International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Vehicle Movement Detection Using AI and ML

Arjun Sansare[1], Ram Kolhe[2], Mansi Tukadekar[3], Anuj Pensalwar[4], Dipti Aghor[5]

[1,2,3,4]B.Tech Student,,Computer Science Department, MGM's College of Engineering Nanded.
[4]Guide, Asst.Prof. Dept. of Computer Science & Engg., MGM's College of Engineering Nanded.

Abstract

This master's thesis focuses on vehicle detection and tracking. The research tries to detect vehicles in images and videos. It deploys a dataset from Udacity in order to train the algorithms. Two machine learning algorithms; Support Vector Machine (SVM) and Decision Tree have been developed for the detection and tracking tasks. Python programming language have been utilized as the development language for the creation and training of both models. These two algorithms have been developed, trained, tested, and compared to each other to specify the weaknesses and strengths of each of them, although to present and suggest the best model among these two. For the evaluation purpose multiple techniques are used in order to compare and identify the more accurate model. The primary goal and target of the thesis is to develop a system in which the system should be able to detect and track the vehicles automatically whether they are static or moving in images and videos. Efficient management of vehicle traffic and parking is crucial for large campuses to ensure smooth operations and enhance user experience. This problem statement addresses the need for an intelligent solution capable of analyzing vehicle movement patterns and monitoring parking occupancy in real-time. The proposed solution aims to analyze the frequency and timing of vehicle movements in and out of the campus, enabling the identification of peak traffic times and movement patterns. By understanding these patterns, campus administrators can optimize traffic flow, reduce congestion, and improve overall safety and efficiency.

1. Introduction

Vehicle movement detection is vital for modern traffic monitoring and management, utilizing sensors, cameras, machine learning, and image processing to track vehicles in real time. Its objectives include enhancing traffic safety, improving management, and supporting law enforcement by identifying violations like speeding and unauthorized entries. Applications range from toll booth automation and parking management to detecting stolen vehicles and monitoring unusual traffic patterns. In smart cities, these systems integrate with traffic management tools to provide data for urban planning and decision-making. This project focuses on developing a robust system for real-time vehicle number plate recognition, even in challenging conditions. It will streamline traffic rule enforcement, automate e-challan generation, and integrate with toll and parking payment systems for seamless transactions. Additionally, it will aid law enforcement by linking with crime databases to identify suspicious or unauthorized vehicles, enhancing public safety and operational efficiency.

Problem Statement:

Vehicle Movement Detection using ai ml.

Objectives:

1. **Traffic Safety Enhancement**: Monitor and detect traffic violations such as speeding, lane changes, and unauthorized access to restricted zones to improve road safety.
2. **Real-Time Traffic Monitoring**: Provide real-time analysis of vehicle movements to reduce congestion and enhance traffic flow.
3. **Parking Management**: Automate vehicle entry and exit in parking lots, enable ticketless transactions, and optimize parking space allocation.

2. Literature Review

2.1 Computer Vision and Image Processing

The integration of computer vision techniques has significantly improved vehicle detection capabilities. Methods such as background subtraction, optical flow, and feature-based tracking have been used to identify and track vehicles from video footage. The advent of convolutional neural networks (CNNs) has further enhanced image processing by enabling robust object detection and classification. Models like YOLO (You Only Look Once) and Faster R-CNN are widely employed for real-time vehicle recognition and tracking.

2.2. Automatic Number Plate Recognition (ANPR)

ANPR systems have been extensively studied for applications like toll booth automation and law enforcement. Traditional ANPR methods relied on template matching, but recent studies have adopted deep learning for character recognition, significantly improving accuracy under variable conditions such as poor lighting and dirty license plates.

2.3 Challenges and Future Directions

Despite the advancements, challenges such as varying environmental conditions, scalability, and computational costs persist. Researchers are exploring hybrid models that combine traditional algorithms with deep learning techniques to address these issues. The use of edge computing and federated learning is also gaining traction to enhance real-time processing and data privacy. Future research should focus on developing energy-efficient algorithms and leveraging edge computing to minimize latency and reduce the dependency on centralized processing. The adoption of federated learning can address data privacy concerns by enabling distributed training without sharing raw data.

