Design and Implementation of a Real-Time Vehicle Overspeed Detection System Using YOLOv8, Optical Character Recognition, and Dual-Camera Analytics

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Abstract - The review of methodologies regarding real-time vehicle speed detection, estimation, and tracking using some advanced computer vision techniques, using modern deep learning techniques, by applying models like YOLOv8, Deep SORT, and GMM by possible application for the accurate detection and tracking of vehicles. Thus, the research refers to fewer techniques that have achieved a Mean Absolute Error of 35 and RMSE of 422 relating to the estimation of speed; it refers to the addition of better time interpolation methods, including vehicle acceleration that lowers the error in the speed estimation to 07% levels. Another discussion incorporated in the paper is the high-resolution dataset for fine-grained vehicle recognition and Classification, Low-Cost Speed Detection Systems that rely on frame difference methods and IoT integration These innovations enhance the real-time surveillance ability especially in sensitive areas such as schools and hospitals, as it is efficient, although some challenges brought about by environmental factors such as lighting conditions, angles, and other cameras bring about difficulties. Below are the results from the survey and indicate in what ways this could be attributed to developing better traffic management, police service, and intelligent transportation systems. Results Specifically, these reveal the feasibility of scalable, accurate, and cost-effective solutions towards road safety and effective traffic management. The fast pace of urbanization, coupled with more and more cars on the road, has resulted in an enormous surge in traffic violations, especially over speeding, that is one of the leading causes of road accidents. Current speed checking devices, like radar guns and single speed sensors, can only detect car speed at a point. This method is prone to cheating by drivers who reduce speed for a short while at familiar locations, thus evading detection. Thus, there is an urgent need for a more secure and safer system to assess car speed over a long distance.

This project presents a real-time overspeed detection system with a two-camera architecture to estimate the average speed of a vehicle between two static observation points. Based on state-of-the-art CV & DL processes, the system is precise and reliable in detection. Vehicle detection is performed using the YOLOv8 (You Only Look Once, Version 8) object detection model, which is precise and efficient. License plate recognition is done by Tesseract OCR, which reads alphanumeric characters from identified vehicle plates to uniquely recognize a vehicle.

The timestamps are captured by the system when the vehicles cross the entry and exit points. The average velocity is obtained using the known distance between the two cameras. If the resultant speed is above the pre-configured threshold (for instance, 100 km/h), the vehicle is detected automatically for the speed limit violation. Detailed information, such as license plate number, speed, and detection time, is reflected on an interactive real-time dashboard, which is developed using Streamlit.

The proposed solution is economically efficient, hardware resource-saving, and suitable for installation in highway and urban environments. Its modularity also renders it easy to integrate into intelligent traffic monitoring systems and smart city infrastructures, thus maximizing the enforcement of traffic regulations and encouraging the enhancement of road safety in general.

Key Words: Vehicle Overspeed Detection, YOLOv8, Tesseract OCR, Average Speed Monitoring, License Plate Recognition, Dual-Camera System, Real-Time Traffic Surveillance, Streamlit Dashboard, Deep Learning, Smart City Infrastructure

1.INTRODUCTION

Road safety is a rapidly emerging problem at the global level with excessive speed being one of the principal reasons for road traffic accidents. World Health Organization (WHO) data show that accidents caused by excessive speed constitute about one-third of all the fatal accidents occurring worldwide. Handheld speed checking devices and point-speed cameras are being used to curb speeding in the conventional way. But such techniques have some major drawbacks. Drivers reduce speed as they are close these cameras, making the control over speed ineffective. These systems are more exposed to failure and have limited range and effectiveness.

The developments in artificial intelligence & DL have enabled new solutions for real-time traffic monitoring. Object detection models like YOLO (You Only Look Once) have transformed real-time video analysis with faster and more accurate object detection. Meanwhile, Optical Character Recognition (OCR) technologies like Tesseract have enhanced the accuracy and usability of automated number plate recognition (ANPR) systems. With such new technologies, a dual-camera overspeed detection system can have the ability to significantly enhance conventional speed detection technology.

Problem Definition

To develop an automated vehicle overspeed detection system using dual cameras mounted at two different checkpoints to identify, detect, and track vehicles, calculate their average speed between checkpoints, and identify over speeding incidents using deep learning and OCR technologies.

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Motivation

The overall objective of this project is to enhance road safety by designing a cost-effective, scalable, and accurate overspeed detection system. Compared to the conventional point-based speed enforcement system, an average speed monitoring system that detects the speed over a given distance is much more difficult to replicate by drivers. According to previous research, average speed enforcement systems can reduce accidents by up to 50% when compared with point-based systems [1]. Through the support of advanced AI Technologies like YOLOv8 and Tesseract OCR, it is easy to design a robust, real-time, and intelligent system that can be optimized for various urban and highway scenarios.
This project is designed to provide a solution that is easily applied with commonly available hardware, such as webcams and mobile phone cameras, thus being accessible in developing countries where expensive surveillance systems are not viable.

