Deep Learning Model for Automatic Number/License Plate Detection and Recognition System in Campus Gates

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***Abstract*— Automatic Number Plate Recognition (ANPR) is a technique designed to read vehicle number plates without human intervention using high speed image capture with supporting illumination. Automatic Number Plate Recognition (ANPR) is a critical technology that enables the monitoring and control of road traffic and parking management, towing systems, vehicle gate entry management, etc. This paper explores the use of deep learning techniques, including OpenCV, YOLO, PaddleOCR, and Tesseract OCR, in combination with Python programming language, to develop ANPR systems. The study investigates the effectiveness of these techniques in detecting and recognizing vehicle number plates under different conditions, including lightly, sunny, rainy, and darkness environments. Additionally, the paper presents the results of experiments conducted to evaluate the accuracy and effectiveness of the ANPR system. The study finds that the integration of deep learning and OCR techniques provides a robust solution for ANPR under different environmental conditions. The findings of this study have important implications for the development of efficient and accurate ANPR systems in the future.**

Keywords*— *Deep learning, computer vision, ANPR, EasyOCR, paddlerOCR, Tesseract OCR, openCV

I. INTRODUCTION

Recently, there has been tremendous growth in the number of active vehicles, which has also led to an increase in illegal activities. It is difficult to keep track of all vehicles due to their rapid increase, making it crucially important for the relevant authorities to keep track of them. With the growing number of vehicles, there is an increasing need for automatic number plate detection. This tool can also be used to monitor the speed of vehicles, which is particularly important given the number of accidents that occur each year. The UK police first discovered Automatic Number Plate Recognition (ANPR) in 1976, and this technology has gained popularity in the last decade [1].

Computer vision is an interdisciplinary scientific field that deals with how computers can gain high-level understanding from digital images or videos. Computer vision tasks involve methods for acquiring, processing, analyzing, and understanding digital images, as well as the extraction of high-dimensional data from the real world to produce numerical or symbolic information, such as decisions. Automatic number plate recognition (ANPR) is a technology that uses optical character recognition on images to read vehicle registration plates and create vehicle location data. Recent advances in computer vision technology and the falling prices of related devices have made it practical to automatically identify vehicles visually, either online or offline using video/CCTV. The objective of the research is to develop a computer vision-based automatic vehicle identification system that uses optical character recognition (OCR) techniques to achieve vehicle identification, as shown in Fig 1. [2]. The work involves investigating real-time automatic number-plate recognition and its potential extension to other aspects of road traffic monitoring and control.

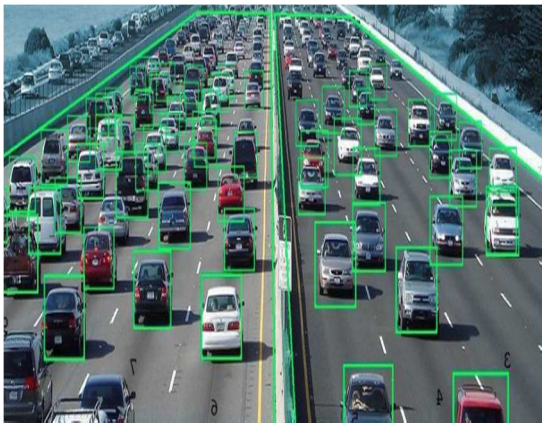

Fig. 1. OCR technology used for object recognition

Automatic License Plate Recognition (ALPR) recognizes a vehicle's license plate number from one or more images taken by a camera, which can be color, black and white, or infrared. It involves a combination of techniques, including object detection, image processing, and pattern recognition. ALPR is also known by other names, such as automatic vehicle identification (AVI), car plate recognition (CPR), automatic number plate recognition (ANPR), and optical character recognition (OCR) for cars. [3].

Developing ANPR systems is a challenging task because it involves multiple steps, and each step depends on the previous one. Achieving 100% accuracy is currently impossible. Moreover, technical challenges arise due to various factors such as differences in illumination or background patterns, picture quality, and test speed of the machine learning model. These factors greatly affect the accuracy of number plate recognition. Additionally, the location, quantity, size, font, color, or inclination of number

plates pose further obstacles in developing a consistent ANPR system. [4].

II. Literature Review

Over the past ten years, as information technology has advanced and the population has grown, various methods for creating license plate detection systems have been developed and explored.

The author emphasizes that Automatic-Number-Plate Recognition (ANPR) systems are crucial in image processing, but they face challenges due to variations in license plate formats, lighting, scales, and colors across different regions. To improve detection and recognition rates, researchers have developed and tested various techniques, such as the Douglas Peucker Algorithm for shape approximation, which detects rectangular contours and extracts the most prominent one as the number plate. Connected component analysis is then used to segment characters, and optical character recognition (OCR) recognizes the number plate characters. [5].

