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IOT based Autonomous Wheelchair for Hospital Environment

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Abstract: The mobility of physically challenged people is a serious concern. Automating a wheelchair can gradually reduce their dependency on others. In addition, the major pandemic crisis of corona virus has made us realize the importance of social-distancing especially in hospital environment, therefore automating of the wheelchair is of utmost importance in the present time. In this project, we automated a wheelchair using IOT which is a rising and advanced technology. The wheelchair gets connected to the internet using Wi-Fi module included in NODEMCU microcontroller. The locomotion of wheelchair will be carried out autonomously using six Infrared sensors, which will follow a map. The automation also consists of an object detection system. Ultrasonic sensor will be used to detect any obstacle in the path. Furthermore, the embedded system will incorporate fall detection in case of emergency which sends an alert message through IOT platform. This is achieved using a motion sensor MPU6050 and BLYNK application.

Keywords: Fall detection, IOT, obstacle detection, line following, wheelchair.

I. INTRODUCTION

Nearly 3 crore people in India have a disability. While electric wheelchairs are on a rising trend, advancements in their automation can help benefit the handicapped society to a greater extent. The existing technologies worldwide are either very expensive or do not live up to the expectations of automation.

Wheelchairs with higher level of autonomy use LIDAR and camera for environment sensing. These have high cost and require more computing power. Our objective is to create a cost-effective autonomous wheelchair which brings together the concepts of line detection, object detection and fall detection incorporated with the help of IOT. This concept can be applied mainly for the transportation of patients in hospitals without any dedicated individual.

II. LITERATURE REVIEW

After going through research papers, journals and periodicals, the list of relevant technologies that exist are discussed.

Gabriel Pires [1], in his study of designing of an autonomous wheelchair for disabled people has implemented the design using twelve infrared sensors, four ultrasonic sensors, one front bumper and optical encoders on wheels. The paper focuses on the obstacle avoiding algorithm and helps in giving a good insight on geometric position of all the subsystems.

Another study by Deepak Kumar Lodhi [2] discussed about his design of a smart, motorized, voice-controlled wheelchair. In this the voice command is using bluetooth which is converted to string by the BT Voice Control which is transferred to the Bluetooth Module SR-04 that is connected to the Arduino which controls the Wheelchair. The Bluetooth system has a short range and cannot be considered reliable for longer distances, therefore to eliminate the distance constraint we decided to communicate with the device using IOT.

Nakib Hayat Chowdhury [3] in his report gives his insight on making an autonomous robot which can follow various types of curves and sharp turns and also discusses the distance required between IR sensors for smooth motion of the robot.

Shaikh Abdul Waheed [4] proposed a paper for fall detection system in elderly people which uses a Pi camera to monitor the patient’s movements, this is achieved with the help of history Image and C-motion algorithm. The electronics components used by them was Raspberry Pi, Bluetooth module, Pi camera and SD card.

G. Rajeswari [5] has introduce an IOT based fall detection system which uses MEMS for sensing the motion. Nodemcu was used to connect the arduino with BLYNK app as it has inbuilt Wi-Fi module.

Devansh Kumar Garg [6] in his paper showcases the use of gyro, accelerometer and load sensor which determine the changes person’s movements almost instantaneously. When fall is detected, an alert is sent by using a wifi module. The whole system was mounted on a wearable glove.

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III.PROPOSED SYSTEM

A. Integrated Working

The overall wheelchair design consists of several subsystems integrated together to perform the task of destination line following, accident/fall detection and object detection operated from an IOT application platform. The design logic of each subsystem used is explained in further section. The fig-1 represents the design architecture of the entire system.

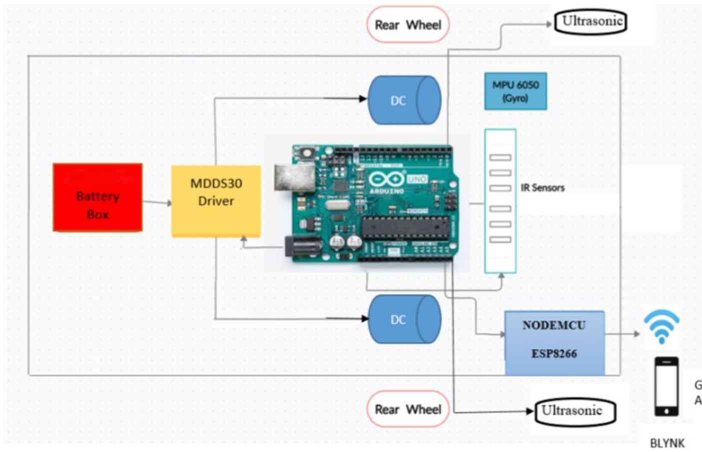

Fig. 1

B. BLYNK Application

BLYNK is a website which provides an IOT platform to connect multiple devices and services with internet. BLYNK receives motion sensors value via ESP8266 Wi-Fi module which when triggered, will alert the user on registered e-mail address.

