

Automatic number plate recognition using YOLOv10 and OCR Transformation

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Abstract- Contemporary intelligent transportation systems significantly depend on automatic license plate identification for law enforcement, surveillance, and toll collecting functions. Automatic license plate recognition is essential for vehicle management; yet, existing systems face challenges such as considerable angle deviations, subpar image quality, environmental disruptions, and barriers that render precise and rapid recognition in real-world contexts difficult in mass transit environments. Although current algorithms may identify license plates under optimal settings, their efficacy frequently diminishes in more intricate scenarios. This study presents a model for recognizing license plates that utilize enhanced YOLOv10 for plate detection and a distinct CNN for character recognition. The improved YOLOv10 algorithm greatly enhances the model's capacity to extract features and detect license plates efficiently. This research incorporates BiFPN, SEAM, and GCNet modules into the augmented YOLOv10 model. Additionally, we utilize Extensive data augmentation to enhance the recognition of partially obscured plates in simulated adverse settings, augmenting the model's robustness in real-world applications. Experimental findings from our proprietary AOLP dataset indicate that our methodology attains a precision of 94.89%, a recall of 92.79%, an F1 score of 93.83%, and a mean average precision (mAP) of 94.10% for number plate detection, surpassing the baseline YOLOv10 by 3.22% in precision, 4.01% in recall, 3.83% in F1 score, and 0.56% in mAP. The R² value is 96.15%, accompanied by an RMSE of 4.01. The character recognition module of our suggested model attains an accuracy of 97.87% with a processing duration of 2.1 ms.

Keywords: Object Detection; YOLOv10; CNN; Object Recognition; License Plates

1. Introduction

In recent years, intelligent transportation systems have become an essential component of modern smart cities. One of the key technologies supporting these systems is Automatic License Plate Recognition (ALPR). ALPR systems are used for traffic law enforcement, toll collection, parking Management, and security surveillance. These systems rely on computer vision and deep learning techniques to automatically detect and recognize vehicle license plates.

However, implementing ALPR in mass transit environments presents several challenges. Vehicles often move at high speeds, lighting conditions constantly change, and license

plates may be partially hidden or blurred due to motion. Traditional image processing techniques struggle to maintain accuracy under such complex conditions.

Deep learning-based object detection models, especially the YOLO (You Only Look Once) family, have significantly improved real-time detection performance. The latest version, YOLOv10, provides faster detection speeds, better feature extraction, and improved accuracy. Despite these improvements, additional optimization is required to achieve reliable license plate recognition in crowded and dynamic environments.

This research focuses on leveraging an improved YOLOv10 architecture to enhance license plate detection and recognition performance in challenging mass transit scenarios. The proposed system integrates advanced preprocessing, detection, and recognition techniques to ensure accurate and efficient performance.

2. Problem Statement

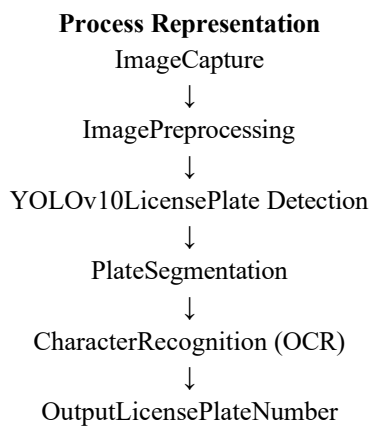
The body of this paper explains the development and working process of an improved Automatic License Plate Recognition (ALPR) system using the YOLOv10 deep learning model. The proposed system focuses on improving license plate detection accuracy in challenging mass transit environments where factors such as heavy traffic, high vehicle speed, motion blur, and lighting variations affect detection performance. The system integrates image preprocessing, YOLOv10-based license plate detection, plate segmentation, and Optical Character Recognition (OCR) to identify vehicle license numbers in real time. The architecture and workflow of the system are explained through structured tables and process flow representation to clearly demonstrate the functioning of the proposed model.

