AUTOMATED WHEELCHAIR FOR DIFFERENTLY ABLED PERSON WITH FALL DETECTION AND MANEUVERABILITY

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Abstract— *While many people with disabilities can benefit from power wheelchairs, some people with disabilities find it difficult or impossible to use a basic power wheelchair. To serve this group, several researchers have developed "smart wheelchairs" that use technologies originally developed for mobile robots to reduce the physical, perceptual, and cognitive skills needed to operate a motorized wheelchair. Smart Wheelchairs are mechanically controlled devices that can move on their own with the help of a user command. This reduces the user's human effort and force required to push the wheelchair wheels. It also allows visually or physically disabled people to move from one location to another. The wheelchair also has an obstacle detection system, which reduces the likelihood of a collision while traveling.*

Keywords— Smart wheelchair, controlled, motorized, command, technology.

1. INTRODUCTION

1.1. General

A manual wheelchair includes two big wheels for movement that the user pushes and two caster wheels in front for stability. Because of recent advances in electronics, it is now possible to convert a manual wheelchair into an electric wheelchair at a reasonable cost. The original push wheels are replaced with motorized ones to achieve this transition. While energy wheelchairs can suit the needs of many people with disabilities, certain people with disabilities (up to 40%) find it difficult or impossible to use a general power wheelchair [1].

The Population and Housing Census of Bhutan (PHCB) 2017, conducted research to analyze and assess the prevalence of disability among people aged 15 years old and greater. Even though Bhutan has a very small population, according to the Population and Housing Census of Bhutan (PHCB) 2017, the prevalence of self-reported disability was 2.8 percent, among whom 34.2 percent reported multiple disabilities. Restriction in walking and hearing were common disabilities [2]. According to Bhutan's Road Safety Country Profile, about 2,085 people suffered serious casualties and injuries [3], resulting in disability. This highlights that although the population is less than 800,000, fatalities due to accidents are frequent [3].

In today's world, automation is developing in every field with greater effect where we can automate everything that is around us [4]. Workload and risk can also be reduced and made it simpler and cost effective. Numerous research is being performed in the field of automating the wheelchair means a smart wheelchair with technology evolved from cellular robots that provides different features with excellent services compared to the older ones [5].

A smart wheelchair with Bluetooth control and Joystick control as an alternative, fall detection, and a humidity and temperature display system are being developed [6]. The same system makes use of sensors like the IMU 6050, which has accelerometer and gyroscope features and can help detect falls [7], as well as a buzzer to indicate the accident and a microcontroller that provides the overall values to those engaged.

1.4. Objective

- Smart fall detection system: that minimizes the consequences of a fall using IMU sensor and GSM Module for communication between users.
- A motor-controlled wheelchair: with a wired Joystick and wireless Bluetooth system which provides the end users with ease of control [8].
- Providing the users with the temperature and humidity current data: with the help of a temperature and humidity sensor.

2. MATERIALS AND METHODS

The block diagram below gives in detail the overall functioning and components of the project. A battery is used to provide a 12V power supply for the system. The main component is the microprocessor unit, which controls all other components such as the joystick, Bluetooth, motor driver, fall detection sensor (IMU MPU6050), and buzzer [9]. Because all the program codes are stored in the program memory of the memory unit in the control processing unit of the microprocessor unit, each component must be interfaced with that unit (i.e., Arduino uno).

In this paper, several methods like motor control using a motor driver, smartphone control through Bluetooth, fall detection using MPU 6050 are discussed.

2.1.1: Block diagram of motor control

The speed and direction of the motor is controlled using motor driver L298N. Motor A and B is connected to the motor driver output pin 1,2,3,4. 12VDC and ground is connected to the VSM and GND. The driver pin ENA, IN1, IN2, IN3, IN4 and ENB are connected to the Arduino digital pin 9,8,7,5,4and 3. Driver GND is connected to Arduino GND. Arduino and motor driver is power by supplying 12 Volt DC.

2.1.2: Block diagram of joystick and Bluetooth module

After gaining proper control over the motors, we began to control the motors using input devices such as a joystick and a Bluetooth module. You can use a Joystick controlled wheelchair or a Bluetooth controlled wheelchair for your patients or elderly people, depending on their willingness and comfortability; you do not need to be with them all the time. Separate graphical representations for Joystick and Bluetooth control methods are provided below.

