Automatic Number Plate Recognition: A Review, Key components and the Challenges

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A b s t r a c t

India's hefty population is tied to a substantial number of vehicles. Predominantly, road transport is a major mode of travel, particularly in urban areas, and is a growing concern due to the limited infrastructure. The number plate recognition system is a technological determination drafted to capture and interpret license plate information from vehicles instinctively. ANPR systems fulfill the basic prerequisites in energizing security and improving management effectiveness of traffic and verifying numerous requests, such as toll and parking fee payment, by using a combination of object identification, character division, and optical character reading. The intention of this study is to state the state of knowledge in various Automatic Number Plate Recognition algorithms by referencing pertinent earlier research, evaluating, and outlining a survey for the upcoming developments. The researcher has compared and analyzed 29 research papers and found the best recognition rate.

Keywords: Automatic Number Plate Recognition, Image processing, Optical character recognition, Machine learning.

1.Introduction

The management of vehicles as conceptual assets within information systems has been made possible by the substantial integration of information technology throughout the contemporary era. Without data, an autonomous information system is meaningless; vehicle information must be converted between the information system and the real environment. Either human interaction or specialized equipment that allows for the identification of automobiles by their registration plates in real-world situations can do this. The detection and identification of vehicle number plates is a vital system among the various kinds of specialized devices. Automatic number plate identification, or number plate detection, uses optical character recognition to decipher license plates [1]. Law enforcement, toll collection, and traffic control are the few of the many uses for this technology.

The future of ANPR technology appears bright, with continuous developments in AI, machine learning, and cloud computing propelling the next wave of innovation. ANPR technology will continue to have an impact on sectors like retail, transportation, and law enforcement. Additionally, ANPR plays a critical role in efficient monitoring, optimized workflows, and vehicle-data-driven targeted marketing campaigns [6]. Ethical issues, especially those pertaining to privacy, will become more significant in the future as ANPR technology spreads. A pithy overview of how Automatic Number Plate Recognition is taking effect is illustrated in this research paper. The rest of this paper is structured in the following manner: The algorithmic steps of automatic number plate recognition are presented in Section 2; Section 3

details the major parts of ANPR systems; Section 4 explains related studies and discussion in automatic number plate recognition and performance evaluation; and Section 5 illustrates ANPR defiances in India.

2. Algorithmic steps of automatic Number Plate Recognition

There are four major steps to be followed in automatic number plate recognition which are given below:

Image Capture

To start this process, the camera first takes an image of the car's license plate, which will be followed by image preprocessing. Even when cars are itinerant at high speeds, high-resolution cameras are used to guarantee clear and detailed images [12].

Image Preprocessing

A standard image preprocessing has some fundamental procedures to be followed. Initially, a high-quality camera takes the picture, and then the picture is preprocessed to remove any irrelevant indications. Next, the image is transformed from RGB to grayscale according to the threshold value. Apart from the above, there are certain image preprocessing steps, like image conversion, binary processing, and noise removal techniques, and these steps are not predetermined [19]. These steps will be mottled according to the application.

Optical Character Recognition (OCR)

Posterior to preprocessing, the image is treated by the OCR system to identify the characters on the license plate. There are different algorithms to handle variations in font, plate size, and obstructions to make certain high accuracy in character recognition. This amble extracts the number plate section from the given image. There are a lot of ways to extort the region of interest.

Data Matching and Storage

Once the characters are recognized, data are matched against relevant databases and the data are securely stored for future reference. This enhances the system’s efficiency and reliability across-the-board.

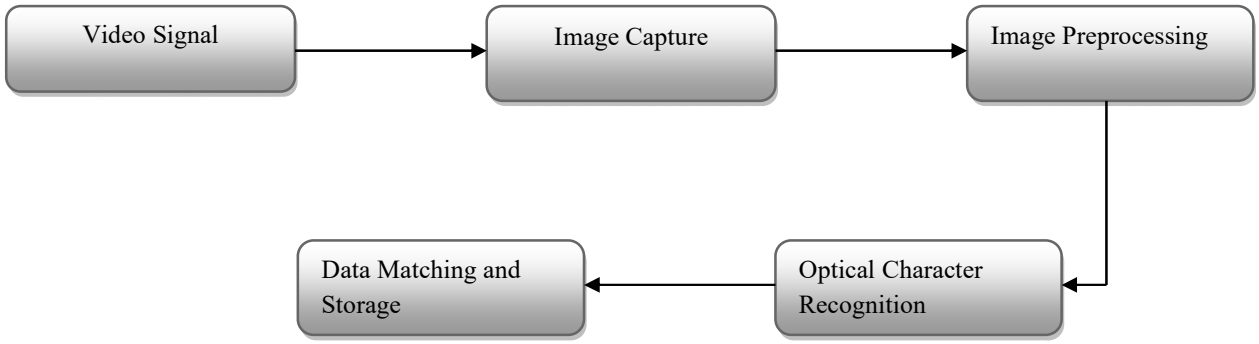

Figure:1 Essential Steps Of Automatic Number plate Recognition

3. Major parts of ANPR systems

Cameras

Cameras are the cornerstones of any ANPR system. High-resolution cameras with fast shutter speeds are important to confine the images of driving vehicles [20]. A high-resolution camera has advanced camera systems, considered to operate efficiently in a variety of lighting conditions.

