International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 12, pp: 33-39 www.ijaem.net ISSN: 2395-5252

Development of Arduino-Powered Robotic Vehicle with Automatic Obstacle Detection and Avoidance

Subit Sharma

Date of Submission: 25-12-2020 Date of Acceptance: 03-01-2021

ABSTRACT: Detection and avoidance of obstacles in real-time have come out to be significant issues in designing robotic cars. This study promotes the design and deployment of an automated vehicle in terms of software, hardware, and communication settings with real-time detection and avoidance of obstacles. The three major technologies used in the deployment of this system are the Android application, the Arduino platform, and Bluetooth. This paper presents the deployment of robotic cars with sensor programming on the platform. The automatic device needs the intervention of an Android device for development. Arduino Uno serves as intelligence for the vehicle. There are many hardware aspects of the robot, including the PIR sensor, Bluetooth module, buzzers, and ultrasonic sensor. The software part of this machine also uses a mobile application. The user can select the mode or direction by using a mobile application and control the movement of the robotic vehicle. The user uses his/her smartphone to control the activities of the vehicle or simply turn on the automatic mode to allow the car to drive automatically. Hence, the robot does not only detect human obstacles, but it can also avoid them. This article is aimed to explain how live detectable sensors can alert military staff and civilians against any terrorist attacks.

Keywords – Arduino platform, Bluetooth, Obstacle Detection and Avoidance, PIR sensor, ultrasonic sensor, Android application

I. INTRODUCTION

With the onset of technological advances over the past decade, manufacturers started making devices with sensors to make lives easier in many aspects. Generally speaking, sensors are electronic devices to turn the forms of energy into electrical energy. Several electronic devices are connected in a physical environment through sensors. The domain can be electronic devices like tablets, laptops, smartwatches, humanoids, and smartphones. These devices are used in different applications to protect, identify, control, and image in industrial settings. With this technological advancement, hundreds of sensors are out there, including obstacle detectors, pressure sensors, heat detectors, and moving objects detectors. Earlier, sensors had limited use with lighting only. Today, they are used in almost all aspects of daily life. Fast developments have become the new normal, especially in the fields of electronics and technology. A new application or invention can easily be made possible in this regard.

Nowadays, AI algorithms are used to develop robotic systems, and the field of robotics is no exception. Perception is the most vital aspect of robotics. Behind any automated design, there is always a perception of an environment. For example, a robot can detect explosives or any terrorist activity with the use of sensors. For doing this, a robot needs to perceive changes like heat in the environment, interpret the same, and make decisions accordingly.

This article focuses on the automated and remote-controlled robotic car, which uses sensors to detect and avoid obstacles. Bluetooth is the most reliable and widely-used technology in Android devices to build connections. This remote-controlled car will also use Bluetooth for connectivity. Arduino Uno is another technology to process input data and help the robot perform actions based on this incoming data. Automatic and Manual are the two significant modes that Android applications on an Android phone will use to control the robotic vehicle. The user will be able to select the actions on the screen with buttons and a menu. The user will be able to use these buttons to move the car left, right, back, and forward, stop, and switch to the automatic mode. The moment the user switches to the automatic mode, the control goes to the robot, and it automatically makes its way while avoiding obstacles. This Arduino-based Robotic Car detects living objects and alerts with the Real-Time Obstacle Alert feature. It perceives the barrier and stops and then makes way without

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 12, pp: 33-39 www.ijaem.net ISSN: 2395-5252

collision. Meanwhile, it uses a heat sensor and live detection to blow the Red LED to alert.

In this study, a fresh design of a robotic vehicle is studied when it is connected with some sensors for obstacle detection and avoidance. It is probably the first time a study is being made on Android and Arduino Uno to investigate how an autonomous vehicle avoids and detects obstacles.

This research is categorized in the following sections – Section 2 covers the works related to this study. Section 3 explains how the robotic vehicle and its architecture work. Section 4 explores the technical specifications of the car and its components. Section 5 covers the vehicle's design and its implementation. Finally, Section 6 concludes the research.

II. SIMILAR STUDIES

In this section, here is the breakdown of some of the working principles and methods used to conduct studies related to Obstacle Avoidance and Detection by an Autonomous, Four-Wheeled Electric Vehicle.