Objectives

The following are the precise project goals:

- To create a dual-camera-based system in real time to recognize vehicles at two different checkpoints.
- To utilize YOLOv8 for accurate automobile detection across various environmental conditions.
- The implementation of Tesseract OCR facilitates the automated extraction of vehicle number plate characters.
- To capture the in and out timestamps as vehicles cross the checkpoints.
- To determine the mean velocity, one must utilize the established distance between checkpoints in conjunction with the recorded timestamps.
- To identify and flag vehicles over the established speed limit.
- To create an interactive and dynamic real-time web dashboard using Streamlit to display all collected data and system output.

Each objective contributes to building a framework that can address the real traffic monitoring and law enforcement issues of the real world.

2. METHODOLOGY

The process describes the structured methodology applied to accomplish the project goals. The process involves automobile detection, number plate recognition, timestamp capture, speed computation, and identification of over speeding status. Use of two cameras provides the facility to capture in and out points of vehicles. The use of YOLOv8 and Tesseract OCR together provides the facility of automation, accuracy, and real-time efficiency. Each module of the system is executed to accomplish a particular task, thereby facilitating a smooth flow from vehicle detection to display on the dashboard.

Overall System Structure

The system has two main hardware components: an entry checkpoint camera and an exit checkpoint camera at a fixed distance apart (represented as 300 km for project purposes). Vehicles passing through these checkpoints are detected using YOLOv8, and license plates are read using Tesseract OCR. Entry and exit times are logged for each vehicle.

The system architecture takes these steps:

1. Entry Camera takes the picture of the vehicle and prompts vehicle detection.
2. The YOLOv8 model detects cars and accurately positions the license plates.
3. Tesseract OCR scans the license plate number.
4. The entry time is recorded.
5. Exit Camera exits the vehicle again and repeats steps 2–4.
6. The Speed Calculation Module calculates the speed by using timestamps.
7. Comparison with the speed limit (100 kmph) to mark over speeding vehicles.
8. Dashboard Module (Streamlit) shows real-time monitoring outcomes.

Overall System Architecture

3. SOFTWARE DESIGN

The software part is subdivided into some modules:

- Detection Module to identify vehicles.
- OCR Module for extraction of text from plates.
- Entry-Exit Tracker for timestamp management.
- Speed Calculator to calculate car speeds.
- Dashboard Application for visualizing everything live.

Every Python module is designed to perform one task, thus not being dependent and promoting modular programming practices.

4. HARDWARE INSTALLATION

The hardware requirements of the project are minimal:

- Entry Point Camera: Web cam or cell phone camera (Android IP Webcam app).
- Exit Point Camera: Laptop webcam.
- Processing Unit: Typical laptop with GPU or decent CPU (Core i5/i7, 8 GB RAM or higher).
- Network: Local Wi-Fi network to connect phone camera with computer.

5. FUTURE SCOPE

Although the existing system is highly functional, there is significant potential for growth and improvement in the future:
Multi-lane Detection:

The present system monitors one lane. Upcoming releases can monitor multiple lanes simultaneously by using multi-object tracking algorithms.

Advanced OCR Models:

While Tesseract OCR works well, the integration of deep learning-based OCR engines like CRNN (Convolutional Recurrent Neural Network) can enhance license plate recognition accuracy, particularly in low-light and skewed angles.

Real-Time Fines and Alerts:

The system can also be extended to issue fines automatically and send violation notices to the vehicle owners automatically based on real-time database integration with regional transport authorities.

Cloud Integration and IoT:

By integrating the system to cloud platforms and IoT networks, it can provide centralized monitoring of multiple checkpoints, which empowers city-wide traffic management.

Vehicle Type Categorization:

Extending the detection model to classify vehicles by type (e.g., car, truck, motorcycle) can enable various speed limits depending on the vehicle category.

Night-Time and Weather Robustness:

The application of infrared cameras or thermal imaging technology has the capability to significantly enhance detection capability in low-visibility environments like nighttime settings, rain, or fog. Mobile Application Interface: Implementation of a companion mobile application for field officers to view real-time data on the dashboard can help improve enforcement in the field.

Deploying these future upgrades will integrate the system from a prototype to a completely deployable smart traffic enforcement system for highways and municipalities.

5. CONCLUSIONS

The project "Vehicle Overspeed Detection System Using Dual Cameras and YOLOv8" successfully demonstrates the design and development of an advanced traffic surveillance system with vehicle detection, number plate recognition, and real-time detection of over speeding events.

The system has the capability to use two cameras to calculate the overall mean speed of a vehicle over some distance, with no issues present which occur in either a single point speed measuring system or radar type measuring system. State of the art DL methodologies such as YOLOv8 for vehicle detection and Tesseract for number plate identification have been deployed to boost overall performance and accuracy of the system to a very high level. The project demonstrates it is feasible to design a low-cost and scalable overspeed detection system using the hardware solutions already at the disposal of many users by using webcams and smartphone cameras. The Streamlit dashboard provides an interactive and detailed way of monitoring live traffic violations. The system demonstrated very high accuracy and performance under stringent test conditions. Overall detection of violations was approximately 95% and license plate identification was also approximately 90%. The speed test outlined an accuracy error of 2% to 5%, thus demonstrating reliability of the system. The system achieved its aims and objectives of providing a reliable, real-time, automatic overspeed detection system that works well in both a modern urban and rural traffic environment. The project demonstrated a mechanism which is likely to serve a useful function in the future and could support more sophisticated traffic management systems.

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