BLYNK app is used to perform the following tasks:

1) Choosing the destinations (A, B and C)
2) Start and stop the wheelchair
3) Alert the guardian with email if fall detected.

The figure 2 shows the APP interface for destinations A, B and C. Furthermore, execution and interaction between BLYNK and wheelchair is shown in Figure 3.

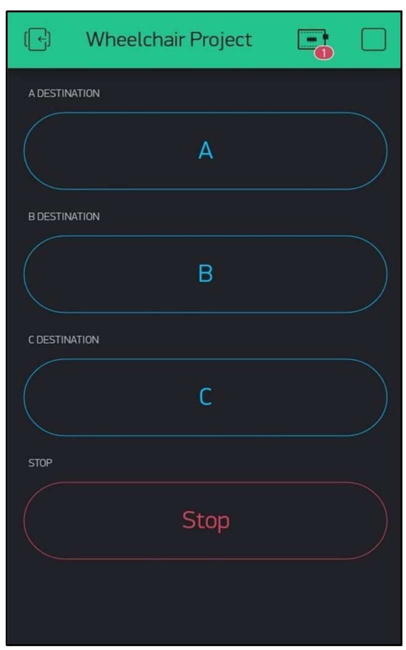

Fig.2

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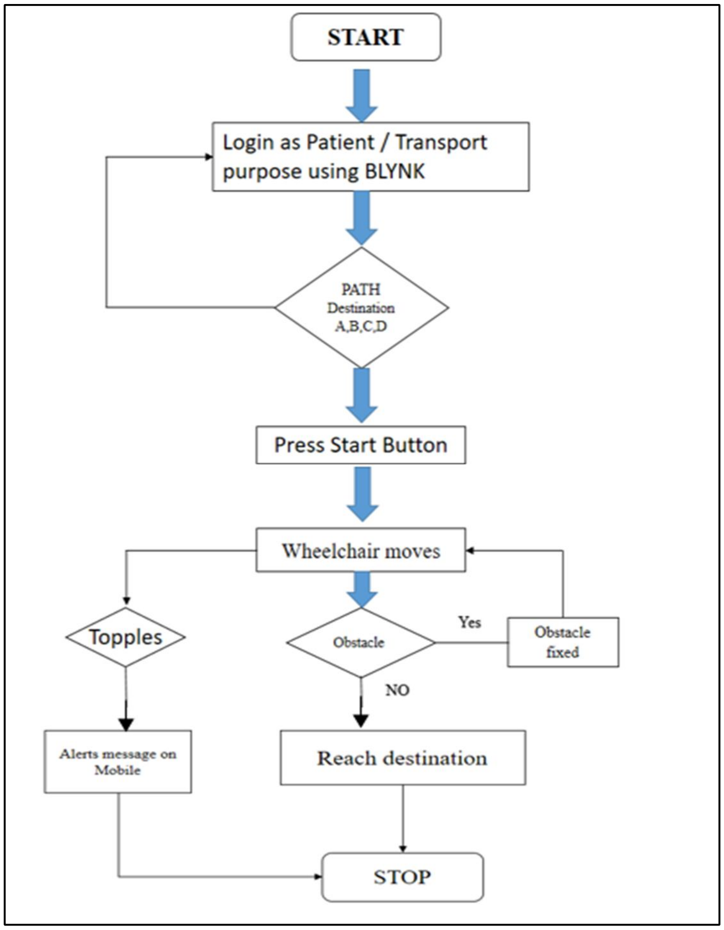
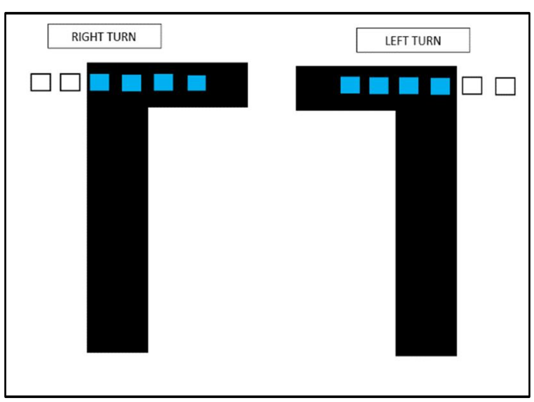


Fig. 3

C. Destination Line following System

The purpose of the line following system is to detect and follow a black line path. The black line is detected using infrared sensor which gives inputs to the microcontroller. Unlike the regular line following or maze logic here the wheelchair needs to follow the black line to the exact route selected by the user and ignore the other turns, thus according to the map of a hospital, each destination must have a unique algorithm. In order to achieve this we have used six IR sensors where the middle two IR sensors work on the general black line following logic and the remaining four IR sensors help in creating various algorithm for different destinations as required for the hospital map.

