An Autonomous Follow Me Platform for Carrying and Moving Objects

Muhammad Saad Amin[1] Syed Tahir Hussain Rizvi[2] Sameer Malik[3]

Muhammad Awais Yousaf [4] Sadaf Mehmood[5]

Abstract

The technology of An Autonomous "follow me" platform for carrying and moving objects has gone through rapid technological advancements. Numerous follow me robots are accessible with various running advancements, yet the expense is high. These robots are not user-friendly and therefore not much successful. In this research, a fully automated, economical, fast, efficient and smart “Follow Me” robot is designed. This robot has the ability to carry luggage or move objects from one place to another place. It will help to pregnant women and elderly people to carry their things. An autonomous follow me robot has two working modes, the first one is the default mode and the second one is Bluetooth mode or remote mode. In default mode, the user will walk in the front of the ultrasonic sensor and it will follow the user until it goes beyond the range. In Bluetooth mode, the customer needs to interact with the robot with the help of a mobile application. The customer by then has the Graphical User Interface (GUI) to control the robot. This framework enables the client to vigorously communicate with the robot at various dimensions of the control (left, right, forward, backward, and stop). The application interface is built as simple as it can be used by a wide range of patients.

Keywords: Follow Me Robot, Autonomous Object Movement, Remote Object Movement

1. Introduction

Traditionally, robots are utilized for heavy industrial tasks such as assembly automation machines, material handling with minimum human interaction. The person following robots has been developed by many analysts, because of their valuable applications in different sectors and activities like carrying the objects, observing the motion of elderly people, etc. This motivates to create the robot which is user-friendly that can concur with humans and can support humans in different tasks.

In every country, there are so many cases exist where elderly peoples and pregnant women require assistance for carrying their things/luggage while shopping or even at home from one place to another. They do not even have enough physical power or capacity to drive the manual trolleys carrying their luggage’s because it takes a lot of effort. Thus, the solution is to pay money to porter or manual lifter. Sometimes, unfortunately, if the porter is not available in the vicinity then they may have to wait for an unlimited time. Even sportsmen have to carry their sports kits

[1]*The University of Sialkot, Sialkot, Pakistan l muhammad.saad@uskt.edu.pk*
[2]*University of Lahore, Lahore Campus, Pakistan l tahir.hussain@dce.uol.edu.pk*
[3]*Universiti Utara Malaysia, Malaysia l Sameer_malik@ahsgs.uum.edu.my*
[4]*University of Lahore, Lahore Campus, Pakistan.*
[5]*University of Sialkot, Sialkot, Pakistan l sadaf.mehmood@uskt.edu.pk*

with them during their practice sessions. A platform having the capability to carry the objects and follow the human can be useful in these situations.

The main aim of the purposed system is to design an autonomous follow me platform for carrying and moving objects by using an ultrasonic sensor and Bluetooth module. Some of the aims and objectives are given below:

- To design and implement an autonomous platform that would be able to carry things and move from one point to another point.
- To implement a user-friendly interface for humans to given instruction to the platform in an easy manner.
- To provide a low-cost solution for the target audience.

Operational mechanism and driven force is required to operate these robots. There are also certain parameters like hurdles, connectivity limitations, power consumption, weight capacity, and modular capability to catch signals remotely. To address these issues following parameters must be considered.

- Solar Panel can be utilized to charge the battery for providing power to the components required to drive the robot.
- The robot only can function properly when the weight of the load is below 20 kilograms.
- Sensors are used to avoid obstacles.

For the physical implementation of a smart robot just like “Follow Me”, certain hardware and software modules will be connected. A complete prototype will be designed with the help of microcontroller and smart sensors like Arduino UNO, Bluetooth module, Ultrasonic sensor, L298N motor driver, 12V DC motor and operational capability of these sensor-based smart prototype will be controlled with the help of software modules. So interconnection of hardware and software will help in complete operational activities.

Considering the structure of the article, section 2 will elaborate on literature review or related work. The methodology will be discussed in detail in section 3. Section 4 will focus on the hardware and software components used in this smart prototype. Implementation and results will be discussed in section 5 and section 6 will present a good concluding statement regarding smart prototype.

2 Literature Review

A human following robot based on a laser range scanner is proposed by Kawarazaki et. al. [1]. This robot worked on the human detecting algorithm where the laser range scanner was used to detect the target person by identifying the shining surface. This human following robot was able to detect and follow the target person based on the position of the shining surface.

A suitcase that identifies its owner using the camera and then follows him has also been proposed by Çelik et. al. [2]. This platform was composed of the two technical fields of image processing and controls. This human following suitcase worked on the tracking algorithm which provided good results as compared to single color-based tracking. The motor of the suitcase had been controlled by using the detected motion information.

