounted on the arm of the chair and

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connected to the robot. Nipanikar (2013*) et al.* implemented voice recognition system to control an automated wheelchair and ultrasonic and infrared sensor system to avoid obstacles [3]. However, the use of voice recognition and voice command to handle the wheelchair may sound innovative but is not so efficient and cannot be relied on. Because it can be risky for outdoors as the noise can manipulate and can even change the voice command of the user. Besides this, it also had the provision of an accelerometer sensor and joystick for disabled people who can easily move their hands. Thereafter, in 2014, Vishal *et al.* structured a wheelchair controlled by hand gesture recognition [4]. This is done with the use of accelerometer sensor which resulted in a controllable wheelchair that can move freely in all directions. Furthermore, a wheelchair which was controllable by the head movement was designed by Rishi *et al.* [5]. Their system used two head orientation detection units (Ultrasonic Sensors). The system could detect the head position via the ultrasonic sensors and could control the motor rotation connected to the two wheels. This idea is useful for those patients who could not move any other part of the body except for the head. In (2017), Balsaraf *et al.* designed a wheelchair controlled by an android device like a mobile phone [6]. The Android Mobile was used as an input which operated the wheelchair to desired directions.

In this era of wireless communication, fixed joystick control is not efficient enough. As using this system, users cannot operate the wheelchair remotely in need. The projects where wireless controlling was used, were based on either gesture or phone application but not on both. So, the users did not have any freedom of option for controlling those wheelchairs according to their comfort.

To overcome all these limitations related with the existing automated wheelchairs, in this paper, a model is proposed for aiding people to handle the wheelchair remotely from a distance via Bluetooth features on a mobile device [7]. Additionally, it can be handled via hand gestures using gyroscope sensors for techno-phobic people who are not comfortable with phone functionalities, to reduce physical labor and aid in an advanced and progressive life [8].

The rest of the paper is presented as follows: Chapter 2 describes the proposed model with hardware implementation and Chapter 3 deals with experimental setup along with result analysis. In the end, Chapter 4 concludes the paper.

2. Literature Review

A lot of remarkable work has been done in the field of wheelchair technology. However, there is still a huge scope of development. Some patients cannot run the wheelchair with their arms, because they cannot move most of the body parts. This is where the demand of automated wheelchairs arises. Some of the earliest work in the development of intelligent wheelchairs was a system implemented by Connell and Viola, in 1990 in which a chair is mounted on top of a robot to make it mobile [7]. It could be controlled by the user using a joystick mounted on the arm of the chair and connected to the robot. Nipanikar (2013) *et al*. implemented voice recognition system to control an automated wheelchair and ultrasonic and infrared sensor system to avoid obstacles [2]. It also had provision of accelerometer sensor and joystick for disabled person who can easily move his/her hand. Thereafter, in 2014, Vishal *et al*. structured a wheelchair controlled by hand gesture recognition [6]. This is done with the use of accelerometer sensor. It provided a controllable wheelchair that has the ability to move freely in all directions. Furthermore, a wheelchair which was controllable by head movement was designed by Rishi *et al*. [9]. Their system used two head orientation detection units (Ultrasonic Sensors). The system could detect the head position via the ultrasonic sensors and could

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3. Proposed Model

In our designed wheelchair, the wheels are powered by DC motors [9] to enable the user for using it automatically. It is much easier than operating manual wheelchairs. The DC motors take energy from rechargeable batteries which can be used for 2-3 hours when fully charged.

We designed a smart automated wheelchair that can be useful for elder and handicapped patients. This wheelchair is mainly divided into two systems: gesture control system and Bluetooth control system using mobile application name (Bluetooth RC controller). In this system, the wheelchair can be controlled by hand gestures with the help of a gesture recognition system [10]. The gesture recognition system depends on the accelerometer sensor [10] which is a low cost and could provide the direction of the hand so it helps to recognize the gestures. This study provided an easily controllable wheelchair for elder and disabled people they can drive it by themselves and with fewer efforts.

To understand the principle of operation of the Hand Gesture Controlled system let us divide the project into three parts.

The first part is getting data from the MPU6050 Accelerometer Gyro Sensor [10] by the Arduino [11]. The Arduino continuously acquires data from the MPU6050 and based on the predefined parameters, it sends data to the RF Transmitter [12].

The next part of the project is the Wireless Communication between the RF modules. The RF Transmitter, upon receiving data from Arduino, transmits it through the RF Communication to the RF Receiver [12] also our wheelchair can be controlled by a mobile application which uses Bluetooth communication system.