Processing Unit

The processing unit investigates the confined images and mines the pertinent data, such as the characters on the license plate. A few processors have the great features to handle several image streams concurrently, which guarantees a fast and exact recognition rate.

Software Algorithms

Software algorithms are important to change visual data into comprehensible data. Very few OCR algorithms precisely identify characters on license plates; still, there are variations in font, design, or destructed plates, which in turn sustain high accuracy.

4. Related Studies and Discussion

This study discusses a lot of existing methodologies and algorithms from the literature. Twenty-nine related studies were reviewed for different algorithms, and the recognition rates are given in Table 1. Yuan et al. [5] presented a robust and efficient method for license plate detection with the purpose of accurately localizing vehicle license plates from complex scenes in real time. A simple yet effective line density transforms and support vector machine are used to achieve a 96% recognition rate. In [7], the authors presented a robust real-time system using a pipeline with two deep learning phases disidentify the whole license plate without character-level segmentation and achieve ignition on the plate component level as 97.67%. Pradyut et al. [25] suggested an automatic license plate detection and recognition using non-max suppression and deep learning and attained a recognition on rate of 88.5%. Ganesh et al. [27] proposed a novel method for Indian number plate detection by bounding box segmentation and contour filtering and gained 99.2% as the recognition rate. The authors [28] employed OCR and Yolov8 detection patterns for the recognition. The authors used the Kaggle ANPR database and attained a maximum accuracy of 98.1 %. In [29], the authors suggested pre-processing operations such as

noise reduction, image binarization, and RGB to grayscale conversion. The license plate is recovered using sobel edge detection method, and then horizontal scanning is used. This output is then fed into deep learning to identify each character.

Table 1: Summary of Recognition rate for various algorithms

S.N	Year	Author Name	Algorithm	Recognition Rate(%)
1.	2004	Shyang-Lih Chang et al.	Self-organizing character recognition, fuzzy aggregation	93.7
2.	2011	D. Wazalwar Et al.	Mexican hat operator for edge detection	96.17
3.	2012	K.D. Ban et al	Ada Boost based on Modified Census Transform	98.7
4.	2013	Gee-Sern Hsu et al	MSER for segmentation and bi layer classifier	97
5.	2017	Yule Yuan et al	Line density transforms,SVM	96
6.	2019	N.O. Yaseen, et al	AdaBoost based HOG features	89.7
7.	2019	Y. Kessentini, et al	YOLOv2 object detection CNNs	97.7
8.	2019	M. Molina-Moreno et al	Scale-adaptive deformable part-based boosting	97.5
9.	2020	I. V. Pustokhina et al.,	Optimal K-means clustering, convolution neural network	98.1
10	2020	Ravi Kiran Varma et al	Contours, K-nearest neighbor algorithm	98
11	2020	A. Hussain,M. S. Hathal	Canny edge detection with MLP	97.8
12	2021	Tae-Gu Kim et al	Super-resolution generative adversarial network	81.4
13	2021	J. Han and H. Y. Bo	Canny edge detection, K-means algorithm	90
14	2021	V. Gnanaprakash et al	Morphological processing, YOLO object detection	97

15	2021	N. L. Yaacob e al	Morphological operations, template matching method	80.3
16	2021	Javid Hamdard, Worarat Krathu	Canny edge detection, Random transform-based techniques, convolution neural network	98.9
17	2021	V Gnanaprakash et al	Deep learning model	97
18	2022	Rayana Antar	Canny edge detection with horizontal projection - OCR	96
19	2023	Dilshad Islam, et al	Bounding box method, Template matching	94.2
20	2023	Shuo Zhu et al	YOLOv5s model	91.6
21	2023	N.I Tushar et al	Mixed CNN and RNN technique	88.5
22	2023	M.A. Jawale et al	Otsu's thresholding, morphological operations, CNN	98.5
23	2024	Povammal E et al	Yolo,super-resolution generative adversarial networks	98.5
24	2024	Lingbing Tao et al	YOLOv5-PDLPR algorithm	99.4
25	2024	Pradyut Agrawal, et al	Non-Max Suppression, Deep learning	88.5
26	2024	Mohanad A. et al	CNN model.	97.8
27	2024	U.Ganesh Naidu etal	Dark channel prior algorithm, Bounding box segmentation	99. 2
28	2024	Amardeep Singh, Kiranpreet Kaur	OCR and Yolov8 detection model	98.1
29	2024	Anamika Rakshe, Nilima Dongre	OCR, CNN	99