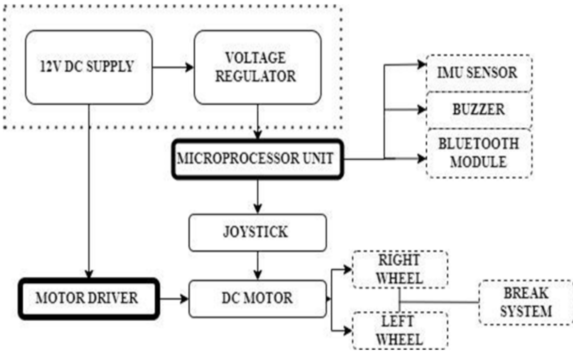


Fig. 1. Block Diagram of Overall Project

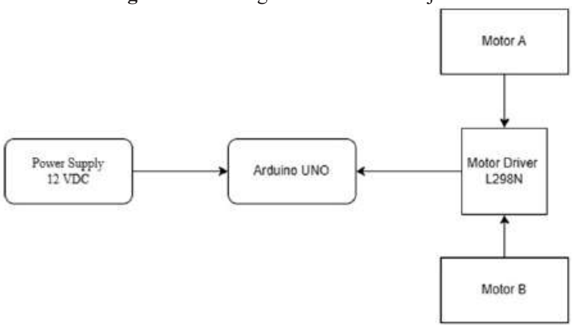
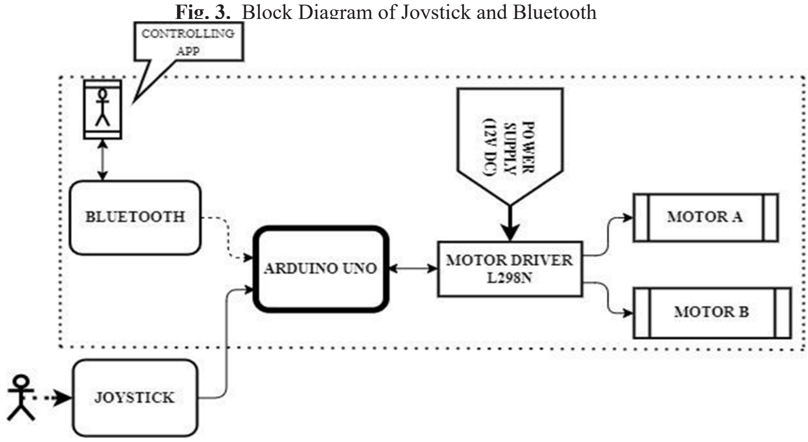


Fig. 2. Block diagram of motor control

Fig. 3. Block Diagram of Joystick and Bluetooth



2.1.3: Block diagram of fall detection

The power supply is given to Arduino Uno. The Arduino Uno further gives 5V supply to buzzer and MPU 6050

- MPU 6050 module 5V pin, is connected it to Arduino's 5V pin. If not, you will have to connect it to the 3.3V pin.
- The GND of the Arduino is connected to the GND of the MPU 6050.
- IMU 6050 pin INT is the interrupt digital output pin. Hence Arduino's digital pin 2 (interrupt pin 0) is connected to the pin labelled as INT on the MPU 6050.
- SCL, is the I2C serial clock. SDA is the I2C serial data pin.
- To set up the I2C lines, connect the pin labelled SDA on the MPU 6050 to the Arduino's analog pin 4 (SDA), and the pin labelled as SCL on the MPU 6050 to the Arduino's analog pin 5 (SCL).
- BUZZER positive label is connected to pin 12 of Arduino Uno and negative to GND.

3.1. Flow charts

3.1.1: Motor control flowchart

The first step is to lay a solid foundation for whatever you're doing so that the result or outcome is satisfactory. Because the entire system is dependent on that controlled motor, the joystick and Bluetooth control systems will not function properly if the motor is not controlled. We started by controlling one motor with the L298N motor driver and gradually increased to controlling both at the same time. Below is a graphic representation of the motor control system.

3.1.2: Fall detection system using IMU 6050 with buzzer.

