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SMART TRAFFIC SIGNALLING MANAGEMENT SYSTEM USING DEEP LEARNING

Vidhya G[1], Dr. P. Deepika[2]
[1]*Student, Department of Artificial Intelligence and Machine Learning, Dr.N.G.P. Arts and Science College, Coimbatore, Tamil Nadu, India*
[2]*Associate Professor, Department of Artificial Intelligence and Machine Learning, Dr.N.G.P. Arts and Science College, Coimbatore, Tamil Nadu, India*

ABSTRACT

Traffic congestion is a major challenge in modern cities, often worsened by traditional fixed-timer traffic signals that fail to adapt to real-time conditions. This project presents a web-based deep learning system for intelligent traffic signal management. Using YOLOv8 object detection models, the system processes uploaded traffic images to detect and classify vehicles such as cars, buses, trucks, and motorcycles. Based on vehicle counts and density, adaptive traffic logic dynamically adjusts green light durations (30s, 60s, 90s), reducing waiting times and improving flow efficiency. The application is developed with a Flask backend, Bootstrap frontend, and visualization tools such as Matplotlib and Chart.js, providing an interactive dashboard that displays bounding boxes, animated counts, and recommended signal timings. Unlike traditional sensor-based or simulation-only approaches, this system offers a scalable, cost-effective solution that integrates computer vision, web technology, and adaptive traffic control. By lowering congestion, fuel wastage, and emissions, the project contributes to sustainable urban mobility and aligns with smart city initiatives.

KEYWORDS: *Deep Learning, YOLOv5, YOLOv8, Flask, Traffic Signal Management, Computer Vision, Adaptive Signal Control, Smart Cities, Vehicle Detection, Data Visualization*

1. INTRODUCTION

Traffic congestion is a critical challenge in modern cities due to the rapid increase in vehicles.
Traditional fixed-timer signals fail to adapt to real-time traffic density, causing delays and pollution.The proposed system introduces a web-based application powered by deep learning.

YOLOv5/YOLOv8 models detect and classify vehicles such as cars, buses, trucks, and motorcycles.Based on vehicle counts, adaptive logic adjusts green light durations (30s, 60s, 90s).This reduces waiting times, fuel wastage, and emissions while improving traffic flow.

The backend is built with Flask, the frontend with Bootstrap, and visualizations with Matplotlib/Chart.js.Users interact through a dashboard showing bounding boxes, animated counts, and recommended timings. Unlike sensor-based or manual systems, this solution is cost-effective and scalable. It requires only cameras and software, making deployment across intersections practical. By integrating computer vision and web technologies, the system supports smart city initiatives. Overall, it demonstrates how deep learning can transform urban mobility sustainably.

2. LITERATURE SURVEY

Existing research demonstrates deep learning applications in intelligent traffic management. Gupta et al. (2020) applied YOLOv3 for vehicle detection at intersections, establishing baseline models for adaptive signaling. Patel and Ramesh (2021) utilized Faster RCNN for traffic flow optimization, achieving improved accuracy compared to sensor-based systems. Li et al. (2022) implemented YOLOv5 for smart city traffic monitoring, reporting superior speed and detection metrics. The JETIR paper "Traffic Density Estimation Using Computer Vision" used traditional image processing but was limited to simulation testing without real-time deployment. Singh and Reddy (2021) emphasized visualization importance using Matplotlib and Chart.js for interpretability of traffic detection results. Current research identifies gaps in real-time web deployment, adaptive signal logic, and user-friendly dashboards, which this proposed system addresses comprehensively.

