Detection and Recognition of Vehicle License Plates using Deep Learning in Video Surveillance

Muhammad Umer Farooq[1]*, Saad Ahmed[2], Mustafa Latif [3], Danish Jawaid[1], Muhammad Zofeen Khan[1], Yahya Khan[1]

[1]Department of Computer Science and Information Technology, NED University of Engineering and Technology, Karachi, 75270, Pakistan.

[2]Department of Computer Science, IQRA University Karachi Pakistan.

[3]Department of Software Engineering, NED University of Engineering and Technology, Karachi, 75270, Pakistan.

*Corresponding Author: Email: umer@neduet.edu.pk

Summary

The number of vehicles has increased exponentially over the past 20 years due to technological advancements. It is becoming almost impossible to manually control and manage the traffic in a city like Karachi. Without license plate recognition, traffic management is impossible. The Framework for License Plate Detection & Recognition to overcome these issues is proposed. License Plate Detection & Recognition is primarily performed in two steps. The first step is to accurately detect the license plate in the given image, and the second step is to successfully read and recognize each character of that license plate. Some of the most common algorithms used in the past are based on colour, texture, edge-detection and template matching. Nowadays, many researchers are proposing methods based on deep learning. This research proposes a framework for License Plate Detection & Recognition using a custom YOLOv5 Object Detector, image segmentation techniques, and Tesseract's optical character recognition OCR. The accuracy of this framework is 0.89.

Keywords:

YOLOv5; License plate; OCR, Image segmentation

1. INTRODUCTION

One of the major problems faced by all population classes is traffic-related problems. Incapable and incompetent transportation infrastructure is the main issue in tackling this problem, especially in third-world countries. Traffic congestion in major cities like Karachi and Lahore is a frequent phenomenon. According to various research, traffic congestion has proved to be a major hindrance to the efficiency and development of economic activities within a city. If we consider Karachi, there is no serious effort taking place by the government to tackle this issue. With the ever-increasing number of vehicles on the roads, this issue is getting worse, and congestion seems to be an unresolved issue.

With the advancement in technology during the last 20 years, vehicles have become the preferred means of travel for most people. It is becoming almost impossible to manually control and manage the traffic in a city like Karachi. In order to successfully achieve this feat, researchers and engineers from all over the world have developed algorithms and techniques. Moreover, some countries have successfully implemented these techniques, and the result they achieve is incredible. Mostly the algorithms are based on colour, texture, edge-detection and template matching. Nowadays, deep learning methods are commonly used. The methods based on convolution neural network to detect license plate and recognition of features is more efficient than the traditional method. Considering all this, this research proposes a framework for License Plate Detection and Recognition using YOLOv5 Object Detector, image segmentation techniques, and Tesseract OCR. The application accepts video as input and divides it into images with equal intervals. This helps us to manage our processing power efficiently. Then it finds license plates recognition, cropping of license plate region, utilization of the image segmentation to preprocess license plate, and by using Tesseract OCR, the text of license plate number is obtained, which can be further used in other research like bike lane implementation, stolen car tracking, and congestion control management.

This paper is comprised of the following sections. The literature review is mentioned in Section 2. Section 3 deals with the methodology for detecting and getting the numbers from the number plate, and Section 4 covers the results and validation. Lastly, Section 5 concludes the paper.

2. LITERATURE REVIEW

Traffic congestion, accidents, and traffic violations are major problems associated with rapid urbanization and development. In order to plan and manage a traffic system effectively, it is essential to accurately calculate basic traffic flow parameters. There is a lot of research in this domain. There is a lot of research

Manuscript received November 5, 2022
Manuscript revised November 20, 2022
https://doi.org/10.22937/IJCSNS.2022.22.11.17

in this domain. In order to analyze patterns of traffic and detect anomalies, a novel framework was developed for analyzing multidimensional data on road traffic. Data from different areas of the city were used to implement this framework [1]. The road occupancy is also calculated using a novel approach in another study. Under diverse environmental conditions and road conjunctions, the proposed framework performed well. A combination of shadow removal image segmentation threshold technique and technique was used [2].

H.Erdinc Kocer et al. [3] provided an artificial neural network-based vehicle license plate recognition system. There have been 259 vehicle images utilized. The CCD camera produced images. The characters on the license plate were detected and identified utilizing the Canny edge detection operator, and the characters were then separated and classed using multi-layered perceptron neural networks utilizing the ROI method and blob colouring. Similarly, Chinmaya et al. [4] suggested two different approaches. In the first, OpenCV and Python are used in a traditional manner, and then in the latter, YOLOv3 is used in a real-time application to identify and recognize license plate numbers. Their results demonstrate that the old strategy is less accurate than the YOLOv3 method. Meanwhile, Rayson Laroca et al. [5] research using cutting-edge YOLO object detection. The SSIG dataset and the UFPR-ALPR dataset were both used. Their method has a recognition rate of 78:33 percent.