Finally, the third part of the project is decoding the Data received by the RF Receiver and sending appropriate signals to the Motor Driver IC [13], which will activate the Wheel Motors of the wheelchair.

3.1. Block Diagram of the Proposed Model

Fig. 1 shows the block diagram of transmitter end, where the hand gesture is recognized by the MPU6050 gyro sensor [10] and processed thus giving commands to the microcontroller [11] accordingly and hence to the system. When an accelerometer sensor finds the movement of hands or change of position thus gives analog signal to microcontroller and convert it into appropriate digital level so as to move the motors of wheelchair, then the digital signal sent via nRF24L01 transceiver module [12].

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Fig. 1. Sample block diagram of Transmitter

Fig. 2 shows the block diagram of the receiver end. Where the data sent by transmitter end received by nRF24L01 transceiver module [12] and convert it into appropriate signal and sent it to the microcontroller [14] accordingly to control the motors to run the wheels. Microcontroller controls the movements of the wheelchair by sending appropriate instructions to the LN29D motor driver IC [13].

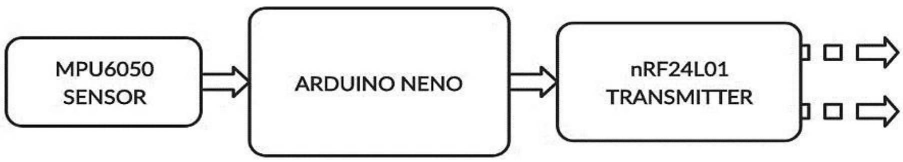

Fig. 2. Sample block diagram of Receiver

3.2. Hardware used

In this model, we have designed a simple Hand Gesture Controlled Robot which also can be used by simple mobile application This Hand Gesture Controlled Robot is based on Arduino Nano [11], Arduino Uno [14], MPU6050 [10], (nRF24l01) RF Transmitter-Receiver Pair (for gesture control) [12], HC-05 Bluetooth module (for connect with mobile application) [15] and L293D Motor Driver [13].

Even though the title says it as a Hand Gesture Controlled wheelchair, technically this wheelchair is controlled by the tilt of the hand. However, as stated by Electronics Hub (2017), the MPU6050 is one of the most commonly used Sensor Modules by hobbyists and enthusiasts. Accelerometer and Gyroscope on the same IC and provides 6 Degrees of Freedom (3-axis of Accelerometer and 3-axis of Gyroscope).

Fig. 3 shows how the components are connected in the transmitter end. The MPU6050 Accelerometer and Gyroscope Module's [10] SCL and SDA connected with A5, A4 pin of the Arduino NENO [11] as shown in the diagram. And for connect with RF module we use NRF24L01's [12] MISO connects to pin 12 , MOSI connects to pin 11 green wire, SCK connects to pin 13, CE connects to pin 9, CSN connects to pin 10 of the NANO , the earth wire , is connected to the ground pin and 5V connects with VCC pin of the both sensor. Lastly the whole system powered by a 9V battery.

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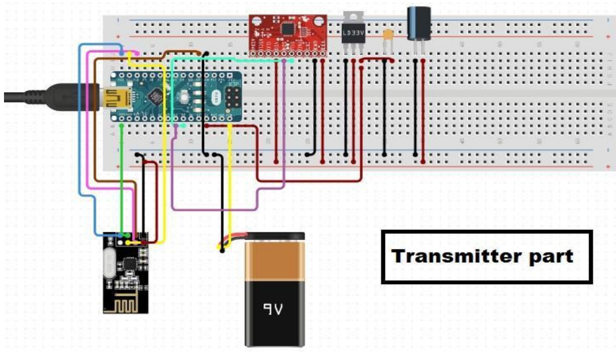

Fig. 3. Hardware implementation of the gesture control unit

Figure 4 shows how the components are connected in the receiver end. With Arduino Uno's [14] pin 5, 6,9,10 firstly connect with DC M Driver L298's [13] INT1, INT2, INT3 and INT 4 accordingly. Moreover, DCMDriverL298 OUT1, OUT2, OUT3, OUT4 connected to DC Motor Coil2, Coil1 Coil2, and Coil1 accordingly and RF module [12] connects with UNO similarly as shown in Fig.3. Lastly the whole system uses 2, 3.7V rechargeable batteries to power up the whole system.

