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Implementation of Android-Controlled Smart Wheelchair Design

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Abstract:
The paper presents the implementation of Arduino-controlled Smart Wheelchair design based on theoretical and experimental approaches. Different types of smart wheelchairs have been developed in the last few years. Inventors and researchers have been an effort to upgrade the standard of human life. Now, new generations of wheelchairs are being developed. This paper describes the implementation of an android controlled smart wheelchair using the user's command. The wheelchair can be operated with five functions which are driving forward, turning left and right, including moving backward and stop, and at the command of the user on an android phone and tablet. This research is connected with a Bluetooth module as a UART port to automatically drive the system. This proposed system is based on Raspberry Pi 3 and a high current motor driver with the gearbox. The proposed system in this paper is intended to help persons who disabilities in the lower body and old age people by implementing a touchscreen-based system for a smart wheelchair. The temperature sensor and heartbeat sensor are used for the patient's health care in this system. The battery is used as the power supply for this system. This system is designed to reduce the user's human effort and force to drive the wheel for the wheelchair. The experimental results had been confirmed the system robustness with theoretical studies in control system design and applications.

Keywords:
Android Controlled Smart Wheelchair, Applied Control System, IoT Applications, Temperature Sensor, Experimental Studies, User Friendly Applications

1. Introduction

In today's world, technologies have been popular in human life. Disabled persons require help to overcome physical challenges. A smart wheelchair is provided an opportunity for physically disabled persons to move from one place to another without external aid. This paper describes the implementation of an android controlled smart wheelchair using the user's command. An android software is required to be installed in the android smartphone to drive the wheelchair. Smartphones are a very important role in human life. The main aim of this research is to design and implement an android controlled smart wheelchair. An elderly/disabled person is able to direct the movement and direction of the wheelchair by using the android smartphone. In this research, the smart wheelchair is driven with the user's command by the user's phone via the android application. The temperature sensor and heartbeat sensor are used for the patient's health care in this system. The wheelchair is also provided with an obstacle detection system by using an ultrasonic sensor. This system is used two ultrasonic sensors to protect any obstacle in the front of the wheelchair path. GSM/GPRS module is also provided a serial port to communicate via GPRS, sending text messages and phone calls. GPS module is used to let the user's family member know the location of the wheelchair in the event of an accident while in use of the wheelchair's user in this proposed system. The two 24V DC motors with respective motor drivers are used to drive the wheelchair to move left, right and linear motion for this proposed system.

2. Literature Review

In this section, it can be provided foundation and theoretical base for successfully achieving the main objectives. This paper references some of the previous journals in the related field as to rule out pros and cons and build a design that has as less disadvantages as possible. A custom designed wheelchair is implemented with a serial Bluetooth module enabling navigation in a horizontal surface without the need of an assistance. By using Android messenger app to transmit the signals required for navigating the wheelchair. The wheelchair also contains a wireless ranging module to help the user in the navigation [1]. The focus of their work is to implement a smart healthcare wheelchair which is capable of moving the four directions. The ultimate purpose of this paper is to make supports to physically challenging people who has a hard time navigating. The wheelchair also contains a gravity sensor for controlling. By tilting the sensor in appropriate direction, the user is able to move the wheelchair in desired directions [2]. Raspberry pi, Camera, Ultrasonic sensor is used in her research. The camera will start to capture the image. If the eye does not move it indicates the eye is in the normal position. When the eye moves to any direction, the respective motor will work and. If the eye is in the center, both right and left motors work, and the wheelchair travels in a forwarding direction. If someone calls the user, the user will stop the wheelchair by emergency switch [3].

3. Proposed Methodology

The operation of the proposed system is controlled by the Raspberry Pi 3 model B+ in which the main control program is embedded. The Raspberry Pi controls other units in our system and the overall block diagram of our implemented system is depicted in Figure 1.