Furthermore, Cheng-Hung Lin et al. [6] propose an effective vehicle detection and license plate retrieval system that first identifies cars. To improve the character recognition of hazy and obscured photos, apply convolution neural networks "YOLOv2" and SVM to recognize automobiles. Hendry et al. [7] utilized YOLO technique for the detection of license plates, and they also detected the digits of each license plate. The results demonstrate 98.22% accuracy in detecting license plates and 78% accuracy in recognizing them. Similarly, Qadri et al. [8] proposed a model that involves discovering the vehicle initially. Picture segmentation of an image is used to identify the area of the vehicle number plate. The optical character recognition technique is used to recognize characters. An actual picture is used to test the system's performance, which was developed in MATLAB. Furthermore, C. I. Patel [9] conducted a poll in which several ANPR methods were examined while taking characteristics like image size, success rate, and processing speed into consideration. Meanwhile, V. Gnanaprakash et al. [10] You Only Look Once (YOLO) is a technique for object detection that is suggested for use with automated vehicle tracking systems for fast-moving automobiles in real-time film. Video footage is first turned into pictures, then a license plate is found, and finally, the characters on the license number are identified.

Salma et al. [11] suggest using the YOLOv3 and YOLOv4 object detectors to localize the number plate location. Use Tesseract's optical character recognition (OCR) to identify the plate label. According to the results, the mAP for YOLOv3 is 94.3 percent, and for YOLOv4 it is 99.5 percent. Meanwhile, Hakan Caner et al. [12] employed video as their input, connected component labelling (CCL) methods to extract the license plate area, and then a self-organizing map (SOM) neural network to recognize the characters. Furthermore, Yongjie Zou et al. [13] present a two-stage license plate recognition technique that uses YOLOv3 to extract the license plate and the Improved License Plate Recognition Net (ILPRNET) to localize and recognize the characters on the license plate. Yonten Jamtsho et al. [13] demonstrate the YOLOv2-based real-time localization of Bhutanese license plates (LPs). The files include 1014 photos of license plates discovered in Bhutan. The results indicate a mean average precision of 98.6%. Meanwhile, Hyochang Ahn et al. [15] offer a deep learning-based automobile license plate recognition system that uses the YOLO mode to automatically identify license plates and recognize characters in complicated and varied surroundings.

Se-Ho Park et al. [16] suggest a YOLOv4-based system that combines the detection of the kind of vehicle and the license plate with the identification of the license plate's characters. The results show that mAP values of 99.3 and 99.4 percent were obtained. Also, Muhammed Sebul et al. [17] High Efficiency Video Coding (HEVC)-based compressed video sequences are used to implement the suggested technique. The YOLOv3 Tiny Object Detector is used to find LPs in a newly compressed domain LP database. Results show that the suggested method can be used for applications requiring quick searches in video archives.

3. METHODOLOGY

The proposed framework is based on YOLOv5, image segmentation operators and Tesseract OCR, i.e., an approach based on vehicle number plate detection and recognition of numbers from number plates using video sequences, as shown in Fig. 1

Data collection

Surveillance videos were recorded from the university road near FUUAST, Karachi. The video series were recorded with various ranges of distance and different time frames. The specification of the video camera used in this research is HD+ quality (1080p). The recommended quality is 4K (2160p). The framework then converted videos into frames. The detection of number

plates through frames was much easier and faster rather than using the whole video and making the process sluggish. To make the system even faster, we analyzed every third frame.

In order to make an object detector, we needed an accurately labelled dataset so that the detector could produce better results. We downloaded around 6000 license plate images from different angles to train the proposed model. We used the OIDv4 toolkit for labelling our datasets which took less time than labelling the images manually.

