Intelligent license Plate Recognition System

Abdul Ahad, M. Saleem Vighio, Muhammad Mudasir, Amir Rasheed Shaikh, Munawar Ali
Department of Computer Science Quaid-e-Awam University of Engineering Science & Technology Nawabshah, Pakistan
*Correspondence: abdulahadarain029@gamil.com, saleem.vighio@quest.edu.pk, muhammadmudasirmps@gmail.com, shykhsahab35@gmail.com, munwaralichandio2021@gmail.com

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Since the 19th century, the number of vehicles has been increasing rapidly with the growth of the human population. To supervise vehicles, license plates are used all over the world. The license plate is the unique identity for vehicles; that's why it is always used to monitor and keep records of vehicles by law enforcement, border monitoring, parking control, and many other applications. Monitoring a huge number of vehicles is a difficult task using traditional (manual) methods. The Intelligent License Plate Recognition (ILPR) system overcomes these problems by recognizing plate identities without human involvement through artificial intelligence and machine learning processes. This system extracts the identity number allocated to each vehicle from the license plate and can provide information about a specific vehicle. It can be further applied in regulated zones such as military areas, parking control, toll collection, and for identifying non-tax-paid vehicles. For developing the ILPR system, text extraction and deep learning techniques must be combined.

The ILPR system, developed by integrating Deep Learning (DL), Image Processing (IP), and image-to-text extraction approaches, is used to detect plate identity. YOLOv8 is used for object detection and the OCR engine for text extraction. The system will be capable of detecting live license plates with high accuracy, which will help in regulated zones and traffic system applications.

Keywords: Vehicles, Lp, Monitoring, Ilpr, Identity, Parking Control.

Introduction:

Humans have always sought automatic and human-independent problem-solving methods for accurate and error-free systems. The number of vehicles on roads is increasing daily as global economic growth and industrialization are peaking. Roadways are the primary means of transportation—even when using sea routes or air facilities, the journey often begins on the road from homes or industries. Seaports, which are the most dominant and cost-effective mode of transportation, also depend on roads to transport goods for intercontinental needs. Therefore, monitoring roads and resolving vehicle identification issues are key reasons for the development of automatic license plate recognition systems. Each vehicle on the road has a unique identification detail represented by its license plate [1]. This identity plays a vital role in establishing a connection with the vehicle's owner and in switching data. Thus, images are regularly used as the primary method for identifying vehicles. Moreover, images are widely embedded in most domains of human life. Therefore, automated management and extraction of license plate information from images has emerged as an effective tool for monitoring public transportation [2][3].

Human-based vehicle identification can be resolved through automated license plate recognition systems. ALPR is used for vehicle recognition across different domains such as E-toll collection, airports, seaports, parking management, highways, and identifying non-tax-paid vehicles. It also plays a critical role in recovering stolen vehicles. Recent advancements in parallel processing and deep learning have supported many computer vision domains, including object detection and optical character recognition (OCR) [4]. ALPR does not rely on humans, reducing dependency on manual labor and minimizing time-consuming identification processes. By capturing plate data and matching it with databases, stolen vehicles or individuals involved in traffic offenses can be tracked.

The automatic number plate recognition system has been developed in multiple technological countries like India [5][6], Australia [7][8], Malaysia[8][9], The United States [10][11][12], Iran, and Bangladesh[13][14] but existing research on ANPR systems for Pakistani vehicles is to limtited[15][14][16].

To bridge this gap this research introduces a new ANPR framework specially designed for Pakistani license plates which is less time-consuming for existing frameworks as mentioned in [17] with more accurate results and more images are used to train the model for accuracy and higher accurate results. Our research is not only a framework but it also gives a higher result section.

The proposed system combines the deep learning object detection algorithm YOLOv8 for vehicle and license plate detection with Easy OCR for character recognition. Once a license plate is detected, Easy OCR extracts the optical text and returns the plate identity by separating the number plate content into text format.

Literature Review:

The development of automatic license plate recognition began in the 1970s in the UK, initiated by the police development branch. The early design was a collaboration between two UK-based companies—Computer Recognition Systems and EMI Electronics. Significant advancements in license plate detection emerged after 1990 with the development of reliable and modern technologies. License plate detection and recognition have since become major research areas, enabling various vehicle monitoring methods and applications.

