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Implementation and Reliability Study of a Bluetooth Controlled Autonomous Car

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Abstract

The rise of Internet of Things (IoT) technology has paved the way for new and engaging initiatives that seamlessly integrate the physical and digital worlds. Here an Arduino Bluetooth controlled autonomous car is introduced which can move itself automatically in order to park itself by accepting instructions from a mobile device. This paper investigates the design, development, and implementation of an Arduino-based Bluetooth-controlled automobile with integrated front and back lighting. The paper has studied the reliability of the device measured in various parameters. The project uses readily available components, such as the Arduino UNO microcontroller, L293D motor driver, and HC-05 Bluetooth module, to develop a low-cost solution. Using Bluetooth communication, users can remotely manage the car's motions and lighting features from a paired device. This chapter expands on past rounds of Bluetooth-controlled automotive projects. The four-wheeler is connected to an Arduino and a Bluetooth module. The remote device i.e mobile already has an Android application installed. Instructions to the vehicle are sent via that application, which is connected to the vehicle's module. The Bluetooth module sends the command as a signal to the Arduino, which can work with signals and convert them into pre-defined actions. Signals were sent to the motors, and the car started to run. This car does not have advanced functions, but we can add features such as line detection or obstacle detection, and we can attach a camera to the vehicle and view it through mobile to make it armed/specially capable. The reliability of this design is studied by executing several different tests and recording the behavior of the car in such tests. The power consumption, the area of activation and the distance covered by the car is recorded to calculate the overall efficiency of the design. The user friendliness of mobile based app to control the car is calculated by taking user feedback in a scale of 1 to 5. Finally, the conclusion and the future direction of the research is stated.

Keywords: Arduino, Bluetooth, Motor driver, Android application, Reliability.

1 | Introduction

Wireless control is one of the most fundamental necessities for people all around the world. Bluetooth is one of the most widely utilized wireless technologies. A Bluetooth control automobile is an autonomous car which can be wirelessly operated with a Bluetooth control system and an Arduino [1], [2]. With the combination of

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Arduino and Bluetooth, we can manage a variety of different devices, including home lighting and air conditioners, via our cell phones. The Arduino can also contribute significantly to the Smart Home system. With microcontrollers, we can now easily turn digital impulses into physical movements. Nowadays, people use autonomy in every field. There are numerous advantages, such as reduced risk of injury, speed, ability to work continuously, dependability, and so on. This Bluetooth-controlled autonomous car is an example of autonomy. This sort of automobile is utilized in law enforcement and military operations for a variety of reasons, including hazard exposure, which is managed from a position of relative safety. Many police bomb teams utilize these vehicles to defuse or explode devices.

NASA uses such vehicles for space exploration. European Space Agency (ESA) and ROSCOSMOS [3] have investigated and collected extensive data from space, the moon, and Mars. In recent times, large corporations have used remote control trucks to deliver their products. Many of the giant factories feature remote-controlled mobility. In this chapter we have proposed and implemented an autonomous car connected to an Arduino and a Bluetooth module. The remote device already has an Android application installed. We send our instructions to the vehicle via that application, which is connected to the vehicle's module. The Bluetooth module sends the command as a signal to the Arduino, which works with it. We implemented code in the Arduino that can work with signals and convert them into pre-defined actions. Signals were sent to the motors, and the car began to run. This car does not have advanced functions, but we can add features such as line detection or obstacle detection, and we can attach a camera to the vehicle and view it with the remote. This is simply a basic prototype of a mobile app based Bluetooth-controlled autonomous car; we may add a lot of advanced features to make it armed/especially capable. This paper sought to create an autonomous car prototype made using Arduino and controlled by Android software that can follow manual or automatic pathways. Until now, research and analysis of the simulation of experiments have shown that it is possible to use the prototype designed for cognitive development, with future users learning to insert custom paths that can process logic issues and more complex mathematics, allowing the prototype to perform the desired movements. Once we have calculated the financial cost of the design, it is believed that it is viable to build this type of prototype because the components utilized are quite inexpensive, especially if they are chosen for large-scale manufacturing. It is worth noting that both the Arduino programming language and the Arduino development language are free, so there are no additional charges for project development, and this also applies to the development tools [4], . Rest of the paper is organized as follows. In Section 2 we discussed the existing recent papers briefly. In Section 3 we described the required hardware and software materials for this in Section 4 the implementation flow, wiring map and the description of the prototype is given. In Section 5 the reliability of the prototype is analyzed in different parameters like efficiency, power consumption and feedback from user and the future scope is discussed.