The fig-4 a,b and c below represents the types of turns that can be encountered by the wheelchair in a map, the blue box indicates that the sensors are on the track whereas white box indicates that the sensors are off the track.



Fug. 4 (a)

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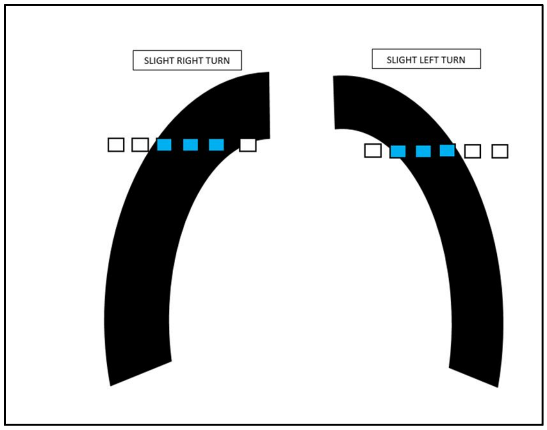

Fig. 4 (b)

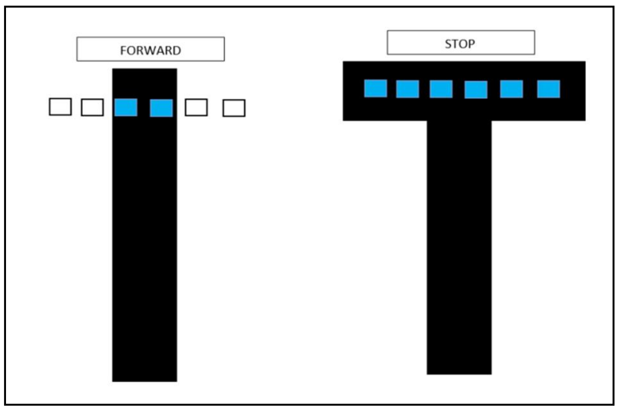

Fig. 4 (c)

The IR sensor combination of each path in Line following logic is shown in the table below, this algorithm is made for the sample destination A,B and C as shown in the prototype map in map Fig. 7

Table 1

ROOM –A	ROOM –B
Step 1- start	Step 1- start
Step 2- Read sensors	Step 2- Read sensors
Step 3-Follow the line following logic	Step 3-Follow the line following logic
Step 4-If the values are [0 0 1 1 0 0], go straight	Step 4-If the values are [0 0 1 1 0 0], go straight
Step 5- If the values are [1 1 1 1 0 0], turn sharp left.	Step 5- If the values are [0 0 1 1 1 1], turn Sharp right
Step 6- If the values are [1 1 1 1 1 1], destination reached	Step 6- If the values are [1 1 1 1 1 1], destination reached
Step 7- Stop	Step 7- Stop

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ROOM –C

Step 1- start

Step 2- Read sensors

Step 3-Follow the line following logic

Step 4-If the values are [0 0 1 1 0 0], go straight

Step 5- If the values are [0 1 1 0 0 0], turn slight left

Step 6- If the values are [1 1 1 1 1 1], destination reached

Step 7- Stop

D. Motor and Motor Driver

The wheelchair is powered by a pair of DC motor which is selected on the basis of required torque as per the calculation which is discussed below. In the calculation we have considered the mass of wheelchair as 50 Kg, and that of patient as 100 Kg. The speed of the wheelchair is assumed as 1.5 m/s as the wheelchair is designed in indoor environment which is capable of climbing a slope if 7.1 deg (Standard slope in Indian hospital).

Motor Torque Calculation

Designing the wheelchair for following parameters:

Maximum speed = 1.5m/s

Mass of the Wheelchair (m) = 150Kg

Maximum angle of inclination for hospital environment (α) = 7.1

Radius of wheel = 10 inch = 0.254m

Torque = (Push Force + Rolling Resistance + Gradient Resistance) * radius of wheel

Push Force is the minimum amount of force needed to start the motion of any automobile.

Rolling resistance is the resistance offered by the tire due to its visco-elasticity and Gradient Resistance is the resistance offered on slope due to gravity.

Mathematically,

$Fp = m*a$

$RR = umg\cos\alpha$

$GR = mg\sin\alpha$

where u = coefficient of rolling resistance = 0.01

The gradient resistance will tend to oppose the motion, the velocity at slope decreases and the acceleration is almost zero. Hence the Push force can be neglected.

