Indian vehicle number plate detection and recognition using morphological operations and state extraction

Kazi S M[1], Dr. Kodge B. G.[2]

Address SRTMU, Nanded, Maharashtra[1], GITAM University, Hederabad, India[2]

Email kazism2020@gmail.com, kodgebg@gmail.com

Abstract

Over the past two decades, there has been a significant growth in the use of vehicles. Vehicle technology has advanced quickly as a result of the luxurious lifestyle. Due to this constant increase, it is exceedingly taxing to monitor every vehicle for safety, traffic control, or law enforcement reasons. The necessity of a vehicle number plate recognition system is highlighted by the phenomenon of continually increasing vehicle numbers. The automatic toll collection, traffic control, parking systems, enforcement of traffic laws, automatic gate openers, etc. are some of the applications for number plate recognition systems. This study proposes a single algorithmic method based on the idea of mathematical morphology for detecting and recognizing a car plate number. The suggested algorithm is straightforward, effective, and adaptable. The popular and effective image processing analysis tools OpenCV and Python were used in the development of this user-friendly software solution. The system also determines which Indian state the vehicle is from.

Keywords. Character segmentation, character recognition, license plate detection, state extraction.

1. INTRODUCTION

Vehicle Number Plate Recognition (VNPR) systems have several uses in intelligent transportation systems, which is increasing interest from many nations in developing such systems that can perform duties like traffic monitoring and law enforcement, among others. In addition, VNPR systems are employed for toll payment collection, security purposes in restricted areas like military bases, and the observation of vehicles entering and exiting parking lots. These VNPR systems are typically used to prevent fraud and to bolster security in specific zones. These systems, for instance, might be useful when looking for lost, stolen, or cars involved in crimes. These duties demand a large amount of time, effort, and resources, excepting the VNPR systems. A moving vehicle's license plate is almost impossible for a human to read and retain, therefore manual intervention may result in incorrect analysis.In essence, a VNPR system receives an input image and, if the image contains a vehicle, outputs the content of the license plate (often as text). These systems include a camera that records photos of the vehicle. These scanned images may be infrared, colorful, or black and white depending on the needs of the system. The car number plate can be found and understood using a variety of methods, including object detection [1], [2], [3],

[4], image processing, and pattern recognition.India's states and automobile codes are covered in Section 2, and a brief overview of related tasks is covered in Section 3. The proposed model is presented in Section 4, the experiment results are shown in Section 5, and the conclusion and future work are presented in Section 6.

2. INDIAN STATES VEHICLE CODES

Government statistics from 2016 show that there are more than 23 crore vehicles registered in India. The district level RTO (Regional Transport Office) of the relevant states is responsible for issuing all of the state codes for Indian vehicles.The 28 states and 8 Union territories' vehicle codes, including any recent modifications, are included in the following tables according to ISO 3166-2.

Table 1. Indian States Vehicle Codes (28)

State	Vehicle Code	State	Vehicle Code
Andhra Pradesh	AP	Manipur	MN
ArunachalPradesh	AR	Meghalaya	ML
Assam	AS	Mizoram	MZ
Bihar	BR	Nagaland	NL
Chhattisgarh	CG	Odisha	OD
Goa	GA	Punjab	PB
Gujarat	GJ	Rajasthan	RJ
Haryana	HR	Sikkim	SK
Himachal Pradesh	HP	Tamil Nadu	TN
Jharkhand	JH	Telangana	TS
Karnataka	KA	Tripura	TR
Kerala	KL	Uttar Pradesh	UP
Madhya Pradesh	MP	Uttarakhand	UK
Maharashtra	MH	West Bengal	WB

Table 2. Union Territories (8)

Union Territory	Vehicle Code	Union Territory	Vehicle Code
Andaman and Nicobar Islands	AN	Jammu and Kashmir	JK
Chandigarh	CH	Ladakh	LA
Dadra and Nagar Haveli & Daman and Diu	DD	Lakshadweep	LD
Delhi	DL	Puducherry	PY

