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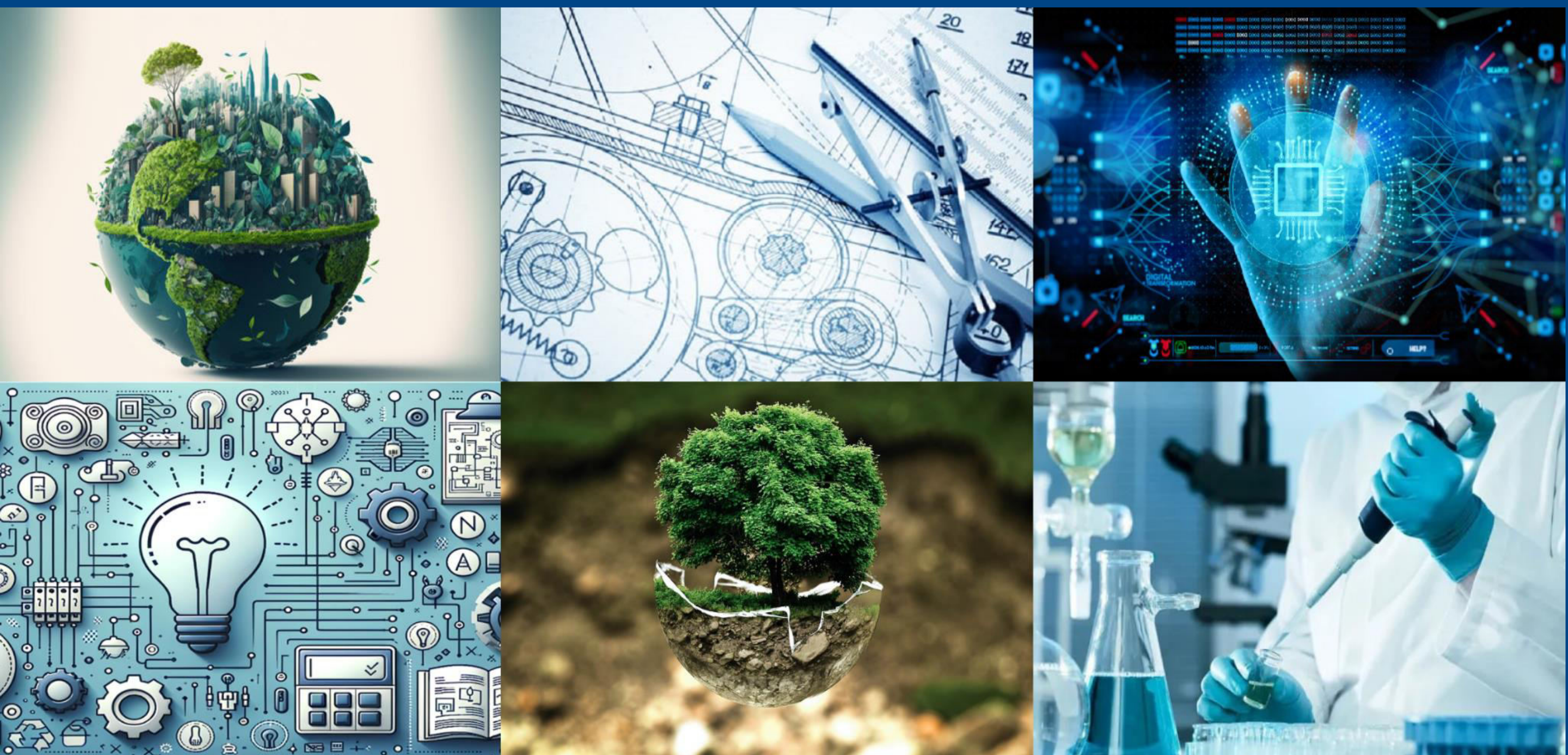

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Smart Highway Road Side Symbol Detection

Prof. Puneshkumar Tembhare, Pratik Khobragade, Pankaj Badipahadi, Alkesh Bagade, Hariom Nimburkar

Department of Computer Technology, Priyadarshini College of Engineering, Nagpur, India

ABSTRACT: Automatic detection of road signs has recently received attention from the computer vision research community. The main objective of this system is to detect signs of a moving vehicle. Road Traffic Sign Detection is a technology by which a vehicle is able to recognize the traffic signs put on the road e.g. "speed limit" or "children" or "turn ahead". Consider a condition user is driving a car at night or in rainy season then it is not possible for drivers to keep watch on each and every road symbol or the message plates like turn, speed breaker, school, diversion etc. This is very useful project in this condition Here we will use one signal transmitter on each and every symbol or message plate on road side and whenever any vehicle passes from that symbol the transmitter situated inside the vehicle will receive the signals and display proper message or the symbol details on LCD connected to car. Now driver can concentrate on driving.