Aye Min et al. [1] researches a robotic Arduino-powered vehicle which uses Bluetooth and ultrasonic sensors to avoid obstacles. It includes an ultrasonic sensor, an Arduino Nano board, two DC motors, one servo motor, Bluetooth, and other technologies. It uses the obstacle-avoidance mechanism to avoid crashes. The ultrasonic sensor transfers the ultrasonic waves from its head.

Sushmita M. Rathod et al. [2] uses the sensor-based system for obstacle detection on a four-wheeled electric robot. Autonomous vehicles have become the hottest topic online as vehicles without accelerators, steering wheels, and state-of-the-art autopilot. She studied an autonomous vehicle that can recognize its environment and choose the right path on its own. It uses different sensors like radar, Lidar, infrared, ultrasonic, and GPS.

FaizaTabassum et al. [3] consider obstacle avoidance and detection as the key challenges in designing mobile robots. This technology is also essential as it provides the senses these robots need to traverse in unknown environments without any damage. They select the Arduino board as the microcontroller and Arduino software as the programmer.

TanmayiSamant et al. [4] combined remote access and automated safety with a cost-effective alternative in designing a multi-featured Robot Vehicle with Arduino technology. These students used this technology in a car without having added weight and components. This project focuses mainly on the safety and luxury of the driver. This car has all the safety features to prevent a collision on a daily basis.

Siddhi Patil et al. [5] used an IR sensor for detecting and fleeing through hurdles in a robotic car. This project uses a smartphone to bridge this project's connection, real-time detection, and avoidance of obstacles is a significant challenge. The robot vehicle can move by mobile, remote controller, and automatically. It collects the data to move back and front from its sensors. It makes its path instantly towards its destination.

III. ROBOTIC VEHICLE AND ITS ARCHITECTURE

Fig.1 shows the overall system architecture of the robotic vehicle developed with all the sensors.

There are two modes of the robotic vehicle displayed in this paper – the Automatic mode and User Control mode. The Bluetooth technology acts as a bridge between Android devices and the motorised vehicle for communication.

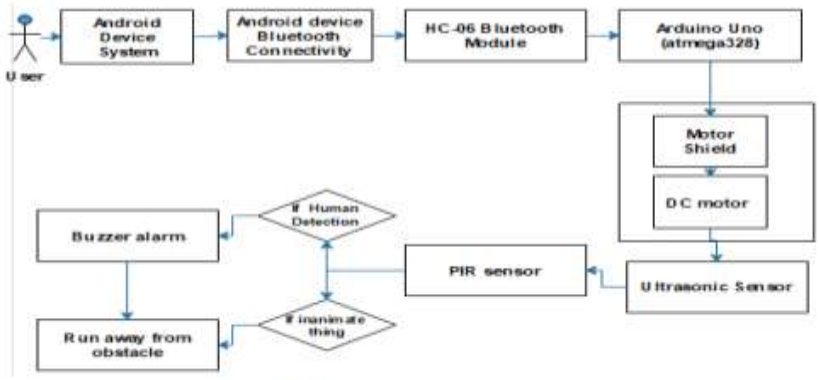

Figure 1. Structure of robotic car

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 12, pp: 33-39 www.ijaem.net ISSN: 2395-5252

IV. TECHNICAL SPECIFICATIONS

4.1. Arduino Uno

Arduino Uno is powered by an ATmega328 microprocessor with 14 pins to work as a brain for the robot. The Arduino UNO (Fig. 2) is the most widely-used model of Arduino card. One can program it effortlessly with Arduino libraries. Easy programming is the best part of any microprocessor. Integrated Development Environment (IDE) is where Arduino Uno is programmed. Embedded C language is the programming language that is selected. It designs systems and robots using sensory signals which affect the environment. Actions like light and sound are specific to the project output.

Figure 2. Arduino Uno

4.2. Hc-06 Bluetooth Module

It connects devices within a short range of around 10-20 meters and communicates via USART Serial Communication to Arduino. This Bluetooth module (Fig. 3) can respond only to input requests, instead sending communication requests to the next module. There are four pins in this Bluetooth module – GND, VCC, Tx, and Rx.