From the above said recognition rates, it is observed that Ling bing Tao et al have better performance level of 99.4% with YOLOv5-PDLPR algorithm. Next comes, U. Ganesh Naidu et al with 99.2% recognition rate for Dark channel prior algorithm with Bounding box segmentation. Figure 2 gives the graphical representation of Recognition rate for various algorithms are discussed in this study.

Figure 2: Graphical representation of Recognition rate for various algorithms

5. ANPR defiances in India

India has a great demand for ANPR, but the country's variety of license plates presents one of the technology's biggest obstacles. An ANPR system finds it challenging to correctly recognize and decode Indian license plates due to their differences. In India, there are 210 million automobiles with more than 50 distinct kinds of license plates [30]. The plates differ in terms of colour, language, and even where they are on the car. For instance, some car generations have their own distinctive quirks, while some parts of India have specific license plate formats. Another issue with ANPR systems is that most cameras installed in India are of inferior quality and are inexpensive, with less sensitive motion and object detection sensors, poor night vision capabilities, and restricted visual coverage [31]. These components increase the probability of blurred images and voids.

Conclusion

This research paper presents a detailed survey on ANPR algorithms proposed in relevant studies and found out the best recognition rate. Each stage is presented in detail as the performance summary. This study discussed the algorithmic methods of automatic number plate recognition, detailed major parts of ANPR systems, related studies in automatic number plate recognition, performance evaluation, and ANPR defiances in India.

References

1. Shyang-Lih Chang, Li-Shien Chen, Yun-Chung Chung, and Sei-Wan Chen, “Automatic License Plate Recognition” IEEE transaction on intelligent transportation systems, vol. 5, no. 1, March 2004.

2. D. Wazalwar, E. Oruklu, J. Saniie, “Design flow for robust license plate localization,” IEEE International Conference on Electro Information Technology, 2011

3. K.D. Ban, Y. Yoon, H.S. Yoon, J. Kim, “Number detection in natural image with boosting classifier,” 2012 9th International Conference on Ubiquitous Robots and Ambient Intelligence, URAI 2012, (Urai), 525–526, 2012.

4. Gee-Sern Hsu, Member, IEEE, Jiun-Chang Chen, and Yu-Zu Chung, “Application-Oriented License Plate Recognition” IEEE Transaction on vehicle technology, vol. 62, no. 2.2013.

5. Yule Yuan, Wenbin Zou, Yong Zhao, Xinan Wang, Xuefeng Hu, and Nikos Komodakis.” A Robust and Efficient Approach to License Plate Detection” IEEE transaction on image processing, vol. 26, no. 3,2017.

6. N.O. Yaseen, S.G.S. Al-Ali, A. Sengur, “An Efficient Model for Automatic Number Plate Detection using HOG Feature from New North Iraq Vehicle Images Dataset,” 1st International Informatics and Software Engineering Conference: Innovative Technologies for Digital Transformation, Proceedings, 2019.

7. Y. Kessentini, M. D. Besbes, S. Ammar, and A. Chabbouh, "A two-stage deep neural network for multi-norm license plate detection and recognition," Expert systems with applications,vol.136,no.1, 2019.

8. M. Molina-Moreno, I. Gonzalez-Diaz, F. Diaz-De-Maria, “Efficient Scale Adaptive License Plate Detection System,” IEEE Transactions on Intelligent Transportation Systems, vol.20, no. 6, 2019.

9. Irina Valeryevna Pustokhina, Denis Alexandrovich Pustokhin, Joel J. P. C. Rodrigues, Deepak Gupta, Ashish Khanna, K.Shankar, IEEE Member, Changho Seo, Gyanendra Prasad Joshi, "Automatic vehicle license plate recognition using optimal K-means with convolutional neural network for intelligent transportation systems",vol.8,2020.

10. Ravi Kiran Varma Pa, Srikanth Gantaa, Hari Krishna Bb, Praveen, "A Novel Method for Indian Vehicle Registration Number Plate Detection and Recognition using Image Processing Techniques”, vol.167,2020.

11. A. Hussain and M. S. Hathal, "Developing Arabic License Plate Recognition System Using Artificial Neural Network and Canny Edge Detection," Baghdad Science Journal, vol. 17, no. 3, 2020.