We are trying to implement the system with signal identification using the radio frequency technology. The traffic signal indication will inform the driver of the current signal status inside the car on the dashboard. The RF transmitter will transmit the RF signal and these transmitted signal will received by RF Receiver fitted to the vehicle and will inform driver about the current signal status of the traffic light to perform necessary action.

I. INTRODUCTION

Autonomous vehicles, capable of sensing their environment and navigating with minimal human input, have become a reality. These vehicles rely on advanced AI control systems to interpret sensory information for identifying navigation paths, obstacles, and road signs. This paper introduces an intelligent road signs classifier to assist autonomous vehicles in recognizing and understanding road signs. The classifier utilizes a deep learning model, specifically Convolutional Neural Networks (CNN), which are effective in solving pattern recognition problems like image classification and object detection. CNNs mimic human brain decision-making processes in handling visual data. The proposed pipeline was trained and tested on two different datasets, achieving high performance with a validation accuracy of 99.8% and a testing accuracy of 99.6%. The method demonstrates easy implementation for real-time applications [1].

Computer vision systems in autonomous vehicles must effectively detect objects and obstacles in various environments, particularly under challenging weather conditions like fog and rain, which can impair image quality and object detection (OD) performance. The primary navigation of autonomous vehicles relies on image processing techniques applied to data from visual sensors. To address these challenges, ensembling multiple baseline deep learning models with various voting strategies and utilizing data augmentation is proposed. Data augmentation is especially beneficial for OD applications with limited training data. Using baseline models accelerates the OD process compared to custom models due to transfer learning. The ensembling approach proves highly effective for resource-constrained devices used in autonomous vehicles in uncertain weather conditions. The applied techniques demonstrated improved accuracy over baseline models, with 32.75% mean average precision (mAP) and 52.56% average precision (AP) in detecting cars in foggy and rainy conditions. Multiple voting strategies for bounding box predictions further enhance the explainability and performance of the ensemble techniques [2].

Perception is crucial for autonomous driving systems, as it gathers all necessary information about the vehicle's environment. The decision-making system uses this data to make optimal decisions, ensuring passenger safety. This paper surveys recent literature on AVP, focusing on Semantic Segmentation and Object Detection, both vital for navigation. It provides a comprehensive overview of deep learning for perception and decision-making processes based on images and LiDAR point clouds. The paper discusses sensors, benchmark datasets, and simulation tools used in semantic segmentation and object detection tasks, specifically for autonomous driving. It serves as a roadmap for current and future research in AVP, highlighting models, assessments, and challenges in the field [3].

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Accident Alert Light and Sound (AALS) System for Smart Roads increasing vehicular traffic elevates the risk of accidents, especially under poor weather conditions like heavy rainfall, strong winds, storms, and fog. To mitigate this risk and inform approaching vehicles of accidents, an Accident Alert Light and Sound (AALS) system is proposed. The AALS system, installed on the roadside, detects accidents and alerts all types of vehicles without requiring modifications to non-equipped vehicles (nEVs) or electric vehicles (EVs). This research focuses on creating smart roads (SRs) with various sensors to detect accidents, reducing the need for a global positioning system (GPS) to locate accidents quickly. The framework aims to reduce multiple-vehicle collisions (MVCs) and human fatalities by ensuring timely alerts and immediate first aid response. Wireless communication is utilized only when an accident is detected, enhancing the system's efficiency [4].

Traffic sign detection is crucial for self-driving cars and driver assistance systems. However, detecting small traffic signs, which cover only 1%-2% of the image area, poses significant challenges. To address this, we propose a YOLOv3 network with layer pruning and patch-wise training strategies for detecting small traffic signs. This approach improves recall percentage and mean Average Precision (mAP) [5].

Speed Sensor Detection System the Malaysian Police Force seeks technological advancements to combat highway thugs and illegal racers. The primary goal is to deter unethical road activities. This project designs a simple speed sensor detection system using an Infra-red (IR) sensor, NodeMCU ESP8266 microcontroller, and the Blynk application platform for control and monitoring via smartphone. The system detects vehicles or objects passing the IR sensor, displaying the vehicle's speed on both a Liquid Crystal Display (LCD) and the Blynk application. If a vehicle exceeds the speed limit, NodeMCU notifies the user's device, alerting them to the speeding vehicle. This innovative system offers authorities several advantages over traditional methods of addressing road rage incidents, enabling prompt action and resolution, ultimately contributing to safer road conditions and improved law enforcement capabilities [6].

