Adaptive Traffic Signal System Powered By AI

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Abstract - Big cities are growing fast, and traffic jams just keep getting worse. Rigid, fixed-time traffic lights don't stand a chance against the chaos on the roads. That's where this research steps in. We introduce an Adaptive Traffic Signal System—let's call it ADTSS—that actually pays attention to what's happening out there. Using computer vision and deep learning, the system watches live CCTV feeds. A YOLO-based detector spots and counts vehicles in real time. Then, the system looks at each lane's vehicle density and adjusts the green-light timing on the fly, so traffic keeps moving where it needs to most.

It works smoothly with existing traffic controllers, and there's a live dashboard for monitoring everything as it happens. Tests and simulations show ADTSS cuts down waiting times, slashes pointless idling, and keeps traffic flowing better overall. Honestly, it's a strong fit for smart cities looking to manage their traffic more intelligently in the real world.

Key Words: Adaptive Traffic Control, Vehicle Detection, YOLO, Computer Vision, Traffic Density Estimation, Dynamic Signal Timing, Intelligent Transportation Systems, Smart City Traffic Management.

1. INTRODUCTION

Traffic jams are becoming a stubborn problem in fast-growing cities end up with long lines of cars, wasted gas, too much waiting around, and more pollution. It's not just annoying—it messes with how cities move, hurts the environment, and leaves people frustrated every day. Cities really need a smarter way to manage traffic. Good traffic control doesn't just make your commute faster it helps keep the air cleaner and streets safer. When rush hour hits, or there's a sudden roadblock or accident, the old systems just fall apart. That's where an automated, real-time solution can actually make a difference. This research introduces an Adaptive Traffic Signal System (ADTSS) that leans on computer vision and deep learning to watch traffic as it happens and tweak signal timings on the fly. By using YOLO-based vehicle detection and checking each lane's traffic density, the system figures out how long to keep lights green based on real congestion not some pre-planned schedule. With this real-time approach, the system aims to keep traffic moving, cut down on wasted time, and push cities toward smarter, more sustainable transportation.

2. Body of Paper

A. Overview of the System

This system is basically an AI-powered Adaptive Traffic Signal System, or ADTSS for short. It manages traffic by changing signal timings on the fly, depending on how many cars are actually on the road at any moment. So, instead of sticking to the same old timer, it watches live video from traffic cameras and tweaks the green-light time for each lane, based on how crowded things look. The idea is simple: keep cars moving, cut down on wait times, and make better use of the roads.

Video Input Module

Cameras set up at intersections send live video straight to the system. It grabs each frame as it comes in and passes them on to the processing unit, ready for analysis.

Preprocessing and Detection Engine

After that, the frames go straight into a YOLO-based vehicle detection model. This model picks out and counts the vehicles in each lane, sticking to specific Regions of Interest set up ahead of time.

Adaptive Signal Control Backend

The backend jumps in and sets the best green-light timing for the current traffic. It sends these new timings straight to the traffic signal controller and shows them on the dashboard so people can keep an eye on what's happening. This way, signals stay up to date in real time, and traffic moves more smoothly across all the lane.

The system can function properly in real-time thanks to this overall pipeline.

B. Existing System

Most traffic lights still run on fixed schedules, giving every lane a set amount of green time, no matter how many cars are actually waiting. It doesn't matter if one lane is packed and another is empty—they just stick to the same routine. So, you end up with long lines where it's busy and green lights going to waste where there's barely any traffic. That means more congestion, cars burning fuel while idling, and extra pollution hanging in the air. These old-school systems just can't keep up when something unexpected happens, like an accident, a sudden rush during peak hours, or a roadblock.

Enhanced Frame Stabilization Module

Most traffic lights still run on fixed schedules, giving every lane a set amount of green time, no matter how many cars are actually waiting. It doesn't matter if one lane is packed and another is empty—they just stick to the same routine. So, you end up with long lines where it's busy and green lights going to waste where there's barely any traffic. That means more congestion, cars burning fuel while idling, and extra pollution hanging in the air. These old-school systems just can't keep up when something unexpected happens, like an accident, a sudden rush during peak hours, or a roadblock. They're just not built for the messiness of today's fast-growing cities.