To detect fall we first measure the accelerometer vector data and gyroscopic angular rotation on those three axes (X, Y, Z). The gyro

angle calculation and accelerometer angle calculation are done based on basic trigonometry functions.
When calculating gyroscopic angles, the operating frequency of 250Hz is taken into consideration. The accelerometer calculation is done based on the vectors in x, y, z axis and its trigonometric functions. The figure defines how the trigonometric functions are considered.

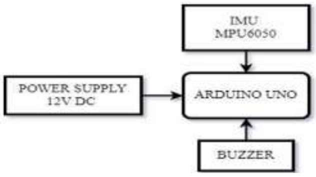


Fig. 4. Block Diagram for fall detection

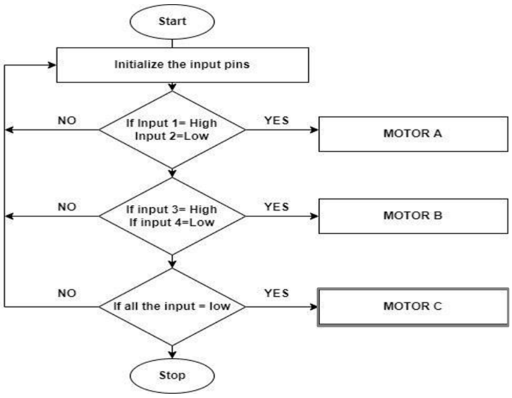


Fig. 5. motor control flowchart

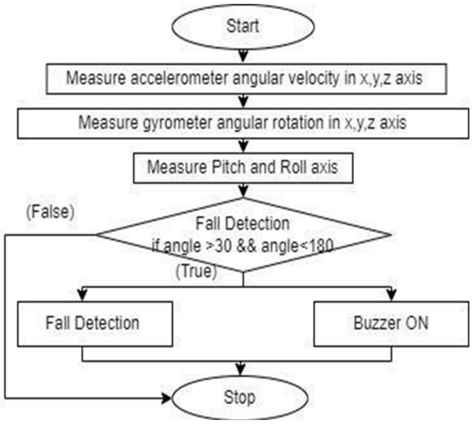


Fig. 6. fall detection using IMU 6050

3.2. Design and Hardware Setup

3.2.1: Motor control setup

Each of the L298N's channels has two types of control pins that allow us to control the speed and direction of the DC motors at the same time. Direction and speed are controlled by pins. The direction control pins can be used to control whether the motor spins forward or backward. The module has two direction control pins for each channel. IN1 and IN2 control the direction of rotation of motor A, while IN3 and IN4 control motor B.

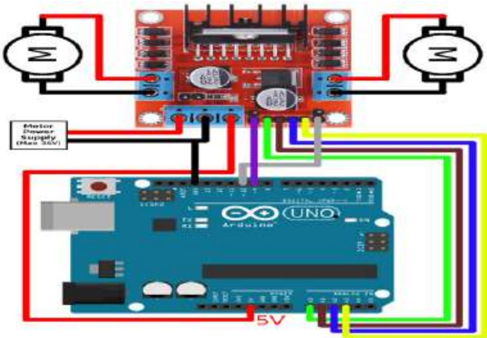


Fig. 7. motor control using L298N's.

3.2.2: Motor control using Joystick.

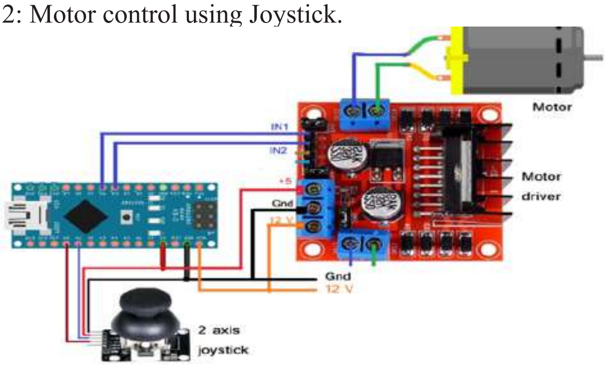


Fig. 8. Motor control using joystick.

3.2.3: Hardware setup for fall detection using IMU 6050 sensor and buzzer.

Our project's focus is a fall detection system, for which we used an IMU 6050 sensor. Someone close to the patient or wheelchair user must be aware of the incident that occurred to the user to be aware that a Buzzer system has been installed to alert that person or others nearby [9]. We can significantly reduce the consequences of the incident if we act in this manner.

