"Autonomous Vehicle Speed Regulation Via Traffic Sign Recognition Models."

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Abstract - The intelligent transportation systems have come a long way in a very short time and have consequently created great chances of integrating aboard the small-scale prototype autos, machine learning, embedded systems, and automation. The purpose behind this undertaking is to show the design and development of a Cruise Control Car. This vehicle will be able to continue operating at the pace that is clearly visible on the road through speed limit signs detection, and even to notify a person who can intervene in case of an accident taking place. The whole project involves combining machine learning-based traffic sign recognition,

motor actuators controlled by an Arduino board, and accident detection that relies on ultrasonic sensors, in such a way making the road safety solution efficient and scalable for use in smart vehicles (fully and semi-autonomous) The system identifies standard speed limit boards (like 40 km/h, 60 km/h, 80 km/h, etc.) that the ML model is primarily a component trained to recognize. Using image processing and classification techniques, the system recognises these signs from the frames captured and via serial communication, it shares the identified speed limit with the hardware unit. The hardware section of the car is made of an Arduino Uno, motor driver, and BO (Battery-Operated) motors which give the capacity of very accurate speed control based on ML inputs. By turning the recognised speed limit into PWM signals for the motor driver, the car automatically keeps a safe and steady speed according to the recognised sign. Another Arduino Uno is assigned for accident detection, and it works in conjunction with the main system, with the ultrasonic sensors being the key elements of the whole process. It has been set up that the sensors will detect frontal or rear impacts or collisions, and they will be positioned accordingly. The moment an accident-like scenario is identified through violation of distance thresholds, the system triggers a buzzer. This module uses two ultrasonic sensors located in such a way to measure sudden frontal or rear accidents or collisions. If an impact is detected by crossing the distance threshold, the system turns on a buzzer for an immediate audible warning and transfers an alert via a Bluetooth module to a mobile phone. This procedure prevents delays in the relay of essential information, thus facilitating prompt action and enhancing situational awareness. The dual-circuit architecture, where one Arduino takes charge of speed regulation and the other one of accident detection, provides modularity, reliability, and ease of debugging. This sharing of duties not only increases the performance but also avoids the single microcontroller overload in processing. The combination of ML-based sign recognition and sensor-based accident detection offers a strong demonstration of intelligent vehicle control, safety automation, and IoT-based alert mechanisms. The project demonstrates how low-cost embedded platforms interfaced with machine learning can imitate the features of modern driver assistance systems, thus opening up access to such systems for engineering students, researchers, and robotics enthusiasts as a perfect educational prototype.

Key Words: Autonomous Vehicle, Traffic Sign Recognition, Machine Learning, Arduino Uno, Speed Regulation, Computer Vision, Accident Detection, Embedded Systems

1. INTRODUCTION

With the integration of intelligent transportation systems increasing at a rapid pace, it is no less true that automation and machine learning implementation in vehicles is considered an integral field of engineering presently. Nowadays, most advanced driver assistance systems and self-driving vehicles are heavily dependent upon efficient perception of the environment, fast decision-making, and intelligent control systems. This project also stems from the same horizons that have emerged from advanced automotive systems presently in vogue and seeks to create an efficient prototype, known as "Cruise Control Car," that will implement two significant components: speed control through machine learning-based speed sign recognition and accident detection with mobile alert functionality.

The initial major component in this prototype is related to detecting speed limit signboards. In roads and highways, speed limit signboards are an essential component in regulating and controlling the safe movements of all vehicles on the road. In self-driven cars, cameras and machine learning algorithms are used to detect speed limit signboards and thereby regulate the speed of the vehicle accordingly. In this project, an ML algorithm is designed and developed to detect different speed limit signboards from their images. After detecting the signboards, the ML algorithm sends this detail to the hardware component of the vehicle through serial communication. This speed limit detail is then analysed by an Arduino Uno, which controls the speed of the motor by using a motor driver and BO motors. The motor's speed is thereby controlled by PWM techniques in the vehicle to regulate its speed automatically, like an actual cruise control system in a real-world vehicle.

The second key part of the system includes an accident detection and alerting system that can be implemented by making use of a special Arduino Uno board and two ultrasonic sensors. A road accident might happen because of human negligence, natural environmental factors, or the system going faulty. To overcome this problem, the accident detection circuit continuously measures the distances of the car from any barriers. In case of any sudden or unsafe proximity, it immediately gives a warning signal through a buzzer. Moreover, an alert message can be sent by a Bluetooth device to a mobile phone.

