License plate recognition

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***Abstract*—License plate recognition is a crucial application in various fields, from traffic management to security. Finding an effective way to recognize license plates, especially in Vietnam, has become easier due to the availability of many methods for this problem. However, we aim to evaluate a modern framework, a state-of-the-art convolutional neural network capable of real-time object detection, called YOLO. Specifically, we want to test how effective YOLOv5m is for a wide range of tasks, including both license plate and letter detection. This method not only excels in accuracy but also offers rapid processing, making it suitable for real-time systems, despite its simple and straightforward design.**

I. Introduction

Background: License plate recognition (LPR) is a technology that automatically identifies and reads vehicle license plates from images or video footage. This technology is widely used in traffic management, parking systems, and security to monitor and manage vehicles efficiently. In many countries, including Vietnam, it is crucial for law enforcement and traffic regulation.

Challenge: There are several methods available for recognizing license plates, ranging from traditional image processing techniques to advanced machine learning models. Traditional methods, while useful, often struggle with images that are unclear or taken in poor lighting conditions. Machine learning models, especially those that use deep learning, have shown to be more effective in dealing with these challenges.

Aim: In this project, we aim to apply YOLOv5, a modern deep learning model, to solve the problem of license plate recognition. YOLOv5 (You Only Look Once version 5) is a state-of-the-art object detection model known for its speed and accuracy. We want to see how well YOLOv5 can recognize and read license plates from different images, including those with various lighting conditions and angles.

Why YOLOv5? YOLOv5 is designed to detect objects in real-time with high accuracy. This means it can quickly identify and read license plates even in a video feed. It is also straightforward to implement, making it an excellent choice for us. By using YOLOv5, we can gain valuable experience and understanding of how advanced machine learning models work.

Objectives: Our main objective is to build a system that can automatically recognize license plates from images using YOLOv5.

Structure: This project report is organized as follows: Section 2 explains the methodology and data. Section 3 presents the results of our experiments and analysis. Section 4 demonstrates the application of YOLOv5 for license plate recognition on real photos. This demonstration aims to showcase the practical capabilities of the YOLOv5 model in detecting and recognizing license plates from real-world images.

II. Proposed method

To tackle the License Plate detection and recognition problem, we propose a method that leverages the YOLOv5 model due to its superior performance in real-time object detection tasks. YOLOv5 offers a balance between detection accuracy and computational efficiency, making it suitable for our application. Our method involves two main stages: License Plate Detection and Letter Detection. Each stage utilizes a distinct dataset tailored to the specific task at hand. The proposed approach ensures efficient detection and recognition of license plates and the characters within them, providing a robust solution for real-world applications.

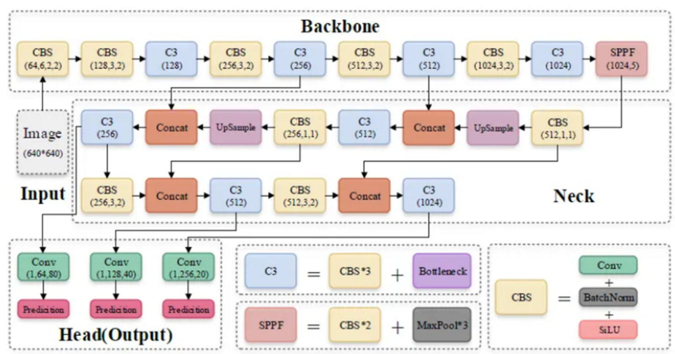

Fig. 1. YOLOv5 Model Architecture

To solve the problem of recognizing license plates, we will divide it into 2 smaller problems: License Plate Detection and Letter Detection.

A. License Plate Detection

In the first stage, the goal is to accurately detect the location of license plates in images of vehicles. This involves identifying and localizing the bounding boxes around license plates, regardless of the vehicle's orientation, lighting conditions, and background clutter.

For this task, we utilize the YOLOv5 medium (yolov5m) variant, which balances performance and computational efficiency. The input images are resized to 320x320 pixels to maintain a balance between detection accuracy and processing speed. Anchor boxes are recalculated using k-means clustering on the dimensions of the license plate bounding boxes in the training dataset. This customization ensures that the anchor boxes are well-suited to the typical sizes of license plates, improving detection accuracy. The model is configured to detect a single class (license plate), simplifying the classification task.

An example is in figure 2

Fig. 2. License Plate Detection

B. Letter Detection

In the second stage, the goal is to detect and recognize individual characters within the detected license plates. This involves localizing and identifying each character, which is crucial for accurate license plate recognition.

We continue using the YOLOv5 medium (yolov5m) variant to maintain consistency and leverage its efficiency. The input images are resized to 640x640 pixels to ensure high resolution and accuracy in character detection. Anchor boxes are recalculated using k-means clustering on the dimensions of character bounding boxes in the training dataset. This adjustment ensures the anchor boxes are optimized for detecting smaller objects like characters. The model is configured to detect multiple classes, corresponding to the different characters (letters and digits) on the license plates.