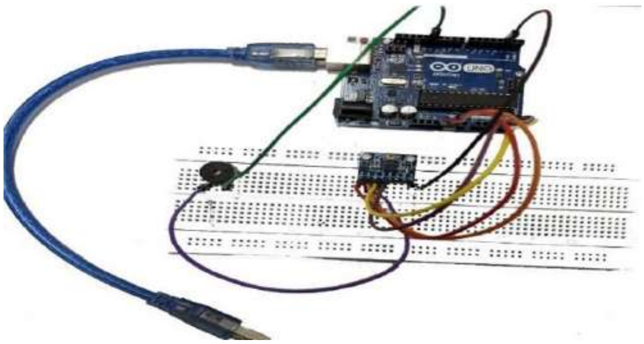


Fig. 9. fall detection using IMU 6050

3.2.4: Hardware setup for overall system

After having individual connections and set ups, we have combined the entire system together on one board. Motor control using both the methods joystick and Bluetooth along with fall detection system embedded in one Arduino board. All the programming codes are collaborated and produced as one to control the system [11]. This represents our fall detection wheelchair, to have temperature and humidity sensing system we need one more Arduino controller board separately.

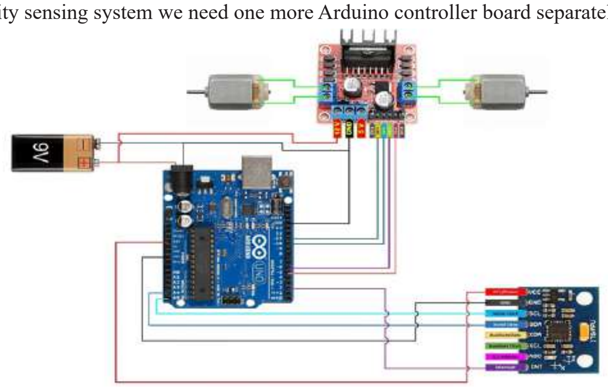


Fig. 10. Hardware setup for overall system

3.3. Components Description

3.3.1. L298N Motor Driver

The L298N is a dual-channel H-Bridge motor driver that can power two DC motors. That means it can drive up to two motors independently, making it ideal for building two-wheel robot platforms. The L298N motor driver module is powered by screw terminals with a pitch of 3.5mm.

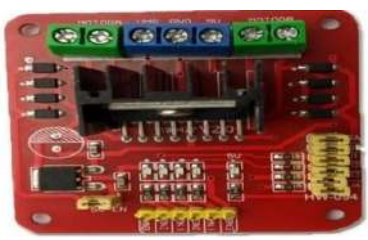


Fig.11. Motor Driver L298N

3.3.2. TT Gear Motor

These low-cost TT Gear Motors are a simple and low-cost way to get your projects moving. These gear motors require a voltage of 3-6VDC, a no-load current of less than 150mA at 3V, a stall torque of 0.8kg.cm at 6V and come with 2 x 200mm wires with breadboard-friendly 0.1" male connectors. It's ideal for use with a breadboard or terminal blocks.

Fig. 12. TT gear Motor

3.3.3. Arduino UNO

The Arduino Uno is a microcontroller board based on the ATmega328. To commemorate the upcoming release of the Arduino Uno Board 1.0 microcontroller board, the name Arduino Uno was chosen. This board has digital I/O pins 14, a power jack, analog I/O pins 6, a ceramic resonator-A16 MHz, a USB connection, an RST button, and an ICSP header. All of these can support the microcontroller for further operation by connecting this board to the computer. If necessary, an AC to DC adapter, a USB cable, or a battery can be used to power this board.

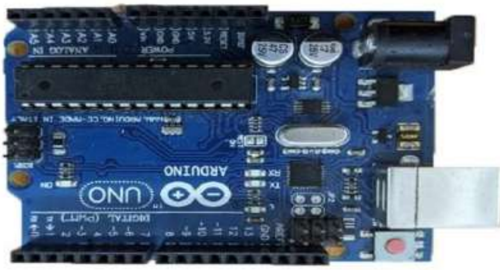


Fig. 13. Arduino UNO

3.3.4. LCD Display

The term LCD refers to a liquid crystal display. It is a type of electronic display module that is used in a wide range of circuits and devices such as mobile phones, calculators, computers, television sets, and so on. Multi-segment light-emitting diodes and seven segments are the most common applications for these displays.

