e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:06/Issue:11/November-2024 Impact Factor- 8.187 www.irjmets.com

VEHICLE NUMBER PLATE RECOGNITION

Nitish Naik*1, Akash Shahane*2, Tanmay Tharkude*3,
Tushar Pathak*4, Jadhav Ganesh D*5
*1,2,3,4,5Department Of Computer Engineering, (SKNCOE- Vadgaon), SPPU Pune, India.

DOI: https://www.doi.org/10.56726/IRJMETS63991

ABSTRACT

With the country's rapid economic growth, the increasing number of vehicles on the road has led to escalating traffic-related issues, including accidents and frequent violations of traffic laws. Efficient traffic management has become essential to mitigate these issues and enhance road safety.

Intelligent systems, such as those using Convolutional Neural Networks (CNNs), offer promising solutions for traffic monitoring and management. Among these, a license plate detection and recognition system has emerged as a viable approach, capable of automatically identifying vehicles and tracking law enforcement more effectively.

This system is designed with two core modules: license plate detection and character recognition. Real-time images of vehicles are captured through digital cameras, which are then processed digitally to isolate and distinguish the license plate region. Advanced techniques are applied to enhance the quality of the extracted license plate image, improving the system's accuracy. For segmentation and recognition, CNNs play a crucial role, where individual characters on the license plate are enclosed in bounding boxes, and each character is classified using a CNN-based approach.

By integrating CNNs for both segmentation and character recognition, this license plate recognition system provides an efficient and accurate solution to support traffic management and law enforcement efforts. This intelligent approach has the potential to improve safety, reduce traffic violations, and streamline vehicle monitoring, contributing to more organized and safer roadways.

Keywords: Feature Engineering, Machine Learning, License Plate Recognition, License Plate Detection, Deep Learning, Text Extraction, CNN.

I. INTRODUCTION

With the growing number of vehicles on the road due to economic and population growth, traffic-related issues such as congestion, accidents, and law violations have surged. These issues highlight the pressing need for intelligent traffic management systems that ensure road safety, efficiency, and organization. Traditional, manual traffic monitoring is increasingly inadequate due to its labor-intensive nature and the high possibility of human error, which is why automated solutions have become essential in modern traffic management.

Numerous methods have been explored for license plate recognition (LPR), a critical tool in traffic management systems. Traditional LPR systems use region-based methods to detect license plates, followed by various algorithms for character segmentation and recognition. These systems, though effective in controlled environments, struggle with real-world conditions like poor lighting, varying plate designs, and motion blur from high-speed vehicles. Recent advancements have introduced Convolutional Neural Networks (CNNs) and YOLO-based (You Only Look Once) object detection, which have improved accuracy but still face challenges with real-time performance under complex conditions

Building on these foundations, our work integrates YOLOv8 for object detection and EasyOCR for optical character recognition, forming a more robust Automated License Plate Recognition (ALPR) system. YOLOv8 enhances license plate detection speed and accuracy, while EasyOCR addresses text recognition challenges, including varied lighting and environmental conditions. This approach aims to optimize real-time processing capabilities, reducing complexity without sacrificing accuracy, making it suitable for high-traffic environments where speed and reliability are critical

This paper presents a detailed study on implementing an ALPR system using YOLOv8 and EasyOCR, focusing on improving real-time detection and character recognition accuracy. We explore the system's potential in traffic management and law enforcement, highlighting its contributions to current research. The paper discusses the integration process, evaluates performance metrics, and assesses the system's feasibility in dynamic traffic environments, providing insights into future applications in smart cities and urban mobility.