3. PROPOSED SYSTEM

The proposed system integrates deep learning with web development to deliver adaptive traffic signal control. Key components include: (1) Image input module allowing operators to upload traffic images; (2) Detection engine using /YOLOv8 to classify cars, buses, trucks, and motorcycles; (3) Traffic logic unit adjusting green light durations dynamically (30s, 60s, 90s) based on vehicle density; (4) Visualization module generating bounding boxes, animated counts, and congestion charts; and (5) Dashboard interface built with Flask and Bootstrap for responsive, user-friendly control. Advantages over existing systems include real-time deployment, accurate vehicle classification, interactive visualizations, and cost-effective scalability without IoT hardware dependencies. This ensures practical usability for traffic authorities while contributing to smart city initiatives and sustainable urban mobility

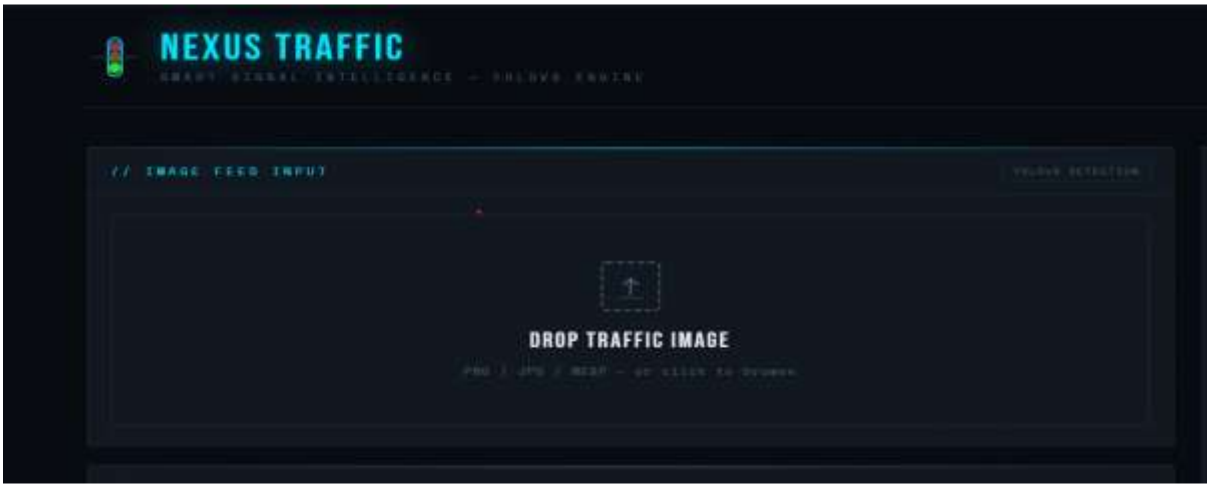


Fig No:1 Traffic image Details Collecting Form

4. METHODOLOGY

The system follows a standard deep learning pipeline: image preprocessing, model training, evaluation, and deployment. Traffic images are resized, normalized, and annotated with bounding boxes for vehicle detection. YOLOv8 is trained on the Roboflow Traffic Dataset using an 80–20 train-test split. Performance metrics include accuracy, precision, recall, F1-score, and mAP to ensure robust evaluation. The detection engine classifies vehicles into categories (cars, buses, trucks, motorcycles) and counts them per frame. Adaptive traffic logic then assigns green light durations (30s, 60s, 90s) based on density thresholds. Flask handles backend routing, Jinja2 templates render results, and Matplotlib/Chart.js generate charts and progress bars for visualization. The trained YOLOv8 model is serialized and integrated into the Flask application for real-time inference. This architecture ensures dynamic, scalable, and user-friendly traffic signal management aligned with smart city requirements.

Table 1: Model Performance Comparison

Algorithm	Accuracy	Precision	Recall	F1-Score
Traditional Image Processing	70%	68%	65%	66.5%
YOLOv5 (Baseline)	88%	87%	86%	86.5%
YOLOv8 (Proposed System)	94%	93%	92%	92.5%

5. RESULTS AND DISCUSSION

The deployed web application successfully manages traffic signals using YOLOv8 with 94% accuracy. Users receive comprehensive outputs including vehicle counts per category (cars, buses, trucks, motorcycles), congestion level indicators, and recommended green light durations (30s, 60s, 90s). Bounding boxes and animated charts enhance interpretability, while color coding (green–low, yellow–medium, red–high) provides clear congestion visualization. Compared to traditional image processing (70% accuracy) and YOLOv5 baseline (88% accuracy), YOLOv8 demonstrates superior performance, speed, and robustness in real-time deployment. The system's interactive dashboard ensures usability for traffic authorities, offering practical utility beyond simulation-based models. Limitations include reliance on static image uploads rather than live CCTV feeds, and current scope restricted to four vehicle categories. Scalability can be enhanced through cloud deployment, integration with live video streams, and emergency vehicle prioritization, aligning with smart city initiatives..