Through the integration of machine learning algorithms, control through embedded systems, and alert systems based on IoT, this project presents a comprehensive smart vehicle system with advanced safety and automated functionalities. The project enables students and scholars to gain practical insight into intelligent models of transport and the role of cost-effective prototypes in vehicle engineering.

2. Body of Paper

Self-driving vehicles have brought a revolution in modern transport systems and reduced human reliance. However, speed regulation while following traffic rules remains an important issue in self-driving technology. Overspeeding and disregard for road signs are some of the main causes of road accidents around the globe. Traditional speed control systems have a significant dependence on human inputs or designed speed limitations, which tend to be inefficient in real-life conditions.

Present advancements in machine learning and computer vision enable cars to perceive and understand their environment intelligently. Traffic sign recognition is a key component for cars to navigate autonomously, enabling them to detect speed signs and change speed accordingly. The proposed system aims to design and develop a cost-effective autonomous vehicle model that recognises speed signs in traffic and regulates the speed of the vehicle automatically.

Figure 1 above portrays the relevance of traffic sign recognition with regards to the safety of self-driving cars and intelligent transport systems. Such an amalgamation of image perception capabilities with embedded control capabilities makes it feasible for decision-making and effective driving action to take place in real time. It also comprises accident notification capabilities for promoting the safety of the vehicle.

System Requirements

In this section, an outline of the functional and non-functional requirements of the proposed speed regulation of an autonomous vehicle is provided. Functional requirements are used to define operations of a system, while non-functional requirements are related to performance characteristics of the system.

Table 1 describes the functional requirements with functionalities such as traffic sign detection, speed control, obstacle detection, and alert notification, among others.

Table 2 describes non-functional requirements such as real-time response, low latency, efficiency in consumption of energy, and reliability of the system, among others.

In section 2.1, there is an explanation of the modelling of system requirements with a focus on input, output, and constraints of the system operation.

Section 2.2 lists the hardware components: Arduino Uno microcontroller board, L298N motor driver module, ultrasonic sensor (HC-SR04), Bluetooth module (HC-05), buzzer, and power source in the form of a lithium-ion battery pack. In this design, the control component in

Fig. 2 is the Arduino Uno board. The ultrasonic component in Fig. 3 is used for the detection of obstacles and accidents.

System Design

This section discusses the system architecture design. The proposed system block diagram is depicted in Fig. 4. The system design combines machine learning-based traffic sign recognition, motor control functions, and safety analysis systems.

The traffic sign recognition algorithm manipulates the images provided to it through computer vision techniques with the help of a machine learning algorithm. When a speed limit traffic sign is recognised, the speed command corresponding to the traffic sign gets transmitted to the Arduino controller. Then, the motor control module changes the speed of the car by sending PWM signals to the motor driver.

Simultaneously, the accident detection module is responsible for constantly tracking the distance of the obstacle using ultrasonic sensors. Upon detecting a potential collision, the system shall instantly trigger a buzzer alarm and an alert message to a mobile device through the Bluetooth communication method.

The diagrams created using the Unified Modelling Language (UML) describe the behaviour of the system and the interactions of the modules. They enable the visual representation of the flow of data, the logic of control, and the flow of communications.

Implementation

The code performs the necessary software image processing, while the vehicle control is purely hardware. It achieves traffic sign recognition using Python and OpenCV on the host computer, while real-time motor control and sensor processing are performed on Arduino Uno microcontrollers.

The system will adopt a modular implementation approach wherein every module, such as traffic sign recognition, speed control, and accident detection, can be tested independently. A design like this improves system reliability by simplifying the debugging and upgrading process.

Testing

The proposed system was evaluated to ensure the accuracy of traffic sign recognition, speed control in real-time, and the ability to detect accidents. Various scenarios tested the system, including the ability to correctly modulate speed according to road signs, correctly identify obstacles using the ultrasonic sensor, and successfully send Bluetooth alerts when an accident is simulated.

Results

It is evident from the experimental results that the designed system is able to identify speed limit signs for vehicle speed regulation successfully. Moreover,to detect accidents and send alert notifications through Bluetooth with high accuracy. Its performance is very efficient with low latency.