One influential technology, as discussed in [18], uses deep neural networks for license plate detection in images. After identification, the license plate undergoes preprocessing and is then recognized using the LSTM Tesseract OCR engine. In a study

by Kasaei [19], a real-time LP detection and recognition system was developed using morphological operations and template matching. Another method, proposed by Serkan O [20], utilizes edge detection and smearing algorithms for LP extraction. Research by Netaji Subhash [21][22] introduced an LP recognition model based on the YOLOv5 object detection algorithm. However, YOLOv5 had limitations in small object detection and contextual understanding in dense environments, especially the trade-off between speed and accuracy. While working on Pakistani license plates there is limited work that exists one implemented approach is done by Muhammad Gufran Khan [23] by using YOLOv3 and YOLOv4 with the help of KNN and LSTM OCR. YOLOv8 achieves high accuracy and overcomes these issues, making it suitable for real-time applications.

In the proposed work, an advanced system for LP detection and recognition is presented, leveraging Deep Learning (DL) and Image Processing (IP) technologies to achieve a more precise and intelligent solution. This system integrates state-of-the-art techniques to enhance the speed and accuracy of real-time LP detection and recognition, making it highly effective for applications such as traffic monitoring, surveys, and related tasks.

Methodology:

The proposed methodology focuses on building a real-time license plate identity detection system called the "Intelligent License Plate Recognition System." The system will be capable of detecting license plate identity numbers from both pictures and live video streams.

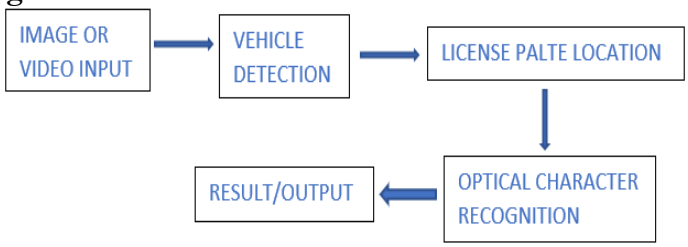
Technology Used YOLOv8:

YOLO (You Only Look Once) is a deep-learning object detection algorithm used in computer vision. It will be used for license plate detection. The YOLOv8 model is a reliable version that can detect license plates quickly in both images and videos.

Optical Character Recognition (Easy OCR):

Easy OCR is a Python-based optical character recognition library that will be used to extract the number plate identity. It separates the text from the license plate and returns the plate number after processing.

Methodology Diagram:



Flow of Study

Image/Video Input:

The system accepts input from either static images or live video streams, which serve as the raw data for license plate detection.

Vehicle Detection:

If required, the system first detects vehicles within the input frame using YOLOv8 to narrow down regions of interest (ROIs) where license plates are likely to be located.

Location of the License Plate:

To correctly detect and parse the license plate region from the detected vehicle or even from the input frame directly, YOLOv8 is used. This technique provides accurate bounding box coordinates around the plate.

EasyOCR:

Abbreviation for optical character recognition translates the visible information into a machine-readable license plate identity by examining the segmented characters to read and extract the alphanumeric text.

Result/Output:

The system immediately yields the recognized license plate number, which can then be used for a number of purposes (e.g., automatic collection of tolls or security checks) or shown on a display or entered into a database.

Dataset:

We use our own dynamically captured data set of 100 images in different environmental conditions and 200 plain images. To train the model and evolution of it.one open source data set from https://www.kaggle.com/datasets/zakirkhanaleemi/pakistani-car-number-plates-data to make our model more efficient which has 104 different types of Pakistani license number plates having various formats of number plates in terms of size, fonts, plate color, and practical in different regions of Pakistan.

Model Training:

The test procedure for the Intelligent License Plate Recognition (ILPR) system was carefully designed to comprehensively test its performance on multiple parameters. The system was tested using a diversified dataset of 100 dynamically captured images captured under various conditions, and 200 static images. It was enhanced further by using an open-source dataset available on Kaggle, consisting of 104 Pakistani license plates having different formats, sizes, and fonts. The analysis focused on precision, recall, F1 score, and mean average precision (mAP@0.5) to estimate detection accuracy. YOLOv8 registered a precision rate of 89%, a recall rate of 87%, and an F1 score of 88%, demonstrating high performance in license plate detection. The mAP@0.5 score of 74% also validated the model's ability to detect plates accurately. In addition, the processing speed of the system was evaluated to ensure its usability in live situations, with the results showing effective performance that is ideal for live video streaming. The measurement of these parameters collectively offered an extensive analysis of the system's effectiveness and reliability for real-world applications.