II. RELATED WORK

Implementation of an Automated License Plate Recognition (ALPR) system using YOLOv8 and EasyOCR to enhance detection and character recognition. The process is broken down into key stages, each contributing to the effectiveness of the ALPR system :

'Luyl da Quach', 'Khang Quaoc Nguyen', and 'Haong Tran Ngoc' in 2023 explain that by treating the detection task as a "unified regression problem", YOLO streamlines the process, eliminating the need for traditional region proposal methods. This efficiency not only accelerates detection speeds but also improves the model's ability to recognize multiple objects in a single frame. As a result, YOLO has become a popular choice for applications requiring rapid and accurate object detection, such as autonomous vehicles and surveillance systems. Its architecture supports continuous learning and adaptation, making it well-suited for dynamic environments.[1]

A team of researchers, including 'Amir Mohammad Ghoreyshi', 'Alireza Akhavan Pour', and 'Alireza Bossaghzadeh' introduces a method for vehicle detection and classification using "CNN and YOLO algorithms". The approach effectively identifies vehicle types and models with high accuracy under varied conditions.[2]

'Daniel Pestana', 'Pedro R. Miranda', 'João D. Lopes', 'Rui P. Duarte', and 'Mário P. Véstias' 2021 presented the design and implementation of a hardware accelerator optimized for object detection using the "YOLO (You Only Look Once) algorithm". The paper discusses the architecture, performance enhancements, and implementation details, emphasizing the balance between efficiency and flexibility.[3]

'Jiefeng Guo', 'Rongxuan You', and Lianfen Huang in 2021 efforts have been focused on "text-based traffic sign detection and recognition". However, two challenges remain. First, while English traffic signs contain only horizontal text, Chinese traffic signs feature both horizontal and vertical text.[4]

'Sweta Rani,' 'Vivek Shukla', 'Ramesh Kumar Mohapatra' in 2023 introduced that under the regulations of the Delhi Transport Department and the Ministry of Road Transport and Highways (MoRTH), all vehicle owners are required to install a "High-Security Registration Plate (HSRP)", as it provides greater security and is tamper-proof compared to traditional plates. These plates use standardized fonts and sizes to improve readability and facilitate easier tracking of vehicle owner information.[5]

'Pushkar Sathe', 'Aditi Rao', 'Ritika Nair', and 'Aditya Singh', in 2022 suggested that in India, every hour, six two-wheeler riders lose their lives in road accidents. Additionally, during the pandemic, we've observed that while many people wear masks, they often neglect to wear helmets to avoid congestion. This issue has raised our concerns, leading us to undertake a "project aimed at penalizing individuals" who ride without helmets in violation of traffic regulations.[6]

'Nafiseh Zarei', 'Payman Moallem', and 'Mohammadreza Shams' in 2022 gave substantial advances and innovations in "deep network-based vehicle detection" methods, achieving a balance between detector accuracy and speed continues to be a major challenge. This study aims to introduce an algorithm that optimizes both speed and accuracy for real-time vehicle detection, enhancing detection speed while maintaining accuracy comparable to that of high-speed detectors.[7]

'Peilin Liu', 'Zhaoyang Xie', and 'Taijun Li' in 2023 wrote that traffic sign detection is essential for traffic safety and management. Considering the challenges posed by complex, dynamic environments and the need for detection accuracy, this paper introduces the "UCN-YOLOv5 model, built on the YOLOv5 framework". This model incorporates a new backbone network that leverages the RSU core module of U2Net to enhance feature extraction capabilities.[8]

'Jamal Hussain Shah', 'Fadl Dahan', 'Rabia Saleem', and 'Anum Masood' 2023 wrote that traffic signs play a crucial role in ensuring smooth traffic flow and safe driving. However, various distractions and unpredictable factors can make it challenging and even dangerous to notice and interpret them. As a solution, traffic sign detection and recognition have become increasingly popular, with significant efforts made to address these challenges. Finally, "OCR combined with NLP" is used to recognize text on these signs.[9]

The proposed ALPR system, combining YOLOv8 and EasyOCR, offers several advantages for modern traffic management. Firstly, YOLOv8 enhances the speed and accuracy of license plate detection, making it highly effective for real-time applications in dynamic environments. This rapid detection capability allows the system to process high volumes of traffic data, ensuring timely identification and tracking of vehicles. Additionally, EasyOCR's adaptability to varied fonts and lighting conditions improves character recognition accuracy, even in challenging scenarios such as low light or motion blur.

