CARBON SENSE: SMART VEHICLE EMISSION MONITORING SYSTEM

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Introduction:

Air pollution caused by vehicle emissions is one of the major environmental challenges faced by modern cities. Harmful gases such as carbon monoxide (CO) and particulate matter (PM2.5) adversely affect human health and the environment. The rapid increase in the number of vehicles has significantly contributed to the deterioration of air quality. Conventional emission testing methods, such as periodic Pollution Under Control (PUC) checks, are manual and fail to provide continuous monitoring. As a result, many high-emission vehicles remain undetected, increasing pollution levels.

To address this issue, the proposed project “Carbon Sense: Smart Vehicle Emission Monitoring System” is developed. The system uses Internet of Things (IoT) and Artificial Intelligence (AI) for real-time emission monitoring. Gas sensors are used to measure emission levels, while a camera-based AI model detects smoke-emitting vehicles. The collected data is transmitted to a cloud platform for visualization and analysis. This system provides an efficient and automated solution for monitoring vehicle emissions and reducing air pollution.

Objectives:

1. To monitor vehicular emission levels in real time using an ESP32 microcontroller integrated with gas sensors (MQ2, MQ7, MQ135, PMS5003).
2. To transmit collected emission data to the ThingSpeak cloud for real-time visualization and analytics through live graphical dashboards.
3. To detect and capture vehicles emitting excessive smoke using a Raspberry Pi 4 equipped with a YOLOv8-based camera module.
4. To recognize and record vehicle details such as images and number plates when emission levels exceed the threshold, storing them in a structured CSV database.
5. To generate automatic alerts and maintain a cloud-based log system to support authorities in identifying and monitoring high-emission vehicles efficiently.

Methodology:

In the proposed project “Carbon Sense: Smart Vehicle Emission Monitoring System”, gas sensors such as MQ2, MQ7, MQ135, and PMS5003 are used to detect harmful gases and particulate matter from vehicle emissions. These sensors are interfaced with an ESP32 microcontroller, which processes the collected data and transmits it to the ThingSpeak cloud platform for real-time monitoring and visualization. A Raspberry Pi 4 is used as the processing unit for implementing Artificial Intelligence features.

A camera module captures images of vehicles, and the YOLOv8 model is used to detect smoke emissions. Optical Character Recognition (OCR) is applied to extract vehicle number plates from the captured images. The system continuously compares emission values with predefined threshold limits, and when emission levels exceed permissible limits, alerts are generated through a buzzer and displayed on an OLED screen. The data is also stored in the cloud for further analysis and tracking, ensuring accurate and real-time monitoring of vehicle emissions.

