A COMPREHENSIVE ANALYSIS ON VECHICLE NUMBER PLATE DETECTION USING DEEP LEARNING APPROACHES

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ABSTARCT
Automatic number plate detection is used in smart cities to investigate and prevent crime. A fixed filming angle and lighting environment are common in parking management systems and toll booths on roads. Because the number of cars on the road is rising, it is necessary to map, comprehend, and analyse the data generated by them. This analysis might be in the form of security, discovering stolen vehicles, toll booth, etc. The number plate is recognised and saved in a database with time and date. It will help minimise traffic violations and improve parking lot security. This survey uses computer vision to recognise moving vehicle number plates. Image sequences are used to identify plate characters. The above technology identifies and differentiates between authentic and false number plates using character detection. This study reviews several pattern categorization and detection approaches. The paper's summary includes comparisons of methods and datasets. The purpose is to offer an overview of several Machine Learning Deep Learning methodologies used for vehicle identification in various settings.
Keywords: Machine Learning, Deep Learning, Classification

1. INTRODUCTION

Vehicular transportation is an essential component of our daily lives. As prices continue to decline, more automobiles are becoming more affordable for everyone. There are number plates on automobiles all around the world that serve as identifying proof of ownership. It is also possible for the angle between the vehicle and the camera to change, and this angle can have a considerable influence on the accuracy with which the plate contents are detected. Furthermore, changes in typefaces, colours, the usage of background pictures, and plate standards make the work of computerised licence plate detection extremely difficult. In recent years, computer vision technology has made significant progress in its ability to cope with difficulties that arise in the actual world. This gives us the ability to predict the emergence of a new age of machine vision applications.

The goal is to investigate contemporary issues in machine vision applications and to encourage knowledge sharing in highly effective and practical machine vision approaches. The use of information to bring insights and meaning to data has evolved significantly in our modern lives. This creation of insights occurs through a variety of methods, one of which is machine learning, in which data is generalised from diverse sets of instances. One option is to employ an ANN (Artificial Neural Network), which attempts to replicate biological equivalents. The CNN (Convolutional Neural Network) is one of the methods used, and it works by simulating computer vision to recognise, detect, and categorise objects or entities in a given field of view.

The techniques get at this point by doing N layer processing on the data and generalising the samples. CNN also has a variety of forward-looking approaches, one of which is YOLO (You Only Look Once). This approach, which is highly accurate and capable of outperforming multiple approaches, as well as its characteristics of real-time data analysis, makes it suitable for a variety of applications, including real-time vehicle detection. As the number of cars on the road grows, so does the need to manage, record, and assess the state of the transportation system. As a result, analysing the cars or the road may provide different essential areas for making modifications to increase traffic efficiency, maintain the flow, and protect people from non-rule breakers. This document provides an overview of the various methodologies used in vehicle detecting systems. In this study, represents look at different techniques used by different writers and their outcomes.

2. VEHICLE NUMBER PLATE DETECTION SYSTEM

Vehicles are a necessary component of our daily lives. As prices fall, everybody can afford a larger car. Number plates are used to identify automobiles all around the world. The angle between the car and the camera can also change, which can have an influence on the accuracy of plate content identification.[29][10][35] [26] Furthermore, variances in typefaces, colours, background pictures, and plate standards make computerised licence plate identification a difficult operation. In recent years, computer vision technology has made significant progress in addressing real-world challenges. In Fig.1 represents Vehicle Number Plate Detection System.

