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Adaptive Speed Control in Vehicles via Zone Recognition

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Abstract: *In today's modern world, where we are using vehicle in every aspect of our life whether it be to transfer the packages, or travelling. Vehicles have made our life easy. But with this, there comes the problem of how to keep this beautiful machine safe for our human need, over speeding which is cause of 70% road accident. It becomes the challenge to tackle this problem. There are several techniques which has been implemented but each technique has some drawback. Some examples of speed limiting technique include Manual Speed Enforcement, vehicle-to-infrastructure (V2I) communication etc. Our project provides the approach of combining various techniques and implementing it to provide best possible output. The principle of our project is to implement the speed limiting zone, this zone acts as the area where the speed of vehicle cannot cross the set value, we implemented this result on small scale using the two NRF24L01 sensors, one connected to the motor driver (which acts as engine) once these two NRF24L01 comes under each other range nrf sensor which is connected to motor driver reduces the speed of the rc car, to form this connection and sending data we are using Arduino UNO, ESP8266 which can be connected to internet*

Keywords: NRF24L01, Arduino UNO, ESP8266, vehicle-to-infrastructure (V2I)

I. INTRODUCTION

It has become a growing concern with the increasing number of accidents caused by over- speeding. Road statistics around the world show that speeding is responsible for a large number of road deaths, and hence it has become a leading cause of traffic deaths. Traditional methods for speed control, such as road signs, speed bumps, and police patrols, have proved to be insufficient in maintaining adherence to speed limits.The "Adaptive Speed Control in Vehicles via Zone Recognition" offer a better alternative by means of automatic speed adjustment of vehicles when entering a designated area. The system is founded on wireless communication technology, which allows real-time transmission of speed limit messages to vehicles. Upon entering a restricted area, the system detects the incoming signal and, in response, restricts the speed of the vehicle, thus remaining within the designated speed limits.

The main aim of this project is to design and develop a Wireless Speed Limiting Jammer for Cars that can automatically regulate the speed of cars within designated areas. The system aims to enhance road safety by making cars follow speed limits without any direct action from the driver.

The aims of this project are as follows:

- To create a wireless system of communication that is able to send speed limit messages to approaching traffic. • To create a microcontroller-controlled speed control system that automatically limits the speed of the vehicle upon receiving the signal that is sent.
- To integrate hardware devices, like NRF24L01 for wireless, Arduino for vehicle control, and LCD display for speed limit indication.
- In order to apply an economic and scalable solution that can be implemented in other areas like school zones, highways, and accident zones.
- To measure the effectiveness of the system through testing its reaction to various speed limit zones and examining its influence on vehicle control.

II. LITERATURE OVERVIEW

Wireless Communication in Automotive Safety Systems

Vehicular Ad Hoc Networks (VANETs): Hartenstein and Laberteaux (2008) discussed the role of VANETs in enhancing road safety by enabling real-time communication among vehicles and infrastructure. VANETs are the backbone for intelligent transport systems (ITS).

Zeadally et al. (2012) analyzed vehicular network communication protocols with a focus on low latency and high reliability as critical factors in safety-related applications such as speed control.

Control Mechanisms and Speed Limiting Wireless

GPS-based Speed Limiting: Bhaskar et al. (2016) suggested GPS-based speed limiting of vehicle speeds within specific areas like hospitals and schools. Effective but not responsive in real time during urban traffic scenarios.

RF Module-Based Speed Limiters: Kumar and Rajalakshmi (2019) designed an RF-based communication system to provide zone control along with limiting the speed of the vehicle. Alerts and throttle control were made through Arduino and RF modules.

IoT in Automotive Safety: Suresh et al. (2021) proposed an IoT-based vehicle tracking system using sensors and GSM modules for real-time monitoring and emergency alerts, demonstrating the applicability of IoT in adaptive control systems.

Jammer-Based Solutions and Challenges

Jamming for Safety: Sharma and Pandey (2017) explored signal jammers to suppress selective communications, especially within sensitive or protected areas. They warned against safety and legal concerns but recognized controlled jamming as a vehicle management tool.

Wireless Jamming Challenges: Singh et al. (2020) explained the impact of environmental interference and regulatory constraints on jammer-based solutions. They emphasized the role of directional jamming and timing accuracy in those applications.