Results:

The proposed new ILPR system addresses the limitations of existing solutions in the most critical areas, especially for Pakistani plates. Previous methods such as those that involve YOLOv3 and YOLOv4 combined with KNN and LSTM OCR, as presented in earlier research by Muhammad Gufran Khan [23], were less accurate and slower. On the other hand, the combination of YOLOv8 and EasyOCR within the ILPR system significantly negates these shortcomings with enhanced accuracy (89%) and recall (87%), together with enhanced contextual perception in high-density environments. Compared to template matching and morphological processing applied in studies like those by Kasaei [19] and Ozbay [20], the ILPR system employs sophisticated deep learning methods to more effectively manage variability in plate size and environmental conditions. The fact that the system utilizes a larger and more diverse dataset to learn also enhances its generalization ability, which differentiates it from other past frameworks, which utilized smaller or less diverse datasets. All these enhance the ILPR system as a better choice for real-time Pakistan and other comparable countries' license plate recognition.

One another similar test was conducted on another data set which has more dynamic and worst condition images which is available at https://github.com/iAhsanJaved/Pakistani-License-Number-Plates-Data-Set/tree/master/Cars.

Manually captured images were also tested in this test. Its results are also the same as the results given below.

Detection metrics with YOLO:

The YOLO-based detection system attained a precision of 89% a recall of 87% and an F1 score of 88% in detecting and locating the vehicle number plates in images.

precision	recall	mAP0.5
0.89	0.87	0.74

Results Pictures:

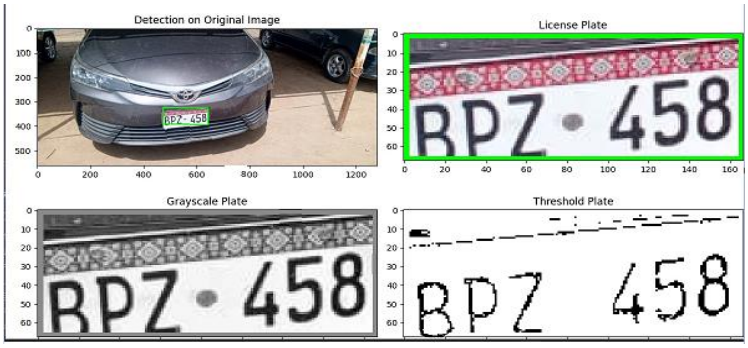


Figure 1. License plate detection and preprocessing steps for character recognition.

As we can see first of all the license plate is detected from the image and then the ILPR system converts it into a gray plate to standardize it and then with OCR desired result is caught.

Gray Plate: Converting the license plate to grayscale enhances contrast, making the characters "BPZ - 458" clearly readable against a mid-tone background.

Extracted Text: The OCR process accurately identifies the license plate number as "BPZ - 458" for both grayscale and threshold images.

Accuracy: The consistent detection across different processing steps (original, grayscale, and threshold) confirms the reliability of the extracted text.

Figure 2. License plate detection and enhancement steps for a Kuwaiti vehicle.

2nd image shows the output for non-Pakistani number plates which is an 8-digit English + Arabic alphabet

This shows the diversity of the ILPR system in that it is applicable to Pakistani number plates and not Pakistani number plates.

Discussion and Comparison with Existing Studies:

The proposed Intelligent License Plate Recognition (ILPR) system, based on YOLOv8 for detection and EasyOCR for text extraction, demonstrates significant enhancement over current methods, particularly in the case of Pakistani license plates. The following is an exhaustive discussion contrasting the results of this research with existing works:

Table 1: Comparative Analysis of Proposed ILPR System (YOLOv8 + EasyOCR) with Existing YOLO-based License Plate Recognition Approaches