Table -1: Hardware and Software Configuration

Sl. No.	Hardware Component	Description	Function
1	Arduino UNO	ATmega328P-based microcontroller board	Controls motor speed, sensors, and system logic
2	L298N Motor Driver	Dual H-Bridge motor driver module	Controls the speed and direction of DC motors
3	DC BO Motors	Low-speed, high-torque DC motors	Provide movement to the vehicle
4	Ultrasonic Sensor (HC-SR04)	Distance measuring ultrasonic sensor	Detects obstacles and collision risks
5	Bluetooth Module (HC-05)	Wireless serial communication module	Sends alerts and communicates with mobile
6	18650 Li-ion Battery Pack	Rechargeable lithium-ion power source	Supplies power to the entire system

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7	Buzzer	Audio alert device	Provides a warning during accident detection
8	Vehicle Chassis	Mechanical base structure	Holds and supports all components
9	Connecting Wires & Switch	Jumper wires and power switch	Provides connections and power control

The hardware components in the Autonomous Vehicle Speed Regulation System include Arduino Uno microcontrollers, an L298N motor driver, DC motors, ultrasonic sensors (HC-SR04), a Bluetooth module (HC-05), a buzzer, and a lithium-ion battery pack. All these hardware parts work in conjunction to achieve real-time speed control, obstacle detection, and alert communication via wireless technology.

The system's performance is also dependent on proper hardware being used to allow it to work in a reliable and real-time manner. The Arduino Uno interprets speed instructions directed by the traffic sign recognition module and varies the motors' speed by using pulse width modulation signals; meanwhile, ultrasonic sensors detect any obstacles in the system's environment continuously. The system's efficiency is amplified by the ability to send notifications via Bluetooth communication technology.