II. LETRATURE REVIEW

Automatic Speed Control in Speed-Limited Zones ensuring the safety of pedestrians in speed-limited zones such as schools and hospital areas is a significant challenge due to drivers often exceeding speed limits. Traditional traffic policing methods are insufficient for constant monitoring and enforcement. To address this, a system utilizing Radio Frequency Identification (RFID) technology is proposed. An RFID reader, attached to the vehicle, interacts with RFID tags placed in speed-limited zones. These tags convey a coded message when the reader comes within range, triggering the vehicle's microcontroller unit to automatically control and reduce the vehicle's speed. The tags are strategically placed at the beginning and end of these zones. This innovative approach eliminates the need for driver intervention and ensures consistent speed regulation, enhancing public safety in critical areas [7].

Lightweight Convolutional Neural Networks for Traffic Sign Recognition traffic sign recognition and classification are vital for traffic safety, surveillance, artificial driver services, and self-driving cars. Recognizing traffic signs helps tackle traffic-related obstacles, and lightweight models are essential for portable devices. To address these challenges, a lightweight convolutional neural network (CNN) with residual blocks is proposed for traffic recognition systems. The proposed model demonstrates high efficiency and exceeds other well-known deep CNN architectures, achieving a remarkable 99.9% accuracy by F-score on the German Traffic Sign Recognition Benchmark. This paper highlights the model's effectiveness and general validity for traffic sign classification, showing its potential for real-world applications in traffic safety and autonomous driving [8].

Automatic Traffic Sign Detection and Recognition (TSDR) systems provide critical information to drivers and are essential for autonomous driving. Misclassifying traffic signs poses severe hazards to the environment, infrastructure, and human lives. Reliable TSDR mechanisms are necessary for safe vehicle circulation. Various Machine Learning (ML) algorithms have been proposed for Traffic Sign Recognition (TSR), but no consensus on a preferred algorithm or perfect classification capability has been achieved. This study employs ML-based classifiers to develop a TSR system that analyzes a sliding window of frames from vehicle sensors. The system utilizes Long Short-Term Memory (LSTM) networks and Stacking Meta-Learners to combine base-learning classification episodes into an improved meta-level classification. Experimental results using publicly available datasets demonstrate that Stacking Meta-Learners significantly reduce misclassifications and achieve perfect classification on all considered datasets. This novel approach based on sliding windows shows potential as an efficient solution for TSR [9].

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Lightweight Neural Networks for Traffic Sign Recognition traffic sign recognition significantly enhances road safety, with deep neural networks achieving impressive results in object identification. However, these systems can be limited by high computational and resource demands. To address this, a lightweight neural network for traffic sign recognition is proposed, offering high accuracy and precision with fewer trainable parameters. Trained on the German Traffic Sign Recognition Benchmark (GTSRB) and Belgium Traffic Sign (BelgiumTS) datasets, the proposed model achieved 98.41% and 92.06% accuracy, respectively. It outperformed several state-of-the-art models, including GoogleNet, AlexNet, VGG16, VGG19, MobileNetv2, and ResNetv2, with accuracy margins ranging from 0.1 to 4.20 percentage points on GTSRB and 9.33 to 33.18 percentage points on BelgiumTS [10].

Road-Type Detection Based on Traffic Sign and Lane Data the RTD system aims to help car drivers by determining the road type using onboard video and sensor data, without relying on GPS. It detects and evaluates traffic control devices (TCDs) along the road, using empirical statistics and heuristics for decision-making. Tested in various countries, the system achieved recognition precisions of 78.9% for European roads and 88.9% for UK roads [11].
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Comparative Analysis Table