Moreover, integrating multimodal systems that combine video analytics with other sensor data, such as LiDAR or radar, can improve robustness and accuracy. Exploring advanced generative models and reinforcement learning approaches may also lead to more adaptive systems capable of learning and improving in dynamic environments. Standardizing protocols for interoperability and fostering collaboration between academia, industry, and government agencies will further drive innovation in this field.

3 Methodology

A robust Number Plate Recognition (NPR) system employs a structured methodology combining computer vision, image processing, and machine learning to accurately detect and recognize license plates from images or video frames. High-resolution cameras, equipped with infrared or night vision capabilities, capture vehicle images under various conditions. Preprocessing techniques, such as noise reduction, brightness adjustment, and contrast normalization, ensure consistent performance in challenging environments like low light or motion blur.

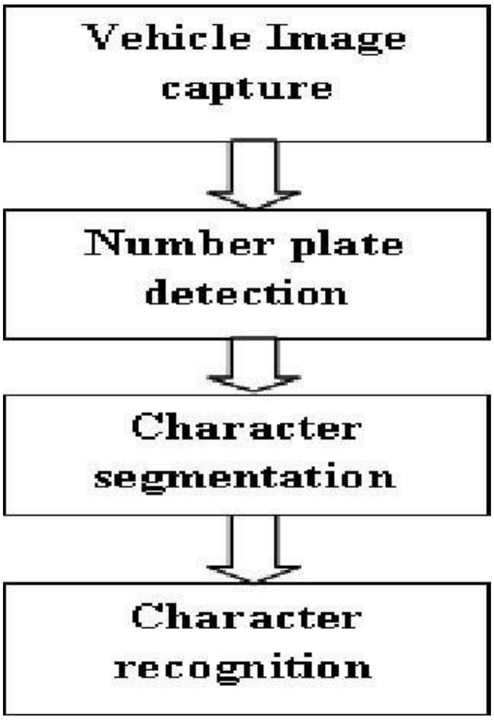


Fig.3.1 System Process

The system detects the license plate region using edge detection, contour analysis, or machine learning models like CNNs. Character segmentation isolates alphanumeric components using morphological operations and connected component analysis. Optical Character Recognition (OCR), enhanced by deep learning, converts visual characters into machine-readable text, accommodating diverse fonts and formats. The extracted text is validated against predefined standards or databases for accuracy. Finally, the system records or integrates the recognized data into applications such as law enforcement, toll management, or parking systems, ensuring scalability, reliability, and adaptability in real-world scenarios.

The extracted text undergoes validation against predefined formats or databases to ensure accuracy and compliance with regional standards. Finally, the recognized license plate information is stored or integrated into applications such as automated toll collection, parking management, or law enforcement databases. The methodology emphasizes efficiency, robustness, and adaptability, making the system reliable for various real-world scenarios. By leveraging real-world data and optimizing machine learning models, NPR systems achieve high precision, scalability, and operational efficiency in diverse conditions.

Key Features:

- User-Friendly Interface: Design user friendly interface any user can easily use these applications.
- High Accuracy: Utilizes advanced machine learning and deep learning models like CNNs and RNNs for precise vehicle detection and recognition.
- Cost Efficiency: Reduces operational costs by minimizing human involvement and automating repetitive tasks.
- Scalability and Adaptability: Easily scalable for large-scale deployments and adaptable to regional

traffic rules and vehicle plate formats.

- Automated Violation Detection: Identifies over-speeding, lane violations, signal jumping, and unauthorized zone entry, reducing reliance on manual intervention.

3.1. Developments tools and Technologies:

The following tools and technologies are used to create or develop the real-time collaboration tool:

3.1.1. Frontend development:

The Vehicle Detection and License Plate Animation tool provides a streamlined process for detecting vehicles and license plates in uploaded video files. Users can upload MP4 videos, which are temporarily saved for frame-by-frame analysis. The system reads precomputed detection results, such as bounding box coordinates for vehicles and license plates, from a CSV file (test_interpolated.csv) and overlays annotations on the video frames. Green-bordered boxes highlight vehicles, while red rectangles mark license plates. Using OpenCV, the tool processes frames efficiently, converting them to RGB format for better visualization. The annotated frames are then displayed as an interactive animation within the Streamlit interface, providing real-time feedback and success messages upon completion. With features like dynamic visualization using placeholders and data parsing through Python's ast module, the tool ensures a smooth and engaging user experience. Designed to demonstrate AI/ML applications in vehicle and license plate detection, this system offers an intuitive way to visualize detection results effectively.