III. PROPOSED SYSTEM

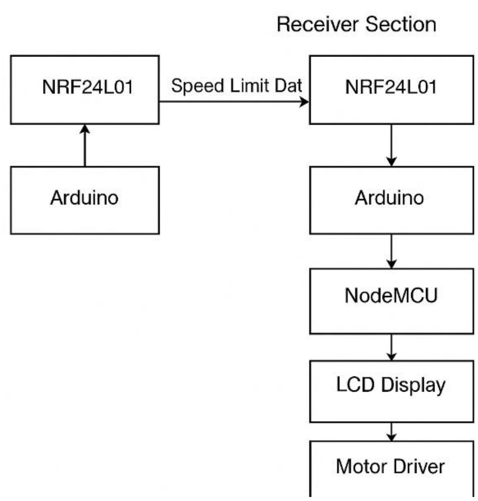

Fig 1: Block Diagram of Project

The solution proposed will try to solve the problem of speeding in sensitive areas, like school zones or residential areas, by utilizing a Wireless Speed Limiting Jammer system. The system includes a transmitter unit transmitting a speed limit signal via the NRF24L01 wireless module, and a receiver unit fixed on the vehicle. The receiver unit, consisting of elements such as the NodeMCU (ESP8266), Arduino, and motor driver, receives the signal and controls the speed of

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the vehicle accordingly. The LCD display on the receiver side indicates the speed limit, giving real-time feedback to the driver.

This system is cost-effective and made using readily available components like Arduino and NRF24L01 modules. The NodeMCU provides Wi-Fi capability, allowing the vehicle to communicate with a central server if needed for further features like logging and monitoring. The system is highly flexible and can be implemented in different zones with minimal changes in infrastructure, hence suitable for urban and suburban settings.

The solution provides a dynamic, real-time adjustment to speed limits, in effect eliminating the risk of accidents in restricted areas.

The Wireless Speed Limiting System is made up of several essential hardware components that work together to enable wireless communication, regulate speed, and provide real-time feedback. These components are split into two main sections: the Transmitter Unit and the Receiver Unit.

Transmitter Unit Components

Arduino Uno/Nano: This acts as the brain of the operation, sending out the speed limit data.

NRF24L01 Module: A nifty wireless transceiver that sends speed limit signals straight to the vehicle.

Fig 2 :NRF24L01, Arduino UNO

Receiver Unit Components

NRF24L01 Module: This one picks up the speed limit data from the transmitter.

Arduino Uno/Nano: It processes the incoming data and sends out signals to manage the motor.

NodeMCU(ESP8266): This is used for extra processing power and can add some IoT features if needed.

LCD Display: It shows the speed limit information that's been received.

-Motor Driver Module (L298N or Similar): This controls the motors' speed based on the processed signals.

-RC Car Chassis: This is the physical structure of the vehicle, complete with wheels and suspension.

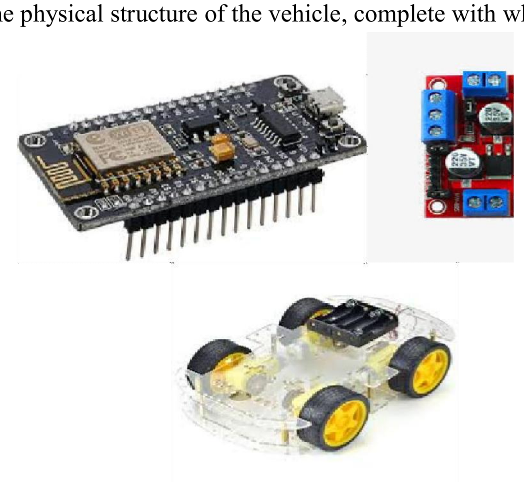

Fig 3 :ESP8266, L298N, 4WD Car Chassis

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Component Functionality

Every component plays a vital role in making sure speed limits are enforced in real-time:

The transmitter unit sends out preset speed limit signals to the vehicle.

The receiver unit processes these signals, displays the speed limit data, and adjusts the motor speed accordingly.

The NRF24L01 modules facilitate real-time wireless communication between both units.

By bringing these hardware components together, the system offers an effective and budget- friendly way to enforce speed limits in areas where it's needed.