Reference	Title	Year	Key Focus	Methodology	Results/Findings
[7]	Automatic Speed Control in Speed-Limited Zones	2021	Ensuring pedestrian safety in speed-limited zones using RFID technology	RFID reader in vehicles interacts with RFID tags placed in speed-limited zones to control vehicle speed automatically	Ensures consistent speed regulation without driver intervention, enhancing public safety
[8]	Lightweight Convolutional Neural Networks for Traffic Sign Recognition	2022	Traffic sign recognition using lightweight CNN models	CNN with residual blocks for improved traffic sign classification efficiency	Achieved 99.9% accuracy on the German Traffic Sign Recognition Benchmark
[9]	Automatic Traffic Sign Detection and Recognition (TSDR)	2022	Reliable TSDR mechanisms using ML-based classifiers	LSTM networks and Stacking Meta-Learners analyze vehicle sensor data	Stacking Meta-Learners significantly reduce misclassifications and achieve perfect classification on all considered datasets
[10]	Lightweight Neural Networks for Traffic Sign Recognition	2023	High-accuracy, low-resource neural network for traffic sign recognition	Lightweight neural network trained on GTSRB and BelgiumTS datasets	Achieved 98.41% (GTSRB) and 92.06% (BelgiumTS), outperforming GoogleNet, AlexNet, VGG16, VGG19, MobileNetv2, and ResNetv2
[11]	Road-Type Detection Based on Traffic Sign and Lane Data	2022	Road type detection using onboard video and sensor data	Detection and evaluation of traffic control devices using empirical statistics and heuristics	Recognition precision: 78.9% (European roads) and 88.9% (UK roads)

III.METHODOLOGY

The system consists of three main modules:

1. Transmitter Module (Installed on Traffic Signs)
- Each traffic sign is fitted with an RF transmitter that continuously broadcasts a signal containing a unique identifier (ID) for the specific traffic symbol.
- The transmitter operates on battery or solar power, ensuring uninterrupted functionality.

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- It uses a predefined frequency channel to communicate with the receiver inside vehicles.

Fig.1 RFID Tag

2. Receiver Module (Installed in Vehicles)
- An RF receiver inside the vehicle continuously scans for signals from road signs.
- When an RF signal is detected, the receiver extracts the unique ID from the signal.
- The system processes the received ID and matches it to a database of traffic symbols.
- The corresponding symbol and message are displayed on the in-car LCD screen, and an audio alert is played if necessary.

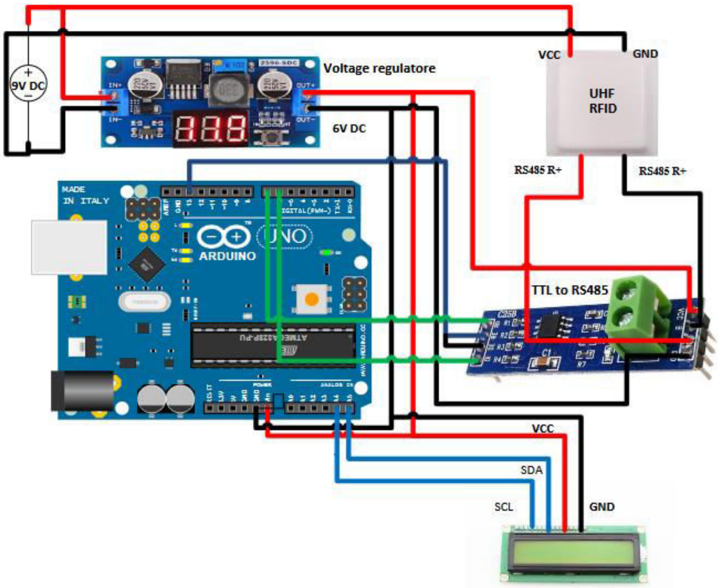

Fig.2 Receiver module in Vehicle

3. Processing Unit (Microcontroller-Based System)
- A microcontroller unit (MCU) is responsible for processing the received RF signals.
- The microcontroller decodes the signal, retrieves the associated symbol, and updates the display.
- It supports both text and graphical symbols for better user experience.

4. Prototype Development
- A scaled-down prototype of traffic signals and road signs is built with RF transmitters.
- Vehicles equipped with RF receivers and display modules are tested under different conditions to evaluate system performance.

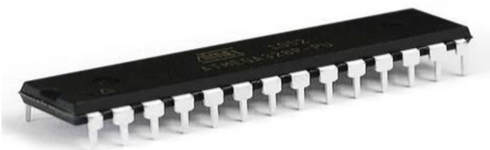

Fig.3 Microcontroller

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IV. OBJECTIVES

In daily life every vehicle (car) driver while driving the car may have to face to face problems like they don't know the status of signal symbol, the nearest path, the status of his/her vehicle. To keep in mind all these problems in this project four modules are developed. They are as follows.