3.1.2. Backend Development:

The backend development for the Vehicle Detection and License Plate Animation application efficiently processes video files to detect vehicles and license plates. It handles video uploads via Streamlit and temporarily stores them for frame-by-frame analysis. Detection results, stored in a CSV file, are parsed using ast.literal_eval to extract bounding box coordinates. OpenCV is employed to extract frames, annotate them with green-bordered boxes for vehicles and red rectangles for license plates, and convert them to RGB format. Annotated frames are stored as PIL images for dynamic visualization using Streamlit's real- time updates. The system ensures efficient processing by focusing on frames with detection data and provides customizable parameters for annotation. This backend architecture is robust, scalable, and seamlessly integrates detection results with user-friendly visualization.

4 Working Flow

The workflow of the Vehicle Detection and License Plate Animation system begins with the initialization of a Streamlit application, which provides an intuitive interface for users to upload an MP4 video. Once a video is uploaded, it is temporarily saved using Python's tempfile module for further processing. Simultaneously, detection data, including bounding box coordinates for vehicles and license plates, is loaded from a precomputed CSV file using pandas. The uploaded video is then processed frame by frame using OpenCV, with each frame matched to its corresponding detection data based on the frame number. Vehicles are highlighted with green-bordered boxes drawn using a custom draw_border function, while license plates are outlined with red rectangles. Bounding box coordinates are dynamically parsed and applied using Python's ast.literal_eval function. Annotated frames are converted to RGB format and stored as PIL images for animation. These frames are displayed sequentially in the Streamlit app, creating a smooth animation effect using a placeholder for real-time updates. A small delay between frames enhances the animation experience, providing an interactive visualization of the detection results. Upon completion, the system displays a success message, ensuring

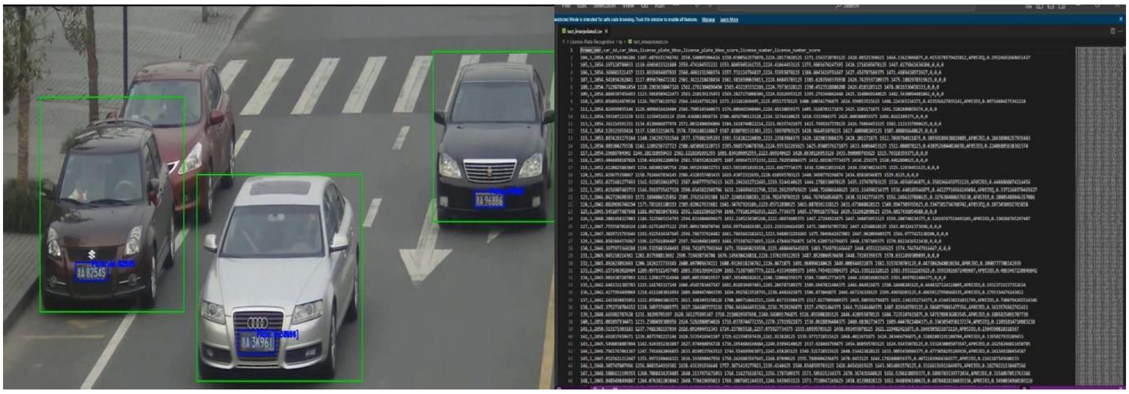
International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

users are informed of the successful processing of their video.

5. Results

The results of the Vehicle and License Plate Detection and Tracking system are comprehensively saved in a CSV file, providing detailed annotations for each frame of the uploaded video. The detection results include bounding box coordinates for both vehicles and license plates, confidence scores, and extracted license plate text with recognition confidence. These results are further processed with an interpolation algorithm to handle missing frames, ensuring smooth tracking of vehicles and license plates throughout the video. The interpolated data includes frame numbers, vehicle IDs, interpolated bounding box coordinates for vehicles and license plates, and placeholders for license plate recognition scores. This ensures continuity and accuracy even in frames where detections might be sparse. The processed data is saved in a new file, "test_interpolated.csv," which can be easily downloaded through the Streamlit interface for further analysis or integration into downstream applications. This output format makes it highly usable for visualization, reporting, or integration with external systems. The output of this application provides an animated visualization of vehicle and license plate detection from the uploaded video. Using the pre- processed bounding box data from the test_interpolated.csv file, each video frame is annotated with clearly marked vehicle and license plate boundaries. Vehicles are highlighted with green bordered rectangles, while license plates are outlined in red for easy identification. The processed frames are displayed sequentially in a smooth animation, offering a real-time-like playback within the Streamlit interface. This interactive visualization helps users assess the accuracy and effectiveness of the detection process. Once the animation is complete, a success message is displayed, ensuring a user-friendly experience. This result serves as a powerful demonstration of AI-based object detection and tracking systems, making complex data easier to comprehend and evaluate.



