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A Review on Automatic Number Plate Recognition

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Abstract - *Automated Number Plate Recognition is an essential tool used in modern traffic management systems. Implementing image processing techniques, this technology performs an automatic detection of characters on a vehicle's license plate . In such a way, ANPR contributes to traffic monitoring, provides for enhanced security, and facilitates the enforcement of applicable traffic rules. Particular ANPR systems are indispensable for efficient traffic control and surveillance, which includes criminal investigation, toll collection, speed management, parking control and many other tasks. Thanks to the advances made in the field of image processing algorithms, ANPR systems can now handle the task of accurately generating and sorting tags of license plates, which is due to providing for the development of intelligent traffic management systems.*

Key Words: *ANPR, Automated Number Plate Recognition, Modern traffic management systems, Image processing techniques, Automatic detection.*

1.INTRODUCTION

In various contexts, vehicle platform detection and identification are utilized, encompassing tasks such as estimating travel times, conducting traffic surveys, detecting violations, and enhancing surveillance systems. The rising population also contributes significantly to the proliferation of automobiles. Recently, many students and faculty members at educational institutions have encountered challenges in finding parking spaces. Due to the lack of security personnel capable of maintaining vehicle records manually, most parking lots are operated by security guards. Consequently, drivers often have to navigate parking lots on foot to secure a spot, which can lead to vehicle thefts and conflicts among drivers vying for parking spaces. Automated License Plate Recognition (ALPR), also known as ANPR, represents a breakthrough in image processing technology utilized for vehicle identification. The integration of ALPR technology into security and traffic management systems is a forward-looking endeavor. The Tag Reconnaissance System exemplifies a computer vision application designed to extract pertinent information from digital images, such as license plate size and contours, which aids in distinguishing between multiple tags.

To utilize the ANPR system, it's necessary to place your vehicle appropriately and capture either a frontal or rear image. Subsequently, the license plate number is located and the plate is extracted. The final segmentation stage of the neural network involves employing a picture segmentation approach, which includes mathematical morphology, color analysis, and histogram analysis. Segmentation, a character recognition technique, is applied to each identified character. Optical Character Recognition (OCR) is utilized as one of the methods to recognize individual characters, utilizing a preserved database for each alphanumeric character.

The VLPR framework facilitates various traffic applications and enhances safety measures, encompassing parking lot surveillance, automated toll collection, road traffic monitoring, vehicle enforcement, traffic volume analysis, and crime prevention. It enables the implementation of traffic control measures. Through frame sequences or still images, this algorithm accurately identifies license plate numbers. Automatic automobile plate recognition (APR) utilizes image processing, object identification, and pattern recognition coupled with optical character recognition (OCR) to detect license plates.

2. LITERATURE REVIEW

Saqib Rasheed et. al (2012) The research article presented an "Automated Number Plate Recognition system using Hough lines and template matching" to develop a viable way of identification and recognition of license plates. This system was built on the principle of Hough Transformation and a template matching model. The detection of plates was done through the use of Canny detector and Hough transformation while the identification of license numbers was done through matching templates. The system was successful in extracting vehicle plate and identified 94.11% of vehicles . The ANPR system produced a success rate of 89.70% after standardization of number plates for Islamabad.

Ravi Kiran Varma et. all (2019) The purpose of the paper was to identify Indian vehicle license plates. Throughout the work, the authors illustrated the progress in terms of pre-processing and providing a scheme that resolves numerous issues, such as varying lighting conditions of images, hazy or skewed images, and background noise. The significance of the study is associated with the use of top-level image processing techniques during the pre-processing run, including morphological transformations and Gaussian filtering, which improve the identification of both standard and partially worn-out numeric plates in wider scenarios.

Alice N Cheeran et. al (2017) Here is the algorithm capable to characterize car numbers given in the article. It implements a modified Ant Colony Optimization Algorithm for plate localization and edge detection. Using the Kohonen neural network, it clusters every position of the character and its width. In addition, it compares CCA and a proposed hybrid network for evaluation with the help of the neural Kohonen network. Finally, the conclusion involves the hybrid hierarchical method of classification on the inductive RULES-3 and SVM approaches. That approach married with the letter segmentation and extraction algorithm has generated the accuracy of 94% .

