Automatic License Plate Recognition System

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2023 14th International Conference on Computing Communication and Networking Technologies (ICCCNT) | 979-8-3503-3509-5/23/$31.00 ©2023 IEEE | DOI: 10.1109/ICCCNT56998.2023.10307008

***Abstract*—ALPR, also known as Automatic License Plate Recognition, is a technological system that employs the characters displayed on a vehicle's license plate to identify and distinguish the vehicle. This information can be used create a reliable license plate-based automatic vehicle identification system. The technology is put into place at security inspection entries in extremely restricted and secure regions including military zones and areas close to significant government institutions like the Supreme Court and Parliament. The suggested ALPR system employs a multi-step approach that involves optical character recognition (OCR), image processing, and character segmentation. In the image processing stage, techniques such as edge detection, noise reduction, and image enhancement are utilized to enhance the quality of the input images. Individual characters are then separated from the license plate by using the character segmentation module, resolving issues like overlapping characters, different fonts, and varying license plate sizes. Through the use of machine learning and pattern recognition algorithms, the OCR module identifies and extracts alphanumeric characters from the segmented regions. The efficiency of the suggested ALPR system is shown by experimental findings, achieving an overall accuracy of 90% with high precision and recall rates for license plate identification. The system's processing time has been observed to fall within acceptable limits, enabling its real-time implementation in practical applications.**

Keywords—Automatic License Plate Recognition (ALPR); Number Plate Recognition (NPL), Automatic Number Plate Recognition (ANPR); Region of Interest (ROI); Optical Character Recognition (OCR); Character Segmentation (CS); Vehicle Number Plate (VNP); Matrix Laboratory (MATLAB).

I. INTRODUCTION

People's lives now include automatic number/license plate recognition, which could be used in upcoming transportation technologies. There are numerous potentials to change the fundamental transportation system using self-driving car concepts. Intelligent transportation systems currently benefit from ANPR technology, which eliminates the need for human intervention. Not only parking lot fences and cameras on the sides of the road. Several of his ANPR systems have also become portable as a result of the development of smartphone technology. Originally employed in automobiles, it has evolved over time to become mobile. Due to its inexpensive implementation costs, ANPR is frequently employed in the toll and parking industries. The primary factor is that, when compared to UHF-RFID systems, ANPR systems recognize registered license plates without the need for additional transponders (Ultra High Frequency-Radio Frequency Identification) systems [1]. In this modern world, the increasing urbanization of nations is a significant development. People are emigrating from rural areas and favoring urban living more and more. As traffic in these places develops, local governments frequently are not aware of the transportation demands of locals and tourists, both now and in the future. ANPR system is increasingly being utilised to research traffic patterns and advance intelligent transportation.

In addition to reading number plates, modern ANPR cameras can also provide useful extra data including number, direction, vehicle group, and speed. The immediate detection and scanning of a huge number of moving cars using ANPR technology has resulted in its integration into numerous sectors of the contemporary digital world. Different ANPR systems are available, however they all perform the same functions. a key capacity that provides an automatic, incredibly accurate method for reading cars. It is used for a variety of purposes, including access control. Additional services include traffic management, parking management, billing for users, tracking deliveries, police and security services, customer assistance, driving instructions, and many more.

The British Police Research and Development Department devised Automatic Number/License Plate Recognition (ANPR/ALPR) in 1976 [2]. Yet, there has been a lot of attention in this decade due to the advancements made in digital cameras and computational power. This function only extracts and identifies car license plate characters automatically from photos. It essentially comprises of a camera or frame grabber that can take a picture, locate the locations of numbers in the image, and extract the characters to transform the pixels into readable numbers using character recognition software. There are numerous uses for ALPR, such as speed enforcement, tool collecting and parking lot management. Furthermore, it could be applied to locate and suppress a range of criminal activity. Compared to other of his ALPR systems, this one has a reduced computational cost. Previous approaches, in addition to being robust, involve feature-based techniques like edge detection or Hough transforms, are computationally costly, or make use of artificial neural networks that need a lot of training. & require data. ANPR is a system that reads a vehicle's license plate number from a picture of the plate using OCR.