2 | Literature Survey

The objective is to build an autonomous electric vehicle which is cost-effective, Bluetooth-controlled to facilitate automatic parking through a mobile app [5]. Numerous research has been published to introduce robotic devices which automates human work. These robotic designs were managed by software applications. A robot was created controlled by Android which was utilized for wireless information transfer [6]. In work [7], the robotic system was implemented using an 8051 microcontroller, Bluetooth module, and a surveillance camera. In work [8] with the help of Android and Bluetooth, a communication-based robotic platform has been developed. We have seen a number of Bluetooth-Controlled autonomous car for material handling which can be used for security surveillance and rescue missions [9–11]. In study [12] an autonomous off road robot is described which can avoid obstacle through a navigation system by the help of a map. Arduino was utilized in [13] to implement a Bluetooth-controlled robot and by with the help of linear interpolation, sensor data were obtained in this collision-free architecture. Additionally, we also have seen in [14] the pick-and-drop robot which can be used in security purposes like defusing a bomb or land mines. In research [15] an Android based robotic automobile with Bluetooth module was described. In [16] the authors have discussed an Arduino based autonomous car. Another battery-based design of an Android-based autonomous car was seen in [17]. How to overcome human errors and manoeuvring from manual and autonomous driving was discussed in [18]. In [19] we have seen a robot which can be used for cleaning fertilizer equipment implemented through a sensor which gathered vital data. At another design, robotics was incorporated.

3|Hardware and Software Requirement for the Project

3.1|Hardware Components

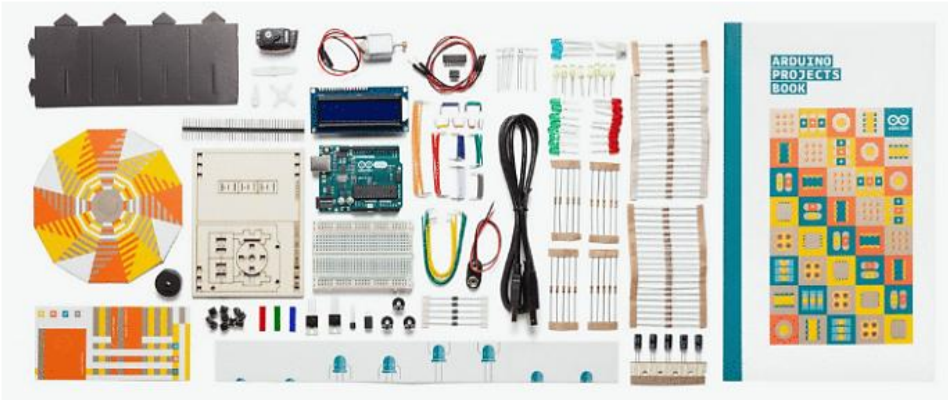

Fig. 1. Hardware components used for the project.

Fig. 2. Soldering iron.

A soldering iron is a handheld tool that melts solder to link electronic components together. It has a heated metal tip that melts solder when in contact with the junction. Soldering irons are available in a variety of wattages and tip shapes, with adjustable temperature settings for precision control [20], [21].

Fig. 3. Glue gun.

A glue gun is a portable equipment used for adhesive bonding in crafts, DIY projects, and repairs. It works by heating a solid glue stick until it melts and then extruding the melted adhesive through a nozzle [20], [21].

Fig. 4. Arduino uno.

The Arduino Uno is a popular microcontroller board that is frequently used in electronics projects and prototyping. It has an ATmega328P microcontroller, digital and analog input/output pins, and built-in power regulation. The Uno is compatible with a variety of sensors, actuators, and shields, which expands its possibilities. Its simplicity, affordability, and open-source nature make it suitable for both novices and advanced users. The Uno is programmed using the Arduino Integrated Development Environment (IDE) and the C/C++ programming language [20], [21].

Fig. 5. TT gear motor (100 RPM).

The TT gear motor, which rotates at 100 RPM, is a popular component in robotics, automation, and home projects. It has a small form with a high torque output, making it ideal for applications that require precision control and moderate speed. The motor includes a gearbox that reduces rotational speed while increasing torque, improving efficiency and performance [20], [21].

Fig. 6. HC-05.

The HC-05 is a popular Bluetooth module used for wireless communication in electronics projects. Operating on the Bluetooth 2.0 protocol, it enables seamless serial communication between devices within a range of up to 10 meters. The module features a UART interface for easy integration with microcontrollers like Arduino, allowing for bidirectional data transmission [20], [21].

Fig. 7. 18650 lithium-ion battery.