Taking the above parameters into consideration,

Torque = 36.18Nm

Power = 213.64 Watts

Based on calculated torque, a 250 W 24V geared motor is selected which can give required torque after adding sprocket ratio of 3.14. The motor driver chosen to drive the DC motor is CYTRON Smart Drive MDDS30_Dual and have current capacity up to 80A peak (few seconds) and 30A continuously. It can be operated even at high temperatures as it consists of in-built heat sink

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E. Object Detection System

Object detection is an important feature for any autonomous robot to avoid unexpected collision. In this project we have used two Ultrasonic sensors, which are mounted on either side of the wheelchair. When the ultrasonic waves are emitted from the sensor and obstruct an object in front of the wheelchair, the waves bounce back and are read by the ultrasonic sensor. The arduino will read the data from the ultrasonic sensor and whenever an obstacle is detected, it will command the motor to stop.

The distance between the obstacle and the sensor is calculated as:

Distance = Time * (340 / 20000);

F. Fall Detection

For safety of the wheelchair user, a smart fall detection system is installed using Arduino UNO R3 and Node MCU ESP8266. Node MCU ESP8266 is microcontroller which has an in-build Wi-Fi module. This micro controller is mostly used for IOT based applications.

This system also consists of a MPU6050 sensor which is an accelerometer and gyro sensor. It detects wheelchair's motion along all three axes. The MPU6050 motion sensor is used as the main fall sensing element which reads the angular rates and acceleration and sends to microcontroller. It can be mounted on wheelchair parallel to ground surface.

The circuit diagram of fall detection system is shown in fig-5.

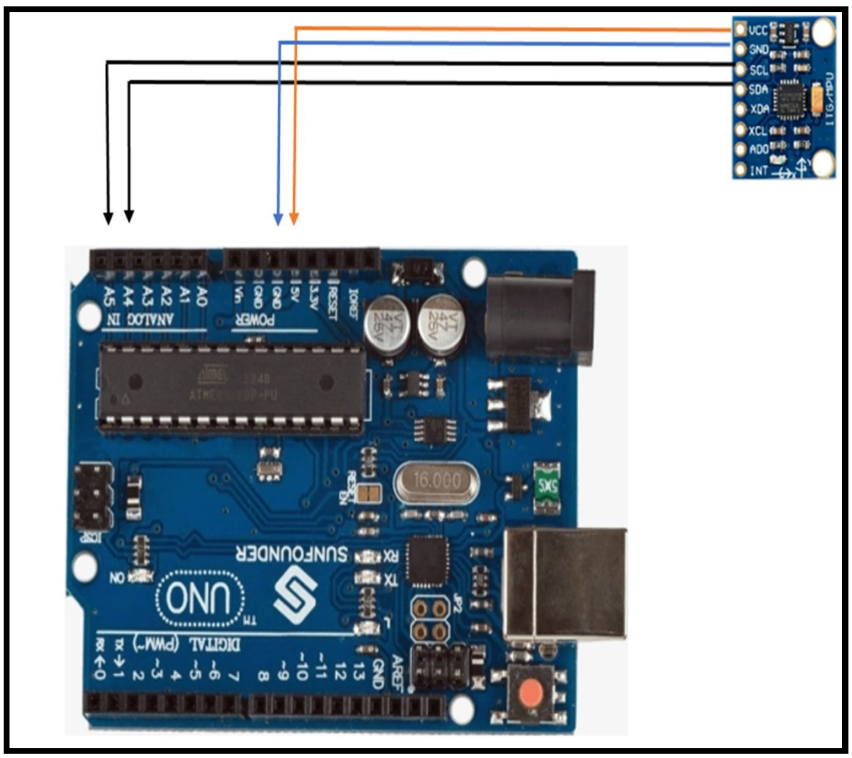

Fig. 5

G. Working Principle

1) The I2C pins of mpu6050 which are named as SDA and SCA are connected to the arduino's A4 and A5 pins with the help of jumper wires on breadboard. This breadboard is then mounted on a plane surface parallel to ground so that initial angle of inclination will be 0 deg.
2) When we tilt the wheelchair, the mpu6050 sense and read the angular rate and then sent it to the microcontroller using I2C communications.
3) This received value is always checked in a loop whether the value exceeds the threshold value which can be of the range 60 to 90 deg. If it exceeds, the microcontroller sends the flag value to BLYNK app with the help of ESP8266 module.
4) BLYNK gets triggered and alerts the guardian by sending an email or SMS to the registered mail or mobile.