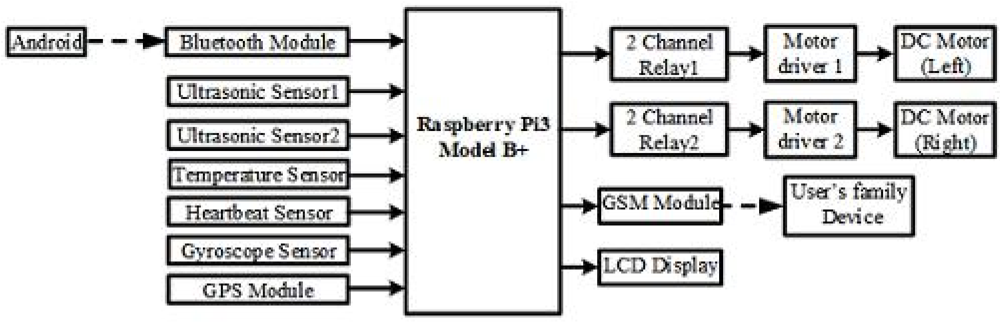

Figure 1. *Overall Block Diagram of the Proposed System.*

3.1. Raspberry Pi 3 Model B+

The raspberry pi is a small computer system which has everything a normal computer system needs. The basic components include a CPU, GPU, GPIO pins. It also contains Bluetooth and WiFi capabilities and even Ethernet features. The core features of the B+ model are almost identical to model B. The most prominent feature is that 3B+ SOC is covered in a metallic cover which enable better cooling. The main SOC contains both Central Processing Unit and Graphic Processing Unit on a single chip and the performance is way better than the previous models. Figure 2 illustrates Raspberry Pi 3 Model B+.

Figure 2. *Raspberry Pi 3 Model B+.*

3.2. Temperature Sensor (MLX90614)

MLX90614 is a I2C interfaced, reliable contactless temperature sensing unit. Because the sensor doesn't need to touch the element, it has a wide temperature range: from -30 ˚C to about +380 ˚C. The precision and I2C compatibility is best suited for healthcare systems. (Figure 3)

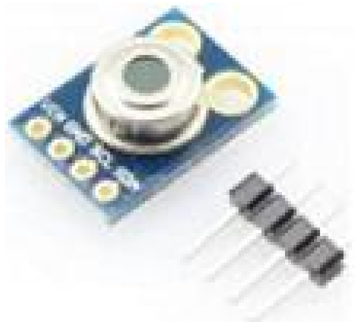

Figure 3. *Temperature Sensor (MLX90614).*

3.3. Heartbeat Sensor (XD-58C)

The heart rate sensor utilizes optical technologies to measure the pulse in a fingertip. A green LED light is constantly emitted while the infrared sensor measures the reflected light from the user's fingertip. The amount of reflected radiation is charted in time domain to calculate the heart rate. XD-58C is a small, low power, analog heart rate sensor, which only consumes 20mW. (Figure 4)

Figure 4. *Heartbeat Sensor (XD-58C).*

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4. Operation of the Motor Drive System

In this section, we explain the motor driving operations of the system. Figure 5 illustrates flowchart of the operation for driving motors.