1. Signal detection module
2. Symbol detection module.

Symbol detection module:- Whenever any vehicle passes away from any symbol its signal get detected by the signals detectors which are connected in car. This signal then converted in to proper symbol and displayed on the display panel connected in the car. This is how it show specific symbols to the driver which help driver in finding specific symbols and there meaning also.

Signal detection module:- When any vehicle comes near square car detector will detect the car status and show it on the display. Now driver can decide what to do by speeding the car or by slow down car speed.

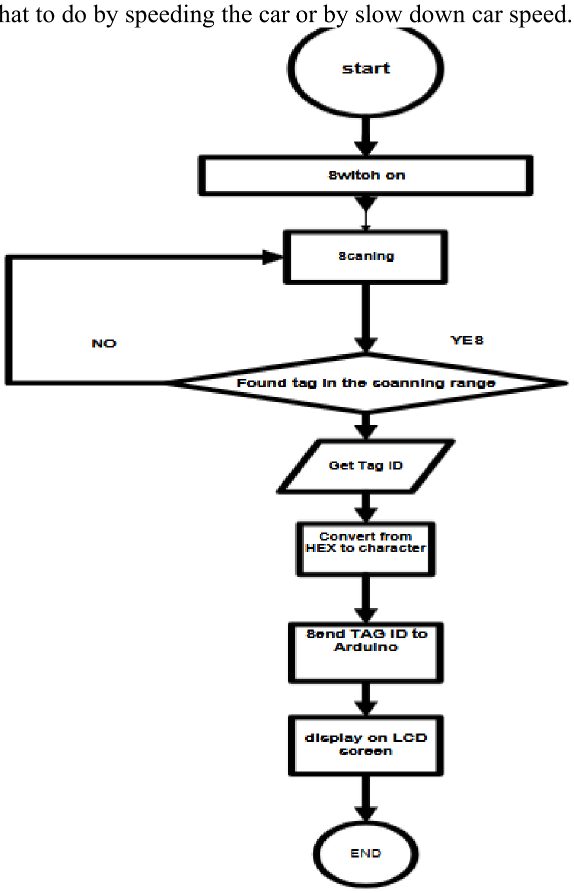

Fig.4 Block Diagram

V. EXPECTED RESULTS

As the infrastructure to vehicle information passing is one of the important aspect in vehicular ad-hoc network and it gives a better assistance to driver so that driver can concentrate on driving. Here in proposed system we are designing the infrastructure to vehicle communication and sharing the road side symbols, sign and text boards' information with in-car system fixed at vehicle cockpit. Once the system is ready with all the functionality it is expected from the system that system should,

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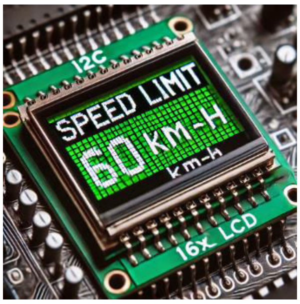

Fig. V Expected output

- System should detect the data from RFID tag and receiver show it on the in-car system.
- System should paly sound on the basis of detected symbol messages.
- System should take power advantages from different power source.

- Future Improvements

- Machine Learning Integration: AI models can be used to predict driver responses and optimize alerts.
- Extended Range: Using advanced RF modules with increased range to cover larger areas.
- Vehicle-to-Vehicle Communication: Enhancing system functionality by allowing vehicles to share detected sign information.

VI. CONCLUSION

As the system is mainly designed for driver assistance on the way or in city it gives wide range of scope to the user or implementer.

- **Helpful in Night traveling:** Much time it is not possible for driver to keep watch on each signal and board on the highways so the system will help drivers to understand the symbol or signals.
- **No need to see board on road:** As system is capable of show the symbol details user can concentrate on driving only.
- **Distance tower can show all spots:** If user misses the signal or can't see the signal or warning from long distance system can able to see the details of board from long distance.
- **Viewing signal information:** It may possible that user can't read long messages on board so the system will also help the driver.

The Road Side Symbol Detection System offers a reliable and efficient method of assisting drivers by providing real-time traffic sign information using RF technology. Unlike traditional image-based systems, RF communication ensures accuracy even in adverse conditions such as nighttime driving or bad weather. The system effectively reduces driver distractions by eliminating the need to visually locate road signs.

Future advancements could integrate AI-based predictive alerts, extended RF range, and V2X (Vehicle-to-Everything) communication for enhanced road safety. This technology has the potential to be adopted in modern smart transportation systems, significantly improving driving efficiency and road safety.

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