Table 1. Summary of Related Work/Gap Analysis

Ref No	Parameter	Algorithm	Limitation and Future work
1	1)YOLO Model 2)Object size Category 3)Mean Average Precision	1)YOLO algorithm 2)Object detection 3).Classification of small objects	1)Requires further optimization for small object detection 2)Struggles with detecting very small objects
2	1)Detection Accuracy 2)Classification Accuracy 3)Vehicle Class Categories	1)YOLO and CNN 2)Vehicle detection and classification	1)Needs improvements in handling environmental conditions. Performance in varied conditions is not thoroughly addressed
3	1)Hardware Accelerator Type 2)Power Consumption 3)Inference Speed	1)YOLO-based hardware accelerator for object detection	1)Lacks adaptability for complex, multi-dimensional object detection 2)Limited scalability for higher-dimensional applications
4	1)Recurrent Processing Efficiency 2)Tracking Consistency 3)Custom YOLO Version	1)YOLO-based detection with LSTM-base 2)Prediction for real-time detection	1)Further improvement required in the balance between speed and accuracy 2)Complexity in implementation
5	1)False Positive Rate 2)Traffic Sign Class Categories 3)Detection Accuracy	1)YOLOv5 with RSU module from U2Net 2)ConvNeXt-V2 for traffic sign	1)Improvement needed in detection of very small or distant traffic signs 2)Limited focus on smaller, distant targets
6	1)Environmental Robustness 2)Real Time Decision Making 3)CNN	1)YOLO with multiscale small object detection structure	1)Performance improvements required for larger object detection in complex driving environments 2)Reduced performance in detecting large or occluded objects
7	1)Weather Condition Types 2)Environmental Adaptability 3)False Positive Rate	1)OCR 2)NLP for traffic sign text recognition	1)Limited scope in detecting non-textual traffic signs 2)Poor performance in non-text-based traffic signs
8	1)Robustness to Text Variations 2)Dataset Variability	1)Mixed vertical and horizontal text recognition algorithm	1)Future applications should include a wider variety of text types in various languages 2)Limited to Chinese text 3)Focus on street scenes may limit broader applicability
9	1)Character Set Used 2)Recognition Accuracy 3)Input Image Quality	1)Deep learning for recognizing standardized HSRP plates	1)Testing on larger datasets and in real-world conditions is required 2)Dataset is relatively small 3)Performance in real-world scenarios remains untested