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Fig 6 shows the flowchart for fall detection system

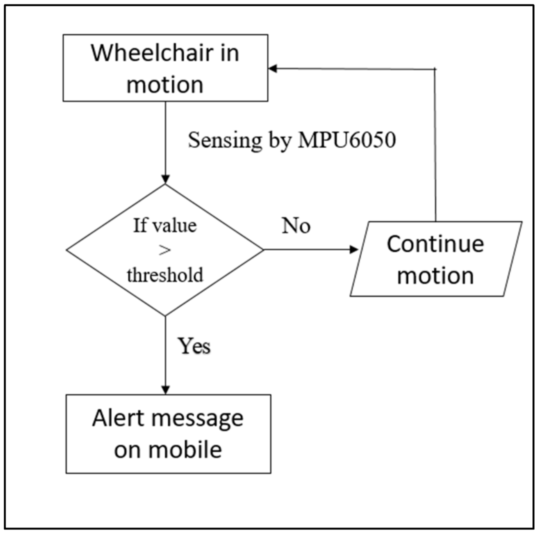

Fig.6

IV. DESIGN AND TESTING

To implement and test the working of the code we have created a prototype using PVC pipes such that it resembles a real scale model of a wheelchair. We have kept most of the essential components same as that required in a real wheelchair, the component selection is shown in the table below:

TABLE I

Components	Real Model	Prototype
1)Main microcontroller	Arduino UNO R3	Arduino UNO R3
2) IOT microcontroller	NODE MCU-ESP8266	NODE MCU-ESP8266
3) Line following sensor	IR Sensor (Qty 6)	IR Sensor (Qty 4)
4) Obstacle detection sensor	Ultrasonic Sensor (Qty 2)	Ultrasonic Sensor (Qty 1)
5) Fall detection sensor	MPU-6050	MPU-6050
6) Motor Driver	CYTRON Smart Drive MDDS30 Dual	Double H bridge Drive Chip: L298N
7) Battery	12V, 7Ah lead acid battery (Qty 2)	12V, 7Ah lead acid battery (Qty 1)
8) Motor	MY1016Z2 250W geared dc motor	100 RPM geared DC motor

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A. Prototype Map

To test the prototype code, we have made a sample map as shown in fig-7, in this map the alphabets A, B and C represents different destinations for the wheelchair.

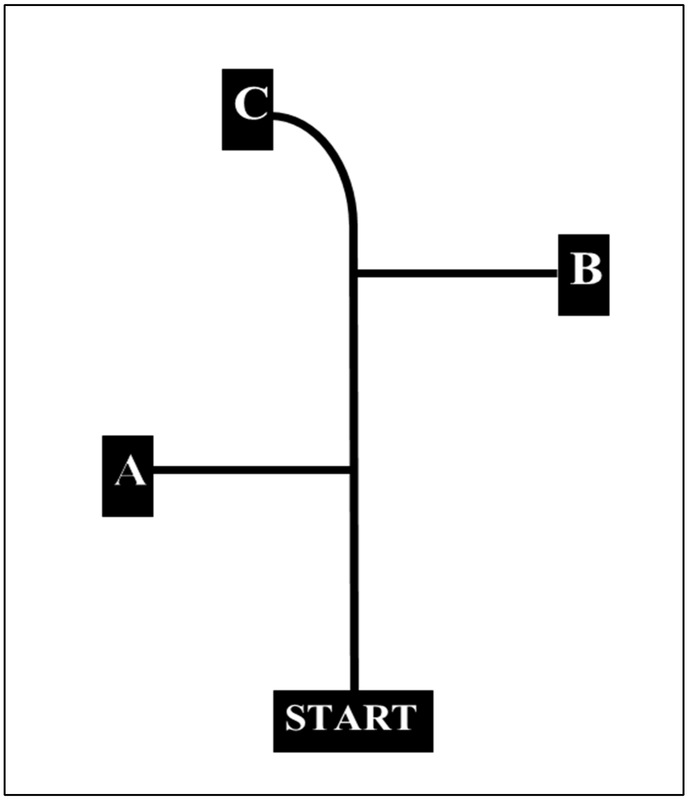

Fig. 7

B. Prototype Algorithm

Algorithm

1) Step1: - Start
2) Step2: - Connecting the controller to the internet via ssid and Password.
3) Step3: -Login to the IOT App BLYNK via Mail id and password.
4) Step3: - Once the app is connected and Hardware is connected to the App/Online.
5) Step 4: - Enter the destination using IOT APP as A, B or C using IOT app GUI (Graphic user interface).
6) Step5: - Then the Wheelchair moves to the location selected.
7) Step6: - While performing step5: it will continuously keep the track of Obstacle detection in the front.
8) Step 7: - While performing step5, 6 it will move to the destination with the help of IR sensors that will follow the black line.
9) Step 8: - When the chair reaches destination to stop the chair obstacle is mounted.
10) Step 9: - While performing steps from 5 to 6 if the user will click stop button using app it will stop the wheelchair at current position.
11) Step 10: - If the Wheelchair is tilted then MPU sensor will detect the tilt and send alert message via mail.
12) Step 11: - End.

C. Testing Result

The prototype successfully reached the desired destination by following the line, stopped when it detected an obstacle ahead of it and also sent an alert message in email when the prototype detected a fall. Fig-8 shows the mounting of an ultrasonic sensors and four IR sensors, Fig-9 shows the complete assembly of the prototype wheelchair and Fig-10shows the alert message which we had received after detection of a fall. The circuit connections for the prototype with four IR sensors is shown in Fig. 11. The integrated circuit diagram of real model with six IR sensors for the whole system is shown in Fig 12.