A human indoor following robot using an IR sensor is proposed by Tsun et. al. [3]. This system also used the help of a few other sensors to detect an accurate position. This robot was designed to follow the person and avoid the nearby obstacles. Islam et. al. [4], an autonomous robot is presented that uses map-assisted Two-Dimensional (2D) path planning to avoid static and dynamic obstacles within the path. Some other techniques to implement human following robots were also presented and their accuracy is compared. The automatic luggage follower robot that tracks the human through the (Global System for Mobile Communications) (GSM) is proposed by Patil et. al. [5]. A mobile robot requires a knowing distance of the person to follow a human and allow it to find its path to follow its target. To prevent the obstacle's collision, the transmitter and receiver methods are used in this research model. A lot of innovative work has been done to lessen the effort of persons by realizing the smart trollies that follow the researchers [6-8].

Another technology to implement follow me a robot is a person following robot with vision-based and sensor fusion tracking algorithms [9]. By using this algorithm, the person following the robot targets person who measures the distance between the person and robot and directs the platform to him/her using stereo vision processing and Laser Range Finder (LRF) sensing data. The speed of the robot can be controlled to keep the distance to the person constant and follows him/her. Another approach to detecting the position of a mobile robot is using an infrared camera that is a basic technique. Dang and Suh [10], a camera, which can capture four groups of Infrared (IR)-Infrared Light-Emitting Diode (LED) installed on the robot, was attached to a human. The robot followed the IR-LEDs and followed with the person.

The person-following robots using active search are proposed by Kim. et. al [11]. This system was to make an ordinary human-robot to learn, detect, and track the feature of humans, and move towards the person. Features like Personal follow-up, planning, and robot behavior were integrated successfully. It is a problem for traveling People to drag heavy luggage at the airport or station. The system of automatic luggage followers can be utilized for solving this problem. The ultrasonic sensor (used to measure distance) and DC motor (used to move the object) play an important role in the implementation of this platform. For the tracking of the anti-theft, GSM and GPS (Global Positioning Systems) can also be integrated into a platform like this [12-13]. The users can access the location of the bag by GSM and GPS tracking system when the bag is lost.

This Automatic trolley can also be guided by the customer with the use of simple line following techniques. Another system is proposed by some researchers that used sensors to track the path where the customers walk [14]. The developed research used the mobile tablet in front of the trolley to track the goods which the person purchased and automatically generate the bill. Based on the literature survey, it is cleared that there are multiple techniques capable of accurately and efficiently directing the robots that carry the objects and moves in an efficient way. And, there is also some research gap related to security that can be filled by working on it.

3 Methodology

The methodology is referred to as the steps or techniques involved in the successful implementation of the desired prototype. In the smart "Follow Me" robot, different types of sensors are included. This prototype contains different sensors like an ultrasonic sensor and a PIR (Passive Infrared) sensor. Through these sensors, persons or obstacles can be identified. The proposed platform is further comprised of a micro-controller and Bluetooth modules to operate the movement of the robot. The purposed platform has two modes:

- Default mode
- Remote or Bluetooth mode

A detailed description and operational functionality of these modules can be identified with the help of a block diagram given in Figure 1. This prototype consists of two modes, one is the default mode and the other is Bluetooth mode. In default mode, the sender side is not required; the system can only work with the receiver side. In default mode, the ultrasonic sensors sense the person and follow the object if the object is in its range. If the person goes out of range of the ultrasonic sensor, the robot will stop. In Bluetooth mode, first, the user connects its smartphone with a Bluetooth module. After connection, the user can give commands through a mobile application to the robot and it can move according to the instructions of the user. At the receiver end, which is based on Arduino UNO provides a controlled environment to the system and connected with the power supply to drive the system, ultrasonic sensors are also interfaced with Arduino. Ultrasonic sensors get the data by detecting a person and send it to the Arduino controller for further processing. And then the controller sends instructions to the motor driver for the movement of the robot.

Figure 1: Block Diagram of Designed Prototype

The operational flow chart of the designed robot is shown in Figure 2. There are two paths of execution in this prototype, one is the default mode and the second is Bluetooth mode. Anyone of these modes can be selected by a switch. This switch also helps in mode transition.

A Default Mode

If the default mode is selected, the microcontroller and sensors are powered on. Then the controller and sensors (like Ultrasonic sensor and PIR sensor) are initialized. Firstly, the reading of distance of the person from the ultrasonic sensor is acquired and then the condition, set according to requirements, is checked. If the condition of distance is matched, then the robot starts following the person at the same time conditions are again checked. If the condition of distance does not match, then the robot will stop and again checks the condition of the distance. This operational activity can be analyzed in Figure 2.

Figure 2: Flow Chart of designed prototype

B Bluetooth Mode

In Bluetooth mode, the microcontroller and Bluetooth module are turned on and initialized. Bluetooth connection is established by using a smartphone and a Bluetooth module. After the connection is established, an instruction can be sent through a mobile application i.e. BLANK. After this, it can be checked if any instruction about the movement of the robot is recorded. If an instruction is recorded, then follow that instruction and wait for the next one. If not received any command from Bluetooth, the robot will stop and check the condition again. If the system is required to remain active, then the program would carry out the same instructions continuously. If the program is required to be stopped then the program will be terminated. The flow chart for the implementation of the "Follow Me" smart path following robot is shown in Figure 2. This flow chart covers both operational aspects i.e. Bluetooth mode and Default mode. All information regarding the operational activity of the proposed work is shown here.