Ayush Mor et. all (2019) Multiple license plate detection systems are widely known. However, their identification success depends on many factors. First, it focuses on three important points: image location, segmentation, and recognition. Secondly, the following present study performs a comprehensive analysis concentrated on comparing recognition plate techniques and provides reviews on five aspects of experimental validation: techniques, databases, accuracy, processing time, and real-time relevance.

Sumanta Subhadhira et. al (2014) The License Plate Recognition Application utilising Extreme Learning Machines proposed in the paper developed a novel license plate recognition system utilising the Extreme Learning Method . It was developed specifically to recognise Thai license plates using ELM as a classifier and Histogram of Oriented Gradients for feature extraction. The principles of its operation are similar to those of provincial LP recognition. ELM is used for data segmentation, and the provincial component demonstrates a 95.05% accuracy rate; however, the data employed is insignificant. In the final result, the proposed application exhibits an 89.05% accuracy in LP recognition, taking both the rok krar hindaran and the province of the vehicle into account.

Olamilekan Shobayo et. all (2020) In the operation, we used a smart IR sensor to detect the motion, a camera to capture the image and also to extract text from the images and save it on a web page. The assigned endeavor created a low-cost and effective system, which used the Raspberry Pi as one unit. Character recognition and segmentation took place using OpenCV together with Python.

Yoshihiro Shima (2016) The paper entitled “Extraction of Number Plate Images Based on Image Category Classification using Deep Learning” presents the novel technique concerning Automatic Number Plate Recognition system combined with the procedure of region extraction using morphological image processing and deep learning approaches. The concept of morphological image processing includes the method of edge detection and CCA. The pre-trained CNN is used as a feature extractor, while Support Vector Machine is applied as the classifier. C++ and PERL are included for the implementation of morphological image processing, while MATLAB is used for the implementation of pre-trained CNN and SVM. The proposed system was tested on 126 example images providing the successful extraction of 113 correct number plates and approximately success rate 89.7%.

Shally Gupta et. all (2020) The topic of this work is the analysis of vehicle number plate identification in the context of traffic management. It is possible to state that this endeavor is beneficial and rather accurate as automatic number plate recognition uses contemporary image processing technology to learn about the ownership of cars. The role of such systems in the creation of smart transport systems is also quite prominent.

Dinesh Bhardwaj et. al (2014) In the study "Automated Vehicle Number Plate Recognition using Machine Learning Algorithms", the authors propose a methodology for the recognition of vehicle number plates. The methodology suggests a five phase approach: Obtaining the image of the number plate using a high-quality camera then performing image pre-processing such as converting the image to its grayscale, performing noise elimination using median filtering, performing edge detection using the Sobel Technique, performing segmentation via a vertical method and performing character recognition (using the K-Star) machine learning algorithm. A dataset containing 320 images of the vehicle number plates was constructed and images were obtained in real-time scenarios such as parking etc.

P.Meghana et. all (2019) License plate recognition has gained increasing popularity with the rapid growth of both vehicles and modes of transportation such as cars, motorcycles, or bicycles. This system integrates various image processing technologies to support vehicle identification. This document is dedicated to the description of different approaches, advantages, and drawbacks of plate recognition to enable the audience to make informed decisions and choose the most user-friendly, efficient, and reliable method. It is emphasized that such factors as speed, lighting, and text variations should not affect the performance of the apparatus.

Wei-chen Liu et. al (2017) Their study, titled "A Novel Hierarchical License Plate Recognition System Employing Supervised K-means and Support Vector Machine," presents a new hierarchical character recognition approach using supervised K-means and SVM. The main goal was to minimize the character classes in each sub-group, which reduced the number of SVMs and their associated complexity's required. The system is 98.89 percent accurate in recognizing blurred and tilted plates. A comparative analysis with state-of-the-art plate recognition systems showed an average improvement of 3.6 percent.