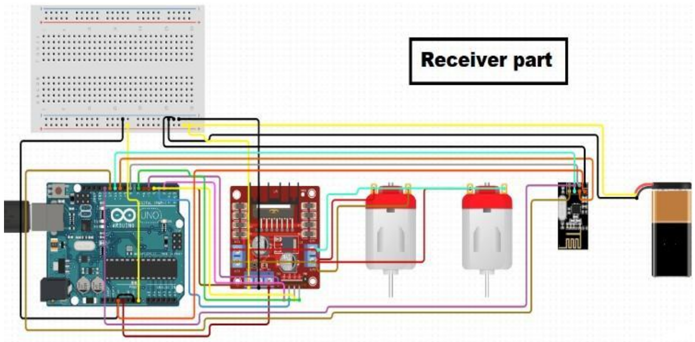

Fig. 4. Hardware implementation of the wheelchair (with nRF24101)

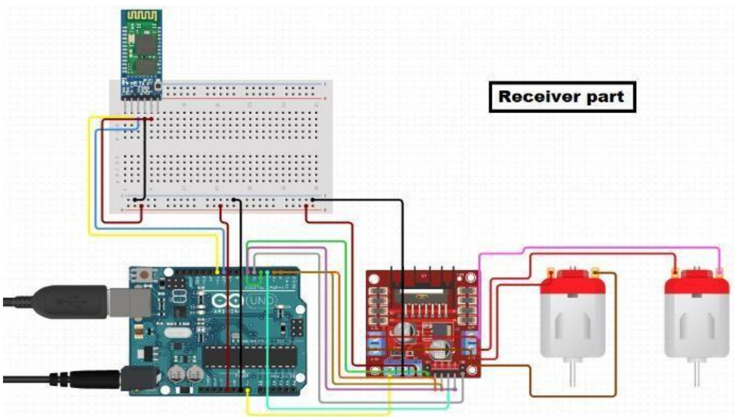

Fig. 5. Hardware implementation of the wheelchair (with Bluetooth module)

Figure 5 shows the connection of Bluetooth module HC-05[12] with Arduino UNO [14] Simply power the module with +5V and connect the Rx pin of the module to the Tx of MCU and Tx pin of module to Rx of MCU, and the other connection are same as Fig.4.

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3.3. Program Pseudocode

The Pseudo code for gesture control (receiver part) is given below.

```
Begin
void setup ()
{
  Define the four input pins: forward, backward, left and right;
  Define the four output pins: MotA1, MotA2, MotB1, MotB2;
}
void loop ()
{
  Read four inputs;
  if(backward==1 && forward==0 && left==0 && right==0)
  backward();
  else if(backward==0 && forward==1 && left==0 && right==0)
  forward();
  else if(backward==0 && forward==0 && left==1 && right==0)
  left();
 else if(backward==0 && forward==0 && left==0 && right==1)
  right();
else
  Stop();
}
End
```

Firstly, four input and four output pins are defined. The input pins take four inputs from the data sent by the MPU-6050 sensor. The four output pins send signals to the motor driver for its control. Afterwards, an infinite loop is run which keeps reading the inputs and checks them with the given conditions to determine the movement of the wheelchair.

4. Experimental Setup and Result Analysis

To begin the experiment, firstly both the prototype model wheel-chair and the signal transmitter device were connected to their power supplies. We tested the transmitter for its functionality and found that it was transmitting data properly. The data collected from the movement of the hand by the MPU-6050 Gyro Accelerometer sensor was encoded by the encoder and sent through the RF transmitter. There were five types of signals or gestures that the device will recognize: Stop, forward, backward, left and right. Afterwards, we tested the receiver end for its functionality. The RF receiver was collecting the data sent by the transmitter device and it was decided by the decoder. Then the decoder sent the data to the Arduino and the wheel-chair followed the instructions according to the signal that was sent.

The five different hand gestures are shown in Fig.6, where the different movement recorded by the MPU-6050 sensor is sent to the wheelchair. Fig.6.(a) shows the gesture for the stop command, (b) shows the gesture for the forward command and (c),(d) and (e) show the gestures for backward, left and right command respectively.