Figure 3. HC-06 Bluetooth Module

Arduino supplies GND and VCC for Bluetooth module, while Tx pin is connected to the Rx so the Bluetooth module can detect the commands from Arduino. Bluetooth messages should be plugged in the Tx of the Rx pin of the Arduino. An Android device can be connected to it through a password.

4.3. Buzzer

This device can produce several sound waves as per the voltage. It is very light, easily produced, and cost-effective. Hence, it can be used in a large area. The buzzer is mainly used to warn the authorities about the concerned event. After receiving several incoming messages, it triggers sound accordingly. First of all, it transforms the incoming DC voltage from the input port into an amplified oscillation signal. By applying a high and discrete voltage, it leads to mechanical contraction and expansion. Due to this phenomenon, the metal plate inside it bends in the reverse direction. In Fig. 4, the metal plate is twisted regularly in the next direction and the iceberg which is shrunk generates sound waves in the air.

Figure 4. Buzzer

4.4. Arduino Motor Shield

Fig.5 displays a motor driver card which has used L298. The Arduino motor shield provides control over direction and speed to DC motor and helps in measuring electric current.

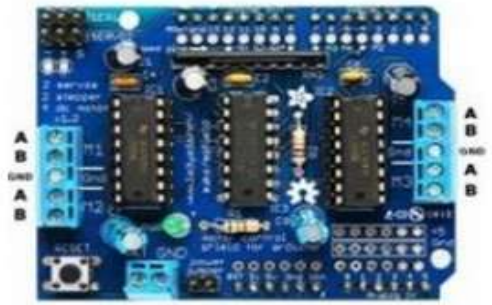

Figure 5. Motor Shield

4.5. DC Motor

Direct Current motor or DC motor, as the name suggests, uses direct current to transform electricity into mechanical energy. This electric machine works according to this principle – A conductor carrying electric current is open to humidity in a magnetic field.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 12, pp: 33-39 www.ijaem.net ISSN: 2395-5252

The DC Motor (Fig. 6) has six main components – magnets, coils, brush, rotors, stator, and DC source. The purpose of the DC motor in this research is turning the wheels. The magnetic field consists of the armature rotated with direct current and generated by the coils to generate the mechanical force.

Figure 6. DC Motor

4.6. PIR Sensor

Passive Infrared Sensor or PIR sensor is able to detect human body temperature. As the name suggests, Passive Infrared Sensor does not release any form of energy or heat. Instead, it detects a person using Infrared Rays. It is also a low-cost component and it consumes less power.

There are two pin slots in the PIR sensor (Fig. 7) and each slot is sensitive to infrared rays. Hence, it determines the visual distance. Both slots in this sensor are IR sensitive and all objects emit the same infrared rays in the room when nothing is detected. Living objects spread the heat and can easily enter its field of view. It leads to a change in temperature. The sensor detects change in temperature when any object emits heat. This change helps the sensor to perceive the movement.

Figure 7. PIR Sensor

4.7. HC-SR04 Ultrasonic Sensor

This sensor is powered by Sound Navigation and Variable (Sonar) to determine the distance between the vehicle and the object. The measurement is quite accurate, i.e. ranging from 2 to 400 cm. The frequencies of ultrasonic sound waves are ranging from 20 kHz to 500 kHz. Ultrasonic sensors, as the name suggests, release ultrasonic sound waves and calculate the time taken to approach the obstacles to determine the distance. (Fig. 8)

Figure 8. Ultrasonic Sensor HC-SR04

The ultrasonic sensors have sensing range of around 30 meters in ideal conditions. There are two transducers in ultrasonic sensors – ultrasonic microphone and ultrasonic speaker. The electronic circuit measures the time taken in the sound wave's broadcast from the loudspeaker, the sound wave coming from the obstacle, reflection of microphone, and the distance from one obstacle to another. This time is divided by calculating the ultrasonic sensor with the speed of sound. (Fig. 9)