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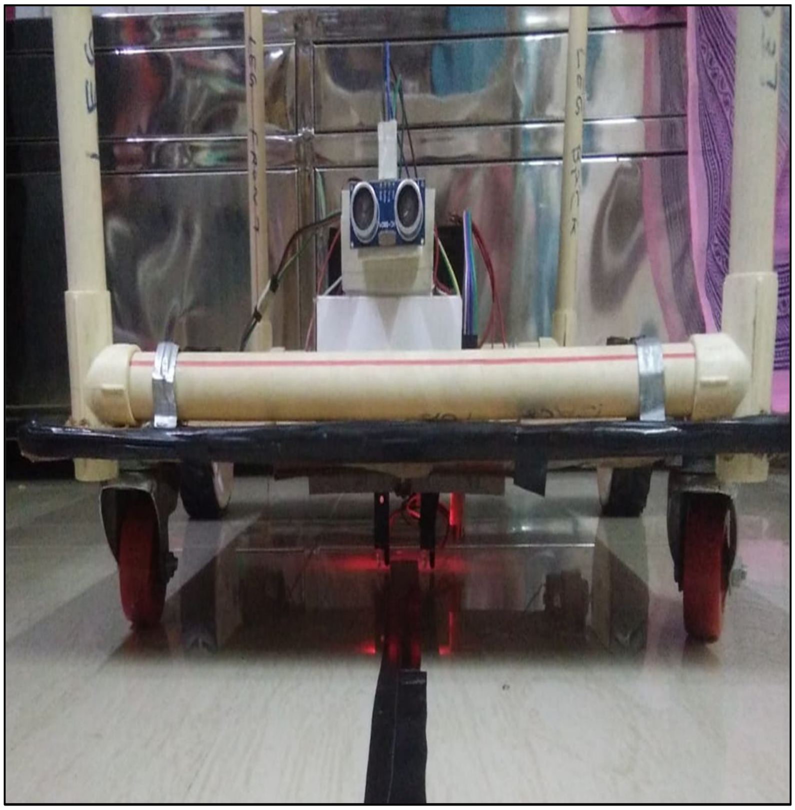

