Vehicle classification and License plate Recognition Through Deep Learning Techniques

T. Prabhu[1], Prameeth D Ganiga[2], Mohammed Ayyan Ahmed[3], Srinidhi G R[4], Karthik K J[5]

[1] *Department of ECE Presidency University, Bengaluru, India, prabhu@presidencyuniversity.in*

[2] *Department of ECE Presidency University, Bengaluru, India, Prameeth.20211ECE0065@presidencyuniversity.in*

[3]*Department of ECE, Presidency University, Bengaluru, India, Mohammed.20211ECE0078@presidencyuniversity.in*

[4] *Department of ECE Presidency University, Bengaluru, India Srinidhi.20211ECE0069@presidencyuniversity.in*

[5] *Department of ECE Presidency University, Bengaluru, India Karthik.20211ECE0099@presidencyuniversity.in*

Abstract

In this study, we propose a novel method based on deep learning technology to improve the accuracy and speed of vehicle classification and automatic license plate recognition. It employs deep CNNs to analyze the visual elements of a vehicle and classify it into categories like cars, trucks, and motorcycles. To improve vehicle detection in dynamic environments, MOG2 is applied, as it provides robust performance. Moreover, a deep learning model based on OCR is applied to extract. The database includes high- and low-resolution photographs of vehicles with different registration plates containing alphanumeric characters in difficult situations such as low light conditions, direct sunlight, rain, fog, standstill traffic, covering of car plate with any object. The proposed system involves the following methods to demonstrate high accuracy in classification and recognition based on deep learning models and preprocessing stages. It is scalable and capable of real-time applications, making it a viable methodology for intelligent transportation systems.

Keywords. Deep Learning, Vehicle classification, License plate Recognitions

1. INTRODUCTION

Vehicle classification and license plate recognition are crucial for intelligent transportation (ITS) systems like toll collection, traffic enforcement, and law enforcement. The adoption of ITS is boosted by better traffic management, safety, and vehicle monitoring. Deep learning works well with large sets of raw data and generalizes well in dealing with variations in the image snapshots; hence its nature is a good fit for capturing vehicle features and classifying them with a good accuracy. Advanced OCR models also extract license plates from even the dirtiest of cars even in low lighting or occluded situations. In this study, we propose a novel deep learning-based approach with the integrated usage of CNN for vehicle classification and OCR for license plate recognition. This method increases accuracy and adaptability, laying the groundwork for future developments in Integrated Traffic Systems (ITS) [1].

2. PROPOSED METHODOLOGY

We propose novel algorithms for vehicle classification and license plate detection for a total, smooth addition to a pre-existing traffic management system. The contribution is vehicle classification and license plate detection.

A. Vehicle classifications

The data is acquired by sampling frames from the video/image. A smoothing fill renders the data set greyscale. To determine if vehicles are moving, the MOG2 background subtraction algorithm is applied. This succinctly distinguishes what's detected from a still background versus a moving object as it acknowledges the time passed

between frames for distinction and recognition of illumination/shading. Once an object is accurately detected, it is detected via a CNN. The CNN trains itself to classify the vehicle based on structure and imagery, processing rendering what kind of vehicle it is a car, truck, or motorcycle, etc shown in **figure 2.1** [2].

1.Segmentations:

- Pre-processing:
  - Convert the image to greyscale to simplify processing.
  - Apply Gaussian Blur or median filter to reduce noise.
- Foreground Extraction (Vehicle Detection):
  - Background Subtraction (MOG2) or Semantic Segmentation can be applied to identify the regions containing vehicles:
  - MOG2 (Mixture of Gaussians) can be used to separate the moving vehicle from the background [3].
- Classification:
  - Send the severed auto part to a CNN to classify it.