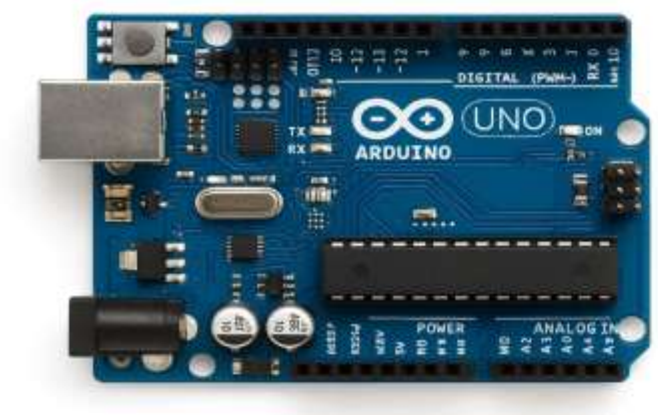

Fig -1: Arduino Uno

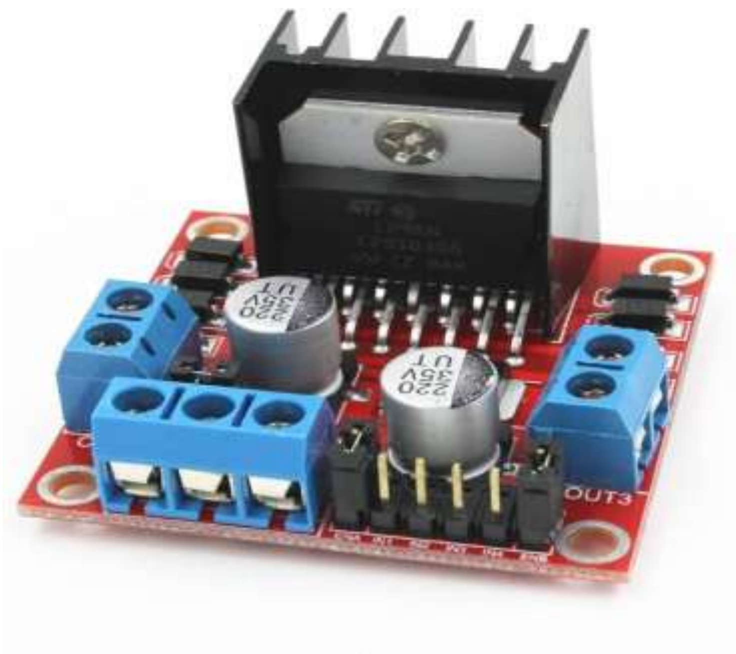

Fig-2: L298N Motor Driver

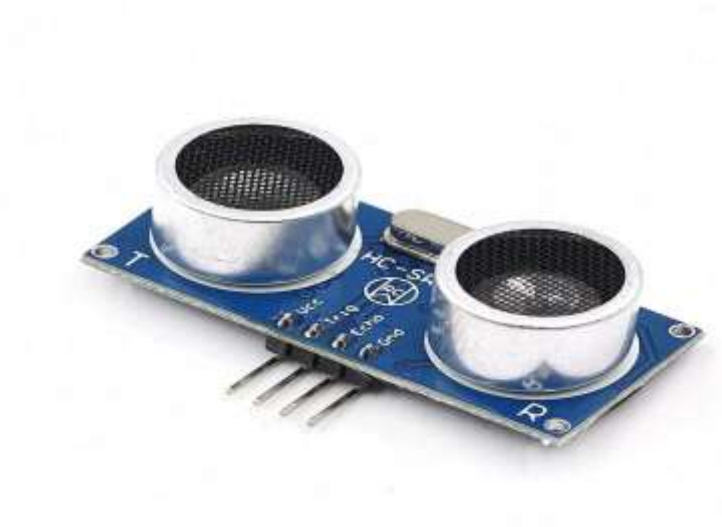

Fig-3: Ultrasonic Sensor (HC-SR04)

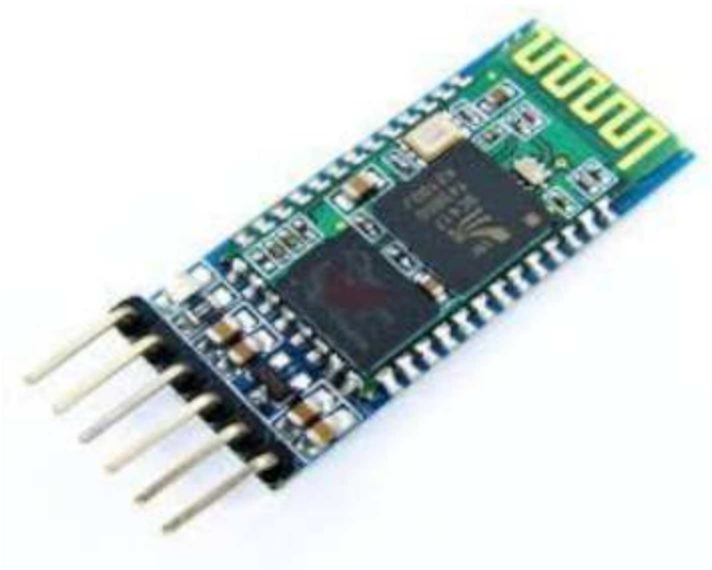

Fig-4: Bluetooth Module (HC-05)

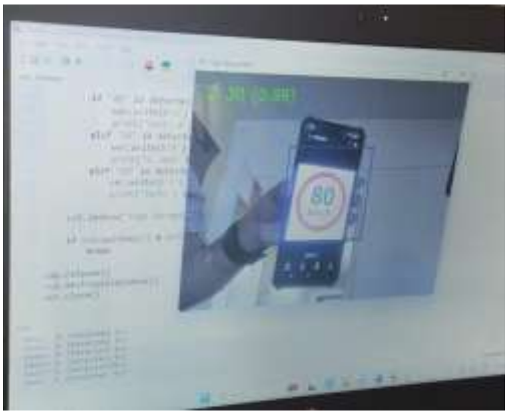

Fig-5: Working of Software Model (Identifying Signs)