Fig. 8

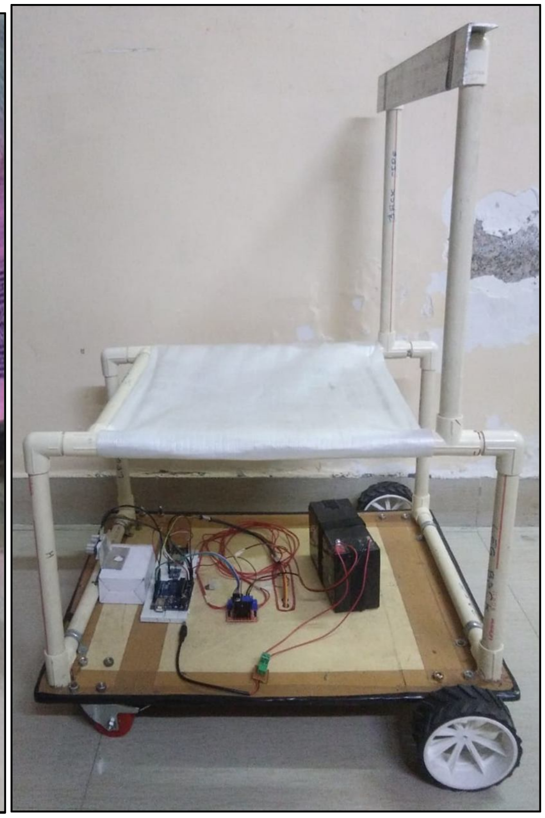

Fig. 9

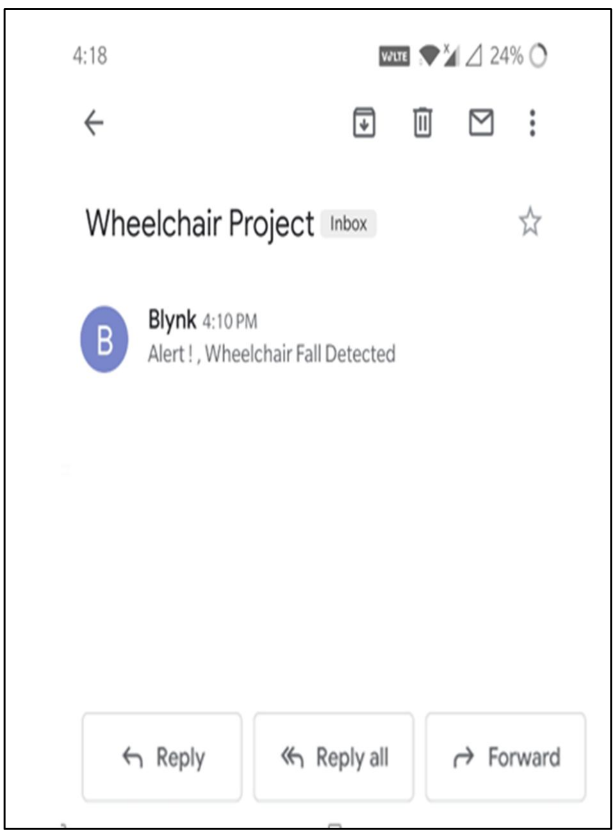

Fig. 10

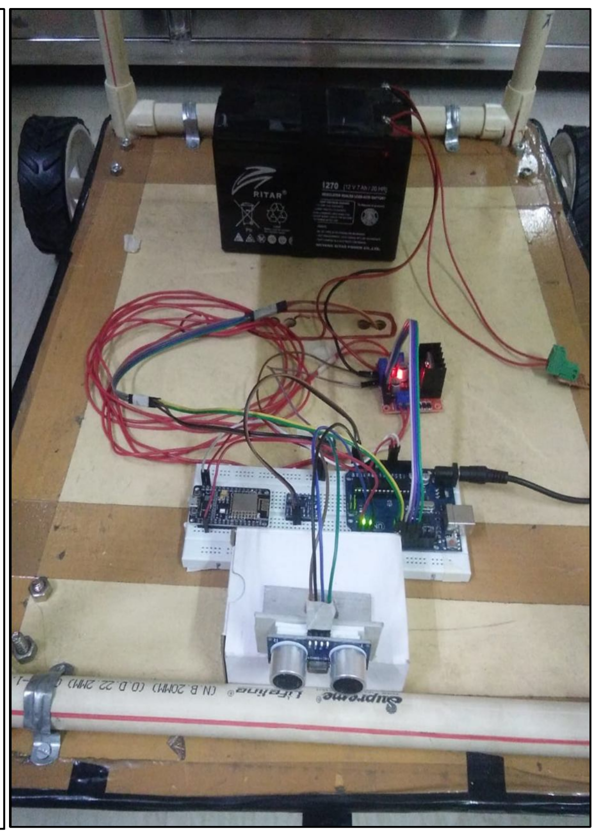

Fig. 11

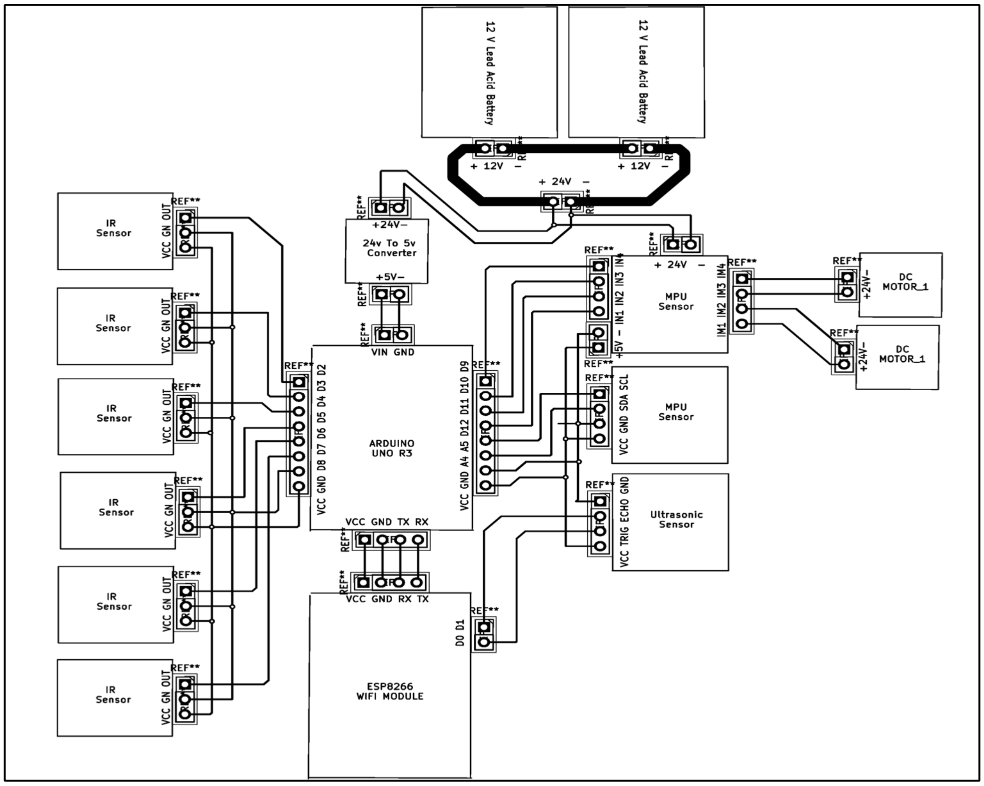

Fig. 12

V. CONCLUSION

The goal of collaborating line following, object detection and fall detection systems with IOT was successfully accomplished in this project. Testing of the wheelchair prototype has showed faultless functioning of all the subsystems. In addition, the total cost of the project is justifiably low to be used in all hospitals across the country. This system can also be helpful in transporting goods in the industries.

