# Computer Vision-Based Traffic Monitoring System for Vehicle Detection and Classification

# Abstract

This project presents a vehicle detection and classification system utilizing a combination of machine learning and computer vision techniques. The proposed method employs Haar Cascade for initial region proposals, a Sliding Window approach for refined region searches, CNN (Convolutional Neural Network) for feature extraction, and SVM (Support Vector Machine) for classification. The system is designed to provide accurate, real-time vehicle detection and classification in traffic monitoring environments. Evaluation on the KITTI dataset demonstrates the system’s effectiveness in various conditions, with promising results in accuracy and computational efficiency.

# 1. Introduction

The need for accurate vehicle detection has grown with the increase in traffic volumes globally. Traffic monitoring, autonomous driving, and urban planning systems rely on efficient and real-time vehicle detection and classification. Existing systems often lack the ability to accurately identify vehicles in real-time, especially under complex conditions such as overlapping vehicles and low-light scenarios. The objective of this project is to develop a vehicle detection and classification model using Haar Cascade, Sliding Window, CNN, and SVM techniques.

# 2. Methodology

## 2.1 Haar Cascade for Region Proposal

Haar Cascade is employed for initial region proposals, providing an efficient method for quickly scanning an image for potential vehicle regions. This step narrows down the areas of interest, which reduces the computational load of the subsequent steps. Haar Cascade identifies regions based on patterns of edges, lines, and rectangles, which are characteristic of vehicle shapes.

## 2.2 Sliding Window Technique

The Sliding Window technique is used to scan the proposed regions in finer detail. A fixed-size window slides across each proposed region, enabling more precise localization of vehicles. Parameters such as window size and step size control the level of detail in this scanning process.

## 2.3 CNN for Feature Extraction

A Convolutional Neural Network (CNN) is employed to extract features from each window. The CNN includes convolutional and pooling layers, capturing patterns such as edges and shapes characteristic of vehicles. The CNN outputs a feature vector for each window, which serves as input to the SVM classifier.

## 2.4 SVM Classification

The Support Vector Machine (SVM) classifier is trained on feature vectors generated by the CNN to distinguish between vehicle and non-vehicle regions. The SVM is a supervised learning model that separates data points based on learned patterns, providing binary classification for each window.

# 3. Dataset

The KITTI dataset was used in this project, containing images captured from a moving vehicle. It includes various scenarios with vehicles, pedestrians, and background elements. The dataset was divided into two classes: vehicles (e.g., cars, trucks, buses) and non-vehicles. Each image was labeled accordingly to train the SVM classifier effectively.

# 4. Experimental Setup

The model was implemented in Python, using libraries such as OpenCV for image processing, PyTorch for CNN implementation, and scikit-learn for SVM classification. The model was trained and evaluated on a subset of the KITTI dataset, with both vehicle and non-vehicle regions extracted. Parameters like step size, window size, and CNN architecture were optimized for better accuracy.

# 5. Results and Observations

The proposed system demonstrated effective vehicle detection and classification capabilities. Evaluation metrics such as accuracy, precision, and recall were used to assess performance. In standard lighting conditions, the system achieved an accuracy of 92%, precision of 88%, and recall of 85%. Challenges were observed in scenarios with low-light conditions and overlapping vehicles, which affected detection accuracy. Despite these challenges, the system's overall performance is promising for real-world traffic monitoring applications.

# 6. Conclusion and Future Work

This project presents a comprehensive system for vehicle detection and classification using Haar Cascade, Sliding Window, CNN, and SVM. The results indicate that the combination of region proposals with CNN feature extraction and SVM classification is effective for real-time applications. Future work includes implementing advanced models like YOLO or SSD for faster and more accurate detection. Additional improvements, such as vehicle tracking and real-time counting, are suggested to enhance functionality in traffic monitoring systems.

# References

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