Table 3. Bharat Series

All over India (Bharat)	Vehicle Code
Bharat Series	BH

Table 4. Review on License Plate Detection

Reference number & Year	Author	Technique
[12] 2019	Khamdamov, R.K.,Rakhmanov, H. E	Contour analysis
[13] 2020	Yaoyao Li, Liu, Chen Zia	YOLO v2 & CNN
[14] 2020	Ascar Davix Jadson D. et al.	Segnet & CNN
[15] 2021	Qiuying Huang,Zhanchuan Cai	One-stage convolutional network
[16] 2021	Farheen Ali and Himanshu Rathor/ Wasim Akram	Radial Basis Function Neural Network: RBFNN
[17] 2022	C. L. P. Chen and B. Wang	CNN Adaboost
[18] 2022	Tian, L. Wang and R. Zhang	CNN

3. RELATED WORK

Due to regional variances in license plate sizes, fonts, colors, and standards, it is difficult to offer a universal solution for the detection and recognition of a license plate from anywhere in the globe. Additionally, other elements like rotations (tilted plates) and other obstacles of the license plates restrict the use of the current systems in practical contexts. Given the current limits, the procedures are therefore more computationally complex and demanding [5], [6], and [7].The identification or extraction of the license plate from the vehicle's photograph constitutes the first stage. Various computer vision approaches with object detection are utilized to determine the license plate area from an image. The key building blocks of these computer vision approaches are the characteristics of the license plate, including its shape [2], [8], color, texture, symmetry, etc.In the second stage, the license plate is segmented, and the characters are extracted using some widely used methods, including mathematical morphology [9], relaxation labelling, connected components, and vertical and horizontal projection. However, not all multi-stage VLPR systems necessarily perform the character segmentation stage.In the last stage, characters are recognized using classifiers like neural networks, SVM, and fuzzy classifiers that match patterns. The one-stage processes have recently seen multiple successful tries. In each of these tries, the license plate is localized and recognized in a single pass using a single neural network that has been trained for end-to-end detection. Recognition of license plates is a particular instance of object detection. These models can take use of the fact that license plate detection and recognition are highly linked, just like single-stage object detectors [10]. Instead of the usual two-stage approach, this allows the models to have fewer parameters and share them. They can therefore be quicker and more effective than the two-stage technique [10], [11].

Methodology

Image acquisition – The image should be delivered in such a way that it shows the car's number plate of either the front or rear of the vehicle. System noise, blur, distortion, and other elements can all have an impact on how successful this stage is.

Image pre-processing – This process involves changing the image from RGB to grayscale. A 2-dimensional grayscale version of the three-dimensional RGB image is created.

Number plate detection – Number plate recognition looks for the precise features in the image that contain the license plate.

Character Segmentation – In this stage, the necessary section of the license plate is cropped out. To correctly recognize each text, it requires separating the image from its background.

Character recognition – This is where OCR and OpenCV are used to their best potential. It entails locating and recognizing image frames and transforming them into pertinent text.

State Extraction – The state to which the vehicle belongs is determined from the recognized alphanumeric characters.

The proposed VNPDRSD (Vehicle number plate detection, recognition and state detection) system has four stages: state detection, character segmentation, optical character recognition (OCR), and license plate localization (LPL). In the LPL stage, every pixel of the image is scanned to identify and pinpoint the location of the license plate. Character segmentation is the stage where each character on a license plate is identified and separated. OCR receives, verifies, and encodes the character's data. The level of state detection determines the state to which the vehicle belongs. A flowchart of the various phases is shown in Figure 1 for your reference.