In order to swiftly and automatically identify vehicles in still photos or real-time video from one or more cameras, automatic license plate recognition systems employ a variety of image processing techniques [3]. OCR and other image processing techniques are combined in ALPR systems to read vehicle license plates. ALPR is among the greatest and most widely used computer vision technologies. ALPR software's performance, accuracy, cost-effectiveness, robustness, and scalability are all continually being improved.

A prototype for the idea was created using digital image processing. Use procedures like taking an image, preprocessing, separating digits from digits, and OCR to save digits as text (optical character recognition). The license plate is shown on the terminal in text format using Tesseract Engine and Pytesseract's OCR language. When security officers are unable to track down or seize automobiles that break traffic laws, both security forces and authorities experience issues. On weekdays, it is difficult, according to officials, to handwrite traffic signs in parking lots. Create a system that will automatically detect automobiles breaking traffic laws, snap pictures, record their license plates in a database, and punish the owners. The tool can be used to take pictures of cars parked in lots and create license plates for a database (the cloud, if it's connected to the internet). This eliminates needless everyday manual labor, lowers labor expenses, and outperforms people in terms of productivity. You can examine and save each car number as text, search the complete database for more details, or enter the text as a search term. This project is adaptable enough to be used as a standalone software application or as an element of a bigger undertaking. An optical character recognition system in images called ANPR analyzes a vehicle's number plate to produce vehicle location data. Currently installed closed circuit television systems may make use of cameras made expressly for this purpose or traffic surveillance cameras. To confirm that a vehicle is registered or registered, ANPR is employed by authorities all around the world. Along with tracking traffic patterns, it is also used to collect electronic tolls on motorways.

Fig. 1: Example of captured image

II. LITERATURE REVIEW

A camera records a video of the vehicle's number plate in the first stage. This movie was read by his MATLAB program. The manipulative videos last approximately 10 to 15 seconds. A video lasting 10 seconds has 240 frames each picture. The video is changed from frames with a frame rate of 24 fps in the second stage. In the third stage, images are created from frames. The procedure of opening and closing is then carried out. To extract the license plate number, image processing techniques like identification, segmentation, and localization were used. The first intelligent edge detection technique locates the image's edges. Morphological operators are then applied. And this is the method used to identify license plates [4].

India has a standard format for license plates that includes the state and district codes as the first two characters, followed by four specific codes for the given vehicle registration plate. When the background and license plate have the same color, identifying and finding the license plate can be challenging. The image is subjected to operations including opening, closing, erosion, and dilation. The following are the several sections that make up the work. The camera provides the first input color image. After that, the color image is transformed into a grayscale version. Images are noise-filtered using a variety of techniques. In this instance, salt and pepper noise is eliminated using median filtering. Histogram equalization can remove the contrast in an image. The plate is then located, and picture areas and edges are created, using a Sobel edge detector. Use the segmentation method to divide the plate number into segments [5].

Image processing and character segmentation techniques are used for license plate recognition. Images and movies can be captured using high resolution cameras; thus, the output must be clear after input. He employs a system that consists of four fundamental steps. In the first stage, the video is recorded as input by the camera. Then, after the video has been converted to frames, choose a clean frame or image from it. The disc area is then extracted using two features: aspect ratio and edge density. Then the license plate is segmented where each number on the plate is identified and segmented. In order to appropriately identify the number, recognition is then performed on the number plate [6].

The following techniques are introduced in this paper: The initial technique entails preprocessing. By doing this, the color input image is turned into a grayscale image and is then divided into a variety of pixels. The Canny edge detector is used for edge detection next. Here, we look for image edges to minimize discontinuities. The input image is then enlarged and the digits' thickness is increased using morphological operators to make them simpler to distinguish. On enlarged images, segmentation is performed. It acts as though each plate number was acquired separately. OCR or another template matching algorithm is used for segmentation. The data are then improved to provide a better output picture. For the output to be of the highest quality, the camera must have a very high resolution [7].

