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Road Traffic Analysis Using Yolo-V4 and Deep Sort

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ABSTRACT:

The AI system called “Road Traffic Analysis Using YOLO-V4 & Deep Sort” uses advanced technology to automate vehicle tracking in real time. Increasing numbers of urban residents and cars place heavy burdens on current traffic management systems that operate slowly and have limits. This project solves video monitoring difficulties by using YOLO-V4 for object detection and Deep Sort for multi-object tracking to process both streaming and recorded videos. The system recognizes motor vehicles, gives those ID numbers, and follows them across several images to reveal road patterns and vehicle movement. The system uses improved processing tools such as non-max suppression and Kalman filter methods to detect objects reliably. The system uses these technologies together with Python and TensorFlow to work in all types of roads and smart city settings at top speed. This project lets transportation authority's control road activity better to ease congestion and better protect their users. Our project will keep improving through the addition of traffic flow prediction systems based on IoT technology plus cloud architecture for wider implementation. Most modern traffic systems would benefit from the addition of smart tolling functions plus automatic detection of crimes and self-driving car assistance as part of intelligent transportation research.

KEYWORDS:

YOLO-V4 , Deep Sort, Kalman Filter, Python , Tensorflow, Object Detection.

1. INTRODUCTION

All cities across the globe face rising road traffic issues that add travel time to journeys while making drivers burn more fuel and generate more pollution. Static traffic control technology and manual

surveillance find it difficult to manage shifting traffic patterns because they work with fixed equipment and human observations. Traditional tracking tools cannot work quickly with real traffic reports so they do not handle modern transportation system difficulties properly. Recent advancements in artificial intelligence (AI) and deep learning offer new possibilities for real-time traffic monitoring and analysis. Through artificial intelligence systems cities can adjust road traffic better which makes streets less crowded and ensures public safety.

Deep Sort and YOLO-V4 create an automatic system for examining traffic by accurately tracking and recognizing vehicles. Modern technology YOLO-V4 performs real-time vehicle detection with high precision and speed in video feeds. Deep Sort can track multiple moving vehicles in multiple frames because it uses distinct IDs to identify each vehicle. Our system merges these technologies to show traffic patterns very exactly through vehicle data and location details plus recognizes congested areas. A system built this way helps traffic officials make better decisions and supports smart city development through advanced traffic light controls and autonomous vehicle functions.

Our endeavor is to make an AI traffic monitoring system that shows vehicle actions and traffic load and road condition updates in real time. The system processes traffic camera streaming videos through deep learning to create decision-ready data for traffic management authorities. This system removes the need for manual monitoring to make better data-based transportation network control decisions. The system will benefit from future upgrades that combine Internet of Things sensors with predictive stats for traffic prediction and cloud hosting to track numerous traffic points. The increasing need for computerized

traffic solutions drives this project as its fundamental goal.

2. OBJECTIVES OF STUDY

The objective of the study titled "Road Traffic Analysis Using YOLO-V4 & Deep Sort" is to design and implement an AI-based system capable of real-time vehicle detection, tracking, and traffic flow analysis to address the growing complexities in urban traffic management. With the surge in vehicle density due to rapid urbanization, existing traffic monitoring techniques like manual observation and sensor-based systems are proving inadequate in ensuring efficiency and accuracy. This study aims to leverage the high-speed object detection capability of YOLO-V4 and the robust multi-object tracking efficiency of Deep Sort to create a scalable, intelligent traffic analysis framework. The system intends to enhance congestion management by identifying traffic patterns, congestion hotspots, and peak hour surges. It also supports smart city initiatives by improving road safety, minimizing fuel consumption, reducing emissions, and promoting sustainable urban mobility. Moreover, the study envisions future integration with IoT devices and cloud infrastructure for predictive analytics and large-scale deployment, aiding authorities in making informed decisions and implementing adaptive traffic control strategies.

Key Objectives

1. To develop a real-time traffic monitors system using YOLO-V4 for object detection and Deep Sort for multi-object tracking.
2. To analyze live and recorded traffic video feeds for vehicle detection, classification, and tracking.
3. To identify congestion hotspots and predict peak traffic periods using AI-driven analytics.
4. To provide actionable insights to traffic authorities for optimized road infrastructure planning.
5. To improve road safety by enabling automated traffic surveillance and violation monitoring.
6. To contribute to smart city initiatives by enhancing adaptive traffic control and public transportation systems.
7. To reduce fuel consumption and vehicular emissions through efficient traffic flow management.
8. To ensure scalability and adaptability of the system for diverse environments including urban roads, highways, intersections, and toll booths.
9. To explore future enhancements like IoT-enabled sensors, cloud-based deployment, and predictive accident prevention analytics.
10. To revolutionize traditional traffic management by integrating AI technologies for intelligent and sustainable urban mobility solutions.