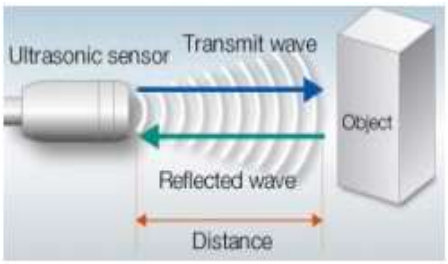

Figure 9. Ultrasonic Sensor working principle

4.8. Arduino IDE

In this software development platform, one can write codes, compile them, use Arduino kits, and load the codes compiled to the Arduino Uno, which is linked to the USB port of the computer. This platform uses the C/C++ programming language. There are two basic functions for C/C++ languages –

- setup: it starts at the program's beginning.
- loop: it works in a loop until the power of the card is turned off.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 12, pp: 33-39 www.ijaem.net ISSN: 2395-5252

4.9. Android Platform

Based on Linux OS, the Android platform is developed by Open Handset Alliance and Google. It is an open-source and low-cost operating system mainly used for smartphones and tablets. There are four layers of Android operating system –

1. Linux Kernel
2. Android Runtime and Libraries
3. App Framework
4. Applications

The first layer of Android is the Kernel used for process management, networking, and memory management. Android Runtime and Libraries is the second layer, including all libraries written in C/C++ on the Android OS. This layer is involved through Java and operates with a virtual machine named Dalvik. It also serves as a mediator between the operating system and the application. Application framework is the third layer to determine an application structure for Android. Application is the final layer to interact between apps written by other users. The app can control the machine via the Bluetooth connectivity.

V. VEHICLE'S DESIGN AND IMPLEMENTATION

There are eight components of a robotic vehicle – HC-06 Bluetooth module, Arduino Uno, DC Motor, Arduino motor shield, PIR Sensor, Ultrasonic HC-SR04 sensor, 9V battery, and buzzer (Fig. 10).

In terms of implementation, the user first has to go to Google Play store and download "Arduino Bluetooth Controller". Turn on the Bluetooth connection on Android phone and connect the application to Bluetooth HC-06 module with a password like "1234". The user needs to assign values to the specific keys. Robots can start sending input values after assignment.

The Bluetooth module sends the data from the Android app to Arduino Uno, which manages input signals and decides the right signals to the motor driver. Hence, the robot follows the command and moves according to the incoming signals.

The user has basic controls of the robot like rotate right/left, back/forward, stop, etc. from their device. The user can choose autopilot mode for the robot and let it drive automatically. The vehicle can detect the obstacles and avoid them. The red LED will light up when it detects an obstacle and triggers a buzzer. It can calculate the shortest distance when the obstacle is an unmovable object. It stops when it reaches the cliff (Fig. 10).

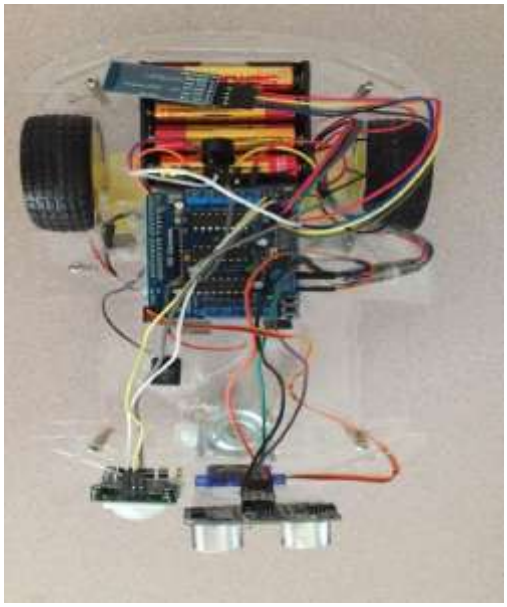

Figure 10 - Robotic car upper view

4.1. Automatic and User Control Mode

Once the user downloads and installs the Arduino Bluetooth Controller app on their Android device, they need to turn Bluetooth on. The user has to enter password '1234' and connect Bluetooth Module (HC-06). After selecting HC-06, some selection will be seen.

Figure 11 – Buttons

In Figure 11, you can see how buttons can be changed on Android applications. After clicking the symbol, the user is able to assign buttons with the value they want. By pressing "Start", the program will start. Now the user can hit the "Select" button to choose the option. Figure 12 shows the values and options assigned.