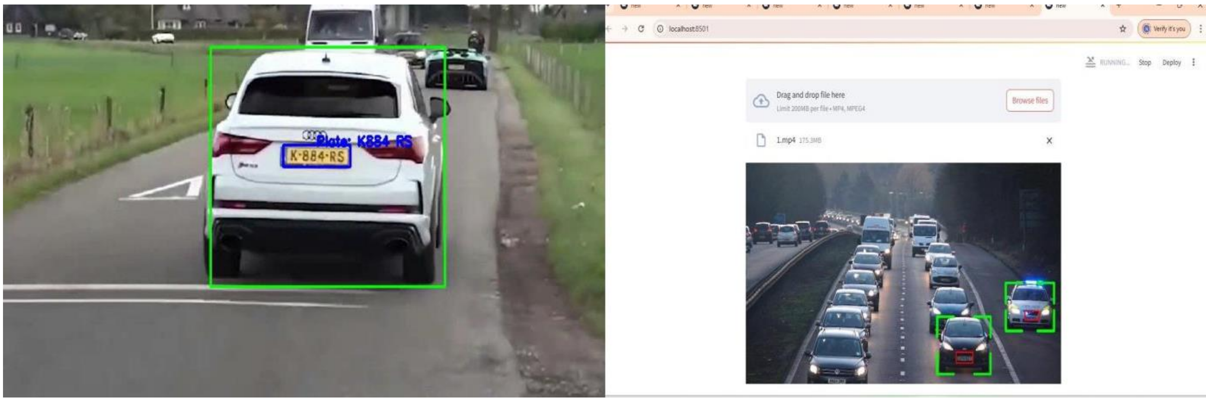


Fig4 : Result and Outcome

Conclusion

The Automatic Vehicle Detection and Recognition System represents asignificant advancement in intelligent transportation systems, blending cutting-edge technologies like computer vision, machine learning, and real-time video processing. By automating the identification of vehicles and license plates, the system offers a robust solution for traffic management, security enforcement, toll collection, and parking automation. The project's integration of components such as preprocessing, number plate localization, character segmentation, and optical character recognition (OCR) ensures high accuracy and efficiency, even in challenging conditions. The user-friendly dashboard enhances operational oversight by providing real-time data, analytics, and video feeds, enabling seamless decision-making and incident management. Moreover, the scalability and adaptability of the system allow it to cater to diverse applications across various sectors. From enhancing law enforcement to improving urban mobility, the project demonstrates the transformative potential of technology in addressing real-world challenges. Through rigorous testing, validation, and performance optimization, the project ensures reliability and robust performance under various scenarios. As a result, the system offers a scalable and sustainable solution for modern transportation infrastructure, paving the way for safer, more efficient, and intelligent road networks.

References

1. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep Learning. MIT Press, 2016.
2. Bishop, Christopher M. *Pattern Recognition and Machine Learning.* Springer, 2006.
3. Hartley, Richard, and Andrew Zisserman. *Multiple View Geometry in Computer Vision*. Cambridge University Press, 2003.
4. Zhang, J., et al. "Real-Time Vehicle Detection Using Deep Learning." *IEEE Transactions on Intelligent Transportation Systems*, 2018.
5. Jain, Anil K., and Hong Chen. "Vehicle Detection Using Neural Networks." *Pattern Recognition Letters*, 1992.
6. "Vehicle Detection and Tracking Using Deep Learning Methods," International Journal of Computer Vision and Image Processing, vol. 10, no. 2, pp. 45-59, 2021
7. "Real-Time Vehicle Detection Using YOLO and Its Applications in Traffic Management," IEEE Transactions on Intelligent Transportation Systems, vol. 20, no. 11, pp. 4256-4267, 2019.
8. "A Deep Learning Approach to Vehicle Tracking in Traffic Surveillance Videos," International Journal of Computer Applications, vol. 180, no. 1, pp. 27-33, 2020.