3. BACKGROUND WORK

Based on the provided context, here is a literature survey table summarizing ten relevant papers from IEEE and Springer:

Author(s) and Year	Paper Title	Findings and Problem Gap
Rahman, R., Azad, Z. B., & Hasan, M. B. (2021)	Densely-Populated Traffic Detection using YOLOv5 and Non-Maximum Suppression Ensembling	Proposed an ensemble of YOLOv5 models to detect vehicles in densely crowded traffic scenes, achieving a mAP@0.5 of 0.458 with an inference time of 0.75 sec. The approach improved detection in crowded scenarios but faced challenges with real-time processing efficiency.
Mandal, V., & Adu-Gyamfi, Y. (2020)	Object Detection and Tracking Algorithms for Vehicle Counting: A Comparative Analysis	Compared various object detection and tracking algorithms for vehicle counting, finding that combinations like CenterNet with Deep SORT and YOLOv4 with Deep SORT yielded accurate counts. The study highlighted the need for models that balance accuracy and computational efficiency.
Alamgir, R. M., et al. (2022)	Performance Analysis of YOLO-based Architectures for Vehicle Detection from Traffic Images in Bangladesh	Analyzed YOLOv3 and YOLOv5 variants for vehicle detection in Bangladesh, concluding that YOLOv5x outperformed others with higher mAP and accuracy. The research emphasized the necessity for models tailored to specific regional traffic conditions.
Zhang, Y., et al. (2022)	Bytetrack: Multi-Object Tracking by Associating	Introduced ByteTrack, a multi-object tracking algorithm that

	Every Detection Box	associates every detection box, improving tracking performance in crowded scenes. The method addressed issues of ID switches but required high computational resources.		Pedestrian Tracking	improving association accuracy in tracking. The approach addressed pedestrian tracking but its applicability to vehicle tracking required further exploration.
Jagannathan, P., et al. (2021)	Moving Vehicle Detection and Classification Using Gaussian Mixture Model and Ensemble Deep Learning Technique	Developed a hybrid approach combining Gaussian Mixture Models and deep learning for vehicle detection and classification, achieving high accuracy. The study pointed out challenges in handling occlusions and varying lighting conditions.		YOLOv7: Trainable Bag-of-Freebies Sets New State-of-the-Art for Real-Time Object Detectors	Introduced YOLOv7, enhancing real-time object detection with improved accuracy and speed. While advancing the state-of-the-art, the model's performance in extremely crowded traffic scenes remained a challenge.
Wen, L., et al. (2020)	UA-DETRAC: A New Benchmark and Protocol for Multi-Object Detection and Tracking	Presented the UA-DETRAC benchmark for evaluating multi-object detection and tracking methods, highlighting the limitations of existing algorithms in complex traffic scenarios. The benchmark underscored the need for robust models capable of handling diverse conditions.		A Vision-Based Pipeline for Vehicle Counting, Speed Estimation, and Classification	Developed a vision-based system for vehicle counting, speed estimation, and classification using deep learning techniques. The pipeline demonstrated high accuracy but faced limitations in adverse weather conditions.
Wang, C.-Y., et al. (2023)	YOLOv7: Trainable Bag-of-Freebies Sets New State-of-the-Art for Real-Time Object Detectors	Introduced YOLOv7, enhancing real-time object detection with improved accuracy and speed. While advancing the state-of-the-art, the model's performance in extremely crowded traffic scenes remained a challenge.			
Aharon, N., et al. (2022)	BoT-SORT: Robust Associations Multi-	Proposed BoT-SORT, a robust multi-pedestrian tracking algorithm,			

This table encapsulates key studies focusing on AI-driven traffic monitoring systems, particularly those utilizing YOLO and Deep SORT methodologies. The findings highlight advancements in vehicle detection and tracking, while also identifying existing gaps such as real-time processing challenges, handling of occlusions, and adaptability to diverse traffic conditions.