Anisha goyal et. all (2016) The presented paper talks about the automated license plate recognition system designed for vehicles. The proposed system recognizes vehicles using the image processing algorithms stored in the computer database. As evidenced by the positive performance across different scenarios and unique types of the license plate so far, the algorithm functioned successfully in the Matlab environment, which is why real-life images can be correctly processed. The highlighted problem with the obscured plate was also discussed, and detecting the characters at the license plate was proposed as a solution.

Yongsheng Li et. al (2019) The paper "Vehicle License Plate Recognition Utilizing MSER and Support Vector Machine in Challenging Environments" (which is available here) has shared an algorithm for license plate recognition using MSER and SVM. This algorithm was pitted against traditional methods like edge detection or color detection. When used in complex environments, where MSER literally extracts the character areas and then recognize without prior plate localization and segment processes, the method exhibits an accuracy of over 90%, a substantial improvement over edge or color detection methods.

Aniruddh Puranic et. all (2016) The implemented matching model consisted of numerical plates extracted from static images and reached an average accuracy of 80.8%. This accuracy can be significantly improved if both the camera placement to capture the best frames and two neural network layers with horizontal kernels are employed. Additionally, the proposed system's performance and overall efficiency can also be increased by incorporating MulTiLeveled Evolutionary Algorithms, thus enabling the system to detect multiple car plates in a single frame.

Yang Guang (2011) The study is "Character Recognition of License Plates Utilizing Wavelet Kernel LS-SVM" which introduces a method using wavelet LS-SVM in character recognition. The Mexico hat wavelet kernel, which has the capability of multi-scale analysis and being near orthogonal, is selected to attain the improvement in generalization. There are two stages of pre-processing and multi-classifier in the character recognition by using this LS-SVM wavelet kernel. Four classifiers are implemented based on the wavelet kernel LS-SVM according to BT-model. The experimental verification is that the testing result with the BP neural network and RBF LS-SVM method achieves a good cumulative recognition rate of 98.3%.

S. Sanjana et. all (2020) The need for urban development is associated with efficient traffic monitoring. The incorporation of number plate recognition with motorcycle and helmet detection allows imposing penalties on motorcyclists not wearing helmets. Various online tools and numerous integrated models available nowadays have provided impetus to machine learning and image processing technology development and made it possible to design a range of solutions suitable for multiple industries.

Mahima Satsangi et. al (2018) In the paper "Comparative Analysis of License Plate Recognition Techniques: Thresholding, OCR and Machine Learning", the authors explored LP recognition utilizing the Viola-Jones algorithm, concentrating on character recognition and classification. A magnetic loop detector sensor was used to capture the images. The process of identifying the image in question is broken down into three steps: image detection, LP extraction and image segmentation. The authors utilized the Viola-Jones algorithm in the Anglo, in paper, as well as methods like Haar features, the use of Integral images, AdaBoost and Cascade classifier. The authors show the results of the algorithm compared to more traditional thresholding and OCR technologies and Viola-Jones demonstrates a clear superior, with an 80% accuracy compared to an 8-20% accuracy for the former two technologies.

Ashwin Jaware et. all (2020) This paper discusses the invention of an automobile license plate recognition system. It is built on image processing algorithms which help to identify cars by comparing different details with the database stored in a computer or system of computers. The technologies used for the system's implementation are Python/Java, and the invention requires the performance of some updates and testing with real photos. The challenges to be overcome related to plate distortion and image clutter. I would also suggest using a new approach, which implies neural network classifiers to support character clarity, and improve overall plate detection.

Kaili Ni et. al (2018) The paper "Novel License Plate Classification Approach Based on Convolutional Neural Networks" presents a novel approach for classifying license plates due to its use of CNNs. The approach is based on the use of a CNN architecture which consists of seven layers; four of the layers are convolutional layers, and are followed by corresponding max-pooling layers, to create a feature extraction and classification layers, then a softmax function is applied in the softmax layer. For vehicle plate localization Faster-CNN is utilized. In the results the classification accuracy is 100% on training set and 98.79% in the testing set.

