

**Traffic Light Simulator**

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**Abstract**

This project presents an intelligent traffic light simulator that uses computer vision to detect vehicles in a video feed and adjust red light duration accordingly. By using YOLOv5 for real-time object detection, the system counts vehicles in a specific region and displays adaptive signal timing. This method offers a more efficient alternative to traditional timer-based traffic lights, improving flow and reducing congestion. The simulation is implemented in Python using OpenCV and PyTorch, and is useful for traffic analysis, smart city planning, and educational purposes.

**Acknowledgement**

I would like to express my sincere thanks to my project members Hamza Tariq and Talmeez-O-Rehman for their dedication, teamwork, and continuous support throughout the development of this semester project. Their active participation, helpful suggestions, and technical collaboration played a vital role in the successful completion of our Traffic Light Simulator. I also appreciate the contributions of the open-source communities behind Python, YOLOv5, and OpenCV, whose tools were essential to this project.

A special thanks to ChatGPT for its helpful guidance, code explanations, and continuous support during every stage of the project.

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# Introduction

Efficient traffic management is crucial in urban areas to reduce congestion, improve road safety, and minimize travel delays. Traditional traffic light systems rely on pre-set timers which do not adapt to real-time traffic conditions. This project presents an intelligent traffic light simulator that dynamically adjusts red light duration based on the number of vehicles detected in a specific region of interest (ROI) from a video feed. The system uses YOLO (You Only Look Once), a real-time object detection model, to detect and count vehicles. Based on traffic density, the red light duration is automatically calculated and displayed, ensuring adaptive and responsive traffic control.

# Background & Literature

Traditional traffic systems are inefficient in handling dynamic traffic loads, leading to long wait times and increased fuel consumption. Researchers have proposed various solutions using sensor networks, camera-based systems, and machine learning to address these challenges.

* Camera-based Traffic Detection: Video surveillance and computer vision provide scalable solutions to detect traffic density and vehicle types.
* YOLO Object Detection: Introduced by Joseph Redmon, YOLO is a state-of-the-art object detection model known for its speed and accuracy in real-time detection tasks. It processes entire images with a single neural network pass.
* Adaptive Signal Control: Previous studies have shown that dynamically adjusting signal timings based on real-time traffic data significantly improves flow and reduces average wait time at intersections.

By combining real-time object detection with adaptive signal logic, this project aligns with modern smart city initiatives.

# Tools & Technologies Used

|  |  |
| --- | --- |
| **Technology** | **Purpose** |
| Python | Core programming language for development |
| OpenCV | Image and video processing |
| PyTorch | Deep learning framework used to load and run the YOLOv5 model |
| YOLOv5 | Object detection model to identify and count vehicles |
| Pre-recorded Video | Simulated traffic footage for testing the system |
| NumPy | Used for numerical operations and image manipulation |

SUMO (Simulation of Urban MObility): Open-source microscopic traffic simulator for realistic simulation (not integrated in the final version).

# System Model

## Input:

* A video file of a road intersection is provided as input.
* A Region of Interest (ROI) is selected manually to focus on a specific lane or direction.

## Detection:

* Each video frame is processed using YOLOv5.
* Vehicles (cars, buses, trucks, motorbikes) are detected and filtered within the ROI.

## Car Counting:

* If a vehicle’s center falls inside the ROI, it is counted.
* The number of vehicles in the ROI is updated frame-by-frame.

## Signal Control Logic:

* Based on the number of vehicles, a red light duration is calculated:
* More cars → Longer red light time (max capped at 10 seconds)
* Fewer cars → Shorter red light time
* If no cars are present, the signal turns green.

## Display Output:

The video is displayed with:

* Vehicle bounding boxes
* Signal color (Red/Green)
* Countdown timer for red light
* Total vehicles detected

# Github Link

<https://github.com/Faizan8232403/Opearating-System-Project>