4 Used Hardware and Software

In the design of any prototype, both hardware and software components are required. Hardware equipment help in sensing external environmental readings whereas software help in decision making based on hardware readings. Interconnection and mutual communication of both technologies result in the best design of the required prototype. Similarly, during the practical execution of the "Follow Me" robot, different hardware and software technologies are involved and utilized. Detailed analysis of equipment along with their specifications are listed in detail in the section below.

A Hardware Modules

Arduino Uno: Arduino microcontroller board is an open-source board dependent on the ATmega328P microcontroller. Arduino Uno is created by Arduino.cc. The Arduino board has fourteen Digital pins, six analog pins, and program is burnt with the Arduino Integrated Development Environment (IDE) via a Type-B Universal Serial Bus (USB) cable. Powered by an external 9-volt battery or by a USB cable, though it accepts voltages between seven and twenty volts. Its functionality is the same as the Arduino Nano and Leonardo. The specifications of Arduino are listed below. Figure 3 represents the Arduino Uno R3 board.

- ATmega328 is the microcontroller.
- The 5 volt is the operating voltage.
- The recommended Input Voltage is 7-12V.
- The Input Voltage is 6-20V.
- It has 14 Digital input and output Pins.

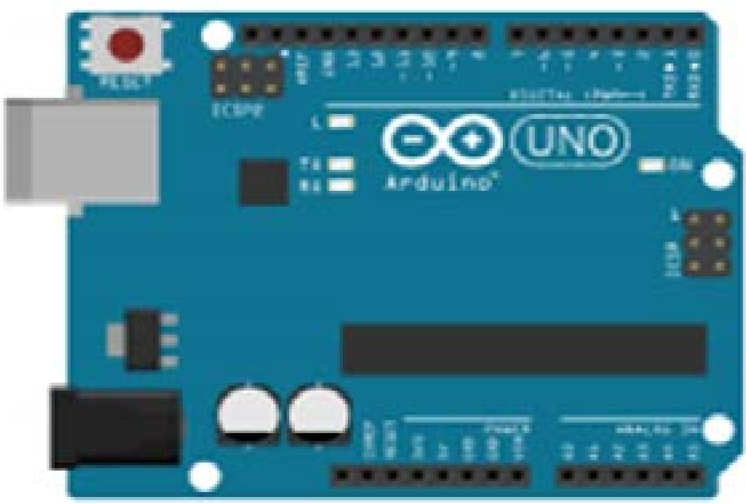

Figure 3: Arduino Uno R3 circuit board

The interconnection of Arduino with a computer is carried through a serial communication with the help of a solid wired connection. The computer USB port is connected with the Arduino serial port with the help of a connecting wire. In this way, a wired connection is established between the both physical devices. The only connection is not enough for operational activities. Arduino is made compatible with a computer with the help of an IDE. This IDE help in performing proper communication between both devices. Arduino interface is also approachable with the help of IDE. The code is written and burnt into Arduino chip with the help of IDE and the output is shown on the serial monitor window of the same IDE. The interconnection between computer and Arduino is shown in Figure 4.

Figure 4. Arduino R3 interfacing with Computer

B HC-05 Bluetooth Module

The HC-05 is a Bluetooth module that can use both sending and receiving commands. One can perform communication between the microcontrollers by using this module like Phone or Arduino. Most of the android applications that are already available which makes this process a lot easier. The specifications of the Bluetooth module is listed below. Figure 5 represents the Bluetooth module.

- Integrated the HC-05 in two-way communication
- The USB protocol which use in the module is USB v1.1/2.0
- Authentication and encryption security features are use in this module.
- The Power Supply of module is +3.3VDC 50mA
- The Working temperature of module is –25 ~ +75 Centigrade