LCD16x2 Specifications:

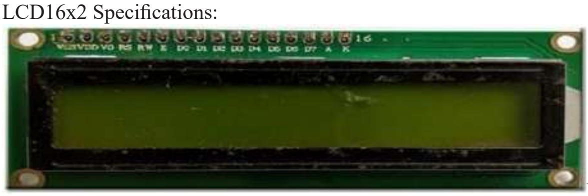


Fig. 14. LCD Display

3.3.5: IMU 6050 sensor

The MPU devices are the world's first integrated 6-axis motion processor solution, removing the need for discrete gyroscope and accelerometer cross-axis alignment. On the same silicon chip, the devices have a 3-axis gyroscope and a 3-axis accelerometer, as well as an inbuilt Digital Motion Processor that can perform complex 9-axis sensor fusion algorithms using the Motion Fusion engine, which has been field tested and patented.

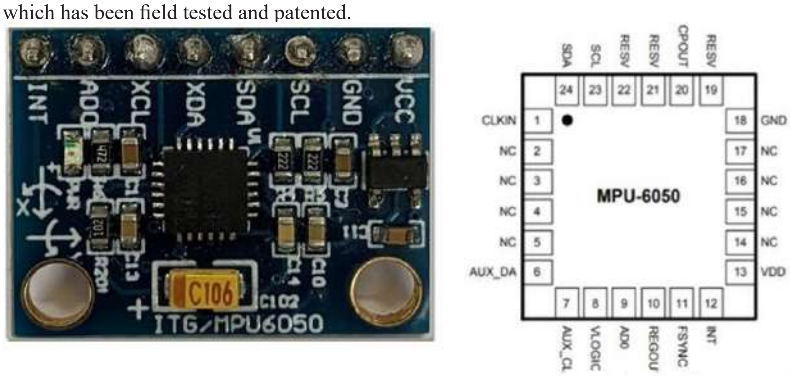


Fig. 15. IMU 6050 sensor

3.3.6. JOYSTICK

To control the entire system, one of the main input devices for this project is a joystick. A joystick is a type of input device that is commonly used to control gaming software and, on occasion, graphics software. C. B. Mirick developed it at the US Naval Research Laboratory and patented it in 1926. A joystick is typically used to control a machine or character in a computer program [7].

Fig. 16. joystick

3.3.7. Bluetooth module-ZS-040

The HC-05 (ZS-040) is a serial to Bluetooth bridge module that enables wireless communication between two microcontrollers or a microcontroller and a Bluetooth-enabled Android phone, laptop, or desktop PC. Both a slave and a master device, the HC-05 (ZS-040) can be used. The module operates at 3.3V internally, but because it contains a 3.3V regulator, the Vcc pin must be supplied with 3.6–6V.

Fig. 17. Bluetooth Module

3.3.8. Power source (Battery)

The source of power could be an electrical outlet, energy storage devices like batteries or fuel cells, generators or alternators, solar power converters, or another power source. We used a Liv-guard motorcycle battery as our power source to run the system in our project.

Fig. 18. power source

4. RESULT AND DISCUSSION

4.1.1. Result of fall detection system

Considering MPU 6050 positive x-axis as the forward direction, negative x-axis as backward direction (overall roll angle) and positive y-axis as the leftward direction, negative y-axis as the rightward direction (overall pitch axis), we have set a threshold 300 of angle up-to which the fall is not detected, but exceeding this angle will cause fall detection by the system.

The result is when mpu6050 is at stable state where there is no motion. The roll and pitch angle are at 0 with some decimal error.