Zied Selmi et. al (2017) In the study "Automated License Plate Detection and Recognition Using Deep Learning", automatic license plate detection and recognition using deep learning methodologies were explored. The research applies two CNN models – the first model for license plate detection and the second model for classification and recognition tasks. Preprocessing steps are performed to distinguish license plates from non-license plates. Character segmentation was performed using the Canny edge detection technique and character recognition applied a TensorFlow framework that was combined with the second CNN model

with 37 classes. Datasets used in the study were obtained from Caltech and AOLP datasets.

Table -1: Summary Table

Sr. No.	Method Used	Result
[1]	Identify lines by utilizing the Hough transform and template matching.	The outcome can identify and recognize the license plates of Islamabad. It provides an accuracy of 89.70 percent, with a recognition time of 0.9 seconds for each image.
[3]	A hierarchical grouped structure is employed in plate location using a modified version of Ant Colony Optimization (ACO), which is based on the inductive RULES-3 and Support Vector Machine (SVM) approach.	The proposed algorithms successfully segment and extract the image of plates, resulting in a precision rate of 94 percent. Moreover, the combined approach enhances the results for character recognition.
[5]	ELM is used for recognition, while HOG is used for feature extraction and pre-processing.	The results validate the recognition of Thai license plates, with a 95.05% accuracy in identifying the province and an 89.05% success rate in matching license plates with their respective provinces.
[7]	The Alex-Net CNN is utilized to extract features in morphological image processing, which is subsequently followed by the SVM classifier.	The success rate of capturing license plate information from 126 rear sample images using the new device is 89.7%.
[9]	The Kstar machine learning algorithm, sobel, and vertical segmentation are used in various applications.	This technique recommends utilizing five steps that involve analyzing Indian plate characters to enhance the speed of recognizing number plates.
[11]	A hierarchical approach that combines supervised K-means with support vector machine.	The accuracy of the device in identifying characters from Taiwan license plates is 98.89% based on 1530 image samples. The system shows high accuracy and requires fewer computations, reducing complexity.
[13]	Algorithm that uses Maximum Stable Extremum Region (MSER) along with Support Vector Machine and Kernel method.	The integration of MSER and SVM yields better results in character recognition compared to conventional methods that do not take into account license plate position and character segmentation. The suggested system is more efficient and accurate, achieving a 90% success rate.
[15]	Mexico has a wavelet LSSVM (least square SVM).	The results of the experiment show that vehicle license plates can be accurately and quickly identified. The study used 500 image samples for training and testing. Additionally, the success rate of the Mexico hat wavelet LS-SVM was compared to the neural network BP and the LSSVM RBF, and it was found that the Mexico hat wavelet LS-SVM achieved a high success rate of 98.3 percent.
[17]	Viola Jones machine learning algorithm.	The Viola Jones machine learning algorithm was employed to identify characters in 510 images. The outcomes were contrasted with conventional methods like threshold and OCR technology. Out of these three technologies, Viola Jones demonstrated superior efficiency, achieving an 80 percent recognition rate.
[18]	Faster-CNN	The CNN model is utilized for number plate classification, with an improved classification process in place to mitigate the impact of low picture quality on character recognition. This program has achieved an impressive accuracy rate of 98.79 percent.

3. CONCLUSIONS

This study presents the implementation of advanced image processing techniques for the recognition of vehicle plate numbers in terms of traffic surveillance. Powerful image processing methods allow detecting vehicles from all possible positions and acquiring detailed information about their owners. Automatic number plate recognition systems supported by today's technologies are among the most common applications used in the development of intelligent transportation systems . To enhance the process of number plate recognition, deep learning algorithms are recommended to be implemented in the circumstance of tilted or side-view images and varying estimated distance, and the You-Only-Look-Once algorithm in combination with CNN are recommendable for character recognition. It is also important to keep in mind the fact that ANPR systems are lightweight and well-protected.

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