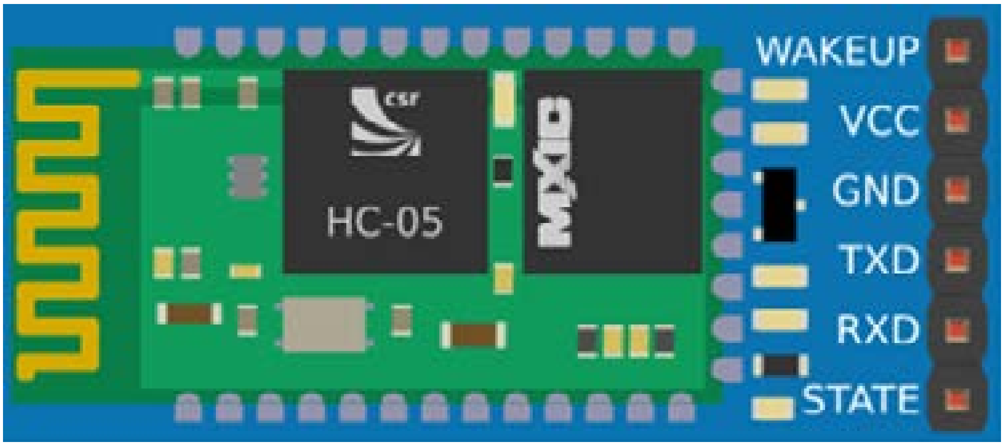

Figure 5: HC-05 Bluetooth Module

The interconnection of the Arduino Uno microcontroller with the HC-05 Bluetooth module is shown in Fig. 6. This figure illustrates pin wise connection of both modules. For connecting the Bluetooth module with Arduino, module VCC (Voltage Common Collector) pin Connect with Arduino Uno port of 5 Volt DC. After initializing power, the module GND pin connected with any Arduino Uno GND pin. Modular receiver pin Rx is connected with Arduino Uno digital pin 2 and modular transmitter pin Tx is connected with Arduino Uno digital pin 3. All connections are shown in below Figure 6.

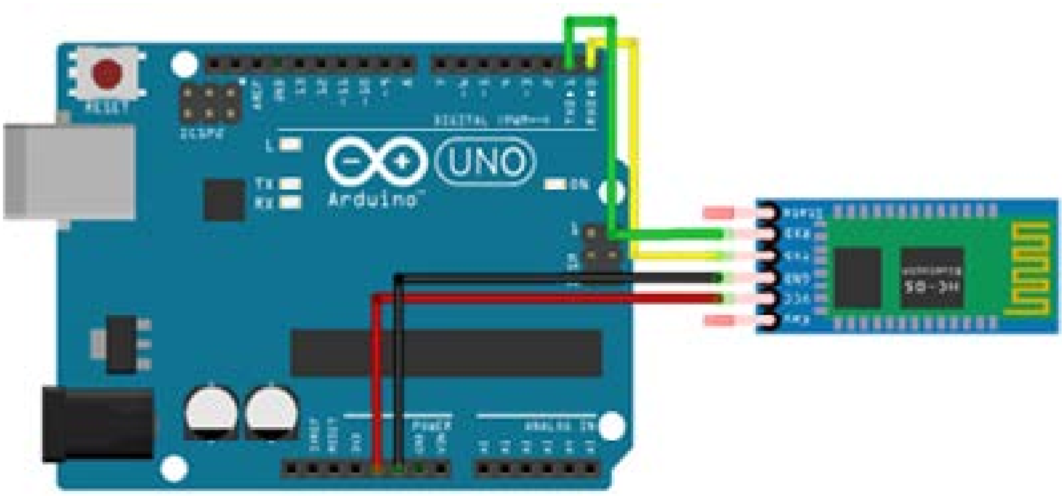

Figure 6: Interconnection of Arduino with HC-05 Bluetooth Module

C HC-SR04 Ultrasonic Sensor Module

The ultrasonic sensor finds the distance to an object by using sonar. It has excellent non-contact range detection. It has high accuracy and stable readings. It is made complete with ultrasonic receiver and transmitter modules. HC-SR04 module is shown in Figure 8. Specifications of the Ultrasonic sensor include the following:

- The power Supply of this sensor is +5V DC.
- The quiescent Current is less than 2mA.
- The Working Current of the sensor is 15mA.
- Effectual Angle of ultrasonic sensor is less than 15°.
- The Ranging Distance is 2cm to 400 cm/1″ to 13ft.
- The Resolution is 0.3 cm.
- The Measuring Angle is 30o.

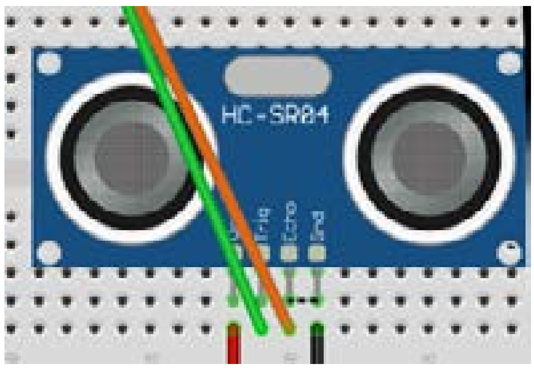

Figure 8: HC-SR04 Ultrasonic Sensor Module

The interconnection of the Arduino Uno microcontroller with the HC-SR04 Ultrasonic Sensor module is shown in Figure 9. This figure illustrates pin wise connection of both modules. For connecting the Ultrasonic sensor module with Arduino, module VCC pin Connect with Arduino Uno port of 5 Volt DC. After initializing power, the module GND pin Connect with any Arduino Uno GND pin. The modular Tigger pin is connected with Arduino Uno pin 11 and the modular Echo pin is connected with Arduino Uno pin 12. All connections are shown in Figure 9.