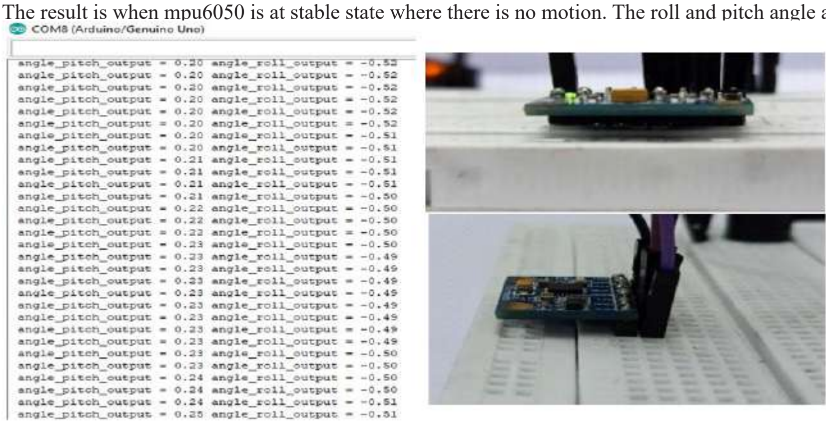


Fig. 19. Result when MPU sensor is in stable position.

This is the result where the roll angle exceeds positive 300 and negative 300, hence fall detected.

Fig. 20. When Roll angle exceeds ±30 degree

Fig. 21. when Pitch angle exceeds ±30 degree

4.1.2: Result of Joystick control system

Joystick gives the values along the X-axis and Y-axis, where it consists of two potentiometers that allow us to measure the movement of stick in 2 dimensions. As we move the Joystick, the value of the resistance of both the potentiometer changes and gives us the values along the X-axis and Y-axis. The joystick gives analog input voltage in the range of 0-5V, by default the output value of joystick will be in the range of 400-600 and that value will either increase or decrease as we move the joystick around.

When the Joystick is resting at the middle position it goes at around 512 and 0 and 1023 on both sides.

Fig. 22. Result when Joystick is at Initial position.

When we go in the Backward direction the values along the X-axis will still be the same, only the values along the Y-axis will change accordingly but this time the values will be in the range of 470 to 0. when we move joystick in forward direction the values along the X-axis will remain same and the values along the Y-axis changes according to the speed of the motor. The values will vary in the range of 574 to 1023. The actual initial position value of the joystick is 512 that is the threshold analog output value of the Joystick, half of its maximum scale range.

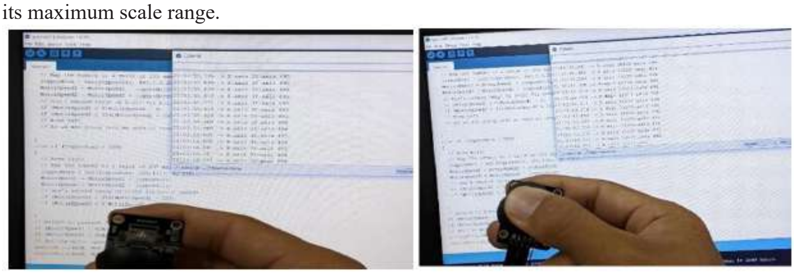


Fig. 23. Joystick control result for Backward and forward directions

When we move the joystick in the right direction the value on the X-axis varies in the range of 574 to 1023 while values along the Y-axis remains same. At the same time, when we move the joystick in the left direction the value along the X-axis varies in the range of 470 to 0.

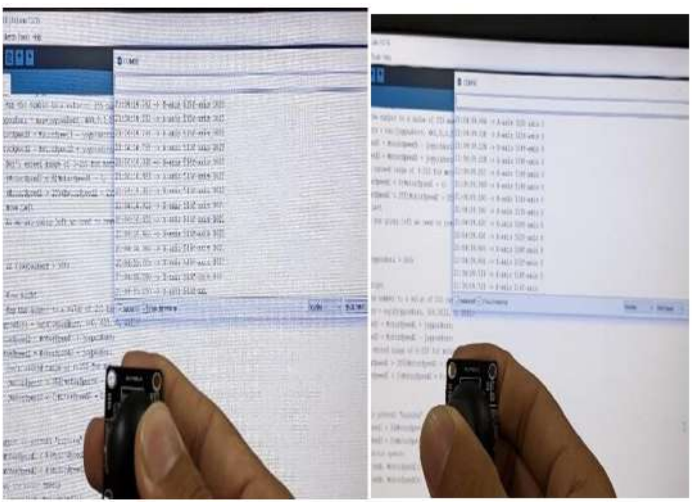


Fig. 24. Joystick control result for Right and Left direction

4.2.1. Result of Bluetooth control system

It is an alternative to using an analog joystick to control the motor direction. Instead, it uses a ZS040 Bluetooth module with an Arduino Uno and an L298N motor driver module to control the wheelchair wirelessly. For Bluetooth communication, we used a smart phone and a simple Android App. Using the MIT App inventor software, we created a simple App called Joystick controller.