12. Tae-Gu Kim, Byoung-Ju Yun, Tae-Hun Kim, Jae-Young Lee Kil-Houm Park, Yoosoo Jeong and Hyun Deok Kim Hyun Deok Kim, "Recognition of Vehicle License Plates Based on Image Processing", Applied Sciences, vol.11, 2021.

13. J. Han and H. Y. Bo, "Analysis and Design of intelligent license Plate recognition system," in 6th International Conference on Intelligent Computing and Signal Processing, Xi'an, China,

14. V Gnanaprakash, N Kanthimathi and N Saranya, "Automatic number plate recognition using deep learning", IOP Conference series: materials science and engineering,vol.1084,2021.

15. N. L. Yaacob, A. A. Alkahtani, F. M. Noman, A. M. Zuhdi, and D. Habeeb, "License plate recognition for campus auto-gate system", Indonesian Journal of Electrical Engineering and Computer Science, vol.21,2021.

16. Javid Hamdard and Worarat Krathu, "Afghanistan Vehicle Number Plate Detection and Recognition Using Image Processing and Convolutional Neural Networks", Proceedings of the 12th International Conference on Advances in Information Technology,2021.

17. V Gnanaprakash, N Kanthimathi, N. Saranya," Automatic number plate recognition using deep learning", IOP Conference Series: Materials Science and Engineering, vol.1084, 2021.

18. Rayana Antar , Shimaa Alghamdi, Johara Alotaibi, Manal Alghamdi, "Automatic Number Plate Recognition of Saudi License Car Plates Engineering", Technology & Applied Science Research Vol. 12, No. 2, 2022.

19. Dilshad Islam, Tanjim Mahmud, Tanjia Chowdhury, "An efficient automated vehicle license plate recognition system under image processing", Indonesian Journal of Electrical Engineering and Computer Science, Vol. 29, no.2,2022.

20. Shuo Zhu, Yu Wang, Zongyang Wang, "A lightweight license plate detection algorithm based on deep learning" IET Image Processing, Vol. 18, 2024.

21. N.I Tushar, Abdullah Saikat A.A.M, Rahat-Bin-Rafique, Minhajul Abedin,K.B.M, "Vehicle Number Plate Detection System Using Image Processing Approach" ,14th International Conference on Computing Communication and Networking Technologies ,2023.

22. M.A. Jawale, P. William, A.B. Pawar, Nikhil Marriwala, "Implementation of number plate detection system for vehicle registration using IOT and recognition using CNN", Measurement: Sensors, vol.27,2023.

23. Kothai G, Povammal E, Amutha S, Deepa V, "An Efficient Deep Learning Approach for Automatic License Plate Detection with Novel Feature Extraction", Procedia Computer Science Volume 235, 2024.

24. Lingbing Tao ,Shunhe Hong ,Yongxing Lin ,Yangbing Chen ,Pingan He and Zhixin Tie, "A Real-Time License Plate Detection and Recognition Model in Unconstrained Scenarios" ,Sensors (Basel),vol.24,no.9,2024.

25.Pradyut Agrawal, Akshansh Jha, Ravneet Kaur, Anju Agrawal, Monika Bhattacharya ,"Automatic License Plate Detection and Recognition using Deep Learning and Image Processing", Symposium on Computing & Intelligent Systems (SCI), May 10, 2024.

26. Mohanad A. Al-Askari, Iehab Abduljabbar Kamil, "Image Processing and Distributed Computing for License Plate Tracking System", International Journal of Computer Science and Engineering, vol.11, no.6,2024.

27.U. Ganesh Naidu, R.Thiruvengatanadhan S. Narayana P. Dhanalakshmi, "A Novel Method For Indian Number Plate Detection And Recognition Using Efficient Net", Journal of Theoretical and Applied Information Technology,Vol. 102, no. 6, 2024.

28. Amardeep Singh, Kiranpreet Kaur, "An Intelligent Architecture for Automatic Number Plate Detection Using OCR and YoloV8 Model", Journal of Propulsion Technology, Vol. 45, no. 1, 2024.

29. Anamika Rakshe, Nilima Dongre, "An Efficient Methodology of Automatic Vehicle Number Plate Detection Using Deep Learning", International Journal of Intelligent Systems and Applications in Engineering, vol.12, no.12,2024.

30.Hanit Karwal, Akshay Girdhar, "Vehicle Number Plate Detection System for Indian vehicles review" IEEE International Conference on Computational Intelligence & Communication Technology,2015.

31. Ms. Shiwani Yadav, "Automatic Number Plate Recognition (ANPR) and Road Safety in India", International Journal of Enhanced Research in Science, Technology & Engineering Vol. 11, no. 12, 2022.