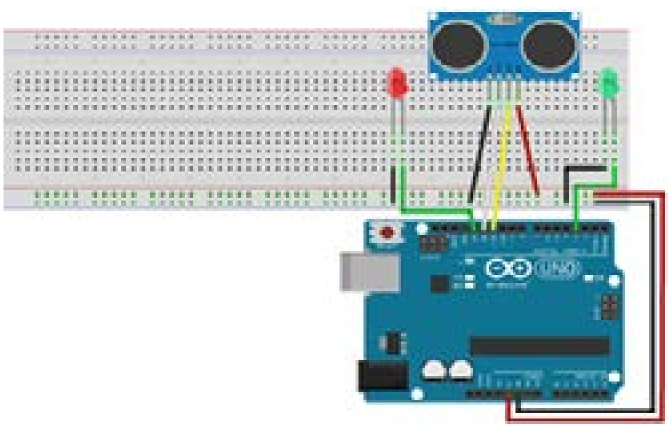

Figure 9: Interconnection of Arduino with HC-SR04 Ultrasonic Sensor Module

Testing of connection between the Ultrasonic Sensor module and Arduino Uno results in LED blinking as output. Whenever any object comes under a 30cm range of ultrasonic sensor an LED is lighted up for instance. Later on, a DC motor will be operated in case of any object under a specified range. The testing based output of Arduino and Ultrasonic Sensor module is shown in Figure10.

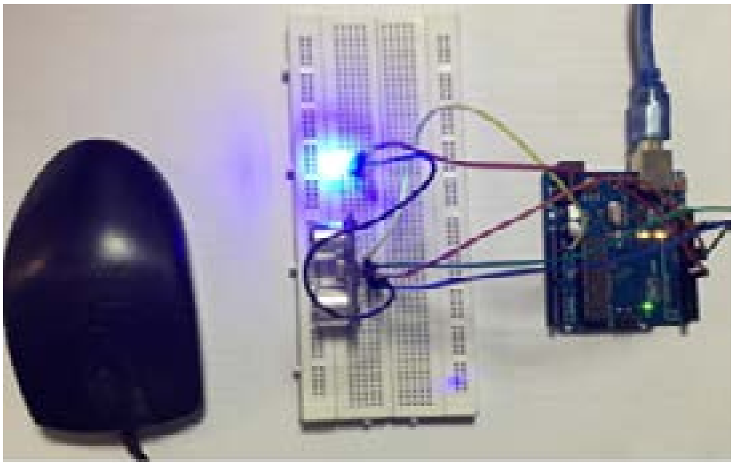

Figure 10: LED indication based testing result of Arduino and Ultrasonic Sensor

D DC Motors and L298N Motor Driver

The motor driver L298N is a dual H-Bridge motor driver. It allows to control the two DC motors speed and direction at the same time. The DC motors which have 5V to 35V voltage with maximum current up to 2A this module can drive. The motor driver L298N is shown in Figure 11. Modular specifications of motor driver L298N are listed as

- The module can drives up to 2 bidirectional DC motors at same time.
- It integrated with 5V power regulator.
- The drive voltage of this module in between o 5-35V.
- The drive current of the module is 2A maximum.
- The double H Bridge Drive Chip is L298N.
- The logical Voltage is 5Volt.
- The logical Current is 0mA to 36mA
- The Max Power is 25W.

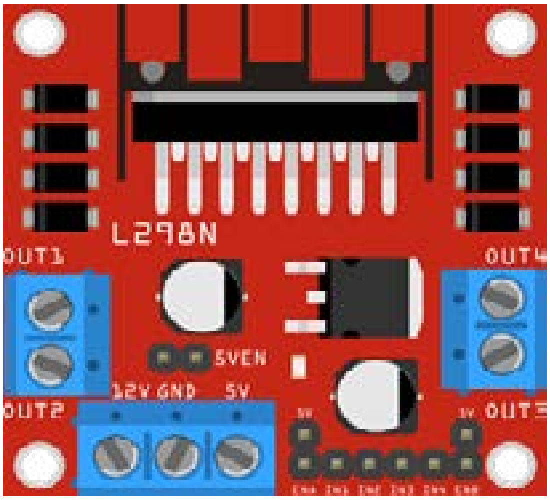

Figure 11: L298N H-Bridge Based Motor Driver

The interconnection of the Arduino Uno microcontroller with the motor driver L298N module is shown Figure 12. This figure illustrates pin wise connection of both modules. For connecting motor driver L298N with Arduino, module 5V pin Connect with Arduino Uno port of 5 Volt DC. After initializing power, the module GND pin Connect with any Arduino Uno GND pin. The motor driver L298N 12V pin is connected with an external 12V DC power supply. Module output 1 and 2 pins are connected with DC motor A and module output 3 and 4 pins are connected with DC motor B. Module IN1 pin is connected with Arduino digital pin 5 and the module IN2 pin is connected with Arduino digital pin 6. Similarly, the module IN3 pin is connected with Arduino digital pin 10, and the module IN4 pin is connected with Arduino digital pin 9. All connections are shown in Figure 12.