VI. ACKNOWLEDGMENT

We are extremely thankful to our beloved Prof. Rehan Siddique for providing necessary guidance and resources for the accomplishment of our project which also helped us in doing a lot of Research and learn many new things. Secondly, we would also like to thank our parents and friends who helped us a lot in finalizing this project within the limited time frame.

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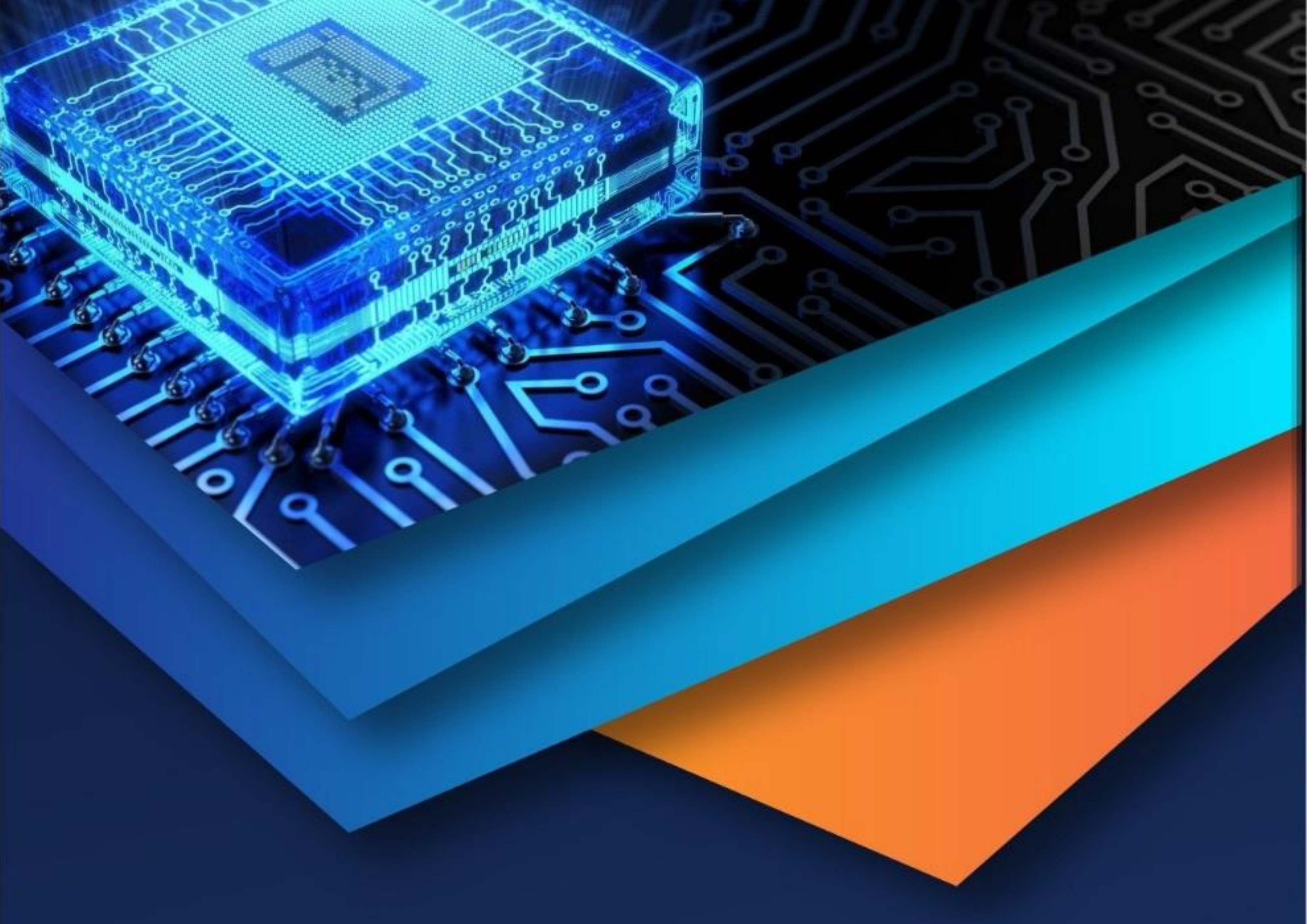

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