IV. RESULT &CONCLUSION

The adaptive speed control systemswas successfully deployed and tested under different conditions. The most important results of the system operation are as follows:

- Speed Regulation: The receiver module properly received the speed limit message from the transmitter module. The NRF24L01 wireless module was used to transmit the message. When the signal was received, the Arduino microcontroller implemented the speed adjustment of the vehicle by controlling the motor driver, which controlled the DC motors. The system properly decreased the vehicle's speed to the set speed limit.
- Signal Range: The signal range of the NRF24L01 module was tested in the open and proved to be efficient up to 100 meters, providing effective communication between the receiver and transmitter units at moderate to long distances. This range can be modified by employing higher-power versions of the module or using antennas.
- LCD Display: The LCD indicated the speed limit at all times, with real-time feedback to the user. The display was readable, even in varying lighting conditions, and gave accurate feedback regarding the speed zone.
- Real-Time Feedback: The system displayed reaction to modifications in speed limits relayed by the transmitter unit. The system controlled the vehicle's speed after 2-3 seconds when receiving the signal, with the vehicle being within the enforced speed limits.
- System Stability: The system worked reliably across a chain of tests with few failures or disconnections between the transmitter and receiver. NodeMCU's integration with Arduino provided stable communication and strong control over the vehicle.
- Power Consumption: The system's power consumption was measured, and the receiver unit's power draw remained within the range of typical low-power devices. This allows for extended use in real-world applications without frequent recharging or power interruptions.

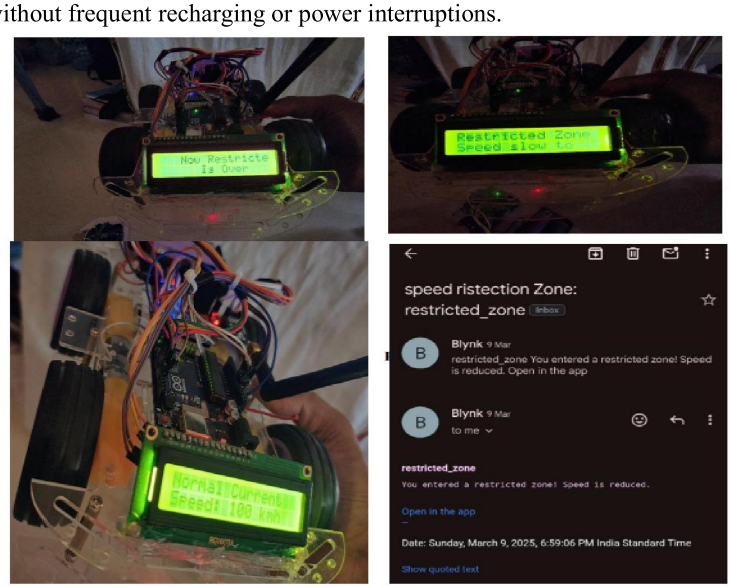

Fig 4: Results

V. FUTURE SCOPE

While the current prototype demonstrates the feasibility of a wireless, zone-based speed-limiting system on an RC car, there are numerous avenues for expanding and enhancing this work:

Full-Scale Vehicle Integration

– Connect directly to an automobile's ECU or OBD-II port to manage throttle-by-wire systems, making field deployment possible on real cars instead of scaled-down models.

Extended Communication Range

– Substitute or supplement NRF24L01 with long-range RF (LoRa), GSM/4G, or mesh networking to service greater areas (e.g. busy town centers, city centers, highways) without line-of-sight limitations.

Dynamic Zone Configuration

– Add GPS or geofencing to enable remotely defining, updating, and managing speed-limit zones through a cloud platform or mobile app, with real-time alteration of restrictions.

Smart‑City & ITS Integration

– Integrate with municipal traffic management systems (V2I) to coordinate speed limits with traffic lights, congestion information, and emergency vehicle preemption for comprehensive urban traffic management.

Data Logging & Analytics

– Utilize NodeMCU (ESP8266/ESP32) or a gateway module to transmit speed-limit and vehicle-performance data to a cloud server to allow analytics of traffic patterns, compliance rates, and system reliability.

Multi-Vehicle Coordination

– Implement a mesh of transmitter nodes such that multiple vehicles can hand over smoothly between zones, and vehicles can exchange speed-limit and hazard information (V2V) for convoy or platooning applications.

Enhanced Safety Features

– Incorporate override logic for emergency vehicles, pedestrians or cyclist detection (through ultrasonic/infrared sensors), and alert systems (audible or smartphone notifications) to enhance situational awareness.

Alternative Actuation Mechanisms

– Investigate the control of regenerative braking systems or electronic parking brakes in addition to throttle control, providing redundant or complementary means of speed regulation.

Through these improvements, the “Adaptive Speed Control in Vehicles via Zone Recognition” can mature from a proof-of-concept RC demonstration to a resilient, real-world solution for smarter, safer city transportation.

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