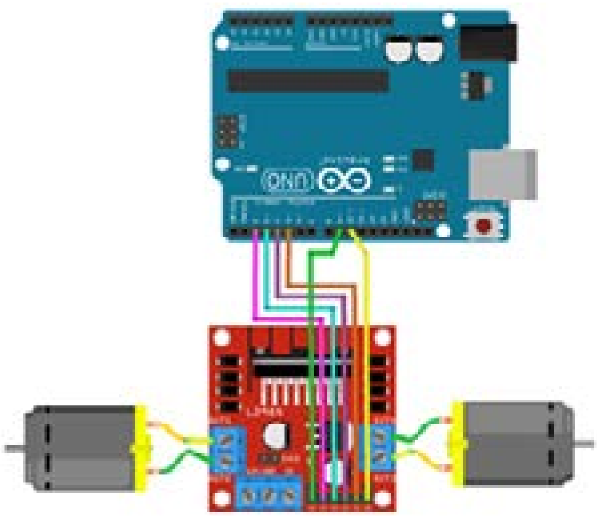

Figure 12: Interconnection of Arduino with Motor Driver L298N Module

Testing of connection between the motor driver L298N module and Arduino Uno results in motor movement as output. Whenever any object comes under a 30cm range of the ultrasonic sensor, motors as an output of the motor driver L298N module start working instantly. In this way, DC motors are operated in case of any object under a specified range. The testing based output of Arduino and motor driver L298N module is shown in Figure 13.

Figure 13: Motor Movement Based Testing Results of Arduino and L298N Motor Driver Module

E Software Modules

Arduino IDE: Arduino IDE is the interfacing platform that helps in controlling, analyzing, and monitoring equipment performance. This can be referred to as the interpreter between external sensors and computers. A lot of libraries are available online that are embedded into the header of the Arduino code. These libraries translate the communication of sensors and modeled their observational readings according to program requirements. As discussed earlier, sensors are attached to the Arduino microcontroller. So programming and translation of readings are basically performed through the Arduino board. Therefore, the Arduino IDE is required to make communication feasible between Arduino based prototype and user requirements. Through Arduino IDE, code can be burnt, modified, and tested on equipped sensors. Furthermore, performance evaluation can also be performed with the help of the Serial monitor window in Arduino IDE. The serial monitor displays resultant information in graphical and digital formats. Arduino IDE based resultant values on the serial monitor are shown in Figure 14. These are the testing values of the Bluetooth module attached in the “Follow Me” prototype.

Figure 14: Serial Terminal Based Testing Results of Bluetooth Module on Arduino IDE

F Mobile Application

A very user-friendly mobile application is developed for controlling the "Follow Me" prototype remotely and wirelessly. (Both words are same). In default mode, there is no such functionality performed therefore there is no need for a mobile application. This application is only applicable when the smart prototype is operated in Bluetooth mode. There is a button attached to the application GUI that helps in producing a connection between the hardware modules of the robot and controlling software application. Other control buttons are also attached to the GUI display. That buttons control the forward, backward, right, and left movement of the robot. Ultrasonic sensor readings can also be displayed on a mobile application. Bluetooth terminal-based connectivity of the device is shown in Figure 15.

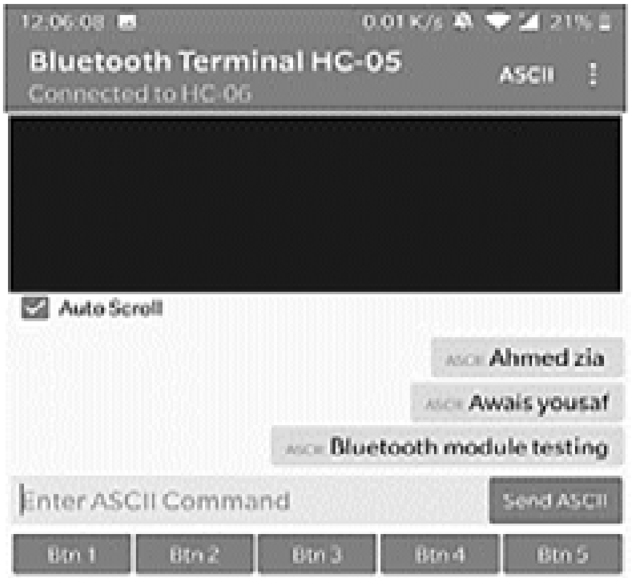

Figure 15: Mobile Application Based Connectivity and Testing Results of Bluetooth Module

5 Implementation and Results

The final integration of the circuit and Follow me platform is shown below. The circuit is attached under the structure of the follow-me robot. The structure of the robot is made of an acrylic sheet. The ultrasonic sensor is in front of the robot. This robot uses the three wheels, the front-wheel is freewheel and the two back wheels are controlled with motors. The robot shape is just like the trolley which carries the objects. The final prototype design is shown in Figure 16.

