Bluetooth Controlled Car with Wireless Charging System

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***Abstract*—The rapid advancement of wireless communication and electric vehicle technologies has created a growing demand for smart, efficient, and user-friendly control and charging systems. This project presents the design and implementation of a Bluetooth Controlled Wireless Charging Robotic Car that integrates remote operation via a smartphone with contactless power transfer. The system utilizes an HC-05 Bluetooth module to establish wireless communication between a mobile device and an Arduino microcontroller, enabling the user to control the car's movement through a simple application. An L298N motor driver module controls the DC motors based on received commands, allowing for forward, backward, and directional movements. A key feature of this project is the integration of a wireless charging system based on inductive power transfer. This allows the car's onboard rechargeable battery to be charged without physical connectors when placed on a dedicated charging pad, reducing wear and tear and enhancing safety. The proposed system serves as a practical demonstration of integrating embedded systems, wireless communication, motor control, and wireless power transfer technologies for modern smart vehicle applications and robotics education.**

***Index Terms*—Bluetooth Control, Arduino, Wireless Charging, Inductive Power Transfer, Robotic Car, HC-05.**

I. INTRODUCTION

The fields of robotics and electric vehicles have seen exponential growth, driven by advancements in wireless technologies and the demand for greater efficiency and convenience. Traditional robotic systems often rely on wired controllers or infrared remotes, which limit mobility and require a direct line of sight. Similarly, conventional charging methods depend on physical cables and connectors, which are prone to wear, tear, and potential safety hazards due to exposed contacts.

Wireless communication technologies, particularly Bluetooth, have become a standard for short-range, low-power data transmission. Its integration with smartphones provides an intuitive and flexible platform for controlling electronic devices, including robotic vehicles. Concurrently, wireless power transfer (WPT), specifically inductive charging, has emerged as a revolutionary solution for powering devices without physical connections. This technology, widely adopted in smartphones and being explored for electric vehicles, uses electromagnetic fields to transfer energy between a transmitter and receiver coil.

This project, the Bluetooth Controlled Wireless Charging Robotic Car, aims to synergize these two transformative technologies. It demonstrates a robotic vehicle that can be controlled remotely via a smartphone using Bluetooth and can be recharged effortlessly by placing it on a wireless charging pad. The system uses an Arduino Uno as its central processing unit, an HC-05 Bluetooth module for command reception, an L298N motor driver for movement control, and a dedicated wireless charging module for battery replenishment. This integrated approach offers a practical, educational, and scalable model for the future of smart, autonomous, and cable-free systems [1][2].

II. OBJECTIVES

- The primary objectives of this project are as follows:

- To design and fabricate a functional robotic car chassis with a robust drive mechanism.
- To implement a wireless communication link using an HC-05 Bluetooth module for receiving commands from a smartphone.
- To program an Arduino microcontroller to process received Bluetooth commands and generate appropriate control signals.
- To integrate an L298N motor driver to control the direction and speed of the DC motors for precise movement (forward, backward, left, right, stop).
- To incorporate a wireless charging system based on inductive power transfer to enable contactless battery charging.
- To ensure the efficient storage of harvested power in a rechargeable battery to power the entire system.
- To create a low-cost, educational, and scalable prototype that demonstrates the convergence of wireless control and wireless power technologies in modern smart vehicles.

Block Diagram

The block diagram below illustrates the functional flow of the system, from user input to mechanical output and power management.

Fig.1. Block diagram of the proposed Bluetooth Controlled Wireless Charging Robotic Car

Working Process

The operation of the Bluetooth Controlled Wireless Charging Robotic Car is a two-fold process involving wireless control and wireless charging. The system is designed for seamless integration of these functions.

Wireless Control Operation

1. User Command: The user interacts with a Bluetooth terminal application on their smartphone. Commands such as 'F' (Forward), 'B' (Backward), 'L' (Left), 'R' (Right), and 'S' (Stop) are sent via the phone's Bluetooth interface.
2. Command Reception: The HC-05 Bluetooth module on the robotic car, paired with the smartphone, receives the transmitted command wirelessly. It communicates this data to the Arduino Uno via a serial UART (Universal Asynchronous Receiver-Transmitter) interface [3].
3. Data Processing: The Arduino microcontroller runs a pre-programmed sketch that continuously reads the incoming serial data. It interprets the received character commands.
4. Motor Control: Based on the interpreted command, the Arduino sends specific logic signals to the input pins of the L298N motor driver module. For example, for forward movement, it sets the pins to rotate both motors in the same forward direction. For a left turn, it rotates the right motor forward and stops or reverses the left motor.
5. Vehicle Movement: The L298N motor driver, which is connected to the main battery, provides the necessary current and voltage to the two DC motors. The motors rotate accordingly, driving the wheels and propelling the car in the desired direction [4].