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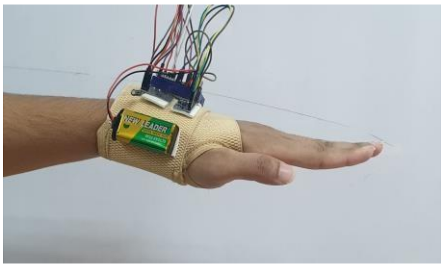
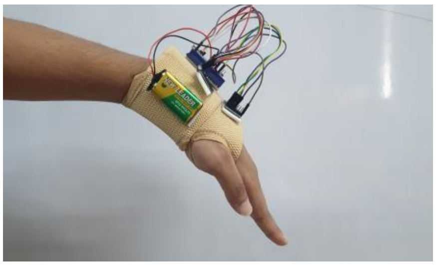
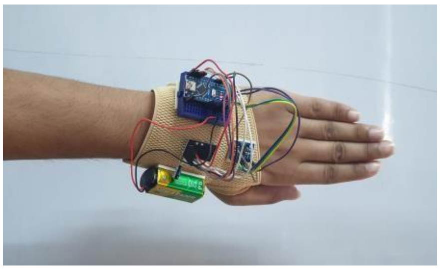


(a)

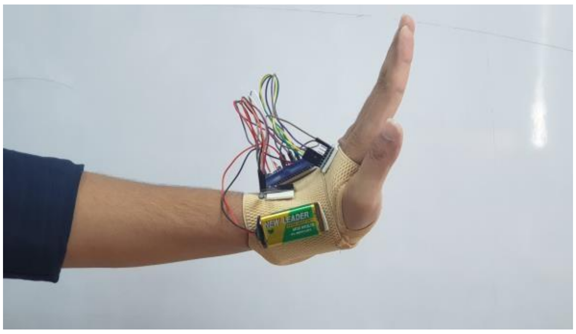


(b)



(c)

(d)



(e)

Fig. 6. Different hand gestures, (a) the stop gesture, (b) the forward gesture, (c) the right gesture, (d) the left gesture and (e) the backward gesture

(a)

(b)

Fig. 7. The receiver end of the device, (a) back view and (b) side view

After finishing the experimental procedure, we got the expected results. The wheelchair was moving according to the hand gesture given by the user. Fig. 7 shows the model body of the wheelchair, the receiving end of the device.

The set of input received by the wheelchair and the movement it makes is shown in Table 1. This device will be very useful for disabled people as they only need to use intuitive hand gestures to control the chair. Moreover, the device will stop at once if the signal is lost. The user can easily reach the device from their bed so that there is minimum assistance required from someone else. This device will be very cost efficient so that

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people of all financial capability can afford it. Hence, the affordability and performance of this chair is satisfactory.

Table 1. The input for Arduino and their corresponding direction of movement

Movement of hand	Input for Arduino from gesture				
Side	D3	D2	D1	D0	Direction
Stable	0	0	0	0	Stop
Tilt right	0	0	0	1	Turn right
Tilt left	0	0	1	0	Turn left
Tilt back	1	0	0	0	Backward
Tilt front	0	1	0	0	Forward

5. Conclusions

This paper is to demonstrate solutions to real-world problems and one of those real-world problems is the growing need for advanced wheelchair machines. There has been a drastic increase in the rate of road-accident in comparison to the last few decades. More accidents, more injuries. The injured people and people who have physical disability deserve an equal opportunity at having a healthy and prosperous life just as the regular people. So to ease their lifestyle a proposal has been made for a wheelchair that can be comfortable, reliable, advanced, sustainable and most importantly affordable to the common people. It will also be efficient and economical and most importantly, eco-friendly as it will be rechargeable. Besides, upgraded features such as head motion, sonar detection, sensation and GPS location can be added in the future which will truly transform the way traditional hand rowed wheelchairs provide services. All in all, this system can be made highly efficient, durable and effective if hard and fast environmental conditions are maintained.

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Authors

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Sabah Shahnoor Anis completed her Bachelor Degree in Computer Science and Engineering (CSE) from BRAC University, Mohakhali, Dhaka, Bangladesh, in 2020. She did her undergraduate thesis/project in the area of IoT and Intelligent Systems. Her research interests include IoT and Smart Intelligent Systems.

Md.Touhiduzzaman Touhid completed his Bachelor Degree in Computer Science and Engineering (CSE) from BRAC University, Mohakhali, Dhaka, Bangladesh, in early 2020. He did his undergraduate thesis/project in the area of Smart Intelligent Systems. Her research interests include IoT and Machine learning.

Jia Uddin received a BSc degree in Computer and Communication Engineering from International Islamic University, Chittagong, Bangladesh, in 2005, and an MS degree in Electrical Engineering with an emphasis on telecommunications from the Blekinge Institute of Technology, Sweden, in 2010. His PhD was earned in Computer Engineering at the University of Ulsan, South Korea, in January 2015. He is an assistant professor in the Department of Technology Studies, Endicott College, Woosong University, Daejeon, South Korea. His research interests include fault diagnosis, parallel computing, and multimedia systems. He is a member of the IEB (Institute of Engineers Bangladesh).

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