Aspect	Proposed ILPR System (YOLOv8 + EasyOCR)	YOLOv3/YOLOv4 + KNN/LSTM	YOLOv3/YOLOv4 + KNN/LSTM	YOLOv5-based Systems
Accuracy	89% precision, 87% recall, 88% F1	80-85% accuracy	75-82%	Accuracy Similar to YOLOv8 but lower mAP for small plates
Detection Model	YOLOv8 (improved small-object detection)	YOLOv3/YOLOv4 (limited small-object handling)	Morphological ops / Edge detection	YOLOv5 (speed-accuracy trade-offs)
OCR Method	EasyOCR (lightweight, fast)	LSTM-based OCR (slower)	Template matching (error-prone)	Varies (often Tesseract, slower)
Dataset Diversity	304+ images (dynamic + static + open-source)	Smaller datasets	Limited datasets	Moderate datasets
Robustness	Handles lighting, distortions, and fonts	Struggles with complex backgrounds	Fails under noise/occlusion	Moderate, but struggles in dense traffic
Real-Time Performance	Optimized for live video streams	Slower due to older YOLO + LSTM OCR	Not real-time	Faster than YOLOv3 but slower than YOLOv8
Key Advantages	Higher accuracy, speed, and generalization	Baseline for Pakistani plates	Simple implementation	Balanced speed/accuracy
Limitations	May need edge-device optimization	Lower accuracy & speed	Poor generalization	Small-plate detection issues

Conclusion:

The ILPR system will contribute an innovative for recognizing license plate identities by combining advanced machine learning approaches, especially YOLOv8 for vehicle detection and EasyOCR for character recognition. ILPR will offer a reliable and cost-effective real-time solution with minimal or no human involvement. This system can be further utilized in real-world traffic-related applications and will be helpful developing effective traffic monitoring systems and strengthening regulated zones.

References:

[1] S. Mehtab and J. Sen, "Stock Price Prediction Using CNN and LSTM-Based Deep Learning Models," *2020 Int. Conf. Decis. Aid Sci. Appl. DASA 2020*, pp. 447–453, Nov. 2020, doi: 10.1109/DASA51403.2020.9317207.

[2] H. M. Hanxiang Wang, Yanfen Li, L.-Minh Dang, "Robust Korean License Plate Recognition Based on Deep Neural Networks," *Sensors*, vol. 21, no. 12, p. 4140, 2021, doi: https://doi.org/10.3390/s21124140.

[3] Hoanh Nguyen, "An Efficient License Plate Detection Approach Using Lightweight Deep Convolutional Neural Networks," *Adv. Multimed.*, 2022, doi: https://doi.org/10.1155/2022/8852142.

[4] M. T. Javier Villena Toro, Anton Wiberg, "Optical character recognition on engineering drawings to achieve automation in production quality control," *Front. Manuf. Technol*, vol. 3, 2023, doi: https://doi.org/10.3389/fmtec.2023.1154132.

[5] S. Shah, N. Rathod, P. K. Saini, V. Patel, H. Rajput, and P. Sheth, "Automated Indian Vehicle Number Plate Detection," *Adv. Intell. Syst. Comput.*, vol. 742, pp. 453–461, 2019, doi: 10.1007/978-981-13-0589-4_42.

[6] L. G. C. Hamey and C. Priest, "Automatic Number Plate Recognition for Australian Conditions," *Digit. Image Comput. Tech. Appl. (DICTA'05), Queensland, Aust.*, pp. 14–14, Oct. 2006, doi: 10.1109/DICTA.2005.17.

[7] H. N. Tran and T. Nguyen, "Supervised learning method for mobile international number plate recognition," *ACM Int. Conf. Proceeding Ser.*, vol. 04-06-December-2014, pp. 212–216, Dec. 2014, doi: 10.1145/2684200.2684307;PAGEGROUP:STRING:PUBLICATION.

[8] W. W. Keong and V. Iranmanesh, "Malaysian automatic number plate recognition system using Pearson correlation," *ISCAIE 2016 - 2016 IEEE Symp. Comput. Appl. Ind. Electron.*, pp. 40–45, Sep. 2016, doi: 10.1109/ISCAIE.2016.7575034.

[9] O. Hommos, A. Al-Qahtani, A. F. A. Al-Zawqari, F. Bensaali, A. Amira, and X. Zhai, "HD Qatari ANPR system," *2016 Int. Conf. Ind. Informatics Comput. Syst. CIICS 2016*, Apr. 2016, doi: 10.1109/ICCSII.2016.7462420.

[10] Y. P. Huang, S. Y. Lai, and W. P. Chuang, "A template-based model for license plate recognition," *Conf. Proceeding - IEEE Int. Conf. Networking, Sens. Control*, vol. 2, pp. 737–742, 2004, doi: 10.1109/ICNSC.2004.1297038.