The 18650 lithium-ion battery is a cylindrical rechargeable cell that is widely used in electronic devices, power equipment, and electric vehicles. It is named for its dimensions, which are 18mm in diameter and 65mm in length. It provides high energy density, a long cycle life, and consistent voltage output. A lithium-ion cathode, a graphite anode, and an electrolyte solution are typical components of an 18650 cell. It has capacities ranging from 1000mAh to more than 3500mAh, providing enough power for a variety of applications. Its small size, durability, and compatibility with charging circuits make it a popular choice for portable electronics, solar power systems, and electric vehicles [20], [21].

Fig. 8. 4S, 18650 lithium-ion battery holder.

4S 18650 lithium-ion battery holder is a convenient solution for organizing and powering multiple 18650 cells in series. Designed to hold four 18650 batteries, it provides a secure and reliable connection between cells while allowing for easy installation and removal. The holder typically features spring-loaded contacts or metal clips to ensure proper electrical contact and stability [20], [21].

Fig. 9. 25W L298N dual hbridge.

The 25W L298N Dual H-Bridge includes two H-bridge circuits that can drive two DC motors bidirectionally or one stepper motor. With a maximum output current of 2A per channel and a total power dissipation of 25W, it can operate medium-sized motors efficiently. The module also has built-in diodes to prevent against back EMF and overcurrent mechanisms. The L298N Dual H-Bridge's interoperability with microcontrollers such as Arduino and Raspberry Pi, together with its ease of use and solid performance, make it a key component in motor control applications [20], [21].

Fig. 10. Portable switch.

A portable tiny switch is a compact device that regulates the flow of electricity in electronic circuits. It is often operated by physically toggling a lever or pressing a button and provides a convenient way to power on or off equipment [5], [6].

Fig. 11. Jumper wire.

Jumper wires connect numerous components on breadboards, circuit boards, and prototyping platforms. These wires often have male connectors on both ends, enabling for simple insertion into breadboard sockets or header pins on components. Jumper wires are available in a variety of lengths, colors, and gauges, making it easier to route signals, power, and ground connections within circuits [20], [21].

Fig. 12. 10MM red LED & 8MM white LED.

The 10mm red LED and 8mm white LED are light-emitting diodes that are widely utilized in electronics and lighting applications. The 10mm red LED provides a vivid red light, and the 8mm white LED produces a dazzling white light. Both LEDs use low voltage and are energy efficient, making them excellent for battery-powered gadgets and illumination [20], [21].

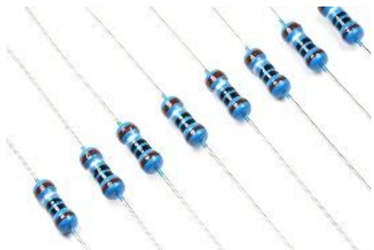

Fig. 13. 180r resistor.

The 180-ohm resistor is resistor with a resistance of 180 ohms, it regulates the amount of current traveling through components like as LEDs, transistors, and integrated circuits, protecting them from being destroyed by excessive current. The 180-ohm resistor is commonly used in low-voltage applications where accurate current regulation is required. Its small size, low cost, and dependability make it an essential component in many electronic circuits [20], [21].

3.2 | Software Components

Arduino IDE: The Arduino IDE is a software platform for programming, compiling, and uploading code to Arduino microcontrollers. It offers a user-friendly interface for programming in the Arduino programming language, which is built on C and C++. The IDE includes a text editor with syntax highlighting, a compiler, and a serial monitor for debugging and communicating with connected devices [20], [21].

4 | Implementation

4.1 | Flowchart for Implementation

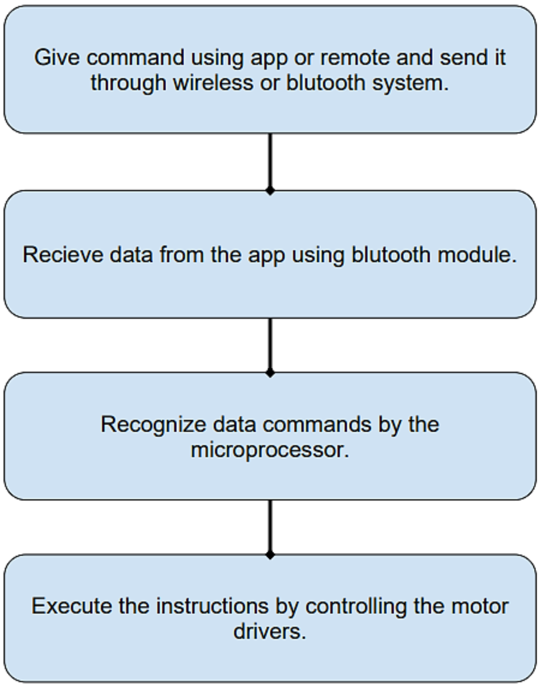

Fig. 14. Flowchart for implementation of autonomous car.

