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Design of Car Based on 5G Network Control

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Abstract: The role of smart cars is pivotal, and this project designs and implements a four-wheel vehicle control system leveraging 5G communication technology. The system aims to enhance the portability of smart cars, reduce their costs, enable remote control functionality, and improve mobility to meet the needs of modern Internet of Things (IoT) applications. The system integrates an ESP8266 Wi-Fi module with the Blinker IoT platform to enable remote, real-time control of car movement via a smartphone app. Using Access Point (AP) mode for fast network configuration, users can input Wi-Fi credentials and a Blinker key through a web interface for easy setup. Through the custom app interface, users can send commands to control the car's forward, backward, turning, and stopping actions, as well as adjust speed and operation delay. Additionally, the system includes Electrically Erasable Programmable Read-Only Memory (EEPROM) data storage to ensure the persistent saving of configuration information, and it features a remote wireless camera for external monitoring of the car's surroundings. The Android-based remote control design allows users to monitor and control the car's movement anytime and anywhere. Experimental results show that the system is stable, provides smooth control, operates at low cost and low power consumption, and offers good portability. Therefore, this intelligent car control system offers valuable insights for smart car development and application. It can also be integrated with popular smart homes, IoT, and other emerging technologies, offering broad application potential and promising development prospects.

Keywords: Smart car; Remote control; Low cost; Internet of things

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1. Background and significance of the subject development

As a key application area of artificial intelligence, intelligent cars have been widely studied by researchers worldwide [1–3]. Between 1966 and 1972, the Artificial Intelligence Center at Stanford Research Institute successfully developed the first intelligent car in history, named Shakey. This early intelligent car relied on two computers for remote control via a wireless network.

China began working on smart car technology in the early 1980s. In 1980, the Chinese government launched the Remote-Controlled Nuclearized Reconnaissance Vehicle project, marking the beginning of domestic research into intelligent car technology. With advancements in science and technology and the advent of the 5G era, applications such as unmanned driving and intelligent distribution systems have become increasingly prominent. Research on intelligent cars is significant for advancing artificial intelligence technology and enhancing the quality of human life.

With the continuous development of mobile Internet technology, smartphone-controlled car systems have become widely used in daily life. However, existing smart car control devices and video surveillance systems often face limitations, such as lack of portability, inadequate remote-control capabilities, and restricted mobility [4,5]. To address these shortcomings, this study aims to improve the portability of smart cars, reduce their costs, enable remote control functionality, and enhance mobility to meet the demands of modern Internet of Things (IoT) applications.

2. Key technologies of the system

2.1. Hardware selection

The main control is based on the ESP8266 Wi-Fi development board, with motor control handled by an L298N motor driver and video captured by an Easy Cloud wireless camera. The design includes two power supply systems. The first system powers the car: the L298N module connects to two 3.7 V rechargeable batteries in series (model 18650), providing a stable 5 V output. The NodeMCU on the ESP8266 module and the L298N motor driver are used to power and drive the direct current (DC) motors. The second power supply is dedicated to the Easy Cloud camera, ensuring stable, long-term power via an integrated lithium battery with a 5 V regulated output and a 2,400 mAh capacity, capable of multiple charge and discharge cycles. Additional components include four DC motors and tires, a portable Wi-Fi unit, a toggle switch, a frame, and various Dupont wires, as shown in **Figure 1**.

Figure 1. Car hardware

In the hardware connection, the four signal terminals IN1, IN2, IN3, and IN4 of the L2998N motor drive module are connected to the signal terminals of D2, D5, D6 and D8 in ESP8266. When the motor drive module generates different high and low levels to make the DC motor turn forward and reverse, so as to realize the car forward and backward, turn left, turn right, and other functions [7]. The connection is shown in **Figure 2**.