We used five keys in the Android app: forward, backward, right, left, and stop, just like in a joystick-controlled system. When a key is pressed, the corresponding data is sent from the Phone to the Bluetooth module via Bluetooth communication. To stop the motor rotation or change the direction of the motor, keep the pointer in the middle, as in the joystick-controlled system.

It functions similarly to a joystick in that when we move the pointer in the forward direction, the motor is driven forward. If we look at the serial monitoring system in the Arduino IDE software, we can see the direction as we move the pointer in the appropriate direction, as shown below.

Fig. 25. Result of Bluetooth control

When we move the pointer in the direction of forward motion on the Android phone, Arduino will set IN1, IN3 to HIGH and, IN2, IN4 to LOW to achieve forward motion. Similarly, when the pointer is pressed at Reverse direction in the android phone from the app, arduino will then make IN1 and IN3 as LOW and IN2 and IN4 as HIGH to make the wheelchair turn in Backward direction.

right-hand side so that users can control their chair. When the pointer is pressed at Right direction in the android phone from the app, arduino will then make IN1, IN2 and IN4 as LOW and IN3 as HIGH to make the wheelchair turn in Right direction. Similarly, when the pointer is pressed at Left direction in the android phone from the app, arduino will then make IN1as High, and IN2, IN3 and IN4 as LOW to make the wheelchair to turn in Left direction.

Fig. 26. Bluetooth control result for all 4 directions

4.3.1: Result for 3D designing.

The project's 3D model is created using the design software 3DS MAX; this platform includes animation, prototype models, interior design, and other features. We can use lines and different shapes to design anything you want. Make a simple chair out of lines first, then enable the viewpoint where you can specify the dimensions of the lines. Then create caster wheels and other supporting wheels. The main component here is the new layer that contains all of the controlling devices.

Fig. 27. 3D Model of the project

The only difference between this wheelchair and our standard wheelchair is the layer that houses all the controlling devices. A joystick is kept on the top right-hand side so that users can control their chair in a specific direction, and an LCD is kept on the top left-hand side to display temperature and humidity values.

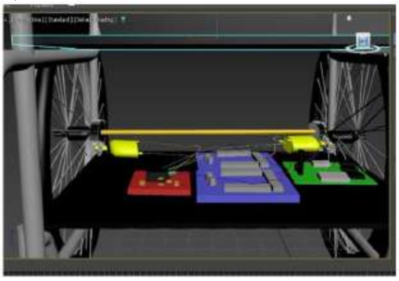


Fig. 28. House of all controlling devices

5. CONCLUSION

Many people are disabled, either temporarily or permanently, because of illness or accidents. The use of a wheelchair is becoming increasingly important in cases where walking is difficult or impossible [. Most low and medium level disability cases where patients can use the wheelchair independently are satisfied with manual electrical wheelchairs. However, in severe cases, using a wheelchair on one's own is difficult or impossible.

A smart wheelchair with fall detection is introduced that minimizes the consequences of falls using IMU sensors and a buzzer which alerts the responsible person. The wheelchair is controlled by joystick and Bluetooth app which gives the users the ease required to control the smart wheelchair. Temperature and humidity are also displayed using a temperature and humidity sensor.

This project discusses various smart technologies for wheelchairs. It focuses on two key characteristics: the human-machine interface using Arduino and various electronic devices and operating methods using joysticks and Bluetooth. It also examines other smart systems such as monitoring and safety systems using fall detection as the principal way of letting the care giver know.

According to a review of many published papers, researchers are constantly attempting to build powerful and useful wheelchairs to ease daily life activities and provide more independent mobility for people with various types of disabilities. There are several difficulties that manufacturers and researchers must address in order for the smart wheelchair to be a commercial success and extensively utilized. One of the most typical issues is the cost versus accuracy trade-off. This difficulty can be solved with the use of inexpensive and advanced sensors. Smart wheelchairs, which can be utilized for a wide range of disabilities, are currently unavailable. Smart wheelchairs should also be able to detect and respond to changes in the patient's condition.

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