Figure 16: Front and Side View of Designed Prototype of Follow Me Robot

The L298N motor driver (which controls the motors), Bluetooth module (Use for connectivity with mobile), and ultrasonic sensor are connected with Arduino Uno. Arduino Uno receives the command from the mobile application through the Bluetooth module and performs the function according to the command. In the second mode, when the robot is in default mode, the ultrasonic sensor sends the data of distance from the object to Arduino and then Arduino insert into the code and perform the function.For implementation purposes, motor driver pins are connected with Arduino Uno that is defined in the program of Arduino. The L298N has six pins that are connected with Arduino. In the robot circuit, the ENA pin is connected with the Arduino digital pin 5. The ENB pin is connected with the Arduino digital pin 6. The IN1 pin is connected with the Arduino digital pin 8. The IN2 pin is connected with the Arduino digital pin 9. The IN3 pin is connected with the Arduino digital pin 10. The IN4 pin is connected with the Arduino digital pin 11. The pins configuration is defined in the Arduino controller board. The internal circuit based design of the robot is shown in Figure 17.

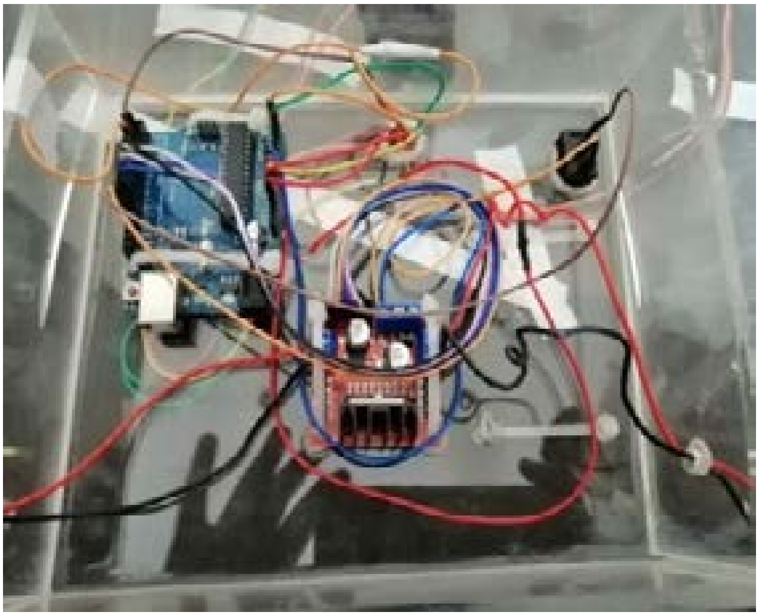

Figure 17: Internal Circuit Based Design of Designed Robot

The Bluetooth module has four pins, two for transmission and receiving and two pins are used for power. Connect the Bluetooth module with Arduino through the connection of all the pins of the module with the Arduino. In the robot circuit, the VCC pin is connected with 3.3V pin of Arduino, the GND pin is connected with the GND Arduino pin, the RDX pin of the module is connected with the Arduino digital pin 3, and the TXD pin of the module is connected with the digital pin 2 of Arduino. The ultrasonic sensor has four pins two for sending data and two pins use for power. Connect the Ultrasonic sensor with Arduino by connecting all the pins of the sensor with the Arduino. In the robot circuit, the Vcc pins are connected with the 5V pin of Arduino, the ground pin is connected with the ground pin of Arduino, and the Echo pin of the sensor is connected with the Arduino analog pin A4 and the Trig pin of the sensor is connected with the Arduino analog pin A5. A4 and A5 pins send the data (data calculated by the sensor) to the Arduino. Integration of Arduino with Bluetooth module and Ultrasonic sensor is shown in Figure 18.

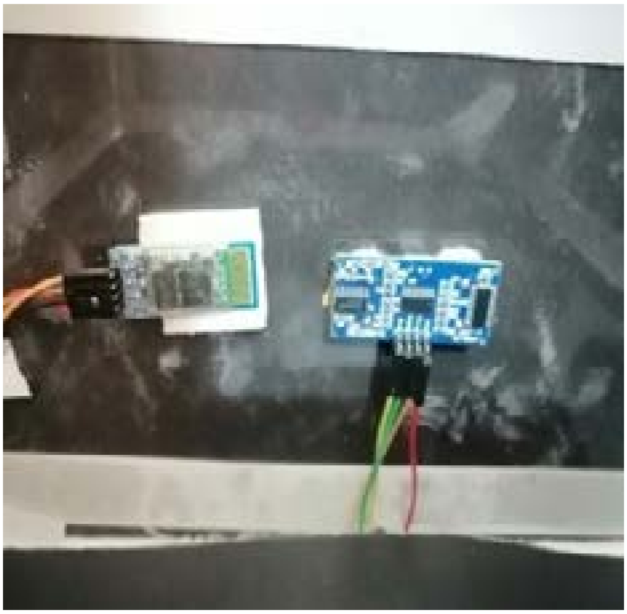

Figure 18: Integration of Arduino with Bluetooth module and Ultrasonic Sensor

In default mode, the robot is controlled with an Ultrasonic sensor. For the second mode, the android application is used for the movement of the robot manually. In application interface, the robot is controlled with the arrow's keys. Every key has a command which is sent to the Arduino by using the Bluetooth module. When the command is received by the Arduino, it performs function grading the command. The command is defined in the program which is burnt in the Arduino controller. In this application, digital values are used for robot movement. The digital value of 92 is used for forward, 91 for reverse, 79 for left, and 71 for right side movement.