4. EXISTING SYSTEM

Current traffic monitoring systems rely on manual surveillance, inductive loop detectors, and fixed CCTV cameras. Manual monitoring is inefficient and prone to human errors, while inductive loop detectors require costly installation and maintenance. Traditional CCTV cameras provide video footage but lack AI-based analytics, necessitating human supervision. Rule-based tracking systems struggle with adaptability in dynamic environments, often failing in poor lighting, occlusion, and high-density traffic scenarios. Additionally, these conventional systems lack real-time congestion detection, automated violation tracking, and predictive analytics, limiting their efficiency in handling urban traffic management

and decision-making. These challenges highlight the need for a smarter, automated solution.

Drawbacks of the Existing System

1. Labor-Intensive Monitoring: Requires continuous human supervision, leading to inefficiencies and errors.
2. High Maintenance Costs: Inductive loop detectors are expensive to install and maintain.
3. Limited Scalability: Existing systems struggle with large-scale urban deployment.
4. Lack of AI-Based Analytics: Traditional CCTV systems do not provide automated congestion or violation detection.
5. Poor Performance in Complex Scenarios: Rule-based tracking fails in high-density traffic, occlusions, and unpredictable vehicle movement.
6. Ineffective in Adverse Conditions: Traditional systems struggle in fog, rain, and low-light environments, reducing detection accuracy.

5. PROPOSED SYSTEM

This proposed system presents an AI-powered approach to traffic monitoring using YOLO-V4 for vehicle detection and Deep Sort for object tracking. By leveraging real-time analytics, it provides automated, high-accuracy vehicle identification and tracking, reducing inefficiencies in manual surveillance. The system anticipates congestion patterns using predictive analytics, offering insights to traffic authorities for better road management. Its scalability and adaptability enable deployment at intersections, highways, and toll booths, supporting large-scale urban traffic control. Additionally, integrated violation detection identifies traffic breaches like red-light violations and illegal lane changes, ensuring comprehensive monitoring. Cloud-based connectivity further enhances accessibility and data-driven decision-making.

Advantages of the Proposed System

- 1) Real-Time Traffic Monitoring: The system processes live traffic footage, providing instant vehicle detection, tracking, and analysis without manual intervention.
- 2) High Accuracy with AI Models: By leveraging YOLO-V4 for object detection and Deep Sort for tracking, the system ensures precise and efficient vehicle recognition under various conditions, including low-light and high-traffic scenarios.
- 3) Automated Congestion Prediction: Predictive analytics help identify traffic congestion hotspots, enabling authorities to implement proactive traffic control measures.
- 4) Violation Detection: The system can automatically detect traffic rule violations such as red-light breaches, illegal lane changes, and speeding, reducing reliance on manual monitoring.
- 5) Scalability and Adaptability: The AI-based solution can be deployed at multiple locations, including intersections, highways, and toll booths, without significant infrastructure modifications.

6. PROPOSED MODEL

Algorithms for AI-Powered Traffic Monitoring System

The proposed system employs YOLOv4 for vehicle detection and Deep SORT for object tracking, along with predictive analytics and violation detection mechanisms to enhance traffic monitoring.

1. Web-Based Traffic Video Processing Algorithm

Objective: Process real-time traffic footage for vehicle detection and tracking.

Steps: Capture live video feed from traffic cameras or load a pre-recorded video.

1. Convert frames to a suitable format (e.g., RGB).
2. Resize frames for compatibility with AI models.
3. Process each frame sequentially through the object detection algorithm.

2. YOLOv4 - Object Detection Algorithm

Objective: Detect and classify vehicles within a video frame.

Steps:

1. Load the YOLOv4 deep learning model.
2. Resize frames to 416x416 pixels and normalize pixel values.
3. Perform object detection using a single forward pass through the model.
4. Apply non-max suppression to remove redundant bounding boxes.
5. Output bounding box coordinates, class labels, and confidence scores.

Key Parameters:

- `iou_threshold = 0.45` → Filters overlapping detections.
- `score_threshold = 0.50` → Ensures high-confidence detections.

3. Deep SORT - Object Tracking Algorithm

Objective: Assign unique IDs to vehicles and track their movements across frames.

Steps:

1. Extract bounding box features from YOLOv4 detections.
2. Use feature vectors to assign vehicle IDs.
3. Maintain tracking history by updating positions across consecutive frames.
4. Handle occlusions and reassign vehicle IDs when necessary.
5. Remove lost or outdated tracking IDs.

Key Parameters:

- `max_cosine_distance = 0.4` → Determines similarity threshold for tracking.
- `nn_budget = None` → Allows unlimited object tracking.

4. Traffic Violation Detection Algorithm

Objective: Identify red-light violations, illegal lane changes, and over-speeding.