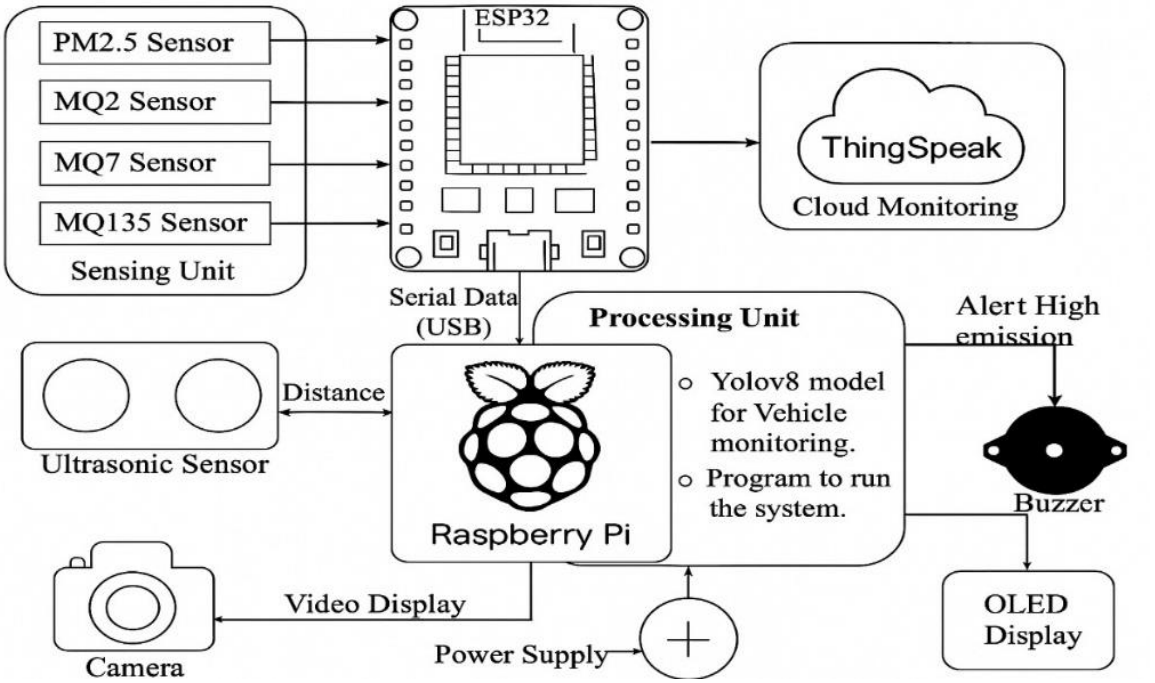

Figure 1: Block Diagram for Carbon Sense System.

Result and Conclusion:

The developed prototype successfully monitored vehicle emission parameters such as carbon monoxide (CO) and particulate matter (PM2.5) using MQ sensors and PMS5003. The system continuously collected data and transmitted it to the ThingSpeak cloud platform, where real-time graphs of emission levels were visualized. The YOLOv8 model accurately detected vehicles and identified smoke emissions using the camera module. Optical Character Recognition (OCR) was used to extract vehicle number plates for identification and record keeping.

Alerts were generated through a buzzer and displayed on an OLED screen whenever emission levels exceeded predefined limits. The system demonstrated reliable performance in real-time monitoring and detection of high-emission vehicles. The integration of IoT and AI improved the accuracy and efficiency of emission monitoring compared to conventional methods. The developed model is cost-effective, scalable, and suitable for practical deployment. Overall, the project provides an efficient and automated solution for monitoring vehicle emissions and reducing air pollution.

Figure 2: Prototype Deployment

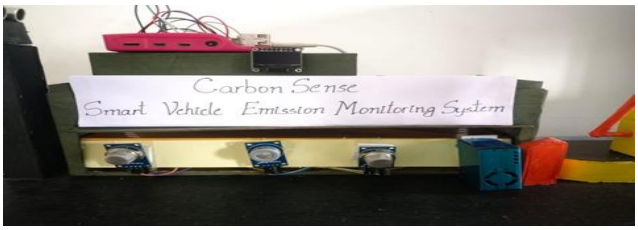

Figure 3: Sensor with ESP32

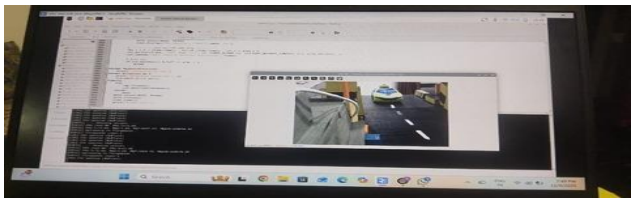

Figure 4: YOLO-Based Vehicle Detection

Figure 5: ThingSpeak Data Visualization

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Future Scope:

Although the current system performs effectively, several enhancements can be incorporated in future versions to expand its capabilities and improve performance:

1. GSM/GPS Integration
2. Mobile Application Development
3. Machine Learning-Based Prediction Models
4. Integration with Government Databases
5. Deployment of Large-Scale Sensor Networks
6. Solar-Powered Operation