RESEARCH PLAN

Project ID:

Project Title: Integrated Traffic Flow Alert and Prevention System using Image Processing

Name of the Student: HANA GAZIYA.T

Name of School: Safa Matriculation School

Address of School: 1, New Military Road, Masjid-E-Mubarak Campus, Avadi, Tamil Nadu 600054

a. Introduction

This research will focus on intelligent traffic management using image processing. The system will aim to measure vehicle density at intersections from CCTV camera feeds and dynamically adjust traffic signals while generating alerts for congestion prevention. The scope of the research will include real-time density detection, adaptive signal control, and alert mechanisms for traffic police and operators.

b. Selection of Problem and Background Information

Urban traffic congestion causes delays, fuel wastage, and accidents. Conventional traffic lights operate on fixed timers, which are not responsive to real-time conditions. Prior research has shown that vision-based methods can provide more accurate traffic density estimation compared with inductive loops or infrared sensors. However, there is a need for integrated systems that combine density detection with adaptive prevention and alerting.

c. Objective

Research Problem: How effectively can image processing–based vehicle density detection be used to control traffic flow and generate congestion alerts compared with traditional fixed-time traffic light systems?

Objectives:

- To develop an image-processing system to measure real-time vehicle density.
- To adjust traffic signal timings based on density levels.
- To generate alerts for congestion or abnormal flow conditions.

Variables:

- Independent Variables: Vehicle density levels (low, medium, high), threshold values, camera angle.
- Dependent Variables: Green signal duration (s), alert generation (yes/no), average waiting time (s).
- Controlled Variables: Camera resolution, lighting conditions (daytime), intersection geometry.

Control in Study: A fixed-timer traffic light system will act as the control, while the experimental setup will use density-based adaptive control.

d. Hypothesis

It is hypothesized that density-based adaptive traffic light control using image processing will reduce congestion and average waiting times compared to fixed-time systems, while providing timely alerts to prevent traffic buildup.

e. Procedure

Design of Study:

1. Install a CCTV camera overlooking a traffic intersection model.
2. Capture real-time video feed and process frames using OpenCV.
3. Apply background subtraction and contour/YOLO detection to count vehicles.
4. Classify density into Low (0–10 vehicles), Medium (11–25 vehicles), High (25 vehicles).

5. Adjust green signal durations: Low = 20s, Medium = 40s, High = 60s.
6. Generate congestion alerts if High density persists for more than 3 cycles.
7. Compare waiting times against fixed-timer results.

Materials Required: CCTV/USB camera, workstation with Python + OpenCV, sim- ulated traffic light setup (LEDs + microcontroller), traffic video datasets, stopwatch for validation.

Proposed Data Tables :

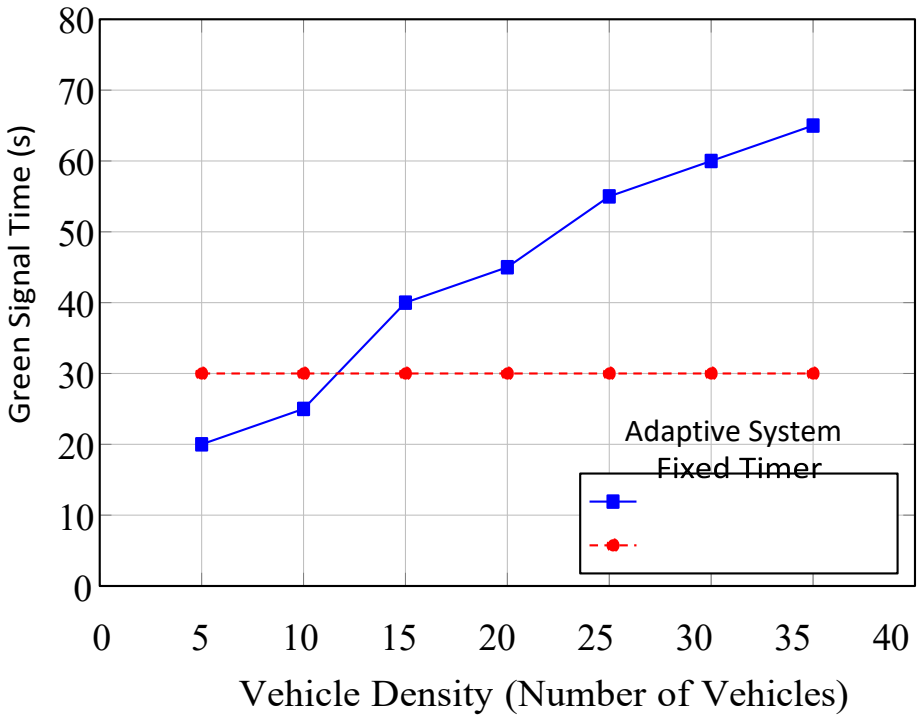
Table 1: Density Detection Results

Test Case	Vehicles Counted	Density Level	Green Time (s)
T1	6	Low	20
T2	15	Medium	40
T3	32	High	60
T4	3	Low	15
T5	25	High	65

Table 2: Comparison of Systems

System Type	Avg Waiting Time (s)	Alerts Generated	Accuracy (%)
Fixed Timer	75	0	100
Adaptive System	50	2	93

Graph: Vehicle Density vs Green Signal Time



f. Risk and Safety

- Minimal risks as only video processing and simulated setups are used.
- If tested on real intersections, operator supervision and traffic safety protocols must be followed.
- Equipment must be handled carefully to avoid electrical hazards.
- Secure network connections should be ensured to prevent data leaks.

g. Data Analysis

The collected data will be analyzed by:

- Computing accuracy of vehicle detection vs manual counts.
- Comparing average waiting times between adaptive and fixed systems.
- Analyzing number and frequency of alerts.
- Using graphs to plot density vs green light duration and waiting time reduction.

REFERENCE

1. Kamal S. et al., “Real-time traffic monitoring using computer vision,” *IEEE Trans. Intelligent Transportation Systems*, 2020.
2. Open CV Documentation: https://docs.opencv.org/
3. Redmon J. et al., “You Only Look Once: Unified, Real-Time Object Detection,” *arXiv*, 2016.
4. Indian Roads Congress, “Urban Traffic Management Guidelines,” 2019.