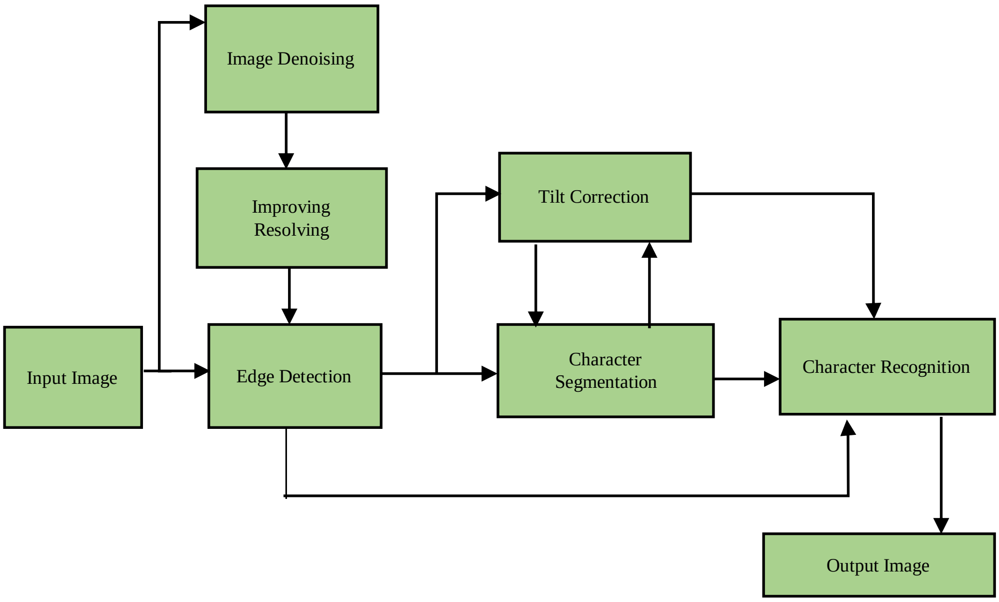

Fig.1 – Vehicle Number Plate Detection System

The Vechicle Number Plate Detection system is following ways:

(a) **Image Acquisition-**Input image captured through camera.

(b) **Image Preprocessing-**

RGB To Gray Conversion- Important edges and other elements cannot be identified in a colour picture. Because processing an RGB image is difficult and time-consuming, to must first convert a colourful image to a grayscale image.

Image Enhancement

The goal of adaptive histogram equalisation is to improve image contrast (gray colour image). to create numerous histograms, each for a different part of the image. This is beneficial since in a traditional histogram, a single histogram represents the whole image.

Median Filtering-To remove noise in the image.

Edge Detection- The goal of adaptive histogram equalisation is to improve image contrast (gray colour image). to create numerous histograms, each for a different part of the image. This is beneficial since in a traditional histogram, a single histogram represents the whole image.

Morphological Image Processing- The goal of the structuring element is to produce output of the same size. To increase the thickness of the edges, use dilation and add pixels to the object's border. Using the Shrinking procedure, thinning the image to remove unnecessary elements.

(c) **Threshold-** Pixels that are above and below the set threshold value are assigned two separate levels in this procedure. The item is transformed to binary form to distinguish it from the backdrop picture. The technique of determining the grey level threshold is straightforward. The threshold (T) value is chosen and compared to each pixel in the picture. It also converts the input binary picture (K) into a segmented output binary image (F). The histogram of the picture is partitioned using a single threshold value in global threshold. The volume of grey level lying between the baseline border, which sits between the pixels in the foreground and background, is referred to as the threshold.

(d) **Segmentation-** Character segmentation serves as a link between the extraction of number plates and character detection. Different characters on a number plate region are divided in this method. The segmentation operation is hampered by a variety of factors such as illumination variations, plate frames, and rotation. Boundary box analysis is another name for a segmentation approach. Characters are allocated to related components using this approach, and they are extracted using boundary box analysis. When the image's noise level is reduced, the segmentation procedure is complete.

(e) **Character Detection-** Using feature extraction to extract the characteristics of characters and their diverse categorization methodologies, the character detection method is finished. The characters on the number plate are recognised using a machine learning technique.

3. RELATED WORKS

During the previous two decades, the widespread use of personal automobiles has posed a number of issues, including effective traffic control, tracking traffic rule violators, locating stolen vehicles, and security surveillance. The licence plates of the cars must be detected and recognised for these duties to be completed. As a result, the literature on licence plate detection has a substantial body of material.

In [4] the authors separate the work of licence plate identification into three channels: red, green, and blue. The images in each channel are fed into CNN, which learns the hierarchical features, and the results are sent into SVM, which generates the target probability label values. Similarly, the multi-directional you only look once (MD-YOLO) architecture based on CNN is employed by [5] for a multi-directional licence plate identification system. With the best detection accuracy, the suggested framework can handle multi-directional challenges. MD-YOLO predicts the centre coordinate of every object with width and height from its width and height. The authors train the informative system using a deep-learning technique separated into three parts: detection,