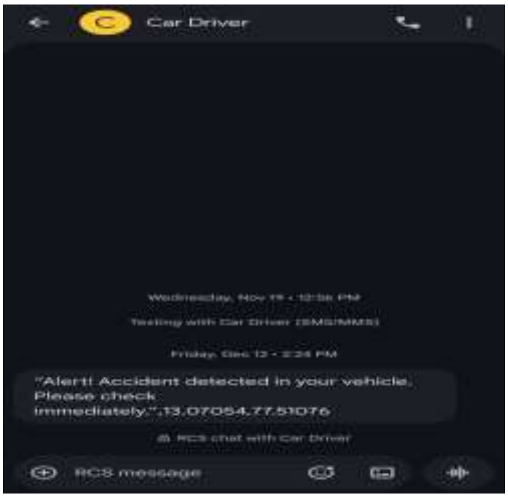

Fig-6: Automatic accident alert message with real-time location

3. CONCLUSIONS

The development and successful simulation of the Autonomous Vehicle Speed Regulation via Traffic Sign Recognition Model with Accident Detection and Alert System marks a significant step toward integrating intelligent automation into transportation safety. This project was built using Python and executed entirely through a laptop environment, eliminating the need for hardware-based implementation during the prototype phase. The core idea was to create a system that not only identifies and understands road traffic signs but also dynamically adjusts the vehicle's speed based on the detected signs. Furthermore, the system was extended to detect sudden changes in motion behaviour that resemble accidents and respond by sending a real-time SMS alert to the registered mobile number of the vehicle owner. This blend of image processing, machine learning, and emergency communication forms a reliable foundation for improving both driver safety and road discipline. Throughout the course of development, the traffic sign recognition module emerged as the backbone of the system. Utilizing computer vision techniques and a convolutional neural network, the system was trained to recognize and classify various traffic signs such as speed limits, stop signs, and no-entry symbols from static images. The model achieved a high level of accuracy, even under different image conditions, thanks to the inclusion of diverse training data and preprocessing techniques. Once a traffic sign was correctly identified, the system processed this information to determine if the simulated vehicle was complying with the speed indicated by the sign. If the vehicle speed exceeded the posted limit, the control logic would automatically adjust the speed to conform to traffic rules. This kind of dynamic behaviour, although simulated, reflects the future of autonomous driving systems where vehicles make real-time decisions based on their environment. The responsiveness and precision of the model, despite being run on a laptop with no real camera feed, clearly demonstrate the effectiveness of software-based simulation in replicating complex real-world scenarios.

The entire project execution showcased how powerful and versatile laptop-based image processing can be when integrated with machine learning and real-time communication tools. Even without the involvement of physical sensors or camera inputs, the system managed to simulate a comprehensive autonomous driving behaviour with speed adaptation and emergency handling. It highlighted how software environments can be utilized to build, test, and evaluate complex decision-making algorithms safely and efficiently. Through continuous image input simulation and variable speed testing, the model proved to be stable, responsive, and adaptable. The project also provided an opportunity to understand the challenges of balancing sensitivity and specificity—especially in accident detection—so that false positives are minimized without compromising on safety responsiveness. In addition to speed regulation, the project tackled the crucial issue of vehicle safety through accident detection and alerting mechanisms. By continuously monitoring simulated speed data, the system could detect sudden, unusual deceleration, which often indicates a potential collision or vehicle malfunction. Once such an incident was identified, an automatic alert mechanism was triggered. The system used a third-party API service to send an SMS message to the vehicle owner's mobile number, providing essential details such as the vehicle ID, the time of the accident, and a simulated location. This feature emphasized the project's objective to not just regulate speed but to enhance the overall safety and accountability of vehicle operations. During testing, the alert system performed reliably, with timely message delivery and accurate event reporting. The ability to notify a user in real-time through a lightweight communication method further reinforced the practicality of implementing such systems in future smart vehicles.

Another important outcome of this project was the successful demonstration of modular system design. Each part of the system—traffic sign detection, speed control, accident detection, and SMS notification—was developed independently but worked together seamlessly in a real-time simulated environment. This modularity ensures that the system is scalable and flexible for future additions such as GPS integration, real-time video feed analysis, or cloud-based storage of traffic and accident logs. Even with a limited testing environment, the model gave valuable insights into how each component contributes to the overall goal of road safety and autonomous driving intelligence. It also enabled experimentation with multiple scenarios, including compliance with different speed limits, detection of various sign types, and varied accident intensities. In essence, this project serves as a strong proof of concept for how traffic-aware autonomous vehicle behavior and real-time accident response can be achieved using image recognition and event-driven logic. It lays the groundwork for further enhancements and integrations that can eventually lead to real-world implementations. Although current deployment was limited to a simulated platform, all core functions of detection, decision-making, and alert generation worked reliably, which is the most critical measure of success in safety-related systems. The insights gained during this development process will be valuable for anyone working in the fields of smart mobility, intelligent systems, or autonomous vehicles, and reflect the growing importance of integrating AI, machine learning, and communication technologies into transportation frameworks for a safer future. Furthermore, the result of this project emphasizes the practicality of using Python and open-source tools to build systems that can support critical features of smart vehicles. By leveraging machine learning libraries and computer vision techniques, the model was able to process complex image data, interpret it accurately, and perform decisions within fractions of a second. The communication module, built using readily available APIs, demonstrated how effectively a system could interface with external networks to ensure timely alerts. This seamless fusion of perception, logic, and action, all developed and tested on a general-purpose laptop, speaks volumes about the accessibility and potential of intelligent transport system development using software-first approaches.

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