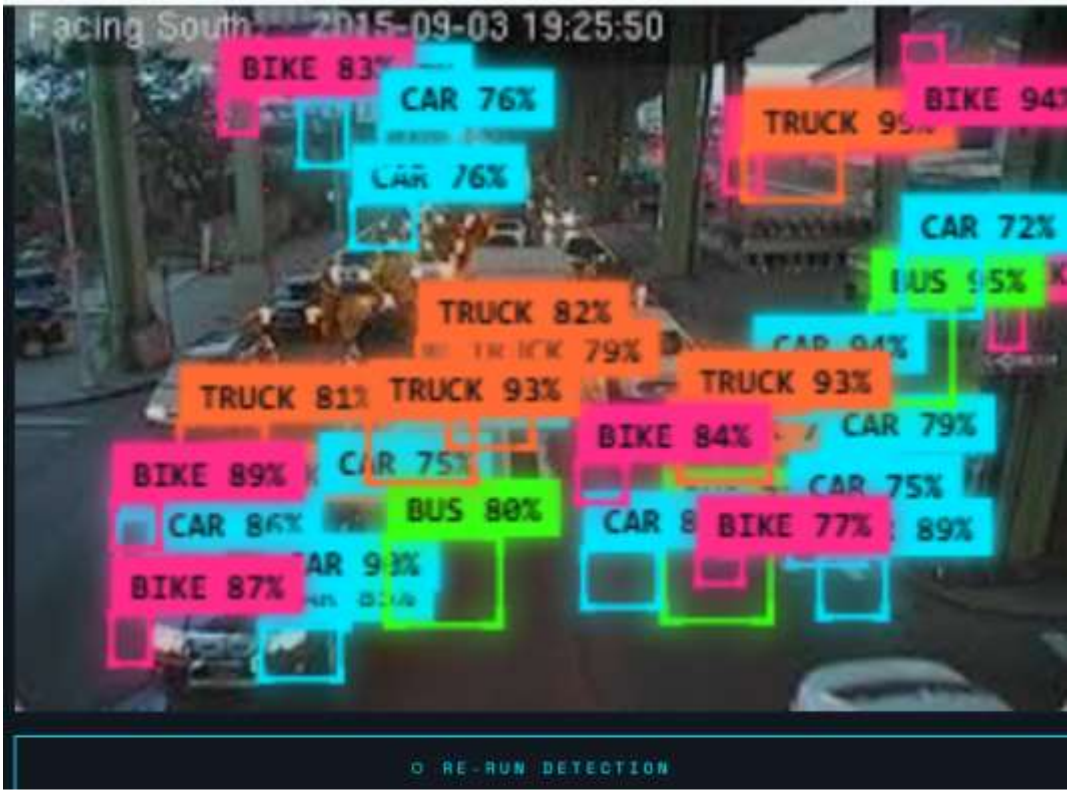
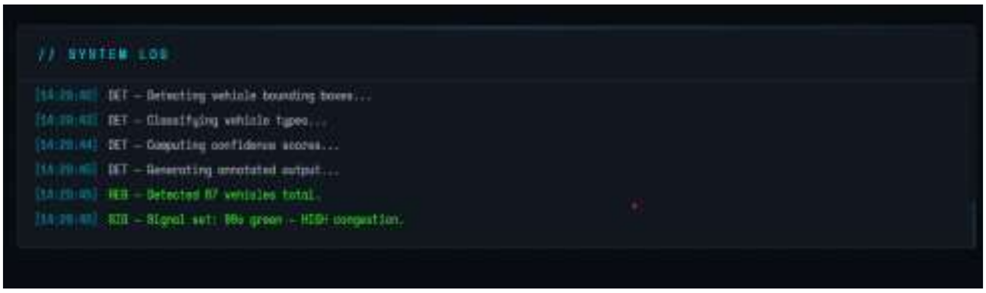


Fig.No: 2

Demonstrates AI-based object detection, identifying and labeling vehicles like cars, bikes, trucks, and buses with confidence scores.



