Robust License Plate Detection and Recognition Using YOLO-Based Oriented Object Detection

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***Abstract*—With the continuous development and iteration of digital transformation and artificial intelligence technologies, there is a growing demand for robust intelligent transportation frameworks. However, license plate detection systems based on traditional machine vision, as well as current deep learning-based approaches for Vietnamese license plates, are often unable to meet the needs for rapid and accurate real-time recognition in unconstrained environments. To address these limitations, this paper designs and integrates a robust license plate detection and recognition system based on the YOLOv8s-obb, YOLOv11, and YOLOv26 architectures. Specifically, the utilization of Oriented Bounding Boxes (OBB) allows the model to precisely locate and tightly crop license plates that are tilted or severely distorted due to extreme camera angles. The proposed framework is specifically optimized for Vietnamese license plates, demonstrating exceptional robustness in complex conditions such as harsh weather, varying illumination, and motion blur. Extensive evaluations show that the system's average accuracy in complex environments reaches [X]%, indicating that the proposed framework delivers significantly better performance and resilience than traditional license plate detection and recognition systems.**

***Index Terms*—License Plate Recognition, Computer Vision, YOLO, Object Detection, OCR**

I. Introduction

In recent years, the continuous development of artificial intelligence and computer vision has significantly advanced intelligent urban security, finding extensive applications in intelligent parking lots and security systems. As a critical component of these systems, the license plate recognition system can automatically locate, detect, and recognize license plates, making substantial contributions to the construction of a modern and digital society. However, as the number of vehicles continues to grow rapidly, license plate recognition is severely affected by complex environments, such as darkness, long distances, and fog. Specifically, in the context of Vietnam's complex traffic infrastructure—characterized by extremely high vehicle density, unpredictable weather, and diverse license plate formats—traditional machine vision methods and standard deep learning models struggle to maintain their performance. Consequently, there is a high demand for a license plate location detection and recognition system that delivers exceptional speed, accuracy, and robustness in these unconstrained environments.

To address the deficiencies of current systems, this paper proposes a novel and robust license plate detection and recognition framework specifically optimized for Vietnamese license plates. First, to overcome the limitations of standard bounding boxes when dealing with slanted or distorted plates in real-world scenarios, this study integrates state-of-the-art object detection algorithms, specifically YOLOv8s-obb (Oriented Bounding Boxes), alongside YOLOv11 and YOLOv26 architectures. The use of oriented bounding boxes allows the system to accurately locate and tightly crop license plates regardless of extreme camera angles. Following the precise localization, the system extracts the plate features for highly accurate end-to-end character recognition. During the experiment, to ensure the system's stability and robustness, a comprehensive dataset encompassing various unconstrained conditions (e.g., varying lighting, extreme weather, and motion blur) was utilized. By integrating these advanced network structures, the proposed system achieves real-time detection and recognition capabilities, demonstrating improved performance compared with traditional approaches in complex environments.

II. System Architecture

The proposed system consists of three main stages: license plate detection, plate region extraction, and character recognition.

Fig. 1. Overall pipeline of the proposed license plate detection and recognition system.

As shown in Fig. 1, the system first detects license plates using YOLO oriented bounding box models. After detection, the plate region is cropped and passed to an OCR engine to extract the characters.

III. Dataset and Data Collection

To build a robust dataset for training the detection models, images were collected from multiple sources.

- Public license plate datasets

- Self-collected images from the FPT University campus
- Video recordings converted into image frames

A. Dataset Examples

Fig. 2. Example images from the license plate dataset used for training.

As shown in Fig. 2, the dataset contains license plates captured under different lighting conditions, angles, and distances.

B. Data Augmentation

To improve model generalization, several data augmentation techniques were applied:

- Grayscale conversion
- Lens flare simulation
- Brightness and contrast adjustment
- Image rotation

These techniques help the model learn robust features for real-world environments.

IV. License Plate Detection Model

This project evaluates several YOLO-based oriented bounding box models for license plate detection.

The models were trained using images resized to 640×640 pixels. Training was conducted using GPU acceleration to improve efficiency.