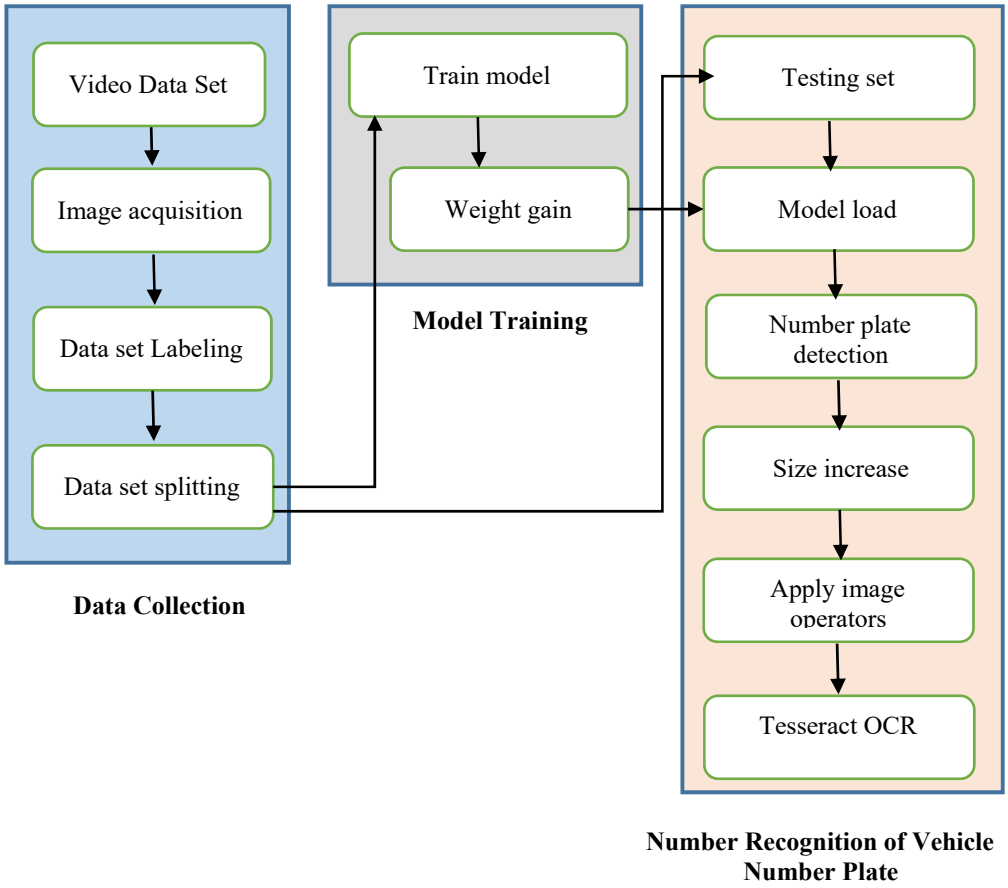

Fig. 1: Proposed Framework for vehicle number plate detection and recognition.

Model Training

The second phase of the framework is training the model. We developed a training dataset for this research that includes several license plate angles. For the training process, we give a batch size of 20 and an epoch of 50. After that, the weights for the convolutional layers of the YOLOv5 network for the training process were given to the testing model.

Optical Character Recognition (OCR) of Number Plate

In the first step, the bounding box of the number plate was obtained by applying YOLOv5. Since the size of the number plate image is small, so the size of the image was doubled from its original image. In the next step, we converted the image into greyscale and applied a high pass filter to it. This was done to have a clear difference between bright and dark regions of image features. After

that, the binary image filter was used to convert the image text into white colour and the background into black colour. Following that, morphological features were applied to further enhance the edges of the image. Next to that contour was used to sort text from left to right. It was noticed that many other contours, other than the contours of each letter of the text in the license plate, were also found. To filter out these unwanted contours Couple of parameters were employed because the only contours of interest are license plate numbers. By segmenting each sub-image and applying a "Bitwise not" mask, the image to black text on white was flipped. All steps are shown in Fig. 2. In the last step, a small median blur to the image was applied and then passed to Tesseract OCR for analysis.

Fig. 2: Different steps of OCR (a-f).

4. RESULT AND VALIDATION

This section will discuss extensive experimental results based on the proposed framework. The framework identified vehicles' registration plate numbers efficiently for different distance range tests, i.e. at 10 m, 30 m, and 50 m. also for different vehicles like bikes, cars and rickshaws. First, we consider the vehicles which are moving at a distance of 10 meters from the camera. Secondly, we consider the vehicles which are moving at a distance of 30 meters from the camera. In the final range test, we consider the vehicles which are moving at a distance of 50 meters from the camera. The framework identified its registration plate number when the vehicles were at 10 m, 30 m and 50 m distances from the camera. Overlapping or occluded vehicles are not a part of this research. All of the numbers of the vehicle's license plate are stored in the database. The results are shown in Fig. 3.We used Precision & Recall and Accuracy methods to validate our framework. The overall precision and recall were calculated by using Eq. 1 and 2. And their values were found to be 1 and 0.89, respectively. The total accuracy, calculated by Eq. 3, of our system was calculated to be 0.89.