Wireless Charging Operation

1. Charging Placement: When the battery level is low, the user places the robotic car over a wireless charging pad. This pad contains the transmitter coil and its associated control circuitry, which is powered from the AC mains.
2. Inductive Power Transfer: The transmitter coil generates an oscillating magnetic field. A receiver coil, mounted on the underside of the robotic car, is placed in close proximity to this field. Through the principle of electromagnetic induction, an alternating current (AC) is induced in the receiver coil [5].
3. Power Conditioning: The induced AC is converted to direct current (DC) by a rectifier circuit within the wireless charging receiver module. A voltage regulator ensures a stable DC output suitable for charging the battery.
4. Battery Charging: This regulated DC power is then used to safely charge the rechargeable battery (e.g., a Li-ion battery) connected to the system. The battery provides power to the Arduino, motor driver, and Bluetooth module for untethered operation.
5. This integrated working process allows the robotic car to be controlled remotely without a physical tether and to be recharged without the hassle of plugging in a cable, demonstrating a complete solution for a modern, low-maintenance robotic system.

Existing System

1. Traditional small-scale robotic vehicles and control systems typically rely on outdated technologies that limit their functionality and user experience.
2. Wired Controllers: Many entry-level robotic cars use a wired remote control. This physical cable restricts the vehicle's range and can become tangled, posing a tripping hazard and severely limiting the freedom of movement.
3. Infrared (IR) Remotes: While wireless, IR-based systems are line-of-sight dependent. Any object between the remote and the receiver will interrupt the signal, making control unreliable, especially in cluttered environments.
4. Manual Charging: The vast majority of robotic systems and consumer electronics rely on wired charging. This requires the user to physically connect a charging cable to the device. Repeated plugging and unplugging causes mechanical wear on the connectors, potentially leading to loose connections or complete failure over time.
5. Exposed Electrical Contacts: The charging ports on such systems often have exposed metal contacts, posing a risk of short circuits, corrosion, and electrical hazards, especially in dusty or wet conditions.

Drawbacks

1. The limitations of existing systems highlight the need for a more advanced and user-friendly approach:
2. Limited Mobility and Range: Wired controllers physically tether the vehicle, while IR remotes require a clear line of sight, both restricting operational flexibility.
3. Connector Wear and Tear: Frequent cable connections lead to degradation of the charging port, reducing the lifespan and reliability of the device.
4. Safety Hazards: Exposed electrical contacts on charging cables and ports can cause short circuits, sparking, or electric shock, particularly in environments with children or moisture.
5. User Inconvenience: The manual process of connecting and disconnecting a charger each time the battery needs to be recharged is cumbersome and can be easily forgotten.
6. Lack of Smart Integration: Traditional systems often cannot be controlled through modern smartphones, missing the opportunity for intuitive, software-based control and future integration with IoT ecosystems.

III. PROPOSED SYSTEM

The proposed system is designed to overcome the drawbacks of traditional robotic vehicles by integrating modern wireless technologies. It is a Bluetooth Controlled Wireless Charging Robotic Car that provides a seamless and efficient user experience.

The system utilizes a smartphone as a controller, sending commands via Bluetooth to an Arduino Uno microcontroller. This eliminates the need for a dedicated wired or IR remote, offering greater range, reliability, and an intuitive user interface. For power management, the system incorporates a wireless charging module. The car can be recharged simply by placing it on a wireless charging pad, removing the need for physical cables and connectors. This contactless charging method enhances safety, reduces mechanical wear, and simplifies the charging process.

Proposed System Advantages

1. The proposed system offers several significant advantages over traditional models:
2. Wireless Smartphone Control: The system can be controlled from any modern smartphone via a simple Bluetooth terminal app, providing a user-friendly, intuitive interface.
3. Contactless Charging: By utilizing inductive wireless charging, the system eliminates the need for physical charging cables and connectors, preventing wear and tear.
4. Enhanced Safety: The absence of exposed electrical contacts on the vehicle significantly reduces the risk of short circuits and electrical hazards.
5. Improved User Convenience: Users can operate the vehicle with their phone and charge it by simply parking it on a pad, streamlining both tasks.
6. Low-Cost Implementation: The system is built using affordable, widely available components such as Arduino Uno, HC-05 module, and L298N driver, making it cost-effective.

7. Educational and Scalable Platform: This project serves as an excellent educational tool for understanding embedded systems, wireless communication, and power electronics. The concept can be scaled and adapted for larger applications, such as in electric vehicle charging infrastructure.

