RED LIGHT VIOLATIONS DETECTION SYSTEM USING DEEP LEARNING

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Abstract: In urban environments, the detection and enforcement of red light violations are crucial for maintaining road safety and reducing traffic accidents. In this paper, we propose a Red Light Violation Detection System leveraging the YOLOv8 deep learning framework to detect violating vehicles. The proposed method is evaluated on a Dong Hoi traffic dataset and the experiment has yielded promising results with an accuracy of 93% in morning dataset. In other conditions, the results are in the range of 23%.

Keywords: YOLOv8; Red Light Violation Detection; Deep Learning

1 Introduction

Traffic signal violations, particularly red light running, pose significant risks to road safety, contributing to numerous accidents, injuries, and fatalities worldwide. According to the Vietnam Traffic Safety Committee, road traffic accidents claim over 11 thousands lives each year, with a substantial proportion resulting from non-compliance with traffic signals. These violations not only endanger the violator but also put pedestrians and other road users at severe risk.

In that context, to ensure traffic safety and minimize accidents, it is necessary to build a traffic signal violation detection system to help effectively monitor traffic and reduce incidents. Driving is potentially dangerous.

This project aims to develop an advanced Red Light Violations Detection System utilizing deep learning techniques. By leveraging the power of convolutional neural networks (CNNs), specifically the YOLOv8 (You Only Look Once, version 8) model, the system is designed to accurately detect vehicles that cross intersections against red lights. YOLOv8, known for its real-time object detection capabilities and high accuracy, is ideally suited for this application due to its efficient architecture and ability to process complex scenes quickly.

The data used to train the vehicle recognition model is extracted from traffic videos in Dong Hoi city and Ho Chi Minh city. The results obtained show that the proposed solution is a promising approach in developing automatic traffic violation detection systems with high accuracy and easy installation in practice. The layout of the article is presented as follows: Related Work, Dataset Creation, Proposed Method, Experiments, Results, Conclusion and Future Development Direction.

2 Related Work

Recently, research using image signals from surveillance cameras is being focused on development. CNNs are used for image classification and object detection tasks through the intersection to detect errors of crossing the red light stop line in [1], [2].

Xiaoling and colleagues [3] used image processing techniques such as edge separation and optical flow to detect traffic violators. In [4], spatio-semporal convolutional LSTM networks was used for racking vehicle movement and determining if a violation has occurred. Convolutional neural networks such as Faster-CNN and Single Shot Mutilbox Detector (SSD) are used in [5] to recognize traffic objects.

Evaluated on a Da Nang traffic data set [6] and used the YOLOv3 neural network to recognize violating vehicles, then giving information about the position of the vehicles identified by tracking object which can be used to classify the traffic violations.

The proposed solution uses the YOLOv8, brings significant improvements over its predecessors, including enhanced network architecture and optimized training algorithms. Building on the strengths of YOLOv8, our research aims to develop a state-of-the-art system for detecting red light violations. We will address the limitations identified in previous studies by leveraging YOLOv8's advanced capabilities in real-time object detection, providing a more accurate and efficient solution for traffic monitoring at intersections.

3 Dataset Creation

3.1 Data collection process

Our dataset is collected from two main sources:

- Vehicle images on image providers from internet.
- Video footage from traffic cameras in Dong Hoi city.

We have collected about 1500 photos with a variety of vehicles and 20 videos with different weather conditions (sunny, rainy, foggy) and times of day (morning, afternoon, night).

3.2 Data preprocess and annotation

Videos are extracted into frames every 0.5 seconds using the Vid converter tool. Then we upload all the collected images to roboflow to rotation, flipping, and noise addition are used to increase the dataset's variability and improve the model's robustness.

Polygon tool on Roboflow are used for manual segment annotation with 9 classes: bike, bus, car, motobike, truck, green_light, red_light, yellow_light, stop_line

After annotation, 2564 images in the dataset is split into training (70%), validation (20%), and test (10%) sets to develop and evaluate models.