This paper provides a detailed survey of current ANPR systems and algorithms, comparing their performance in real-time testing and simulations. The goal is to advance ANPR technology built on computer vision (CV) algorithms by analyzing extraction, segmentation, and recognition techniques and providing guidelines for future trends. Additional hardware may be required to maximize accuracy even with the best algorithms [6].

The main objective of this research is to investigate the segmentation and recognition issues in the License Plate Recognition Framework and develop alternative solutions. This involves three phases: locating and extracting the license plate area from a larger scene image, removing the alphanumeric characters from the background using the license plate region, and then providing them for recognition in an OCR system. To successfully identify a vehicle through the license plate, the plate must be visible in the image captured by the acquisition system, such as a video or still camera. [7].

The use of an automated license detection system in today's busy traffic system is crucial. It automatically monitors traffic regulations and helps enforce them. In India, there are many incidents of rash driving and violation of traffic rules by drivers, making it difficult for traffic police officers to identify car details. To simplify and expedite traffic regulation monitoring on cars, an automated license detection system has been developed and implemented over time. This article provides a brief overview of various approaches for automatic license detection. [8].

III. Automatic Number Plate Recognition

Automatic Number Plate Recognition (ANPR) is a system that uses optical recognition to identify license plate numbers after detecting them in an image. The accuracy of the system depends largely on the quality of the acquired images. Images are two-dimensional visual perceptions that are critical to the algorithm's functionality. The car can be captured in this frame, and the plate number can be extracted provided the image is not blurry, obscured or defective. A car can be identified uniquely by its number plate. The system processes the image and returns the vehicle's data, which includes the plate number. [10].

ANPR is a system that utilizes Optical Character Recognition (OCR) to recognize characters from various sources like surveillance cameras or other cameras. It is crucial to position the camera at the correct angle to capture the best and most precise image [11]. OCR analyzes each character separately. OCR is a method of transmitting written or printed information from any source, including written or printed documents and images, to a text decryption machine to obtain the desired source. It is a complex process that involves multiple algorithmic steps, such as uploading the image, detecting characters, adjusting them on the page, eliminating blurriness, and producing a final editable format. [12].

The OCR system is utilized in various domains, including business, industries, research, security, literature, and even medicine, to develop devices for individuals with vision impairments. It is commonly used in applications such as license plate recognition, passport recognition in airports, barcodes in institutions, and converting handwritten text to electronic documents. [13].

The ANPR system has different algorithms or rules for processing each part of the license plate image. However, there are several challenges in processing the image due to factors such as blurriness, insufficient lighting, obstructive objects, poor angles, font differences, and inconsistencies between states. [14].

IV. Limitations of Existing System

Below are some significant constraints of the current system. The differences in plate types or surroundings make it difficult to identify and recognize license plates. These can be summarized as follows: [15, 16, 17]:

1- Location: License plates can be found in various parts of an image.

2- Poor resolution: The plate may be too far away, or the camera used may have low-quality black and white settings.

3- Blurry images: Images with motion blur are hard to process.

4- Quantity: An image may contain no plates or multiple plates.

5- Size: The plates can have different sizes based on the camera's distance and zoom level.

6- Poor lighting and low contrast: Overexposure or shadows can cause difficulties in reading the plate.

7- Different font: Custom or vanity plates can have unique fonts.

8- Lane changes: Vehicles may change lanes during plate recognition, affecting the camera's angle of view.

9- Obstructions: Objects like tow bars or dirt can obstruct parts of the plate.

10- Lack of coordination between countries or states: Plates from different states or countries may have the same number but different designs.

11- Color: Plates can have different background colors and characters due to capturing devices or plate types.

12- Font: Plates from different nations may have different fonts and languages.

13- Inclination: Plates may be tilted.

14- Other elements: Plates may contain frames and screws in addition to characters.

V. Proposed Methodology

The proposed project aims to combine object detection and automatic license plate recognition (ALPR) with text extraction using Optical Character Recognition (OCR). The system will detect the license plate, then use OCR to extract the text and numbers from the image. Two OCR methods, Easy OCR and Pytesseract OCR, will be used to compare the accuracy rates of the dataset [18]. It The process involves using algorithms to detect the rectangular area of a license plate from an image captured by a video camera. Optical Character Recognition (OCR) is then used to scan each group of pixels within the image to identify letters, replacing them with ASCII code. ANPR cameras need to be of a special type and set up in designated parameters. The identification and recognition process occurs in four main phases. (1) Preprocessing of Image (2) Localizing Registration Plate (3) Segmentation of Characters (4) Recognition of Actual number plate [19, 20].