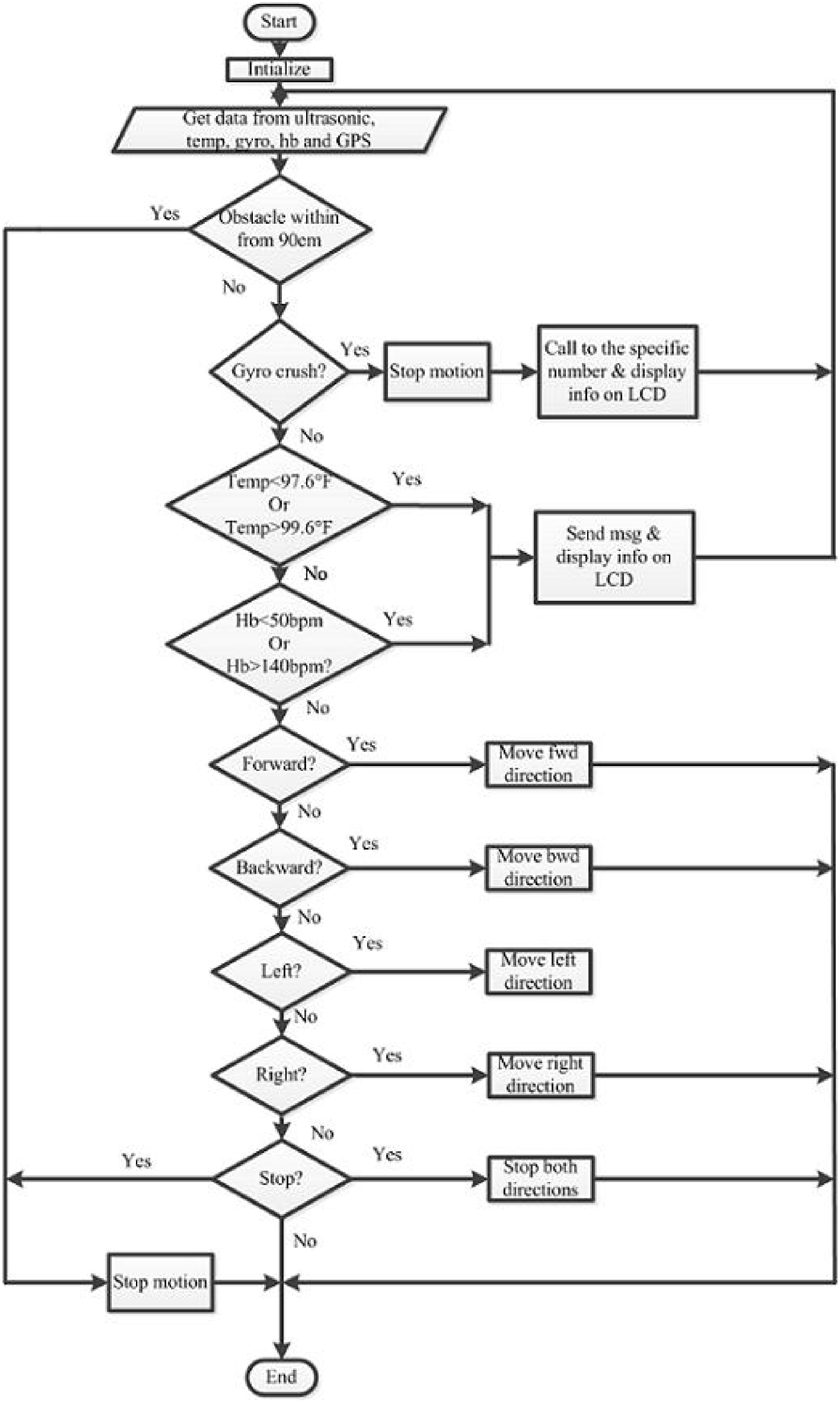

Figure 5. *The Flowchart of the Operation for the Motor Drive System.*

The user is to navigate the device from an android smartphone by the use of a specially developed application. The first step is always to connect the app to the wheelchair. As soon as the devices are connected, the wheelchair can be driven with ease, without further steps. The application automatically converts the user's commands in the form of 8 bit ASCII character and then transmit to Raspberry Pi. The Raspberry Pi then translates the ASCII command into directions and produces a corresponding output at its GPIO pins. The motor driver amplifies these signals and use a differential steering method to drive the wheelchair in four possible directions.

5. Hardware Implementation

In this section, we described six main components; Raspberry Pi board, motor driver, 24V DC motor, Bluetooth module, power supply, and Relay. The two DC motors were fixed near the wheels. The main control box and power supply are placed below the seat of the wheelchair shown in Figure 6. The main hardware components as listed in Table 1.

Figure 6. *Hardware Design of the Wheelchair.*

Table 1. *The main hardware components.*

No.	Components	Descriptions
1	Raspberry Pi board	Pi 3 Model B+
2	Motor driver	BLH-69218
3	DC Motor	WY1016Z2
4	Bluetooth Module	HC-05
5	Power Supply	Motor cycle battery (24V, 4Ah)
6	Relay	2-Channel Relay

5.1. Interfacing Bluetooth Module with Raspberry Pi

The Interfacing Bluetooth module with raspberry Pi3 is shown in Figure 7. In this figure, the HC-05 Bluetooth is configured to accept connections from a smartphone. A CP-2102 USB-TTL converter is first connected to Raspberry Pi to provide additional UART port. The Vcc and GND pins of CP-2012 are connected to the corresponding Vcc and GND of HC-05 to provide power. The main idea here is that the bluetooth module will send the wirelessly received commend to the Raspberry Pi via UART protocol. So the Tx and Rx pins of the adapter is crossly connected to the Rx and Tx pins of the HC-05. The Raspberry Pi will be continuously listening for the new commands so that the user's command will be immediately processed, further reducing risk of collision.