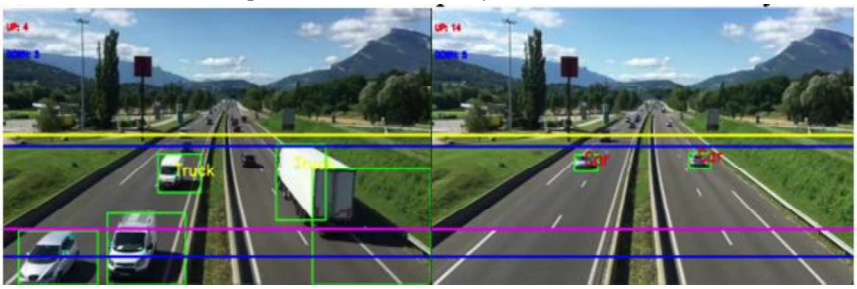

Figure 2.1. Vehicle classifications

B. License plate detections:

The first step is the license plate detection within the frame via the method of YOLO, which is best for real-time detection because of its efficiency and accuracy. After license plate detection, a cropping of the area of interest occurs within the frame, which is followed by secondary image pre-processing resizing and contrast enhancement to facilitate extraction. Once this step occurs, the next step involves OCR, which detects the alphanumeric characters on the detected license plate. Finally, for the last step, a convolutional neural network is used for precision since this works best with recognizing characters due to differing fonts, sizes, and orientations as shown in **figure 2.2** [4].

1. Segmentation:

- Vehicle Detection (First Step):
  - YOLO can be used for detecting the vehicle and license plate regions. Once a vehicle is detected, YOLO can locate the license plate within the vehicle.
  - The license plate region is typically represented by a bounding box (coordinates x, y, w, h).
- License Plate Region Extraction:
  - Bounding Box Segmentation: Use the coordinates provided by YOLO to crop the license plate area from the detected vehicle region.
- Thresholding and Binarization:

Convert the license plate area to a binary image (using Thresholding or Otsu's method): utilizing key metrics specific to classification, object detection, and text recognition tasks.

- Connected Component Analysis:
  - Segment characters from the license plate by identifying connected components. This step is essential for OCR or ResNet recognition of each character [5].

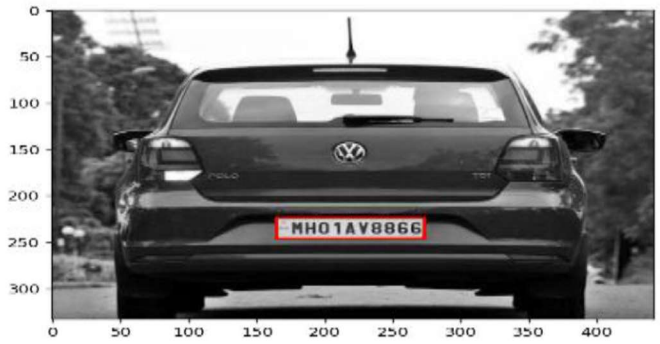

Figure 2.2. Licence plate recognition

3. PERFORMANCE EVALUATION

The performance evaluation of vehicle classification and license plate detection involves assessing the accuracy, efficiency, and reliability of the system. This is achieved by

A. Vehicle classifications:

Detailed analysis revealed that the model exhibited varying levels of accuracy for different vehicle types. For example, the model demonstrated higher accuracy for cars compared to motorcycles, potentially, due to the smaller size and more complex shapes of motorcycles.

1. Environmental Factors:

- Lighting conditions: The model's performances was influenced by varying lighting conditions.
- In low-light conditions, the model's accuracy deceased slightly, highlighting the need for robust illumination handling mechanisms.
- Camera Angle: The angle of the camera affected model performance as well [6].

B. License plate recognitions:

The license plate recognition accuracy in the plate classification portion came about because of vehicle classification being done here, i.e. CNN transfer learning.

Table 1: Average accuracy matrix

Ref No	Algorithms	Accuracy (5)	Observations
[7]	YOLO	90 – 93%	YOLO achieves high and recall detecting license plates in real-time due to its efficient object detection mechanisms. Variations in lighting or occlusion can slightly impact accuracy.
[8]	ResNet	92 – 94%	ResNet performs well in extracting robust features, even in challenging scenarios, due to its ability to handle vanishing gradients using residual blocks.
[9]-[10]	CNN	90-95%	CNN models trained on diverse license plate datasets provide reliable character recognition. Errors can occur in blurred or damaged license plates.
Proposed method	YOLO + ResNet + OCR + CNN	88-95%	This method combines the strength of YOLO, ResNet and OCR, ensuring high accuracy in detecting and

			reading license plate under various conditions.