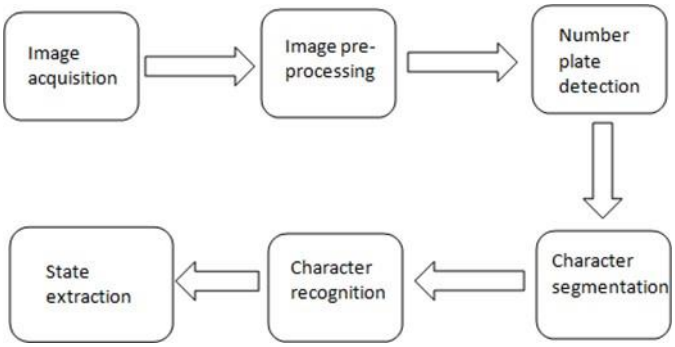


Figure. 1. The stages of a VNPDRSD system.

Various components inside the image are sorted out using mathematical morphology, given the right size and shape of the structural elements. Because undesired portions of the image can be found, improved, or removed, the size and shape are crucial. In order to extract the pertinent structures from a given collection, morphological operators are essential. The interaction between that particular set and the structural component is what causes this process to happen. The morphological operator's dilatation and erosion make up a basic pair in theory. Initially, preparation for the License Plate Localization (LPL) involves turning the colored original image into a grayscale image. The image is then scaled using morphological transformation, binary thresholding is applied, noise is eliminated by closing and opening

morphological features, and finally the license plate is extracted. Following the license plate extraction, the characters are recognized using the Python OCR tool pytesseract, and then the condition of the vehicle to which it belongs is deduced from the extracted characters. We made use of the Kaggle and Google Image datasets.

4. OpenCV, Python Implementation Results

After the system receives the image, it recognizes the license plate and displays the number as well as the state or union territory that it belongs to. Otherwise, "License plate not recognized" is shown if it cannot read the license plate (for example, because of image noise, a tilted license plate, excessive brightness, etc.).We have tested 25 samples where the extraction of the plate region and it's segmentation was successful with 100% accuracy, whereas the accuracy obtained from alphanumeric character recognition was 96% which in turn resulted in 96% of accuracy in identifying the state or union territory.

Table 5. Result Images

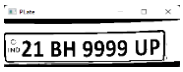
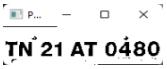
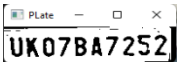
Sr. No.	Source image	Result image- License plate localization and detection	Result image- detection, recognition andstate or union territory identification of Indian car license plates
1			
2			
3			
4			
5			

Table 5. Result Analysis

Applied stages	Sample Number	No. of correct detection	Accuracy (%)
Extraction of plate region	25	25	100%
Segmentation	25	25	100%
Recognition of alphanumeric characters	25	24	96%
State or union territory identification	25	24	96%

5. CONCLUSION AND FUTURE SCOPE

There are currently several license plate locating algorithms available. Each technique has a certain range of applications and constraints. This work adopts an edge detection-based method for the placing of license plates using mathematical morphology. For the rapid positioning of the license plate region, a combination of mathematical morphology and the edge detection filtering function is employed to lessen the interference of noises from the photos. The algorithm is easy to use, quick, and reliable.Future research should focus on methods for extracting intrinsic images (such as lighting, reflectance, and depth images) and real-time license plate recognition from videos. Although the license plates are focused on a single nation (India), they can be extended to use with license plates of other countries.

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Biographies

Kazi Saira M. received the bachelor's, master's and M. Phil. degree in Computer Science. Her research areas of interest are Digital Image Processing, Machine learning and Data science. She has published 7 papers in national conference proceedings. She is a research scholar at SRTMU Nanded, Maharashtra.

Dr. Kodge Bheemashanker G. received the bachelor's, master's, M. Phil. and Ph.D. degree in Computer Science and is currently working as an Associate Professor at the Dept. of Computer Science, School of Science of GITAM (Deemed to Be University) Hyderabad, India. His research areas of interest are Geo-spatial technologies, Digital Image Processing and Pattern Recognition. He has published more than 30 research papers in reputed national and international journals and conference proceedings. Similarly, he is a recognized research Guide and successfully guided 03 Ph.D. and 01 M. Phil. scholars in Computer Science and Applications subjects.