III. OBSERVATIONS AND FINDINGS

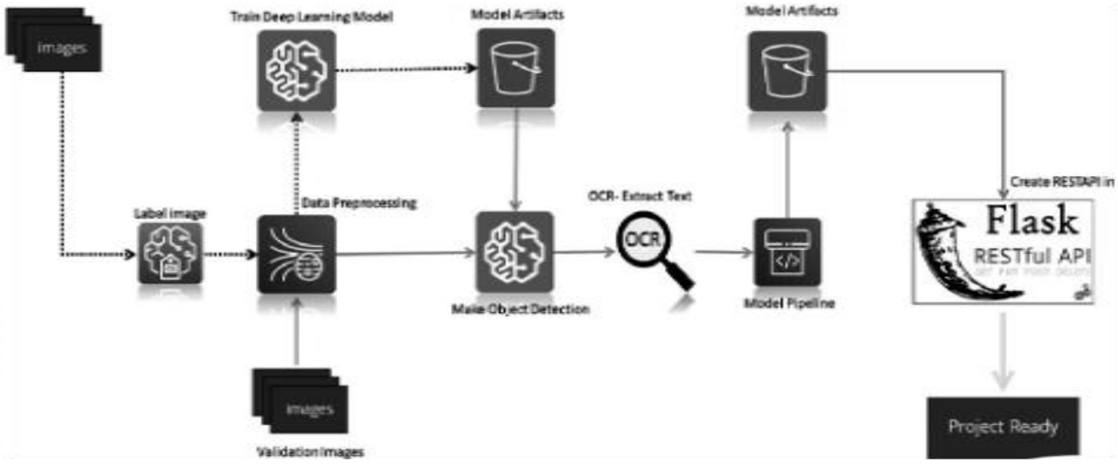

Fig. 1. Character Recognition System

ANPR systems utilize a range of learning techniques to enhance the accuracy of license plate identification and interpretation. This survey delves deeply into the methods, challenges, and advancements within this domain, examining how these approaches improve detection. The accompanying diagram provides an overview of an ANPR system, highlighting two main approaches for license plate detection: traditional methods and image processing techniques. Traditional methods primarily rely on knowledge-based systems that use predefined rules and patterns to identify plates. Meanwhile, image processing techniques offer more nuanced methods, further divided into model-based systems, including multimodal and unimodal approaches, as well as machine learning and deep learning methods.

In a multimodal approach, model fusion or hybridization techniques are applied, combining different inputs—such as image data, feature vectors, and sensor data from cameras—to achieve more comprehensive detection. This fusion allows the system to incorporate varied data types, improving robustness in complex environments. Unimodal approaches, on the other hand, rely solely on image data, focusing on license plate images as the single source of input. This single-stream method is simpler but may be less adaptable in challenging conditions compared to multimodal systems.

The system is designed to adapt its approach based on the complexity of the data and the specific requirements of the detection task, combining or selecting methods as needed. The diagram further illustrates that both machine learning and deep learning models rely heavily on image data as their primary input for processing license plates, underscoring the importance of high-quality imagery for successful ANPR outcomes.

A. Key Issues and Insights

Amidst traffic and urbanization, ANPR systems face challenges due to varying lighting conditions, diverse number plate designs, and detecting plates on rapidly moving vehicles. Inconsistent lighting reduces plate clarity, while diverse designs require a universally applicable solution. Motion blur from high vehicle speeds further complicates real-time plate capture. These challenges emphasize the urgent need for robust and adaptable ANPR solutions.

Many existing ANPR systems, while accurate, are also computationally demanding. They rely on complex algorithms that enhance image quality, handle character recognition, and compensate for distortions. However, these processes require significant computing power, which may not be feasible in all environments due to cost, power consumption, and processing time constraints. Moreover, in real-world traffic scenarios, variables like weather conditions, overlapping vehicles, and cluttered backgrounds make accurate recognition more challenging. Many ANPR solutions, which may perform well in controlled environments, often struggle with these complexities in the field, leading to reduced accuracy and reliability.

Traditional methods for ANPR, such as YOLOv5 and YOLOv6, come with their own limitations. These models are generally effective for detecting larger objects but may fail when objects are small or partially visible, as is often the case with license plates captured from a distance. Additionally, fast-moving vehicles are difficult to track with these models, as their frame-by-frame processing can lead to blurred or incomplete detections. The lack of continuous tracking across frames means that these methods cannot provide real-time vehicle monitoring, which is essential for high-traffic areas. Moreover, the slower processing speeds of traditional YOLO models hinder their suitability for real-time applications, as delays in detection can prevent timely decision-making for tasks like law enforcement or incident response.

YOLOv8 offers several advantages for ANPR applications. It provides faster, more accurate detection and recognition, making it ideal for real-time monitoring. Its architecture handles complex conditions like low light, varied backgrounds, and crowded traffic scenes effectively. This adaptability makes it highly reliable for dynamic environments. YOLOv8 is versatile and can detect pedestrians, vehicle types, and helmet usage. It's also customizable for specific operational requirements, providing greater flexibility for diverse use cases.

YOLOv8's adaptability offers significant potential for expansion and application across various domains. Unlike previous ANPR solutions, YOLOv8-based systems can be tailored for various needs as technology and traffic management evolve. This versatility makes it an ideal candidate for integration with smart city infrastructure, contributing to real-time law enforcement, traffic analytics, and environmental monitoring. YOLOv8's ability to evolve ensures its relevance and value in supporting future innovations in traffic management and urban planning.