There are four buttons for moving left, right, forward, and backward. Whenever a button is pressed, a string that is coded behind the button is sent to Arduino through Bluetooth and then the Arduino operates according to received instructions. When a user came in the range of the sensor, it will send instructions to Arduino and the robot will start following that user until he will accede its range. The robot stops when the object out from the range of the sensor. The android application interface is shown in Figure 19.

Figure 19: Android Application Based User Interface for Robot Controlling

6 Conclusion

In our daily life, different types of robots are used which are known or unknown by different users. In this research model, a planned Autonomous follow me platform is developed for carrying and moving objects with the help of an Ultrasonic Sensor and android application. The circuit will work properly after receiving the commands from the user through Ultrasonic Sensor or by a mobile application. This prototype will empower pregnant women and elder people to control their Autonomous "follow me" platform of carrying and moving objects by using an android application in their smartphones or by using an Ultrasonic Sensor. This proposed framework adds to the self-reliance of various pregnant women and elder people. In the future, more features would be added by attaching various smart sensors and cameras. In this way, it is our believed that the research-based prototype will be fruitful for many daily life purposes. Hence the purpose will be successful.

7 Recommendations

The mechanism of the steering is to be modified for competence in extensive vehicles. It is fatigue for non-electric vehicles like the power of petrol. This makes it not suitable for a rough territory from the lack of a three-wheel drive. This makes the robot unstable from the lack of speed control at times.

Acknowledgment

The authors of designed prototype entitled "An Autonomous Follow Me Platform for Carrying and Moving Objects" humbly acknowledge the support and guidance provided by supervisor Engr. Dr. Tahir Hussain Rizvi, Department of Computer Engineering, The University of Lahore, Lahore for their continuous guidance in development of prototype.

References

[1] Kawarazaki, N., Kuwae, L.T., and Yoshidome, T., 2015, "Development of Human Following Mobile Robot System Using Laser Range Scanner", Procedia Computer Science, Volume 76, pp. 455-460.

[2] Çelik, Y., Tekin, M., Şekkeli, M., and Güneş, M., 2018, "Tracking Algorithm for Suitcase That Follows Its Owner Autonomously", Proceedings of 4th International Conference on Virtual Reality.

[3] Tsun, M.T.K., Lau, B.T., and Jo, H.S., 2018, "An Improved Indoor Robot Human-Following Navigation Model Using Depth Camera, Active IR Marker and Proximity Sensors Fusion", Faculty of Engineering, Computing & Science, Swinburne University of Technology Sarawak.

[4] Islam, M.J., Hong, J., and Sattar, J., 2018, "Person Following by Autonomous Robots", International Journal of Radiation Research, Volume 4.

[5] Patil, S., Anuja, S., and Deshmukh, P., February 2019, "Automatic Luggage Follower", International Research Journal of Engineering and Technology, 6(2).

[6] Raja, M.R., Kumar, R.A., Hemanthi, C., Keerthana, G., and Kirudiha, B., March 2018, "Follow Me Trolley", International Journal of Recent Trends in Engineering & Research Conference on Electronics, Information and Communication Systems, Special Issue.

[7] Dehigaspege, L.S.Y., Liyanage, M.K.C., Liyanage, N.A.M., Marzook, M.I., and Dhammearatchi, D., July 2017, "Follow Me Multifunctional Automated Trolley", International Journal of Engineering Research & Technology, 6(7).

[8] Ali, A.A., Mayank, P., Shivang, S., and Abhishek, S., 2014, "Follow Me Trolley", Department of Electronics & Communication Engineering, Government Engineering College, Bharuch, Volume 2.

[9] Sonoura, T., Yoshimi, T., Nishiyama, M., Nakamoto, H., Tokura, S., and Matsuhira, N., 2008, "Person Following Robot with Vision-Based and Sensor Fusion Tracking Algorithm", Corporate R&D Center, Toshiba Corporation, Japan.

[10] Dang, Q.K., and Suh, Y.S., 2011, "Human-Following Robot Using Infrared Camera", 11th International Conference on Control, Automation and Systems, Gyeonggi-Do, pp. 1054-1058.

[11] Kim, M., Arduengo, M., Walker, N., Jiang, Y., Hart, J.W., Stone, P., and Sentis, L., 2018, "An Architecture for Person-Following using Active Target Search", Department of Computer Engineering, Austin.

[12] Gigliotta, O., Caretti1, M., Shokur, S., and Nolfi1, S., 2002, "Toward a Person-Follower Robot", Institute of Cognitive Sciences & Technologies, CNR Viale Marx, 15, 00137, Roma, Italy.

[13] Hao, Y.C., 2005, "A Person-Tracking Mobile Robot Using an Ultrasonic Positioning System", The NPS Institutional Archive, Calhoun.

[14] Yathisha, L., Abhishek, A., Harshith, R., Koundinya, D., and Srinidhi, K.M., June 2015, "Autatopm of Shopping Cart tp Ease Queue in Malls by Using RFID", International Research Journal of Engineering and Technology, 2(3).