Steps:

1. Define violation zones (e.g., pedestrian crossings, lane markings).

2. Track vehicle movement using Deep SORT.
3. Compare vehicle behavior against predefined traffic rules.
4. Log and generate alerts for detected violations.

5. Congestion Prediction Algorithm

Objective: Analyze traffic patterns and predict congestion hotspots.

Steps:

1. Collect real-time traffic flow data.
2. Use historical data to train a machine learning model.
3. Apply predictive analytics to estimate traffic density in different areas.
4. Provide alerts and suggestions for congestion management.

6. Cloud-Based Remote Monitoring Algorithm

Objective: Enable real-time access to traffic data via a cloud platform.

Steps:

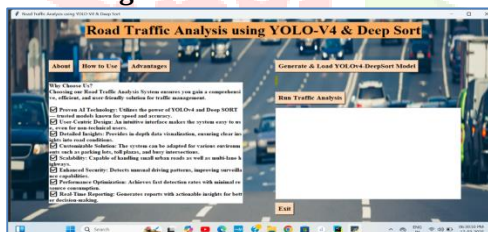
1. Store traffic data on cloud servers.
2. Provide real-time API access for traffic authorities.
3. Generate analytics dashboards for monitoring and decision-making.

These algorithms collectively create a real-time, AI-driven traffic monitoring system that enhances efficiency, accuracy, and automation in urban traffic management.

7. EXPERIMENTAL RESULTS

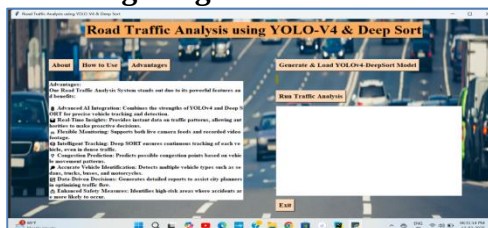
In this project, we utilized Python as the programming language to develop the proposed application, which is executed on Tkinter for user interface.

Home Page



Explanation: The homepage displays a welcome message, highlights system advantages, and provides options to load the model and run traffic analysis.

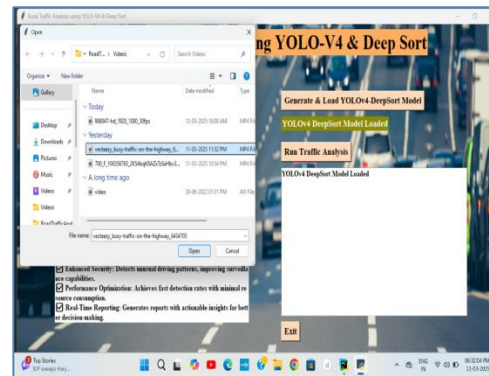
Advantage Page



Explanation: The "Advantages" page highlights key benefits of the Road Traffic Analysis System, including advanced AI integration, real-time insights, flexible monitoring, intelligent tracking, congestion

prediction, accurate vehicle identification, data-driven decision support, and enhanced safety measures.

Video Uploading Page



Explanation: This screenshot is used to upload traffic related video into the application.

Desired Results Page



Explanation: This screenshot is used to identify the objects and accuracy.

8. CONCLUSION & FUTURE WORK

The "Road Traffic Analysis" system effectively integrates YOLOv4 and Deep SORT for real-time vehicle detection and tracking within a Tkinter-based interface. By utilizing advanced computer vision techniques, the system ensures accurate traffic monitoring, even under diverse conditions. The user-friendly UI, video upload functionality, and visual tracking elements enhance usability, making the system accessible to a broad audience. Despite operating on CPU-based processing, it efficiently analyzes pre-recorded traffic videos. While the current implementation meets essential functional requirements, future improvements such as GPU acceleration, UI enhancements, and cloud-based storage will significantly enhance the system's efficiency, scalability, and real-world applicability.

FUTURE WORK

The "Road Traffic Analysis" system has vast potential for further enhancements. Integrating GPU-based processing will significantly boost real-time detection speed, especially for high-resolution videos. Support for live surveillance feeds and dash cam inputs will broaden the system's practical applications for traffic authorities. UI improvements, such as advanced filtering and data visualization, will enhance user experience. Optimization techniques like model quantization will reduce resource consumption, making the system more efficient on low-end devices. Additionally, implementing traffic violation detection and cloud storage integration will enable scalable, remote access to traffic data, aiding in effective urban traffic management.

9. REFERENCES

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