IV. RESULTS AND FUTURE WORK

The following project aims to enhance the existing ANPR systems by incorporating the unique characteristics of the YOLOv8 model in the domain of object detection. Presented as a potential solution to the current challenges faced by these systems, this approach holds the promise of delivering enhanced accuracy, increased speed, and improved reliability for practical applications. The successful implementation of this system will contribute to the advancement of vehicle management across various domains.

Future work in this area will focus on several key aspects to enhance the system's overall functionality. First, real-time performance optimization will be prioritized to improve detection and recognition speeds, particularly for large-scale deployments like smart cities. Another key aspect is cross-region adaptability, which focuses on improving the system's ability to process diverse license plate formats across different countries and regions.

Additionally, integrating the system with existing traffic management frameworks will enable automation of processes such as ticketing, toll collection, and traffic law enforcement. To ensure higher accuracy in varying conditions, including low lighting and occluded plates, incorporating the latest advancements in deep learning will be vital. Lastly, scalability will be essential to effectively manage the significant data streams generated by multiple cameras in urban environments, ensuring that the system can expand while maintaining efficiency and performance.

V. REFERENCES

[1] 'Pushkar Sathe', 'Aditi Rao', 'Ritika Nair', 'Aditya Singh', "Helmet Detection And Number Plate Recognition Using Deep Learning", 2022

[2] 'Sweta Rani', 'Vivek Shukla', 'Ramesh Kumar Mohapatra' "Recognition of High-Security Registration Plate for Indian Vehicles", 2023

[3] Jiefeng Guo, Rongxuan You, Lianfen Huang "Mixed Vertical-and-Horizontal-Text Traffic Sign Detection and Recognition for Street-Level Scene", 2021

[4] 'Jamal Hussain Shah', 'Fadl Dahan', 'Rabia Saleem', 'Anum Masood' "A Robust Intelligent System for Text-Based Traffic Signs Detection and Recognition in Challenging Weather Conditions", 2023

[5] 'Yining Cao', 'Chao Li', 'Yakun Peng', 'Huiying Ru' "MCS-YOLO: A Multiscale Object Detection Method for Autonomous Driving Road Environment Recognition", 2023

[6] 'Peilin Liu', 'Zhaoyang Xie', 'Taijun Li' "UCN-YOLOv5: Traffic Sign Object Detection Algorithm Based on Deep Learning", 2023

[7] 'Nafiseh Zarei', 'Payman Moallem', 'Mohammadreza Shams' "Fast-Yolo-Rec: Incorporating Yolo-Base Detection and Recurrent-Base Prediction Networks for Fast Vehicle Detection in Consecutive Images.", 2022

[8] 'Daniel Pestana', 'Pedro R. Miranda', 'João D. Lopes', 'Rui P. Duarte', 'Mário P. Véstias' "A Full Featured Configurable Accelerator for Object Detection With YOLO.", 2021

[9] 'Amir Mohammad Ghoreyshi', 'Alireza AkhavanPour', 'Alireza Bossaghzadeh' "Simultaneous Vehicle Detection and Classification Model based on Deep YOLO Networks.", 2021

[10] 'Luyl da Quach', 'Khang Quaoc Nguyen', 'Haong Tran Ngoc' "Evaluating the Effectiveness of YOLO Models in Different Sized Object Detection and Feature-Based Classification of Small Objects.", 2023

[11] Redmon, J., & Farhadi, A. (2018). YOLOv8: An Incremental Improvement. arXiv preprint arXiv:1804.02767.

[12] Bochkovsky, A., Wang, C.-Y., & Liao, H.-Y. M. (2020). YOLOv4: Optimal Speed and Accuracy of Object Detection. arXiv preprint arXiv:2004.10934.

[13] Ultralytics. (2023). YOLOv8 Documentation. Retrieved from https://docs.ultralytics.com/yolov8

[14] Zhang, S., Chi, C., Yao, Y., Lei, Z., & Li, S. Z. (2020). RefineDet++: Single-Shot Refinement Neural Network for Object Detection. arXiv preprint arXiv:2004.01888.

[15] National Institute of Standards and Technology. (2020). NIST Special Database 19: Hand Printed Forms and Characters Database.