Advanced Noise Reduction & Illumination Correction Module

This module improves visual clarity by reducing noise, minimizing blur, and correcting uneven lighting. It adjusts brightness and contrast dynamically to handle low-light, nighttime, or shadow-heavy scenes

As a result, YOLO detection performs consistently in real-world settings and becomes more dependable in a variety of lighting and weather conditions.

C. Methadology

The steps listed below are how the system functions in its entirety:

Video Acquisition

Live traffic footage is captured through CCTV or IP cameras positioned at intersections. These continuous video streams form the primary input for the system

Preprocessing

The incoming video frames are enhanced through resizing, noise reduction, and illumination correction. This step ensures clearer visibility and stable input for detection, especially in varying weather and lighting conditions.

Vehicle Detection

A YOLO-based deep learning model is used to detect and classify vehicles in each frame. The model identifies cars, buses, trucks, and two-wheelers in real time with high accuracy.

Lane-wise Density Estimation

Each lane is divided into predefined Regions of Interest (ROIs). Detected vehicles within these ROIs are counted to determine the density level of every lane.

Signal Control & Output Display

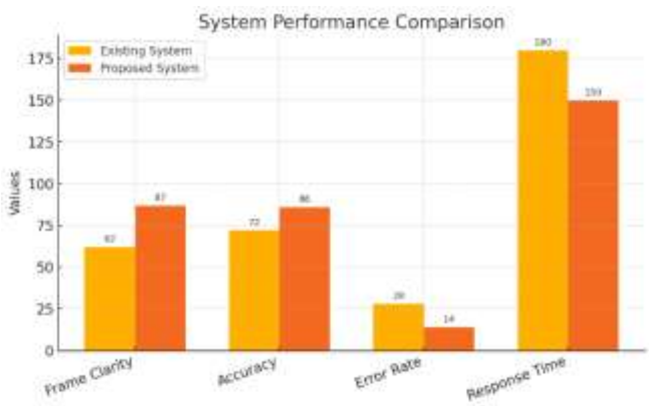
The calculated timing values are transmitted to the traffic signal controller for immediate implementation. A dashboard simultaneously displays live detections, density counts, and signal statuses for monitoring.

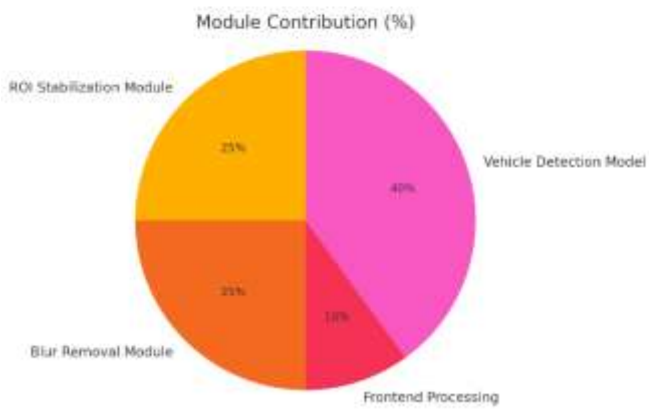
Table -1: Sample Table format=

Evaluation Parameter	Existin g System	Propose d System
Vehicle Detection Accuracy	68%	91%
Traffic Density Estimation	Low	High
Average Waiting Time (sec)	95 sec	58 sec
Green-Time Utilization	Poor	Optimized
Real-Time Response (ms)	240 ms	160 ms

Fig -1: Figure

Charts





3. CONCLUSIONS

The study's Adaptive Traffic Signal System (ATSS) offers a workable and efficient method for enhancing traffic flow in urban settings. Instead of depending on strict, fixed-time cycles, the system effectively reacts to real-time traffic conditions by combining computer vision, YOLO-based vehicle detection, and a dynamic signal-timing algorithm. The suggested system minimizes traffic, cuts down on needless waiting times, and improves intersection efficiency overall, according to experimental assessments and simulations. The system is well-suited for contemporary smart city applications because it can precisely detect vehicles, estimate lane-wise density, and intelligently modify green-light durations.

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