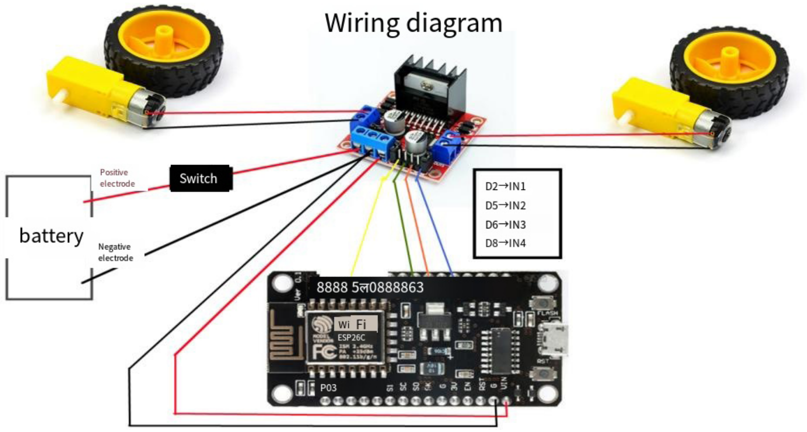

Figure 2. Trolley connection diagram

2.2. Development environment

In the Android Integrated Development Environment (IDE), this study carefully developed an application specifically for the Android operating system [8]. The application employs modern interface design techniques to provide a simple and intuitive user interaction experience. The interface consists of four main components: a user login area, personalized settings options, an intuitive main interface, and a fully functional control panel.

2.3. Distribution network mode

This paper uses the Access Point (AP) distribution network. In wireless communication, AP mode enables a device, typically a wireless router, to broadcast a network for other devices (like smartphones and laptops) to connect, facilitating data transmission and Internet access [9]. In this study's code, AP mode is used for device network configuration. The device first attempts to connect to a pre-configured Wi-Fi network; if unsuccessful, it switches to AP mode, creating an open network that allows a user to connect via smartphone or computer to enter new Wi-Fi credentials, as shown in **Figure 3**.

The setupMode() function sets the device into AP mode, starts a Domaine Name System (DNS) and web server, and enables Wi-Fi configuration via a browser interface [11]. The startWebServer() function launches a web server, allowing users to select a Wi-Fi network, enter a password, and input the Blinker key [12].

For remote communication, the car connects through the Blinker platform, an IoT communication library facilitating device-to-cloud and device-to-device communication. Key processes include the following.

(1) Process 1: Cloud connection. The device connects to Blinker cloud via Wi-Fi, enabling data exchange with the cloud server [13].

(2) Process 2: Data transfer. Once connected, the device transfers data through the Blinker Application Programming Interface (API). Users can control the device remotely via the Blinker application, operating components like buttons and sliders on a smartphone application or web interface.

Upon starting the car, the ESP8266 board shows a blue light, indicating Wi-Fi setup mode. Users connect to the ESP8266 hotspot with their mobile phone, input Wi-Fi credentials, and wait for the blue light to stop flashing to complete the setup. The device can be controlled remotely via the app or locally with onboard buttons, providing an offline mode when no network is available. Wi-Fi settings can also be managed via a web server, and data is stored in Electrically Erasable Programmable Read-Only Memory (EEPROM) for easy reconnection after restart. Note that the car needs to be within range of the router or a portable Wi-Fi hotspot to enable remote control.

3. Principle and experimental verification of remote video real-time monitoring system

The remote real-time video monitoring system operates with an independent data transmission system. It primarily relies on the wireless pan-tilt camera of Easy Vision Cloud, which has an independent control app that connects to the remote network for real-time video transmission. As shown in **Figure 3**.

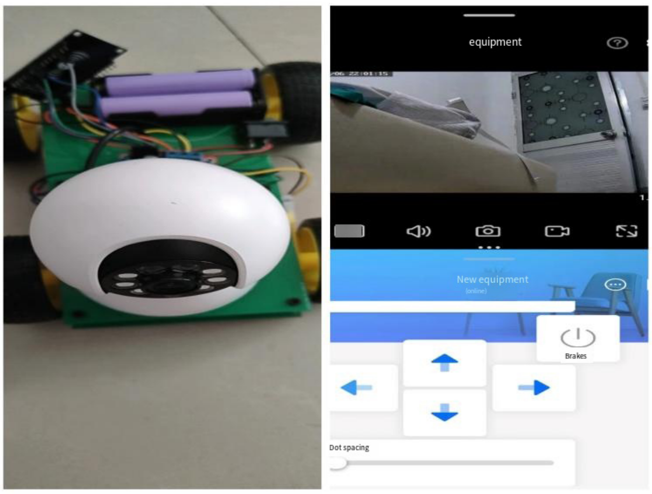

Figure 3. Diagram of the car test setup

It has been verified that the system runs stably and provides a smooth control experience when the car and the controlling device are on the same network. The stability of the car's driving control through the mobile phone interface is also good. In other words, the system supports both remote control of the car and real-time video monitoring via the Android application, which aligns with the research objectives of this paper.