4 Proposed Method

4.1 Proposed System

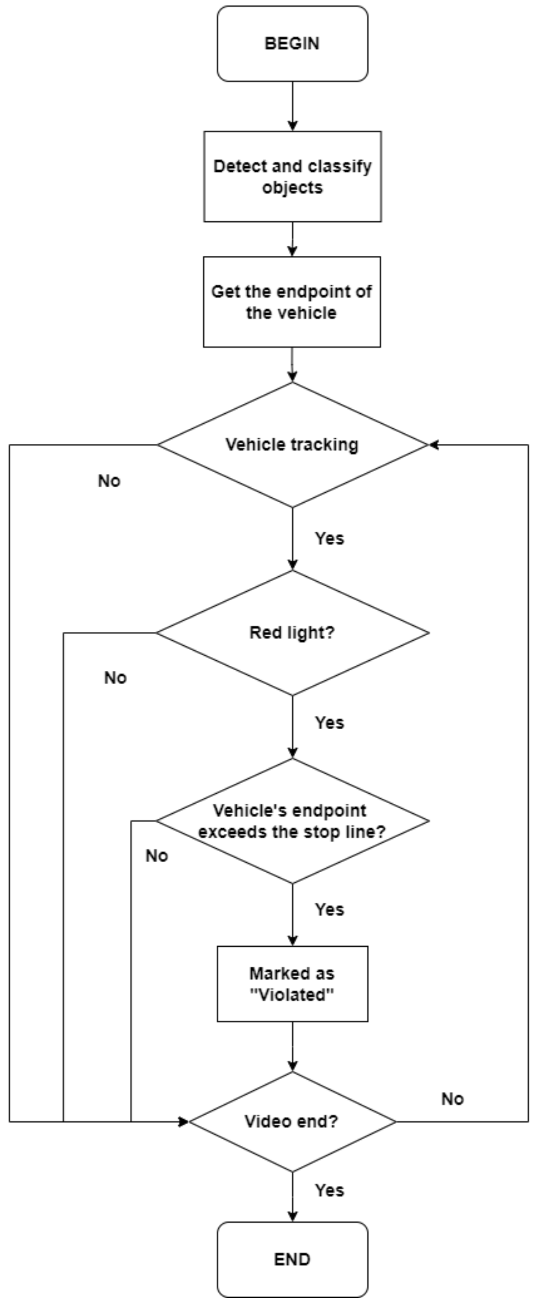

Figure 1: Proposed System

According to Figure 1, the proposed system is divided into three main stages: object detection, vehicle tracking and violation detection. The object detection phase will identify and determine the location of vehicles, traffic lights, and stop lines. The vehicle's position is determined by the endpoint of the bounding box.In the next stage, track multiple vehicle in videos by associating object detections across frames using a combination of motion and appearance information. In violation detection, based on information about the vehicle's position and the stop line, violation will be detected.

4.2 Object detection with Yolov8s

YOLOv8 is a computer vision algorithm used for object detection. YOLov8 uses a backbone network to extract features from the original image. Usually networks like Darknet or variants of ResNet help identify objects and classify them.

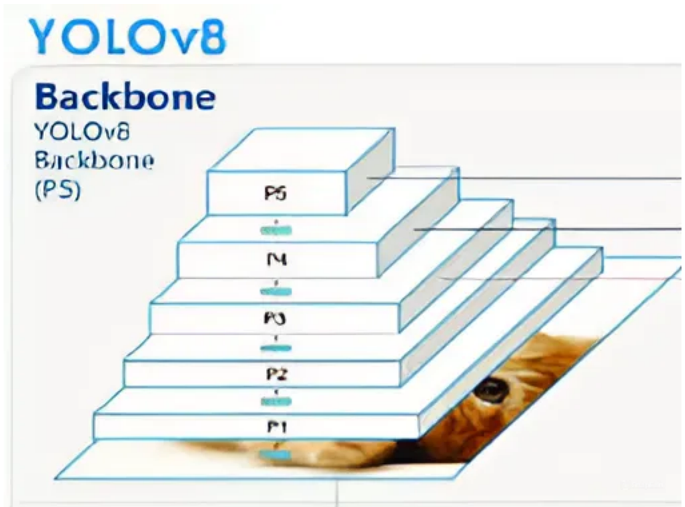

Figure 2: Yolov8 backbone network

4.3 Vehicle tracking with SORT

SORT (Simple Online Realtime Object Tracking) focuses on linking the problem between detections and post-detection follow-up from Yolov8. The two core algorithms of SORT are Kalman Filter and Hungarian algorithm. SORT proceeds to use Kalman Filter to predict new track states based on past tracks. From Yolov8, build a cost matrix for the Assignment Problem and use the Hungarian algorithm to solve the Assignment Problem. Finally, use the Kalman filter to update the detections associated with the track.