These options facilitate basic robotic vehicle movements. The robot controls itself when the user chooses the automatic mode button.

Hence, the robot will alert when it detects a living object and escapes from the obstacle.

The user can control the basic robotic movement in the manual mode with the application. Bluetooth technology is used to forward the user inputs to the robot. The device will send the input to the robot and it will process the information in the Arduino Uno processor and let them move as per the input order. Forward, backward, left, and right are the basic movements of the robot. The robot can be stopped anytime along with it.

Figure 12 – User-specified Buttons

The user can turn on the automatic mode to allow the robotic vehicle to move on its own and the user can see its movement in the app interface. The robot will detect the obstacles with ultrasonic sensors at a distance of only 25 cm. The robot stops automatically when any hurdle comes in its way and reverses 2 cm. The robot will activate the PIR sensor and detect whether there is a living or non-living obstacle. It calculates the heat that the obstacle releases. The object radiates heat and the robot observes that it is alive when it moves. It will activate the buzzer and trigger an audible alarm when the obstacle is a living being.

The robot will escape the obstacle and keep going on its own way. If it detects an unmovable object as an obstacle, it calculates the distance away to the farthest point from the obstacle. It keeps going to avoid obstacles in that way. The process keeps up until the robot is stopped and the user leaves the application. Along with it, the user can set the buttons on their own by giving the desired value. The user can track the path manually or let the robot do this in automatic mode. All in all, the robotic vehicle can move as per the user's command while avoiding obstacles in real-time or it can move until the obstacle is detected with autonomous mode.

VI. CONCLUSION

Many papers have addressed the robotic car powered by Android platform, Raspberry pi and Arduino Uno. However, scientists are yet to study the use of Android and Arduino Uno for real-time obstacle avoidance and detection of the autonomous and remote-controlled car. This article has been aimed to explore the use of an Android app to detect potential terror attacks in sensitive areas like the military field. The basic robotic movements are defined by getting information from the application. The HC-06 Bluetooth module bridges the communication gap between the application and the robot. The HC-SR04 ultrasonic sensor prevents collision for the robot. The robot escapes the crash with this sensor. The robot perceives that it has reached the cliff and avoids falling. The ultrasonic sensor detects the heat radiated by the human obstacle by using a PIR sensor. When the robot detects a human obstacle, it triggers the audible alarm. An ultrasonic sensor is important to detect the obstacle's distance in this research. It helps detect simultaneous human obstacles and avoid inanimate objects. Hence, the commissioning of this robot can control tasks on the go and improve effective operation. This study uses smarter sensors to further improve the results. The Bluetooth can be replaced by the Wi-Fi module to build connection. It is because the Wi-Fi signal is stable and fast even in wider areas.

REFERENCES

[1]. https://www.hu.edu.mm/wp-content/uploads/2020/10/10_HURJ_Phy_01_U-Aye-Min.pdf

[2]. S. M. Rathod and S. K. Apte, "Obstacle Detection Using Sensor Based System For An Four Wheeled Autonomous Electric Robot," 2019 International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2019, pp. 493-497,doi:10.1109/ICCES45898.2019.9002065.Retrievedfromhttps://ieeexplore.ieee.org/document/9002065

[3]. Tabassum, F., Lopa, S., Tarek, M. M., &Ferdosi, B. J., Dr. (2017). Obstacle Avoiding Robot. Obstacle Avoiding

Robot, 17(1), 1.0st ser. Retrieved from https://globaljournals.org/GJRE_Volume17/2-Obstacle-Avoiding-Robot.pdf.

[4]. Samant, T., Rana, J., Rathore, P. S., & Sharma, R. (2018). Multi Featured Robot Car with Arduino. Multi Featured Robot Car with Arduino, 7(1), 1-6. Retrieved from https:// www.ijirset.com/ upload/2018/ january/81_Multi.pdf

[5]. Patil, S., Ovhal, P., Jigale, S., &Aneesh, R., Prof. (2020). Robotic Car for Avoidance and Detection of obstacles using IR Sensor. Robotic Car for Avoidance and Detection of Obstacles Using IR Sensor, 7(4), 1-5. Retrieved from https:// www.irjet.net/archives/V7/i4/IRJET-V7I4163.pdf