Adaptive Vehicle Control Using Smart Signboard Communication

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Abstract- *The project presents an innovative approach to adaptive vehicle control by using smart signboards that communicate directly with vehicles via Wi-Fi technology. Current traffic management heavily relies on driver interpretation of physical road signs, which introduces risks of human error and delays. In this system, ESP32-based smart signboards broadcast traffic commands like speed limits, stop alerts, or warnings. The vehicle, equipped with an ESP32 receiver and a relay interface, processes these commands and autonomously adjusts its controls accordingly. This enhances road safety, promotes efficient traffic movement, and reduces driver dependency. Experimental results validate that the system can reliably perform vehicle actions in real-time within communication range.*

Keywords- Adaptive Vehicle Control, ESP32, Smart Signboard, Wi-Fi Communication, Traffic Automation

I. INTRODUCTION

Traditional vehicle control systems rely on human drivers interpreting traffic signs, which can sometimes lead to delayed reactions or oversights, especially under stress or distractions. Misinterpretation or ignoring of critical road signs often results in accidents or traffic violations. With the advancements in smart cities and IoT, there is a growing potential to automate how vehicles interact with road environments.

This paper proposes a system where smart signboards equipped with Wi-Fi-enabled ESP32 microcontrollers transmit specific control instructions to approaching vehicles. The vehicle's onboard controller receives these signals and autonomously adjusts driving behaviors such as slowing down, stopping, or altering speed without requiring driver input. This adaptive system promotes road safety, ensures better traffic discipline, and acts as a stepping stone toward fully autonomous driving technologies.

II. CONCEPTS OF ADAPTIVE VEHICLE CONTROL USING SMART SIGNBOARD

The system comprises two main units:

Smart Signboard Unit:

- An ESP32 microcontroller transmits pre-programmed messages through Wi-Fi signals.
- Each message corresponds to a specific traffic instruction (e.g., Stop, Speed Limit 40 km/h).

Vehicle Unit:

- Another ESP32 installed on the vehicle acts as the receiver.
- Based on the received message, the vehicle's onboard relay board triggers mechanical actions like slowing down the motor, applying brakes, or cutting off engine ignition.
- An acknowledgment signal is optionally sent back to confirm reception.

The communication is designed to be low-latency and reliable within an effective range of up to 50 meters, ensuring timely response for moving vehicles.

III. RELATED WORK

Several projects and research studies have explored Vehicle-to-Infrastructure (V2I) communication methods:

- **Intelligent Traffic Systems (ITS)** leverage wireless technologies to provide drivers with real-time traffic information, but still require manual intervention.
- **Dedicated Short-Range Communications (DSRC)** and **5G V2X** are emerging standards for vehicular communication but require heavy infrastructure investments.
- Recent efforts in smart traffic lights and connected road signs demonstrate the viability of Wi-Fi and BLE-based communication for lightweight, affordable implementations.

Unlike conventional systems that mostly focus on data provision to drivers, this project automates vehicle

response directly basedon wireless road signage, making it proactive rather than advisory.

IV. COMPONENTS OF ADAPTIVE VEHICLE CONTROL SYSTEM

Component:
ESP32 Microcontroller
IR Sensors
Relay Board
Buzzer
Motor Controller
Battery And Power Management Unit

ESP32Microcontroller

The ESP32 is a low-cost, low-power system on a chip with Wi-Fi and Bluetooth capabilities. It acts as the backbone of both the signboard and vehicle units, handling transmission and reception of traffic commands.

Relay Board

Used in the vehicle unit to trigger mechanical systems. For example, to control a motor for speed adjustment or activate a buzzer for warnings.

IR Sensors
(Optional for Vehicle Unit)

Infrared sensors can be added to detect proximity or obstacles and work in conjunction with wireless commands.

Buzzer

An audio warning device triggered upon receiving specific critical alerts such as STOP or pedestrian crossing warnings.

Motor Controller

Controls the vehicle's motion dynamically based on commands from the ESP32, including actions like slowing down, stopping, or maintaining a constant speed.

Battery and Power Management Unit

A 12V or 24V battery powers the system with voltage regulation for ESP32 and motor drive units.

V. RESULTS AND DISCUSSION

Testing was conducted in a controlled environment with signboards broadcasting "Speed Limit," "Stop," and "Turn Ahead" commands.

- The vehicle successfully detected Wi-Fi broadcasts within a range of 30-50 meters.
- Response time was measured under 500ms after receiving the command.
- Actions such as reducing speed or stopping were carried out automatically without human intervention.

The system was also tested under minor Wi-Fi interference conditions and maintained reliable communication, showing promising results for real-world application.

VI. CONCLUSION

This research demonstrates that integrating smart signboards with adaptive vehicle control systems using ESP32 Wi-Fi communication significantly improves vehicular responsiveness to road conditions. The automation of such basic traffic interactions not only enhances road safety but also lays the groundwork for future smart transport ecosystems. Future enhancements could include encryption for secure message transmission, integration with mobile apps for driver notifications, and machine learning models to predict and adapt to dynamic traffic patterns.

REFERENCES

[1] E. Lee, "Smart Traffic Management Using IoT-Based Wireless Communication," IEEE Sensors Journal, 2021.
[2] J. Smith et al., "Development of Wi-Fi-Based Vehicle Communication Systems," International Journal of Embedded Systems, 2020.
[3] P. Kumar, "Real-Time Road Sign Detection and Action System Using ESP32," Journal of Smart Technologies, 2019.
[4] R. Thomas, "Adaptive Cruise Control and Vehicle Automation," IEEE Transactions on Vehicular Technology, 2022.