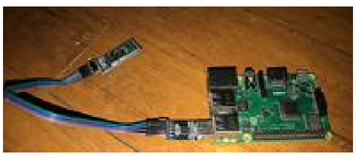

Figure 7. *Interfacing Bluetooth module with Raspberry Pi3.*

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5.2. Movement of the wheelchair with Android App

The condition of movement for the wheelchair when the user selected the various directions such as forward, backward, left, right, and stop are shown in Table 2. And the android application is also shown in Figure 8.

Table 2. *The condition of movement for the wheelchair.*

User Command	Left motor	Right motor	Condition of movement for the wheelchair
⇧	Forward	Forward	Moving forward direction
⇩	Backward	Backward	Moving backward direction
⇦	Backward	Forward	Moving left direction
⇨	Forward	Backward	Moving right direction
○	Stop	Stop	Stop both direction

Figure 8. *Android Application.*

6. Working Procedure for the Proposed System

The Raspberry Pi is the main controller of the proposed system in this paper, which controls the overall system operation. The Raspberry Pi’s operating voltage is 5V. The user's commands are given to the Bluetooth module through an Android application via Bluetooth. The application is designed in such a way that it converts the instructions. When the Bluetooth module receives the data from the Android Smartphone it will give the signals to Raspberry Pi. According to the received signals, the controller will send the appropriate signal to drive the motors. This will choose the motor to run forward, backward, left, right, or stop according to the user command. This system includes four sensors; they are detected the wheelchair’s movement, body temperature, heartbeat and obstacle. The sensing signal feed to the Raspberry Pi. An HC-SR04 Ultrasonic sensor is utilized to detect objects and identify obstacles in front of the wheelchair. Temperature sensor is used to measure patient’s body temperature

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and heartbeat sensor is also equipped to measure patient's heart rhythm. The measured values are described on the LCD display. If the condition is unusual, Raspberry Pi will send message to family member or nurse via GSM module. Gyroscope sensor is used to sense the dangerous condition of the wheelchair. If the wheelchair faces any dangerous condition, Raspberry Pi will send message or call. The overall circuit diagram illustrates in Figure 9.