[11] B. Diaz Acosta, "Experiments in Image Segmentation for Automatic US License Plate Recognition," *Virginia Tech*, 2004, [Online]. Available: https://vtechworks.lib.vt.edu/items/88b162d8-5691-42d5-a31a-6f0a3f46613c

[12] S. M. M. K. and S. A. M. S.H. Mohades Kasaei, "A Novel Morphological Method for Detection and Recognition of Vehicle License Plates," *Am. J. Appl. Sci.*, vol. 6, no. 12, pp. 2066–2070, 2009, [Online]. Available: https://www.thescipub.com/abstract/10.3844/ajassp.2009.2066.2070

[13] P. Dhar, M. Z. Abedin, R. Karim, Fatema-Tuj-Johora, and M. S. Hossain, "Bangladeshi license plate recognition using adaboost classifier," *2019 Jt. 8th Int. Conf. Informatics, Electron. Vision, ICIEV 2019 3rd Int. Conf. Imaging, Vis. Pattern Recognition, icIVPR 2019 with Int. Conf. Act. Behav. Comput. ABC 2019*, pp. 342–347, May 2019, doi: 10.1109/ICIEV.2019.8858580.

[14] S. A. Haider and K. Khurshid, "An implementable system for detection and recognition of license plates in Pakistan," *ICIEECT 2017 - Int. Conf. Innov. Electr. Eng. Comput. Technol. 2017, Proc.*, May 2017, doi: 10.1109/ICIEECT.2017.7916553.

[15] N. Saleem, H. Muazzam, H. M. Tahir, and U. Farooq, "Automatic license plate recognition using extracted features," *2016 4th Int. Symp. Comput. Bus. Intell. ISCBI 2016*, pp. 221–225, Nov. 2016, doi: 10.1109/ISCBI.2016.7743288.

[16] J. A. Khan, M. A. Shah, A. Wahid, M. H. Khan, and M. B. Shahid, "Enhanced car number plate recognition (ECNPR) system by improving efficiency in preprocessing steps," *Int. Conf. Commun. Technol. ComTech 2017*, pp. 156–161, Oct. 2017, doi: 10.1109/COMTECH.2017.8065766.

[17] B. Sachin Prabhu, S. Kalambur, and D. Sitaram, "Recognition of Indian License Plate number from live stream videos," *2017 Int. Conf. Adv. Comput. Commun. Informatics, ICACCI 2017*, vol. 2017-January, pp. 2359–2365, Nov. 2017, doi: 10.1109/ICACCI.2017.8126199.

[18] J. Singh and B. Bhushan, "Real Time Indian License Plate Detection using Deep Neural Networks and Optical Character Recognition using LSTM Tesseract," *Proc. - 2019 Int. Conf. Comput. Commun. Intell. Syst. ICCCIS 2019*, vol. 2019-January, pp. 347–352, Oct. 2019, doi: 10.1109/ICCCIS48478.2019.8974469.

[19] S. H. Kasaei, S. M. Kasaei, and S. A. Kasaei, "New Morphology-Based Method for RobustIranian Car Plate Detection and Recognition," *Int. J. Comput. Theory Eng.*, pp. 264–268, 2010, doi: 10.7763/IJCTE.2010.V2.150.

[20] S. L. Prasun Gokhlani, Ridhi Jhamb, "Automatic Vehicle Identification by Plate Recognition," *Int. Res. J. Eng. Technol.*, vol. 8, no. 7, 2021, [Online]. Available: https://www.irjet.net/archives/V8/i7/IRJET-V8I7128.pdf

[21] M. Pradyut Agrawal, Akshansh Jha, Ravneet Kaur, Anju Agrawal and Bhattacharya, "Automatic License Plate Detection and Recognition using Deep Learning and Image Processing," *Div. Electron.*, 20214, [Online]. Available: https://ceur-ws.org/Vol-3682/Paper1.pdf

[22] S. U. Rehman, M. Ahmad, A. Nawaz, and T. Ali, "An Efficient Approach for Vehicle Number Plate Recognition in Pakistan," *AACE Clin. Case Reports*, vol. 7, no. 1, p. 1, Jun. 2021, doi: 10.2174/1874061802006010012.

[23] M. T. B. Salma, Maham Saeed, Rauf ur Rahim, Muhammad Gufran Khan, Adil Zulfiqar, "Development of ANPR Framework for Pakistani Vehicle Number Plates Using Object Detection and OCR," *Complexity*, 2021, [Online]. Available: https://onlinelibrary.wiley.com/doi/10.1155/2021/5597337