cutting, and role identification [16]. Many pre-treatment processes were used to detect licence plates, and then the CNN model was used. The shapes (A–Z) and numerals (0–9) are then recognised.
[25] talks about a particular type of feed-forward multi-layer perception. To conduct licence detection, the suggested supervised model can automatically extract features. The implemented method's primary goal is to improve character detection performance by utilising a modified CNN. As the characters used in different languages change, several techniques to licence plate identification are proposed. In [1] the authors, for example, propose an excellent identification method for Malaysian licence plates. A smearing algorithm is used to recognise licence plates in single and double lines. The accuracy of plate localisation is 97.4 percent, character segmentation is 96 percent, and character detection is 76%. In [6], the authors used the inception technique to solve the problem of detecting licence plates. The suggested method tries to recognise licence plates in low-intensity pictures that are dull. Blob extraction, segmentation, and character detection are just a few of the plate identification issues addressed. The method can get a 98.40 percent detection accuracy.
In a similar vein, the authors [15] offer a method for recognising licence plates in Australian settings. It is concerned with the diversity in the look of a large number of plats as a result of the employment of various patterns and colours from various states. The plates used in the covers, as well as the usage of non-standard materials, add to the difficulty. Using image processing and an artificial neural network-based method, the suggested method accurately detects distinct plates with 0.95 accuracy. In [34] scale-invariant feature transform (SIFT) characteristics are used to create a licence plate identification system. The goal of this research is to find the licence plate. The method is used to recognise Chinese characters on licence plates. Lighting fluctuation, partial occlusion, and poor character are all factors taken into account. Candidate filtration accuracy is 96 percent, while character segmentation accuracy is 100 percent.
In [28], an automated number plate identification system for real-world use was developed. The system incorporates several real-world features, such as screw fastening, typeface variations, spacing, colour, and the various symbols seen on number plates. [8] describes a two-stage licence plate identification method in which fuzzy disciplines are used for plate localisation and neural networks are used for detection. The performance of the suggested technique is assessed using images acquired from diverse scenarios. The licence plate location accuracy is 97.9%, with a 95.6 percent plate identification rate.
In [32], the authors present a sensor platform for controlling a vehicle barrier with image-based licence plate identification. The suggested method recognises licence plates in difficult situations, such as those with varying licence plate backgrounds, typefaces, and deformations. A conventional optical character detection pipeline is used to recognise characters for this purpose. For licence plate extraction, character segmentation, and character identification, respectively, the method achieves 98 percent, 96 percent, and 93 percent accuracy. Multiple plate identification utilising a single frame is described in [22]. The goal is to improve detection accuracy for characters with different sizes or shapes on plates in acquired photos. Only Spanish plates are used for plate detection, whereas only Spanish plates are used for plate identification.
In [14], an adaptive picture segmentation approach and connected component analysis are used to provide a unique system for automobile licence plate detection. A neural network for character detection is also used. According to the findings, the proposed technique can appropriately segment 96.5 percent of the plates. Similarly, the accuracy of plate identification is 89.1%. According to research, limits in distance, angle of view, lighting conditions, and backdrop complexity impact plate detection outcomes. Controlling these variables can improve detection accuracy.
Despite the correctness of the study papers mentioned above, these methodologies are constrained by a number of issues. Several systems, for example, concentrate on licence plate detection in static or low-motion contexts, such as underground parking garages with limited vehicle speeds. Others, meanwhile, concentrate on single-stage deep-learning techniques, which have a high plate detection accuracy but are difficult to implement in real-world contexts because to their computational complexity. Many crucial elements, such as the employment of non-traditional number plates with various fonts and sizes, as well as colour schemes, are also not well examined. The goal of this research is to provide a method for accurately recognising licence plates in the tough environment of developing nations such as Pakistan.

Table.1- Related Works for Vehicle Number Plate Detection System

Year	Author and Title of the Paper	Journal Name	Techniques used	Limitations
2010	. R. Sanap, S. P. Narote, "License Plate Detection System for Indian Vehicles"	AIP Conference Proceedings	FCRN (Fully Convolutional Regression Network) [23]	High Complexity
2014	Dinesh Bhardwaj, Shruti Gujral,"Automated Number Plate Detection System Using Machine learning algorithms (Kstar)"	International Journal of Enhanced Research in Management & Computer Applications,	HOG, SVM [13]	Less Response Time & More Accurate Results
2014	Jun-Wei Hsieh, Li-Chih Chen, Duan-Yu Chen, "Symmetrical SURF and Its Applications to Vehicle Detection and Vehicle Make and	IEEE Transactions on Intelligent Transportation Systems,	CNN (Convolutional Neural Network) [12]	High Resolution & Less Accuracy