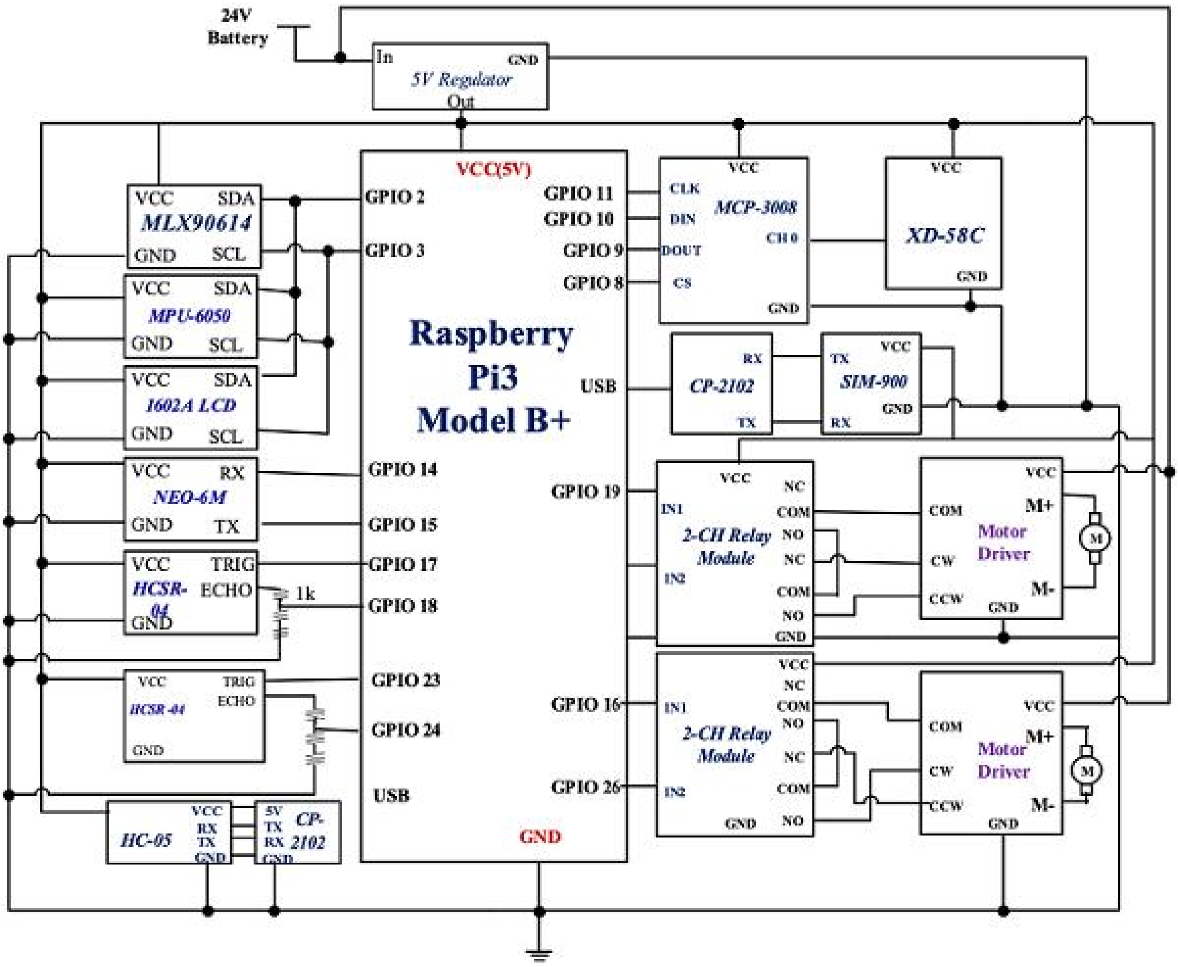

Figure 9. Overall Circuit Diagram of the Proposed System.

7. Design Calculation of the Voltage Divider Circuit

In this system, the ultrasonic sensors also sense the obstacles in the path of the wheelchair. If they detect any obstacle in the path of the wheelchair, the wheelchair will stop automatically. The voltage diver circuit is connected between the ultrasonic sensor and Raspberry Pi to adjust the voltage level. This voltage divider circuit can produce a voltage (3.3V) acceptable to the raspberry pi. The voltage divider circuit is constructed and tested as shown in Figure 9. To get a 3.3V, Raspberry Pi's operating voltage, the ratio of the resistors that is used for this design is shown in the following calculation. The voltage divider equation is expressed in equation (1).

$$Vout = Vin \times R2/(R1+R2) \quad (1)$$

Vout = 3.3 V, Vin = 5V

Vout/Vin = R2/R1+R2

R2/R1+R2 = 0.66 (kilo ohms)

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R1 = 0.5R2 , R2 = 1.94R1

So choose R1 = 1kΩ and R2 = 2kΩ.

8. Experimental Result

Figure 10 shows the testing condition of the voltage divider circuit.

Figure 10. *Measuring the Voltage Divider.*

Testing photo for the motor of the wheelchair is as shown in Figure 11.

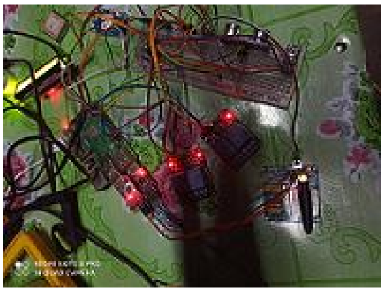

Figure 11. *Testing Photo for the Motor of the Wheelchair.*

Figure 12 shows the picture of the wheelchair for the proposed system.

Figure 12. *The Picture of the Wheelchair for the Proposed System.*

When the power is supplied to the circuit, the indicator LEDs are turned on respectively. This condition is shown in Figure 13.

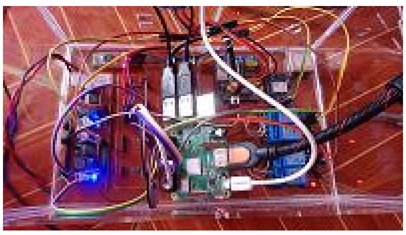

Figure 13. *Power ON Condition.*

The body temperature and heart rate result condition of the disabled person are shown in Figure 14(a). And also the current location result of the wheelchair is illustrated in Figure 14(b)

Figure 14(a). *Testing Result of Temperature and Heart Rate.*

Figure 14(b). *Testing Result of Location of the Wheelchair on LCD Display.*

This proposed system will send the alert message of the current abnormal condition of the disabled person to the family member. This condition is shown in Figure 15(a). If the wheelchair is fallen state, the disabled person's family member can know the location of the wheelchair by using google map as shown in Figure 15(b).