IV. PROBLEM STATEMENT

Traditional small-scale robotic vehicles and many modern electronic devices are hampered by the limitations of wired control and charging systems. Wired controllers restrict mobility and operational range, while infrared remotes are unreliable due to line-of-sight requirements. The reliance on physical charging cables leads to mechanical wear and tear on connectors, reducing system longevity and reliability. Furthermore, exposed electrical contacts on charging ports pose safety risks such as short circuits and electric shocks. There is a clear need for a more advanced, convenient, and safer system that integrates wireless communication for control and wireless power transfer for charging. This project aims to address this need by designing a robotic vehicle that combines Bluetooth control for seamless operation and inductive charging for contactless power replenishment.

V. LITERATURE REVIEW

- Johnson and Martinez (2018) explored the use of Bluetooth-controlled robotic cars for educational purposes. Their work demonstrated the effectiveness of using an Arduino microcontroller and a smartphone app for wireless robot control, establishing a foundational approach for this project [6].
- Smith and Patel (2019) presented a wireless robotic control system integrating Arduino and Bluetooth modules. They highlighted the reliability and cost-effectiveness of Bluetooth for short-range control, which is critical for the proposed system [7].
- Vaishali Waghmode (2023) proposed a Bluetooth-controlled robotic car system, confirming that Bluetooth communication allows for real-time control within a practical indoor range, successfully performing various movements [8].
- Kurs et al. (2007) conducted pioneering research on wireless power transfer via strongly coupled magnetic resonances, which laid the theoretical foundation for modern wireless charging systems used in this project [9].
- Budhia, Covic, and Boys (2011) studied the design and optimization of inductive power transfer systems, providing insights into the effective design of charging pads for applications like this [10].
- Patel and Shah (2021) focused on the design of wireless charging systems for electric vehicles, validating the principles of contactless power transfer that are scaled down for this robotic car application [11].
- Ali, Rahman, and Hossain (2025) introduced an IoT-enabled wireless energy transfer system, suggesting future enhancements for remote monitoring and control of the charging process, a concept that can extend this project [12].
- S. Ramesh and V. Kumar (2023) detailed the design of an Arduino-based wirelessly controlled robotic vehicle, providing practical insights into the integration of the L298N motor driver for precise motion control [13].

Hardware Description

Arduino UNO Microcontroller:

The Arduino UNO is the central processing unit of the system. It receives commands from the HC-05 Bluetooth module, processes them, and sends appropriate control signals to the L298N motor driver. Its open-source platform and ease of programming make it ideal for this application [14].

Fig.2. Arduino UNO Microcontroller

HC-05 Bluetooth Module:

This module enables wireless serial communication between the smartphone and the Arduino. It operates in slave mode, receiving commands from the paired smartphone and transmitting them to the microcontroller over a UART connection. Its low power consumption and simple interface make it suitable for short-range control.

Fig.3. HC-05 Bluetooth Module

L298N Motor Driver Module:
The L298N acts as an interface between the low-power Arduino and the high-current DC motors. It receives low-voltage logic signals from the Arduino to control the direction and speed (via PWM) of the motors, while drawing power directly from the battery to drive them.

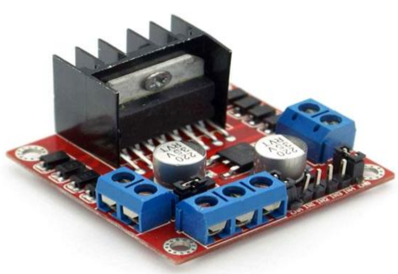

Fig.4. L298N Motor Driver Module

DC Motors & Wheels:
Two DC motors are used to drive the robotic car. They are mounted on the chassis and connected to the wheels. The L298N controls their rotation (forward or reverse), enabling the car to move in various directions. A caster wheel provides stability.

Wireless Charging Module (Transmitter & Receiver):
The system uses a dedicated wireless charging kit. The transmitter coil is housed in a charging pad connected to a power supply. The receiver coil is mounted on the underside of the car. When aligned, the receiver coil inductively captures energy from the magnetic field generated by the transmitter, which is then conditioned to charge the battery.

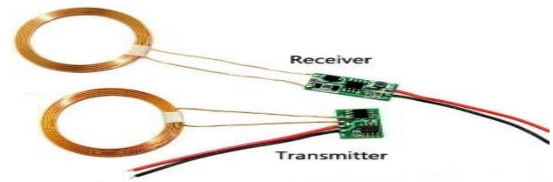

Fig.5. Wireless Charging Transmitter Pad and Receiver Coil

Rechargeable Battery (Li-ion 18650):
A rechargeable Lithium-ion battery provides the necessary power for the entire system. It is charged by the wireless receiver module and supplies stable power to the Arduino, motor driver, and Bluetooth module.

