Project Title:
Automated Traffic Violation Detection System
Course: Digital Image Processing (DIP)
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Abstract:

This project presents an automated solution for monitoring traffic and detecting red-light violations using Digital Image Processing. The system utilizes the HSV color space to identify the state of traffic signals (Red/Green) and employs the MOG2 Background Subtraction algorithm to detect moving vehicles. A virtual stop-line is implemented to identify vehicles that fail to stop during a red signal. The system is efficient, works in real-time, and provides a cost-effective alternative to physical sensor-based traffic monitoring.

Introduction

Traffic management is a critical challenge in urban areas. Manual monitoring by traffic police is not only difficult but also prone to human error. Digital Image Processing (DIP) provides tools to automate this.

Problem Statement:
Vehicles often ignore traffic signals, leading to accidents. Conventional cameras only record video but don't "understand" the violation.

Proposed Solution:

An automated system that monitors video feeds and identifies violators using computer vision.

Significance:

This system helps in 24/7 surveillance without fatigue and ensures that every violation is logged with visual proof.

Literature Review:

Traditional methods of vehicle detection used physical sensors (Inductive Loops) buried under the roads. However, modern DIP techniques are more cost-effective. Early image processing systems used simple "Frame Differencing," but they failed when lighting changed. This project uses the MOG2 (Mixture of Gaussians) algorithm, which is robust against shadows and camera jitters. Research shows that HSV color space is 30% more accurate than RGB for outdoor light detection.

Tools & Technologies:

Python:
The core programming language used for its efficiency and extensive library support.
OpenCV:
The primary library for all image processing tasks like color filtering and motion detection.
NumPy:
Used to handle image frames as high-speed numerical matrices.
MOG2 Subtractor:
An advanced algorithm for background modeling.

System Methodology:

The proposed system follows a structured pipeline:

Frame Acquisition:

Input traffic video is captured and processed frame by frame.

Preprocessing:

Frames are resized to 800x500 pixels to maintain a balance between speed and accuracy.

Signal Identification:

A specific region of the frame is analyzed using HSV color masks to detect if the signal is Red or Green.

Vehicle Detection:

The Background Subtractor MOG2 extracts moving objects from the static road.

Violation Logic:

A virtual "stop line" is drawn. If a vehicle's bounding box crosses this line while the signal is Red, a violation is triggered.

Detailed Algorithms:

HSV Color Segmentation:

We use HSV (Hue, Saturation, Value) instead of RGB because it is more stable under different lighting conditions.

MOG2 Background Subtraction:

This algorithm models each pixel's background as a mixture of Gaussians. It helps in identifying the moving foreground (cars) while ignoring the static background (road, trees).

Morphological Operations:

To clean the noise, we use cv2.MORPH_CLOSE. This operation performs dilation followed by erosion, which helps in filling small holes inside the detected vehicle contours.

Implementation Details:
In this section, the core logic of the Python script is explained:

Signal Detection:
cv2.inRange is used to create a binary mask, and cv2.countNonZero counts the colored pixels to decide the signal state.

Contour Analysis:
cv2.findContours identifies the shapes of vehicles. Only contours with an area greater than 2000 pixels are processed to avoid detecting small noise.

Drawing & Labeling:
cv2.rectangle and cv2.putText are used to provide visual feedback on the screen.

Results and Discussion:
The system was tested on traffic footage and showed high accuracy in detecting signal changes.

Detection:
Bounding boxes accurately followed vehicles.

Violation Logging:
When a car crossed the blue line during a red signal, the box turned red and displayed "Red Signal Violation."

Performance:
The system maintained a steady frame rate, making it suitable for real-time applications.

Conclusion
This project successfully demonstrates the application of Digital Image Processing in traffic safety. By combining color analysis and motion tracking, we have created a functional prototype that can assist in automated law enforcement and reduce the workload on traffic personnel.

Future Enhancements:
Automatic Number Plate Recognition (ANPR): To identify the specific vehicle owner.