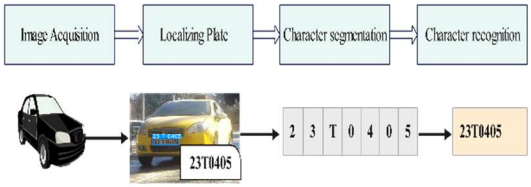

Fig. 2. ALPR proposed system

To begin the implementation, the vehicle's number plate is captured by the camera. The software takes multiple snapshots of the approaching vehicle and saves them in a file. When the number plate is of an adequate size for the OCR software, the frame is scanned, and the registration number is converted into ASCII code and stored in a list. This process is repeated for a series of images based on the speed and position of the vehicle, to ensure the best possible view of the license plate is obtained. Car Image →Grayscale Image → Binary Image → Applying Connected Component Analysis (CCA) to get connected regions → Detect license plate out of all connected regions. Initially, the images are preprocessed by applying edge detection and grayscale filter to isolate the number plate region, which is a smaller part of the extracted image. The grayscale image is obtained by quantizing from neutral gray starting from the weakest intensity of black to the strongest intensity of white. Then, the image is binarized by assigning the pixel values of 0 for black shade and 1 for white shade. The registration plate is identified by detecting the quick change in the contrast. The rest of the image is filtered out, and the actual registration plate location is determined by matching its width and height [21]. The gray level of the registration plate image is enhanced using contract extension and median filtering techniques. Then, character segmentation is performed to separate individual characters from the number plate. The first step in character segmentation is to crop out the characters from the input image, leaving the extra spaces on the sides and top intact. The characters are resized to fit in the plate region for easy comparison with the database. Finally, Optical Character Recognition (OCR) is applied. OCR is a process that separates different characters from an image and converts them into a string of characters. One approach to OCR is template matching, where the cropped image is compared to the template data in the database. OCR automatically recognizes and identifies the characters without any indirect input. If the characters on the number plate have uniform fonts, then OCR for number plate recognition is less complex. OCR is the fundamental technology used in ANPR and provides the ability to store and sort data, recognizing the extracted characters [22] Automatic Number Plate Recognition (ANPR) technology has multiple applications such as smart city entrances and various IoT-enabled locations. [23 - 25].

VI. Experimental Result

This section presents the results of number plate recognition using OpenCV and EasyOCR. A Lenovo PC with 8GB RAM and NVidia VGA was used for the work. EasyOCR is a user-friendly and open-source Python package that can perform Optical Character Recognition (OCR) to extract text from images and videos. It can handle over 80 languages, such as Chinese, Arabic, French, English, and Cyrillic. To use EasyOCR and OpenCV for the project, they need to be installed and matched appropriately. Once the required packages are installed, the first step is to import them. After that, the image is loaded and resized to the desired specifications. Then, a series of operations is performed, such as converting it to grayscale, applying a Gaussian blur to remove noise, and detecting edges using the Canny edge detector.

Fig. 3. convert image to canny filter

In order to analyze the image, the contours in the image will be detected and the contour of the license plate will be extracted. The contours were located in the image with edges and then arranged from the biggest to the smallest. Only the five largest contours were kept. Then, the contours were examined and approximated, and if a contour with four points was identified, the license plate was considered detected. After that, the bounding box of the license plate's contour was obtained, and the number plate was extracted from the image using Numpy slicing.

Fig. 4. extract license plate

The next step is Optical Character Recognition (OCR) using the EasyOCR package. The first thing is to initialize the Reader object, and then the license plate image is given as

input to the readtext function. The function returns a list with three elements which are the bounding box of the text, the detected text, and the confidence level of detection. If the length of the returned list is 0, it means that the text was not detected by the function, and a custom message is displayed to the user.

On the other hand, if text is detected, the contour of the license plate on the image is drawn along with the detected text and its probability. The final outcome is illustrated below:

Fig. 5. Result and detect ANPR Realtime

The system has been tested in various conditions such as sunny, rainy, cloudy, and at night, and it has successfully and automatically detected and recognized license plate numbers on vehicles. The photos below illustrate different situations.

Fig. 6. Detection and recognition of license plate numbers in the evening

The system has also been tested successfully in another condition, and the photo below illustrates the results.

Fig. 7. Detection and recognition of license plate numbers at night

The image below reveals that this is not always the case.

Fig. 8. Find Mistake During Detection and recognition of license plate numbers

VII. Conclussion

In conclusion, Automatic Number Plate Recognition (ANPR) is an important application of computer vision and deep learning that has numerous practical applications in areas such as traffic management, law enforcement, and parking management. In this paper, we have demonstrated how ANPR can be implemented using open-source computer vision libraries like OpenCV and PaddleOCR, as well as TensorFlow for deep learning.

Our approach involved several steps, including image pre-processing, license plate detection, character segmentation, and optical character recognition. By leveraging the power of deep learning algorithms and neural networks, we were able to achieve high accuracy rates in license plate recognition, even in challenging lighting and weather conditions.

Overall, ANPR is an exciting and rapidly evolving field with a great deal of potential for real-world applications. By using open-source tools like Python and TensorFlow, developers and researchers can continue to push the boundaries of what is possible with ANPR, helping to create safer and more efficient transportation systems for everyone.

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