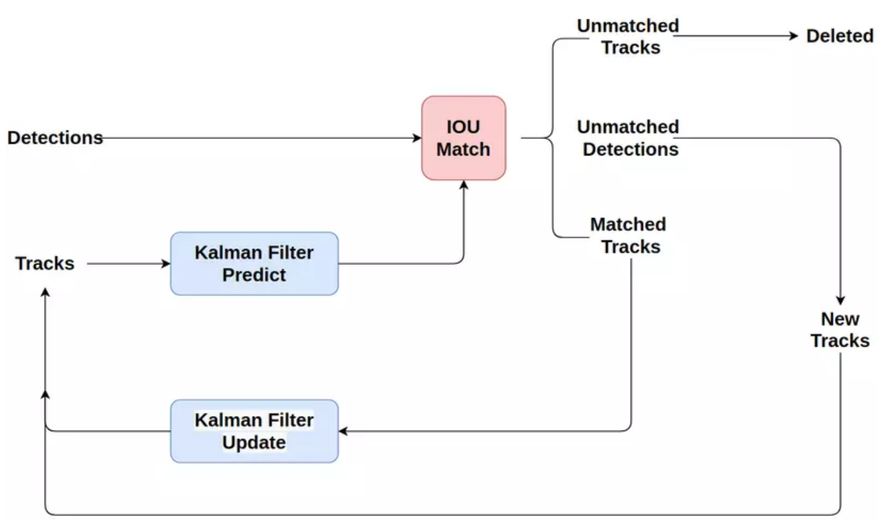

Figure 3: SORT algorithm

4.4 Violation detection

Red light signal parameters and stop line positions were detected on the Yolov8 network. The identified vehicle will have its location information extracted to determine whether the vehicle ran a red light or not. During the time the traffic light turns red, if vehicle is detected beyond the stop line, it will be marked as a "Violated".

Figure 4: Illustration of a red light violation

5 Experiments and Results

5.1 Train Yolov8 model

YOLOv8 model was trained on our annotated dataset. After adjust hyperparameters such as learning rate, batch size, and number of epochs to optimize performance.The following is the result of our trained YOLOv8 model.

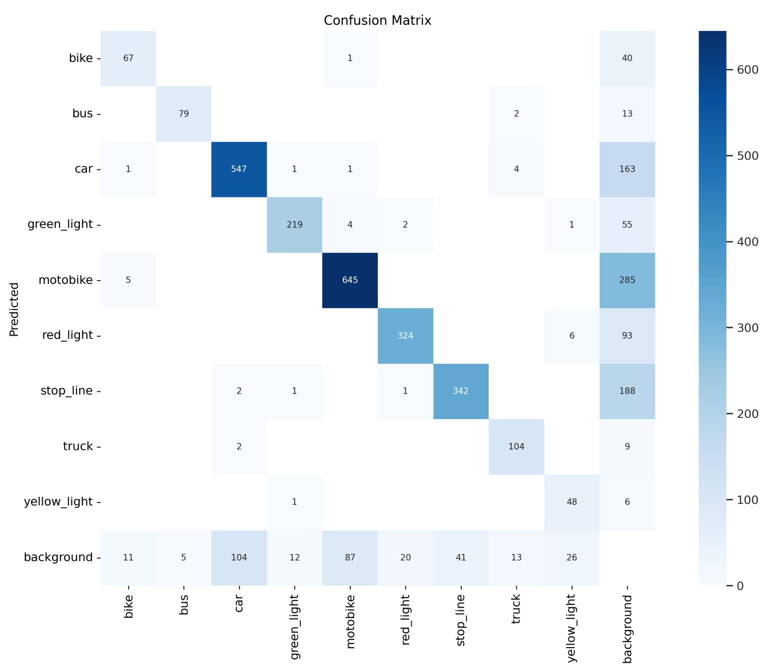

Figure 5: Yolov8 confusion matrix

	P (Precision)	R (Recall)	mAP50	mAP50-95
Box	0.836	0.83	0.878	0.644
Mask	0.784	0.788	0.826	0.545