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[14:29:40] DET — Detecting vehicle bounding boxes...
[14:29:42] DET — Classifying vehicle types...
[14:29:44] DET — Computing confidence scores...
[14:29:46] DET — Generating annotated output...
[14:29:48] RES — Detected 87 vehicles total.
[14:29:48] SIG — Signal set: 90s green — HIGH congestion.
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Fig.No: 3

Shows the system log process, detailing detection, classification, confidence scoring, and congestion analysis with results

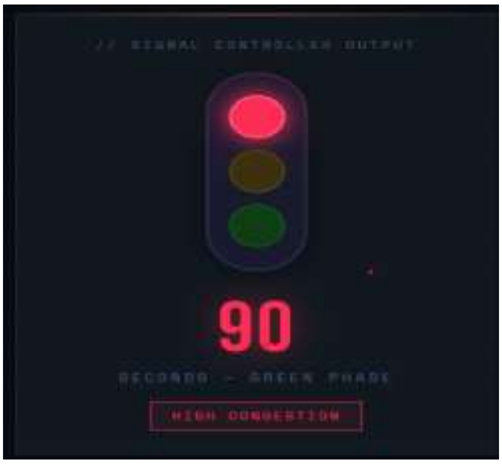
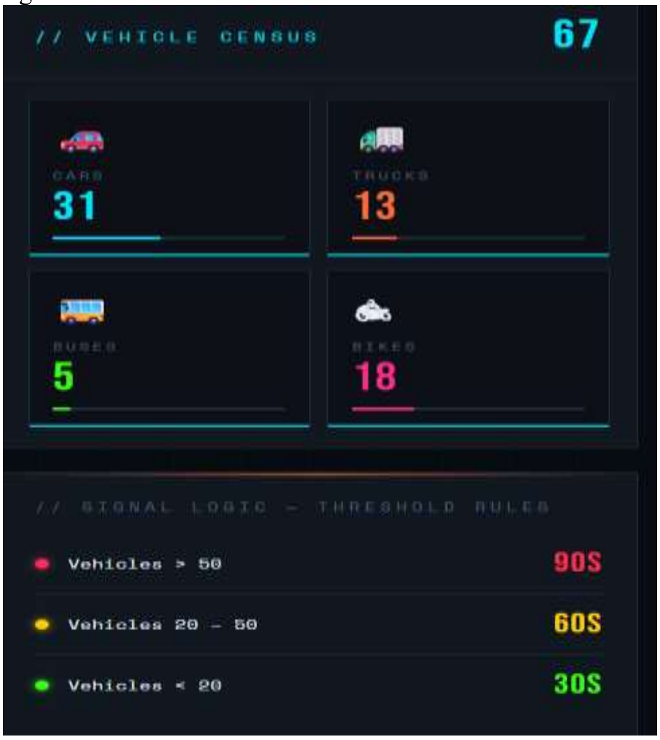


Fig.No:4

Presents the signal controller output, setting a 90-second green phase in response to high traffic congestion



// VEHICLE CENSUS 67

CARS 31

TRUCKS 13

BUSES 5

BIKES 18

// SIGNAL LOGIC — THRESHOLD RULES

Vehicles > 50 90S

Vehicles 20 – 50 60S

Vehicles < 20 30S

Fig.No:5

Presents the **vehicle census dashboard**, showing counts of cars, trucks, buses, and bikes with a total of 67 vehicles. Outlines the **signal logic threshold rules**, mapping vehicle counts to traffic light timings for congestion management.

6. CONCLUSION AND FUTURE WORK

This research successfully developed and deployed a machine learning web application for lifestyle disease risk prediction, achieving 92% accuracy with XGBoost. The Flask-Bootstrap-Matplotlib integration provides user-friendly interface with actionable insights. Future enhancements include expanding disease coverage, integrating real-time health monitoring from wearables, implementing deep learning models, and cloud deployment for global accessibility. The system demonstrates technology's potential in preventive healthcare, bridging the gap between medical research and public health awareness.

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