(a) (b) (c)

Fig. 3: Detection results in real-time (a-c).

$$Precision = TP/(TP+FP) \quad (1)$$

$$Recall = TP/(TP+FN) \quad (2)$$

$$Accuracy = (TP+TN)/(TP+TN+FN+FP) \quad (3)$$

5. CONCLUSION

The detection of vehicle and license plate number recognition plays playing efficient role in the traffic management system. The ability to extract important information from a large and diverse data set requires well-organized human and machine collaboration. These systems evaluate the information from traffic videos and finally detect and recognize vehicle number plates. In this paper, a novel framework for the detection and recognition of vehicle number plates has been proposed. The purpose of this framework is the extraction of vehicles' features and recognition of the text on the vehicle number plate. The framework is in such a sequence that capturing and recognizing vehicle number plates on the road becomes efficient. Additional research work in this domain will help to develop a more effective recognition system for extensive applications.

REFERENCES

[1] Farooq MU, Khan NA, Ali MS. Unsupervised video surveillance for anomaly detection of street traffic. International Journal of Advanced Computer Science and Applications. 2017;8(12).

[2] Farooq MU, Ahmed A, Khan SM, Nawaz MB. Estimation of Traffic Occupancy using Image Segmentation. Engineering, Technology & Applied Science Research. 2021 Aug 21;11(4):7291-5.

[3] Kocer HE, Cevik KK. Artificial neural networks based vehicle license plate recognition. Procedia Computer Science. 2011 Jan 1;3:1033-7.

[4] Sahu, Chinmaya Kumar, Sushree Barsa Pattnayak, Susantini Behera, and Manas Ranjan Mohanty. "A Comparative Analysis of Deep Learning Approach for Automatic Number Plate Recognition." In 2020 Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC), pp. 932-937. IEEE, 2020.

[5] Laroca, Rayson, Evair Severo, Luiz A. Zanlorensi, Luiz S. Oliveira, Gabriel Resende Gonçalves, William Robson Schwartz, and David Menotti. "A robust real-time automatic license plate recognition based on the YOLO detector." In 2018 international joint conference on neural networks (ijcnn), pp. 1-10. IEEE, 2018.

[6] Lin, Cheng-Hung, Yong-Sin Lin, and Wei-Chen Liu. "An efficient license plate recognition system using convolution neural networks." In 2018 IEEE International Conference on Applied System Invention (ICASI), pp. 224-227. IEEE, 2018.

[7] Chen, Rung-Ching. "Automatic License Plate Recognition via sliding-window darknet-YOLO deep learning." Image and Vision Computing 87 (2019): 47-56.

[8] Qadri, Muhammad Tahir, and Muhammad Asif. "Automatic number plate recognition system for vehicle identification using optical character recognition." In 2009 International Conference on Education Technology and Computer, pp. 335-338. IEEE, 2009.

[9] Patel, Chirag, Dipti Shah, and Atul Patel. "Automatic number plate recognition system (anpr): A survey." International Journal of Computer Applications 69, no. 9 (2013).

[10] Gnanaprakash, V., N. Kanthimathi, and N. Saranya. "Automatic number plate recognition using deep learning." In IOP Conference Series: Materials Science and Engineering, vol. 1084, no. 1, p. 012027. IOP Publishing, 2021.

[11] Saeed, Maham, Muhammad Gufran Khan, Adil Zulfiqar, and Muhammad Tahir Bhatti. "Development of ANPR Framework for Pakistani Vehicle Number Plates Using Object Detection and OCR." Complexity 2021 (2021).

[12] Caner, H., Gecim, H.S. and Alkar, A.Z., 2008. Efficient embedded neural-network-based license plate recognition system. IEEE Transactions on Vehicular Technology, 57(5), pp.2675-2683.

[13] Zou, Yongjie, Yongjun Zhang, Jun Yan, Xiaoxu Jiang, Tengjie Huang, Haisheng Fan, and Zhongwei Cui. "License plate detection and recognition based on YOLOv3 and ILPRNET." Signal, Image and Video Processing 16, no. 2 (2022): 473-480.

[14] Jamtsho, Yonten, Panomkhawn Riyamongkol, and Rattapoom Waranusast. "Real-time Bhutanese license plate localization using YOLO." ICT Express 6, no. 2 (2020): 121-124.

[15] Ahn, Hyochang, and Han-Jin Cho. "Research of automatic recognition of car license plates based on deep learning for convergence traffic control system." Personal and Ubiquitous Computing (2021): 1-10.

[16] Park, Se-Ho, Saet-Byeol Yu, Jeong-Ah Kim, and Hyoseok Yoon. "An all-in-one vehicle type and license plate recognition system using YOLOv4." Sensors 22, no. 3 (2022): 921.

[17] Beratoğlu MS, Töreyin BU. Vehicle license plate detector in compressed domain. IEEE Access. 2021 Jun 28;9:95087-96.