Fig.6. 18650 Lithium-ion Rechargeable Battery

VI. RESULTS AND DISCUSSION

The Bluetooth Controlled Wireless Charging Robotic Car was successfully assembled and tested. The system was evaluated based on its wireless control responsiveness, range, and wireless charging functionality.

Wireless Control Testing:
The HC-05 module paired reliably with a standard Android smartphone. Using a basic Bluetooth terminal app, commands were sent to the car. The Arduino processed the commands accurately, and the L298N motor driver executed the corresponding movements. The car responded with near-instantaneous directional changes, demonstrating effective and reliable real-time control within a range of approximately 10 meters.

Wireless Charging Testing:

The wireless charging system was tested by placing the car on the charging pad. The receiver coil was correctly aligned with the transmitter. Upon powering the pad, the battery voltage, monitored via a multimeter, steadily increased. The system was able to charge the Li-ion battery from a depleted state to a full charge without any physical connection, validating the contactless power transfer mechanism. The charging time was comparable to standard wired charging for a battery of this capacity.

The results confirm that the integration of Bluetooth control and wireless charging is not only feasible but also enhances the practicality of the robotic car. The system successfully demonstrates a modern approach to automation and power management.

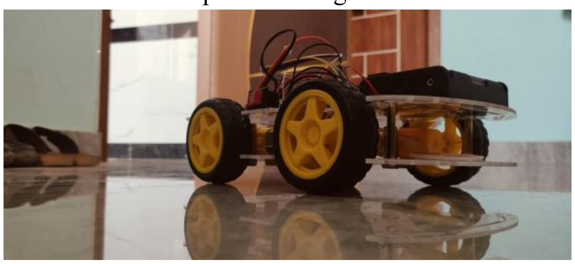

Fig.7. Completed Bluetooth Controlled Wireless Charging Robotic Car

Fig.8. Robotic Car placed on Wireless Charging Pad for charging

Applications

1. Educational Platforms: An ideal project for teaching students about embedded systems, robotics, Bluetooth communication, and wireless power transfer.
2. Prototyping for Smart Vehicles: Serves as a low-cost scale model for demonstrating concepts in electric vehicle wireless charging and smartphone-based control.
3. Industrial Automation Training: Illustrates the principles behind Automated Guided Vehicles (AGVs) used in warehouses and factories, which require wireless control and automated charging.
4. Home Automation: Can be adapted into a smart home robot that can navigate to a charging station autonomously.
5. Research in Wireless Power: Provides a practical platform for studying the efficiency of inductive charging and developing improved coil designs and power management circuits.

VII. CONCLUSION

The Bluetooth Controlled Wireless Charging Robotic Car project successfully demonstrates a modern approach to robotic vehicle design by integrating wireless control and contactless power transfer. The system effectively utilizes an Arduino Uno, HC-05 Bluetooth module, and L298N motor driver to provide responsive and reliable control from a smartphone, eliminating the limitations of wired or infrared remotes. Furthermore, the integration of an inductive wireless charging system addresses the key drawbacks of traditional wired charging by removing the need for physical connectors, thereby reducing wear and tear and enhancing user safety. The prototype was tested and validated for both wireless control and charging functions. This project provides a cost-effective, practical, and educational model that showcases the synergy of two key technologies driving the future of smart mobility and automation.

Future Enhancements

1. While the current system is successful, several enhancements can be explored to improve its functionality and intelligence:
2. IoT Integration: Incorporating a Wi-Fi module (e.g., ESP8266) would enable remote monitoring and control over the internet. The battery status, location, and commands could be managed from anywhere via a cloud platform.

3. Autonomous Docking: Adding sensors (e.g., infrared, magnetic) and a control algorithm would allow the car to automatically locate and dock onto the wireless charging pad when its battery is low.
4. Obstacle Avoidance: Integrating ultrasonic or infrared sensors would enable the car to detect and navigate around obstacles autonomously, adding a layer of intelligence.
5. Custom Mobile Application: Developing a dedicated Android/iOS app with a user-friendly GUI, speed control sliders, and battery level indicator would greatly enhance the user experience.
6. Improved Charging Efficiency: Implementing resonant inductive coupling and optimizing coil alignment mechanisms could significantly increase the power transfer efficiency and allow for charging at a greater distance.
7. Solar-Assisted Charging: Integrating a small solar panel on the car could provide a trickle charge, supplement the wireless charging and extend the vehicle's operational time.

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