4. Summary

(1) This paper successfully implements a network connection scheme based on a Wi-Fi module, utilizing various library files provided by Blinker technology [14]. When the smart device and the smart car are within the same local area network, they can communicate seamlessly. For communication outside the local area network, this paper utilizes the network support provided by the car's Wi-Fi link, with the Blinker platform enabling remote communication between the smart device and the car. Building on this, the paper designs and develops a subsystem for controlling the smart car's motion via an Android platform. This system allows users to control the car's basic movements—such as forward, backward, turning, and stopping—using an Android device. Moreover, the system provides real-time feedback on the car's motion to the Android client, with updates delivered through the Blinker app in the form of message prompts [15].

(2) To enable motion control and video monitoring of the smart car, this paper connects the Wi-Fi module to the router's Local Area Network (LAN). Through careful design, a LAN-based intelligent car motion control and video surveillance system was successfully constructed. Additionally, port mapping technology on the router is used to enable external network access for the system. This innovative design overcomes the limitations of traditional geographical constraints, allowing users to remotely monitor the smart car's environment and accurately control its movements from anywhere based on external conditions.

In summary, this paper focuses on the smart car as the research object, integrating the ESP8266 Wi-Fi module with the Blinker Internet of Things platform to enable remote, real-time motion control via a smartphone application. The system uses AP mode for fast network distribution, allowing users to input Wi-Fi credentials and Blinker keys through a web interface to configure the car's network. Through the custom application interface, users can send commands to control the car's forward, backward, turn, and stop actions. The overall structure process of the car is shown in **Figure 4**.

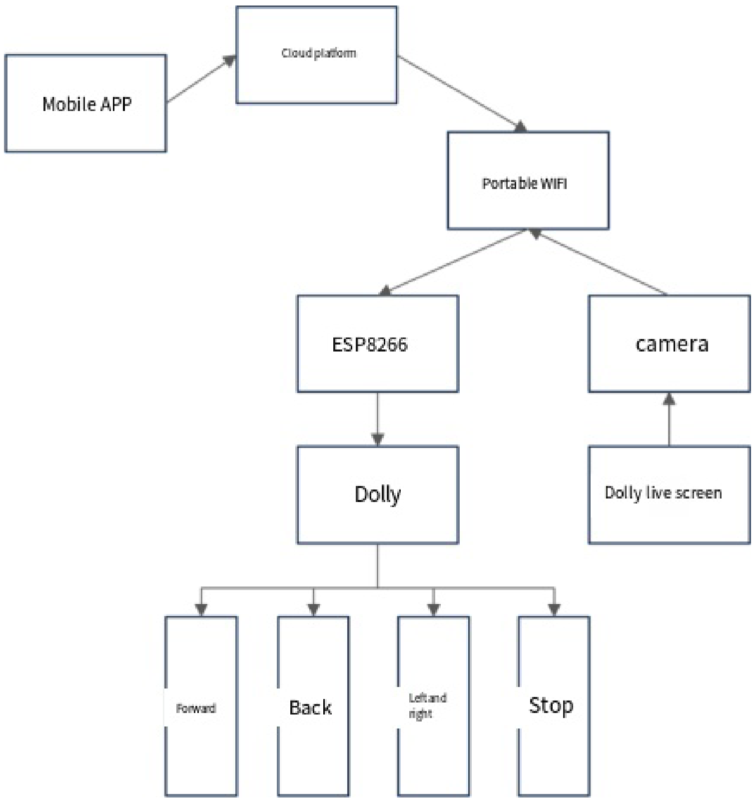

Figure 4. The flow chart of the car

A remote control and video surveillance system for smart cars based on the Android platform is designed and implemented. The system is notable for its cost-effectiveness, low energy consumption, high portability, and excellent reliability. It can be seamlessly integrated with smart home, the Internet of Things (IoT), and other emerging technologies, showcasing significant market potential and application value. Based on an in-depth analysis of the research background of intelligent car control systems and video surveillance technology, this paper discusses the research progress both domestically and internationally in these two fields, highlighting the importance and significance of this research topic.

Disclosure statement

The authors declare no conflict of interest.

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