	Model Detection"			
2016	Carlo Migel Bautista, Clifford Austin Dy, Miguel Inigo Manalac, Raphael Angelo Orbe, Macario Cordel, "Convolutional neural network for vehicle detection in low resolution traffic videos"	IEEE Region Symposium, Bali, Indonesia	CNN (Convolutional Neural Network) [7]	Low Resolution & High Accuracy
2016	Shaoqing Ren, Kaiming He, Ross Girshick, Jian Sun, —Faster R- "CNN: Towards Real-Time Object Detection with Region Proposal Networks"	IEEE Transactions on Pattern Analysis and Machine Intelligence	Faster R-CNN [31]	High Quality Region
2016	Yuan Li, Andreas Møgelmose, Mohan M. Trivedi, "Pushing the Speed Limit: High-Accuracy U.S. Traffic Sign Detection with Convolutional Neural Networks"	IEEE Transactions on Intelligent Vehicle	CNN (Convolutional Neural Network) [39]	Detection Accuracy is High
2017	Zied Selmi, Mohamed Ben Halima, Adel M. Alimi, "Deep Learning System for Automatic License Plate Detection and Detection"	IAPR International Conference on Document Analysis and Detection	R-CNN (Regional Convolutional Neural Network) [41]	High Quality & Accuracy
2017	Kelathodi Kumaran Santhosh, Debi Prasad Dogra, Partha Pratim Roy, "Real-time Moving Object Classification Using DPMM for Road Traffic Management in Smart Cities"	IEEE Region Symposium	Mixture Model (DPMM) [21]	High Accuracy
2017	Kaijing Shi, Hong Bao, Nan Ma, "Forward Vehicle Detection Based on Incremental Learning and Fast R-CNN"	13th International Conference on Computational intelligence and Security	Rapid Learning Algorithm [20]	Robustness & Accuracy High
2017	Yuan Yuan, Zhitong Xiong, Qi Wang, "An Incremental Framework for Video-Based Traffic Sign Detection, Tracking, and Detection"	IEEE Transactions on Intelligent Transportation Systems	Yolo (you look only once) [40]	Good Effectiveness
2017	Reshu Kumari, Surya Prakash Sharma,"A Machine Learning Algorithm for Automatic Number Plate Detection"	International Journal of Computer Applications	Sobel Edge Detection [27]	Based on the HOG Features Accuracy is High
2020	ALI TOURANI "A Robust Deep Learning Approach for Automatic Iranian Vehicle License Plate Detection and Detection for Surveillance Systems"	IEEE	Proposed YOLO.V3 [2]	Real Time Performance & High Accuracy
2020	Chao Xu "License Plate Detection System Based on Deep Learning"	IEEE	SVM [9]	Less Accuracy
2020	CHRIS HENRY "Multinational License Plate Detection Using Generalized Character Sequence Detection"	IEEE	YOLO v3 [11]	Effective Detection
2020	WANG Weihong "Research on License Plate Detection Algorithms Based on Deep Learning in Complex Environment"	IEEE	Deep CNN [33]	Environmental Complexity

2020	Yizhou Zhang “A Novel Deep Learning Based Number Plate Detect Algorithm under Dark Lighting Conditions”	IEEE	CNN [38]	Robustness
2020	Irina Valeryevna Pustokhina ”Automatic Vehicle License Plate Detection using Optimal K-Means with Convolutional Neural Network for Intelligent Transportation Systems”	IEEE	OKM-CNN [17]	Effective Performance
2020	Yanyang Liu “Research on License Plate Detection Algorithm Based on ABCNet”	IEEE	ABCNet CRNN-CTC [37]	To improve the Accuracy
2020	Real-time Automatic License Plate Detection System using YOLOv4	IEEE	YOLO v4 [18]	Improving Performance for recognize contorted Characters
2021	Sergio M. Silva “A Flexible Approach for Automatic License Plate Detection in Unconstrained Scenarios”	IEEE	IWPOD-NET [30]	Achieve Zero Error rate
2021	QIUYING HUANG “A Single Neural Network for Mixed Style License Plate Detection and Detection”	IEEE	ALPRNet [24]	More Effectively & Multiple and Mixed LP Detection
2021	JITHMI SHASHIRANGANA ”Automated License Plate Detection: A Survey on Methods and Techniques”	IEEE	Deep Learning based ALPR System [19]	High Performance
2021	BEDIR BEDIR YOUSIF “ ‘‘Toward an Optimized Neutrosophic k-Means With Genetic Algorithm for Automatic Vehicle License Plate Detection (ONKM-AVLPR)’’	IEEE	ONKM-AVLPR [3]	Detection Accuracy is High
2021	XINYI QI “Vehicle Trajectory Reconstruction on Urban Traffic Network Using Automatic License Plate Detection Data”	IEEE	Improved KSP [36]	Improve the Searching Efficiency

4. CONCLUSION

ANPR systems are based on complicated optical, computing and digitizing capabilities that may result in a slow detection process of plates. The ANPR solutions available in the market do not offer a standardized set for all the countries; each company has to be provided with a well optimized system for different parts/regions of the world, since the same system as developed is not sufficient and needs to be designed according to the region where deployed; keeping all the affecting factors in considerations. It needs to be made sure if the required countries are supported in the library or engine that is installed on the camera. Each ANPR solutions system provided by vendors has its own strengths and weaknesses. With the increase in the number of vehicles, vehicle tracking has become an important research area for efficient traffic control, surveillance, and finding stolen cars. For this purpose, efficient real-time license plate detection and detection are of great importance. This study paper presents a concise description of the vehicle number plate detection as well as detection techniques used for effective traffic monitoring and observation of the reliability of the methods. This study includes a comprehensive evaluation of the progress and future patterns in the identification and detection of recent vehicle number plates which could be of value to researchers interested in such development. This survey represents various deep learning based approaches for Vehicle Number Plate Detection System.

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