1. Character Recognition Accuracy:

- The model demonstrated robust performance in recognizing characters from different fonts, styles, and sizes.
- The impact of factors such as character distortion, blur, and partial occlusion on character recognition accuracy was analysed [11].

2. End-to-End Accuracy:

The end-to-end license plate recognition system, which integrates vehicle detection, license plate localization, and character recognition, achieved an overall high success rate.

- The system's performance was evaluated under various challenging conditions, including varying lighting, occlusion, and camera angles.
- The impact of these factors on the end-to-end recognition rate was analyze [12].

Total of 17 different vehicles and it has detected and recognized 15 vehicles that makes the overall system accuracy 88.23%. The average accuracy matrix compared with other approaches of the license plate recognitions shown in table 1.

4. CONCLUSION

A system that classifies Vehicles and recognize plate numbers well has a combination of both Traditional approaches and Deep learning methods. In this step we implement MOG2 background subtractor as part of the feature extraction process, which reduces the irrelevant information from our images and extracts features only about the foreground (in our case, moving vehicles) from our dataset. We feed the pre- processed data to CNN which extracts features for prediction. Multi Algorithm approach to license plate recognition using YOLO, ResNet, CNN and OCR. YOLO is used because it ensures that the plate can be detected in real time, and ResNet and CNN enhance feature extraction and can manage such circumstances as changes in lighting conditions and occlusions. OCR: Last but definitely not least, OCR converts alphanumeric characters into machine-readable text.

5. REFERENCES

1. Aman Jain, Jatin Gupta, Somya Khandelwal, Surinder Kaur. “Vehicle License plate Recognitions.” practice and Applications (FPA) Vol. 4, No. 1, PP. 15-21, 2021.
2. R. Manikandan, R. Ramakrishnan.” Video object extractions by using background subtraction techniques for sport applications.” CiiT International Journal of Digital Image Processing, Vol 5, No 9, September 2013.
3. Ali Darwich, Pierre-Alexandre Héber, André Bigand, Yasser Mohanna.” Background subtractions based on a new fuzzy mixture of gaussian for moving object detection.” J. Imaging 2018,4, 92.
4. Hengiang Shi, Dongaan Zhao,” License plate recognitions system based on improved YOLOv5 and GRU.” IEE access VOLUME 11, 2023.
5. Mehak Arshid, Muhammed Raees Azam, Zhaid Mahmood.” A comparative on detection and recognitions of nonuniform license plate.” Big Data Cogn. Comput. 2024, 8(11), 155
6. K. Kishor, Ankit Shulka, Anubhav Thakur.” Vehicle classification and license plate detection using deep learning.” https://doi.org/10.1007/978-981-99-9562-2_5.
7. Budi Setiyono, Dyan Ayu Amini, Dwi Ratna Sulistyaningrum.” Number plate recognitions on YOLO – Darknet.” Journal of physics: conference series 1821 (2021) 012049.
8. Rashmita Pandey, Uday Joshi.” Deep leaning based Automatic license plate detection and extraction.” ISSN (Online) 2394-2320.
9. R. Athilakshmi, Raghav Khatoria, Subhasri Srinivasan.” Automatic number plate detection using deep learning techniques.” International Conference on Recent Trends in Data Science and its Applications. DOI: rp-9788770040723.026

10. Shefali Arora, Ruchi Mittal, Dhruv Arora, Avinash K Shrivastava.” A Robust Approach for License Plate Detection Using Deep Learning.” Inteligencia Artificial 73(2024). Dio: 10.4114/intartif. vol27iss73pp129-141.
11. Liuxu Ding, Yuefeng Liu, Qiyan Zhao, Yunong Liu.” Text Font Correction and Alignment Method for Scene Text Recognition.” *Sensors* 2024, *24*(24), 7917, dio: https://doi.org/10.3390/s24247917
12. Naaman Omar, Subhi R. M. Zeebaree, Mohammed A. M. Sadeeq, Rizgar, R. Zebari, Hanan M. Shukur, Ahmed Alkhayyat, Lailan M. Haji, Shakir, Fattah Kak.” License Plate Detection and Recognition: A Study of Review.” AIP Conf. Proc. 2834, 050045 (2023).