An example is in figure 3

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III. Experiment

A. Dataset

This paper utilizes two datasets:

- License Plate Detection Dataset (LPDD):
  - Purpose: Train a model to detect the location of license plates within images.
  - Size:
    - Training set: 6000 images
    - Validation set: 1500 images
  - Annotations: Bounding box coordinates enclosing the license plates.

Fig. 3. Letter Detection

  - Link dataset: License Plate Detection Dataset
- Character Detection Dataset (CDD):
  - Purpose: Train a model to detect and recognize individual characters on license plates.
  - Size:
    - Training set: 3000 images
    - Validation set: 750 images
  - Annotations: Bounding box coordinates for each character and the corresponding character label.
  - Link dataset: Character Detection Dataset

B. Evaluation Metrics

Mean Average Precision (mAP): averages the precision and recall scores for each object class to determine the overall accuracy of the object detector. Intersection over Union (IoU) measures the overlap between the predicted bounding box and the ground-truth bounding box

- Mean Average Precision (mAP): Assesses the accuracy and coverage of the detection model.
- Intersection over Union (IoU): Measures the overlap between predicted bounding boxes and ground truth bounding boxes.

IV. Evaluation

A. Plate Detection

–img 320: Input image size of 320x320 pixels. –batch 32: Batch size of 32. –epochs 30: Training for 30 epochs.

B. Character Detection

–img 640: Input image size of 640x640 pixels. –batch 32: Batch size of 32. –epochs 30: Training for 30 epochs.

C. Result analysis

- The character detection model demonstrates exceptional performance, achieving a mAP@.5 of 0.983, indicating highly accurate and reliable character recognition. However, the mAP@.5:.95 of 0.763

Class	Images	Labels	P	R	mAP@.5	mAP@.5:.95:
all	767	6236	0.976	0.974	0.983	0.763
1	767	836	0.991	0.972	0.984	0.674
2	767	541	0.996	0.991	0.994	0.798
3	767	423	0.998	0.98	0.995	0.802
4	767	425	0.993	0.993	0.992	0.752
5	767	754	0.985	0.995	0.991	0.797
6	767	428	0.993	0.986	0.994	0.796
7	767	418	0.986	0.984	0.99	0.777
8	767	373	0.984	0.981	0.992	0.78
9	767	630	0.994	0.991	0.994	0.799
A	767	64	0.955	1	0.993	0.723
B	767	153	0.967	0.963	0.986	0.787
C	767	52	0.994	0.923	0.965	0.757
D	767	56	0.914	0.929	0.936	0.731
E	767	40	0.973	1	0.995	0.808
F	767	72	0.984	1	0.995	0.776
G	767	68	1	0.976	0.995	0.71
H	767	39	0.986	0.872	0.979	0.786
K	767	34	0.989	1	0.995	0.738
L	767	42	1	0.981	0.995	0.738
M	767	60	0.932	0.907	0.972	0.776
N	767	22	0.956	0.999	0.975	0.754
P	767	34	0.995	1	0.995	0.751
S	767	40	0.972	1	0.995	0.75
T	767	33	0.985	0.97	0.994	0.783
U	767	31	0.992	1	0.995	0.788
V	767	17	0.923	0.941	0.964	0.753
X	767	26	0.996	1	0.995	0.74
Y	767	9	0.873	0.889	0.872	0.728
Z	767	55	0.998	1	0.995	0.756
0	767	461	0.992	0.991	0.99	0.793

Fig. 4. Plate Detection

Class	Images	Labels	P	R	mAP@.5	mAP@.5:.95:
all	1652	1667	0.993	0.996	0.994	0.72

Fig. 5. Character Detection

suggests that there is room for improvement in precise character localization, especially when stricter overlap criteria are applied

- The license plate detection model also exhibits strong performance with a mAP@.5 of 0.994, demonstrating reliable license plate detection. However, the mAP@.5:.95 of 0.72 indicates that there is potential for enhancing the precise localization of license plates, particularly under higher IoU thresholds.

V. Conclusion

This study developed an effective license plate recognition system comprising license plate detection and character recognition models. Both models achieved high performance on the validation set, particularly the character recognition model. However, evaluation results also indicate potential for improving localization accuracy, especially under stricter overlap criteria. Future work will focus on enhancing localization accuracy, handling challenging cases, and evaluating the system on real-world data to ensure practical applicability.

References

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TABLE I
Task Assigned

Task	Tuan Anh	Vinh Huy	Thanh Ha	Minh Hieu
Research the content and knowledge about the project	x	x	x	x
Write a report	x	x	x	x
Make a slide	x			
Train model License Plate Detection			x	
Train model Letter Detection				x
Build demo	x			
Push to Docker and server		x		