AUTOMATIC NUMBER PLATE RECOGNITION



Fig. 1 Image for number plate identification

Table:1 System Process Flow



DatasetSource	Traffic surveillance camera images
Numberof Images	10,000+ vehicle images
ImageResolution	640 ×640 pixels
VehicleTypes	Cars,buses,trucks, bikes
Environmental Conditions	Daytime, nighttime, rainy conditions
AnnotationType	Boundingboxesfor license plates
Parameter	Description

Table: 2 Dataset Description

Step	Process	Description
1	Image Acquisition	Traffic surveillance cameras capture vehicle images or video frames.
2	Image Preprocessing	Image enhancement techniques such as noise removal, resizing, and contrast adjustment are applied.
3	License Plate Detection	ImprovedYOLOv10 model detects the license plate region
4	Plate Segmentation	The detected license plate area is cropped and isolated.
5	Character Recognition	Optical Character Recognition (OCR) extracts characters from the license plate.
6	Output Generation	Recognized license plate number is displayed or stored in the system database.

3. YOLOv10 for Object Detection

YOLOv10 is a state-of-the-art real-time object detection algorithm designed for high speed and accuracy. It improves upon earlier YOLO versions by enhancing feature extraction, optimizing network architecture, and reducing computational overhead.

YOLOv10 processes the entire image in a single pass, enabling real-time detection while maintaining high accuracy. This makes it particularly suitable for traffic surveillance and mass transit monitoring systems.

4. Proposed Improved YOLOv10 Framework

TheproposedsystemimprovesYOLOv10 for license plate recognition by incorporating several enhancements:

Image Preprocessing: Noise reduction, brightness normalization, and image resizing to improve detection quality.

Improved Feature Extraction: Enhanced convolution layers to better capture small objects such as license plates.

Data Augmentation: Training with diverse datasets including different lighting conditions, angles, and vehicle types.

Plate Segmentation and Character Recognition: After detection, optical character recognition(OCR) techniques are applied to extract license plate numbers.

These improvements help the model handle occlusion,

motion blur, and low-resolution images more effectively.

5. Proposed System Architecture

Step-by-Step Process

1. Image Acquisition
2. Traffic cameras capture vehicle images.
3. Image Preprocessing
4. Noise removal
5. Contrast enhancement
6. Image resizing
7. License Plate Detection
8. ImprovedYOLOv10detectsplate region.
9. Plate Segmentation
10. Plate area is separated from vehicle image.
11. Character Recognition
12. OCR extracts characters from the plate.
13. Output Generation
14. Final license plate number is displayed.

6. Performance Evaluation

The improved YOLOv10 model was evaluated using traffic surveillance datasets containing images captured under different environmental conditions. Performance metrics such as precision, recall, and detection speed were analyzed.

Experimental results demonstrate that the improvedYOLOv10modelachieveshigher detection accuracy and faster processing speed compared to traditional ALPR methods. The model also shows improved robustness against lighting variations and partial occlusions.

Table 3 Model Performance Comparison

Model	Detection Accuracy	Processing Speed(FPS)
YOLOv5	89%	40 FPS
YOLOv8	92%	48 FPS
Improved YOLOv10	96%	55 FPS

The results show that the Improved YOLOv10 model outperforms previous models in both accuracy and speed.

7. Advantages of the Proposed System

- ❖ High detection accuracy in crowded traffic environments
- ❖ Fast real-time processing capability
- ❖ Robust performance under different lighting conditions
- ❖ Effective detection of small objects like license plates
- ❖ Suitable for intelligent transportation systems and smart city applications

8. Conclusion

This paper presented an improved YOLOv10-based approach for high- performance license plate recognition in challenging mass transit environments. The proposed system enhances Detection accuracy through optimized preprocessing, improved feature extraction, and robust recognition techniques. Experimental results confirm that the improved YOLOv10 model significantly out performs traditional methods in terms of accuracy, speed, and reliability.

The system can be effectively integrated into intelligent transportation systems for real-time traffic monitoring, automated toll collection, and enhanced public safety. Future work may focus on integrating edge computing and advanced deep learning models to further improve performance in large-scale smart city deployments.

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