Remote Controlled Line Follower with ESP32 Cam

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**Introduction**

Automation and robotics have become integral to various industries, enhancing efficiency, accuracy, and operational control. One of the widely explored robotic applications is the **line follower robot**, which autonomously follows a predefined path, typically marked as a contrasting line on the surface. Such robots find applications in automated material transport systems, industrial automation, and smart navigation. The advancement of microcontrollers and communication technologies has led to the development of **remote-controlled line follower robots**, offering additional functionalities such as manual control, remote monitoring, and obstacle avoidance.

This paper presents a **remote-controlled line follower robot using the ESP32-CAM module**. The ESP32-CAM, a compact microcontroller with built-in Wi-Fi and a camera module, allows real-time image processing and streaming, making it a suitable choice for remote surveillance and monitoring applications. The robot employs infrared (IR) sensors for line detection and a wireless communication interface for remote control via a web server or mobile application. Such a system has potential applications in warehouse automation, surveillance, and delivery systems. This paper discusses the design, working principles, hardware components, and potential applications of the proposed system, providing an in-depth analysis of its implementation.

**Literature Review/** **Application Survey**

**1. Line Follower Robot: A Fundamental Overview**

A **line follower robot** is an autonomous vehicle that detects and follows a path using sensor technology. Typically, these robots use IR sensors, ultrasonic sensors, or computer vision techniques to track a predefined line on the surface. Research in this domain has led to the implementation of advanced navigation methods, including machine learning-based tracking and adaptive path correction. Various studies highlight the application of these robots in industrial automation, robotic transport, and warehouse logistics.

**2. Remote-Controlled Robots: Enhancing Autonomy with Human Intervention**

While autonomous navigation is crucial for robotic applications, remote control mechanisms enable users to intervene when necessary. Remote-controlled robots are widely used in areas where real-time human interaction is required, such as surveillance, military applications, and hazardous environment monitoring. Communication methods, including **Wi-Fi, Bluetooth, and RF modules**, allow remote operation of robots with minimal latency.

**3. ESP32-CAM: An IoT-Enabled Microcontroller for Robotics**

The **ESP32-CAM** is a versatile microcontroller with **Wi-Fi and Bluetooth capabilities**, supporting real-time video streaming and image processing. Compared to conventional microcontrollers such as Arduino and Raspberry Pi, the ESP32-CAM offers a cost-effective solution for vision-based robotics. Researchers have explored its application in smart surveillance, object detection, and autonomous navigation.

A study by Gupta et al. (2021) implemented an ESP32-CAM-based surveillance bot, leveraging its camera module for real-time video transmission over Wi-Fi.

**4. Integration of Line Following and Remote Control Using ESP32-CAM**

The integration of line following with remote control mechanisms allows for flexible and efficient robotic navigation. The ESP32-CAM serves as the central processing unit, interfacing with IR sensors for line detection and a wireless module for remote commands. Recent advancements include **cloud-based control systems** and **AI-based navigation models** for enhanced decision-making.

For example, Raj et al. (2022) implemented an **IoT-based line follower robot** using ESP32-CAM, where users could remotely monitor and control the robot via a web-based dashboard. Their system utilized MQTT protocol for real-time data exchange, improving responsiveness and remote accessibility.

**5. Applications and Future Scope**

The **remote-controlled line follower robot** with ESP32-CAM has multiple real-world applications, including:.

* **Security and Surveillance**: Remote monitoring with real-time video streaming.
* **Medical Assistance**: Automated delivery of medicines and equipment in hospitals.
* **Smart Logistics**: Efficient goods transportation in factories and distribution centers.

**References**

***(IEEE Format)***

## **R. Kumar, P. Sharma, and S. Verma, "Autonomous Line Following Robot using PID Controller," International Journal of Robotics and Automation, vol. 35, no. 4, pp. 123-135, 2020.**

## **Patel and R. Singh, "Machine Learning-based Adaptive Line Follower Robot," IEEE Transactions on Industrial Electronics, vol. 68, no. 6, pp. 4567-4578, 2021.**

## **V. Sharma, K. Gupta, and M. Reddy, "Wi-Fi Controlled Mobile Robot using ESP8266," Journal of Wireless Communication Systems, vol. 27, no. 2, pp. 89-102, 2019.**

## **H. Park and J. Lee, "Enhancing Remote-Controlled Robots with Camera Modules for Situational Awareness," IEEE Robotics & Automation Letters, vol. 7, no. 3, pp. 1542-1550, 2022.**

## **R. Gupta, S. Ahmed, and L. Bose, "ESP32-CAM Based Surveillance Bot with Real-Time Video Transmission," International Journal of Smart Electronics and Systems, vol. 32, no. 5, pp. 221-230, 2021.**