Table 1: Yolov8 result

The model shows high precision (0.836) and recall (0.83), indicating that it is good at both identifying objects correctly and retrieving all relevant instances. A high mAP50 (0.878) and a lower but decent mAP50-95 (0.644) suggest that the model performs very well at IoU thresholds of 0.5 but less consistently as the threshold increases. Slightly lower performance in mask precision and recall compared to the overall metrics, indicating that instance segmentation is a bit more challenging for the model.

5.2 Red light violations detect model

The model was built to detect red light violations in traffic videos by using the YOLOv8 model for object detection and SORT (Simple Online and Realtime Tracking) for object tracking.

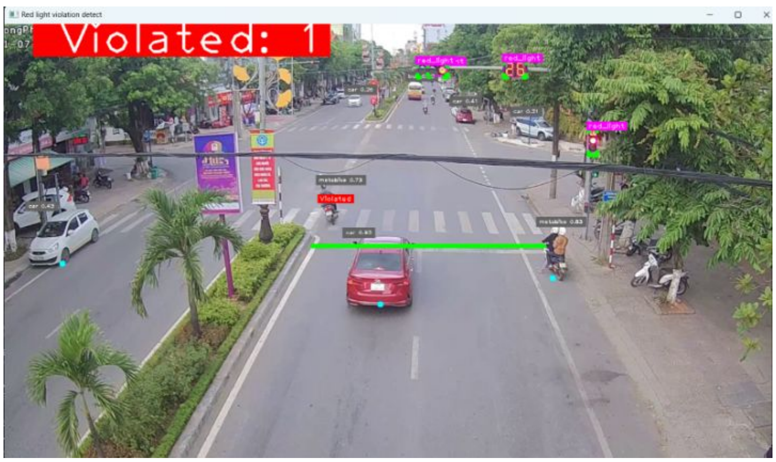

Figure 6: Red light violations detect model

On the other hand, to evaluate the model's ability to classify violations, we used many traffic violation videos in different external conditions and times. The following is the results of Red light violations detect model:

	Reality	Model	accuracy
Motobike	30	28	93%
Car	18	16	89%
Other	5	4	80%

Table 2: Morning test results

	Reality	Model	accuracy
Motobike	21	5	23%
Car	16	6	37%
Other	3	1	33%

Table 3: Night test results

From the results tables for detecting red light violations, it can be seen that the proposed model works effectively in well-lit environments. Specifically, when vehicles move during the day, with high accuracy above 80% in Table 2. In inadequate lighting conditions as in Table 3, the model's accuracy decreases.

6 Conclusion and Future Development Direction

6.1 Conclusion

Red Light Violation Detection System using deep learning shows promising results, offering a robust solution for traffic enforcement. By taking advantage of the Yolov8 model and SORT algorithm, the system can accurately detect and identify vehicles running red lights, significantly improving traffic safety and law enforcement efficiency.

6.2 Future Development Direction

Although the project has achieved some successes, there are still some shortcomings that need to be developed in the future to improve the system's capabilities and performance further:

- Improving the dataset: The dataset should include different traffic situations such as different camera views, different lighting conditions (day, night, in the rain, fog), and complexity of traffic situations (e.g. complex intersections, crowded streets).
- Handles different weather and lighting conditions: The system must operate effectively in all weather and lighting conditions, from day to night, in rain and fog.
- The data set needs to include boundary situations such as vehicles passing through intersections at high speeds, vehicles moving in the opposite direction, and difficult-to-identify situations such as ambulances or priority vehicles.

References

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