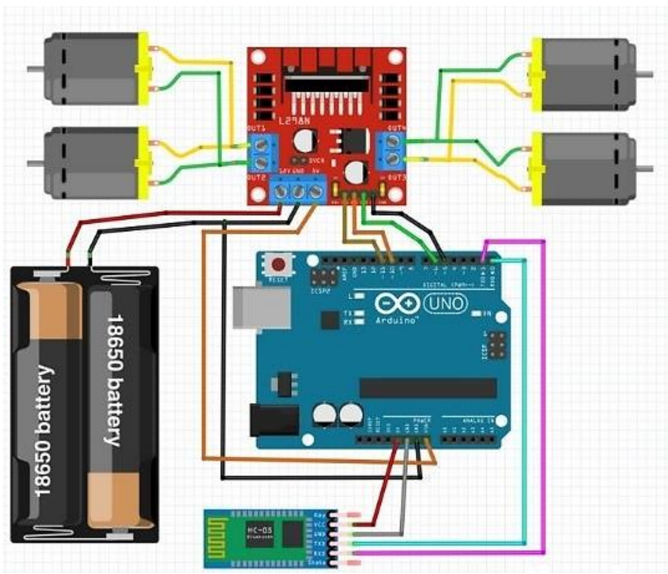

Fig. 15. Wiring map of the autonomous car.

The prototype is built using four DC motors powered by an H-bridge with dual outputs, which connect the two left wheels and the two right wheels to the outputs. The car is operated remotely using Bluetooth, an app, or infrared. Some additional features can be added to the software.

Improved line tracking mode: When the robot encounters an object in front of the line, it will attempt to navigate around it (because the user is controlling by his own) until it reaches the line again, at which point it will proceed. This feature can be implemented with an ultrasonic sensor.

Custom mode: The option to program the prototype from the app has not been provided, even though it is reasonably simple to use the custom mode by editing the code.

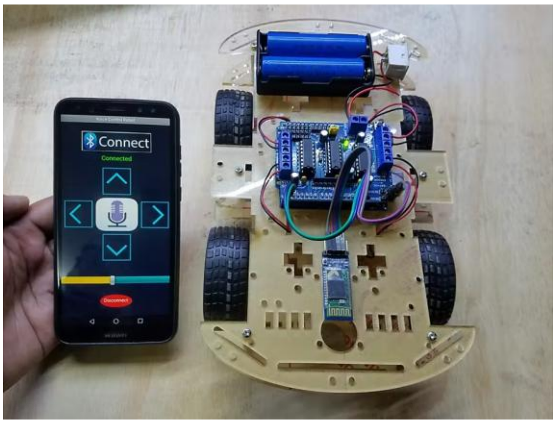

Fig. 16. Picture of the implemented autonomous car.

5| Discussion and Conclusion

To understand the efficiency and reliability of the design we have carried out some study. The autonomous car was powered by 4 Lithium-ion battery with a diameter of 18 mm and a length of 65 mm with a capacity of 2000 MaH each. The 4 batteries can drive the prototype car having a weight of 2.5 Kg within a distance of 15 meters for 4 hours and running a distance of 2.5 Km. The reliability of the design is tested almost to the capacity of 100% as during the testing period the instructions of 6 types are given through the mobile app and followed by the autonomous car with a minor glitch of 3 out of 120 times (20 per instructions). The three glitches where the instruction was not smoothly carried out was due to some mistake in soldering process and once rectified was working smoothly. We briefly present in *Table 1* the result of the testing we have carried out.

Table 1. Testing result of 6 instructions through mobile app and the corresponding response by the autonomous car.

Instruction	No of Times	No of Success
Move-forward	20	20
Move-backward	20	20
Turn-left	20	20
Turn-right	20	20
Blink frontlight	20	18
Blink backlight	20	19

A study of user-satisfaction was carried to a group of 50 users asking them to rate the ease of usability in a scale of 1-5 (1 is lowest and 5 is best). Out of this study 46 users have rate this mobile app usability as 5 and 4 of them has rated as 4. The autonomous car built so far is sufficient to be used for automatic parking through the mobile app. The future development of this project can be manifold. We can use camera to make this autonomous car fit for surveillance. A motion sensor can be used to make this car avoid obstacle which makes it fit for automatic carrier of goods and their can be use of other sensors through which it can perform other duties.

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