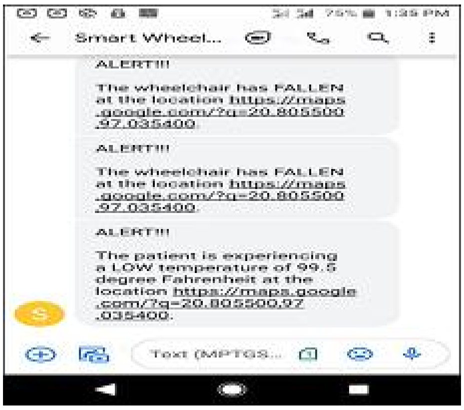

Figure 15(a). *The Alert message on the Mobile Phone.*

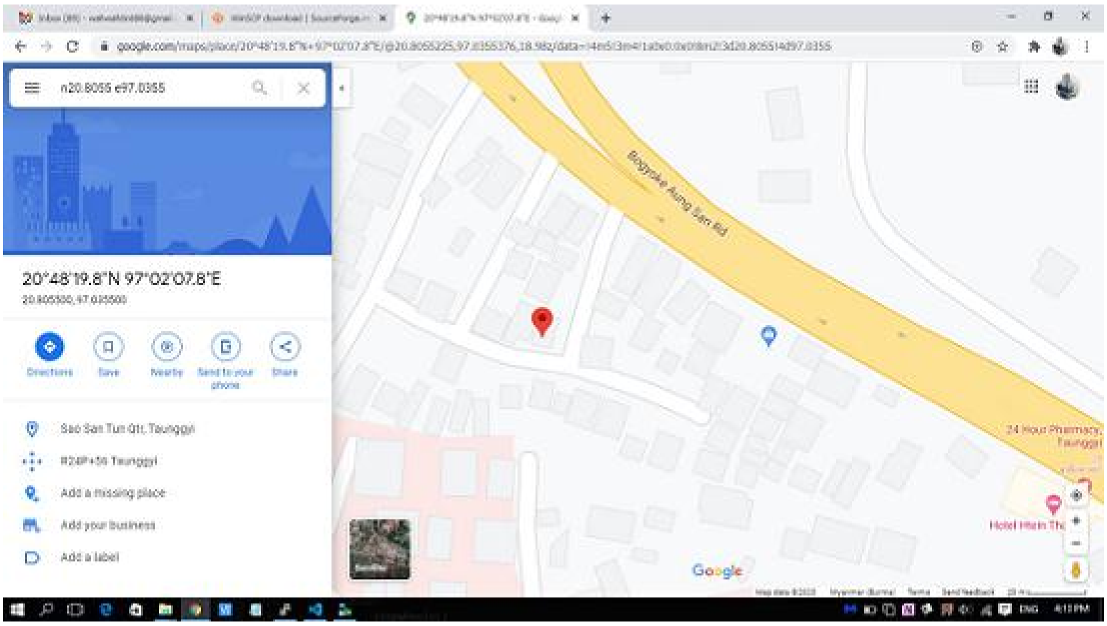

Figure 15(b). *The Location of the Current Wheelchair.*

Figure 16 shows the top view of the wheelchair, Figure 17 shows the back view of the wheelchair.

Figure 16. *Top View of the Weelchair.*

Figure 17. *Back View of the Wheelchair.*

9. Conclusions

The proposed system expressed in this paper is done successfully. The design is operated by all the specifications. This proposed system has implemented the requirements by combining them with the microcontroller board. This system uses two 12V batteries to supply all the devices. The performance of the system has been verified both in the software and hardware perspectives. The overall circuit is successfully tested which results in reliable outcomes. This system is to help disabled persons by implementing an android control system for the wheelchair and providing sensors to control the user's health thereby serving many disabilities. The wheelchair recognizes the signals getting from the control system and performs accordingly. The functional smart wheelchair is practical and helpful to people with disabilities. In conclusions, the system implemented in the research provides portability, and the power efficiency while maintaining usability and reliability.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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