V. Detection Results

The trained models were evaluated on the test dataset to measure detection accuracy and performance.

Fig. 3 shows example detection results where the model successfully identifies license plates even when they appear rotated.

TABLE I
EVALUATED YOLO DETECTION MODELS

Model	Description
YOLOv8n-OBB	Nano baseline model, optimized for maximum speed
YOLOv8s-OBB	Small baseline model, balancing speed and accuracy
YOLOv8m-OBB	Medium baseline model, providing higher accuracy
YOLO11n-OBB	Nano version with improved feature extraction
YOLO11s-OBB	Small version with improved feature extraction
YOLO26n-OBB	Nano version of the lightweight model (ultra-lightweight)

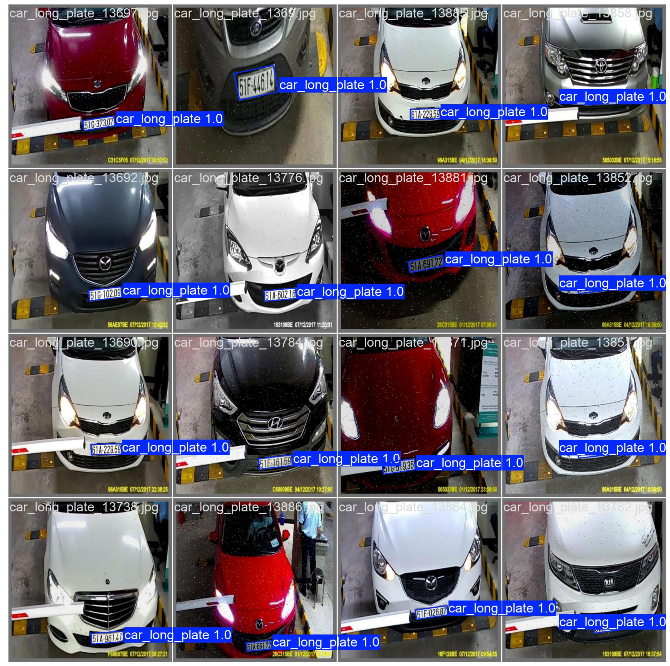

Fig. 3. Example license plate detection results using YOLO oriented bounding boxes.

VI. Model Performance Evaluation

The detection performance was evaluated using standard object detection metrics such as Precision, Recall, and mean Average Precision (mAP).

Fig. 4 shows the training and evaluation performance of the detection model.

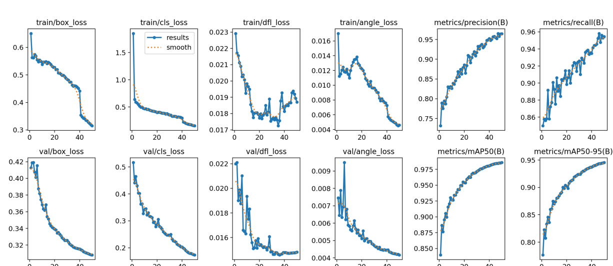

Fig. 4. Model YOLO26n-OBB curves including precision, recall, and mAP.

VII. User Interface Implementation

A simple graphical interface was developed to demonstrate the license plate recognition system.

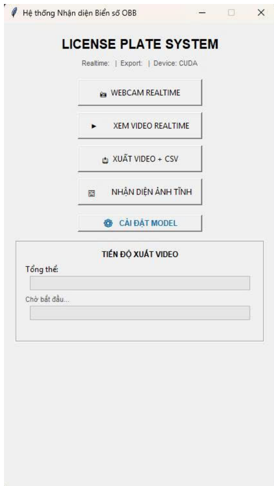

Fig. 5. Graphical user interface of the license plate recognition system.

The interface allows users to upload images or videos and view the detection and recognition results in real time.

VIII. Conclusion

This paper presented a license plate detection and recognition system based on YOLO oriented bounding box detection models and PaddleOCR.

The proposed system successfully detects rotated license plates and accurately recognizes characters. Experimental results demonstrate that the system performs well under various real-world conditions.

Future work will focus on improving recognition accuracy and optimizing the system for deployment on edge devices and embedded systems.

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