The recognition of license plates in various situations utilizing reconstruction approaches is the main driving force behind this work. The method of recovery is comparable to image enhancement. Image quality is raised by image augmentation. The system used in this paper operates as follows: Start by positioning a camera in a specific location and taking a video. Upon acquisition, frames are created and MATLAB algorithms are used to divide the video into frames. The video lasts for 10 seconds and has 240 frames per image. It will be transformed to a picture after being converted from video to frames. For these photos, a specific license plate extraction technique is carried out. For the chosen ones, various melting methods are used. To identify license plates, apply image restoration and contrast amplification to the retrieved photos. Filtering with an unsharp mask is used to get rid of background noise like rain and fog. We obtain an output image that includes the license plate once the noise is eliminated. [8].

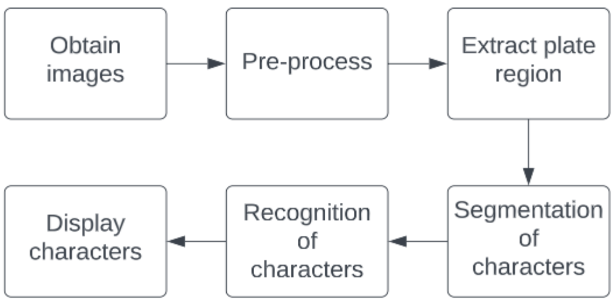

Fig. 2: Flow diagram representing number plate extraction

The Pi camera is utilized to capture an image in this document, which is then stored in color JPEG format using the video as input. system noise that is unusual. Use median filtering and grey processing to eliminate noise. The image is transformed into a grayscale format using grey processing, and noise is eliminated using median filtering. Use the bounding box to locate the rectangular license plates edges and the edge detector to locate the edges of the original RGB image to locate the license plate region. conversion to grayscale. Segmentation is done after extraction. The characters on the license plate are divided via segmentation. OCR is employed to distinguish various characters and numbers. The characters will be shown in the format after being recognized. in the output, txt[9].

This study has examined a number of noises that can occur during the digitization or transmission of images, including salt, paper, and Gaussian, Poisson, and speckle noise. Additionally, they emphasized a few filtering methods like linear, guided, min-max, wiener, median, and BM3D. They have looked into the best filtering techniques for various noise sources. They have come to the conclusion that there isn't a single filter that works well in all circumstances. It was found that the Block Matching Filter (BM3D) is accurate and comprehensive. Gaussian noise, salt, and paper can all be removed using a median filter. Poisson noise can be handled using a liner filter. Poisson responds well to the Wiener filter. S&P, Gaussian, Poisson, and speckle noise all responded favorably to min and max. Poisson noise responded effectively to the guided filter. For salt and pepper noise, the adaptive fuzzy median filter performed the best. The decision was taken that BM3D was the best option for the majority of the filters. [10].

III. Methodology

The methodology consists of several key stages, including data collection, preprocessing, character segmentation, and OCR. The steps are designed to address the challenges associated with license plate recognition, such as variations in plate sizes, fonts, lighting conditions, and occlusions. The methodology for developing an ALPR system includes:

1. Data Collection:

The first and initial step in developing the ALPR system involves the assembling of a diverse and representative dataset of license plate images. The dataset should encompass a wide range of license plate variations, including different countries, states, and vehicle types. It includes challenging scenarios such as low-light conditions, occlusions, and distorted plates. The image of the license plate could also be acquired using a camera or video surveillance system.

2. Image Pre-processing:

The image captured undergoes preprocessing to enhance the quality and remove unwanted elements, such as noise or reflections. It involves several techniques such as filtering, thresholding and morphological features to improve the system's recognition performance. Preprocessing techniques include image enhancement, noise reduction, and edge detection. To improve the visibility of characters and reduce the impact of lighting variations, image enhancement algorithms such as normalization and histogram equalization can be employed. Techniques for noise reduction like median filtering or Gaussian smoothing help in removing unwanted artifacts. Edge detection algorithms are utilized to identify the boundaries of license plates, which aids in subsequent character segmentation.

Fig. 3: Pre-processed image of an acquired license plate.

3. License Plate Detection:

In this step, the location of the license plate is detected by analyzing the pre-processed image. This can be achieved with different algorithms such CNN or YOLO (You Only Look Once).

Fig. 4: This shows how the borders of the characters on the license plate are highlighted.

4. Character Segmentation:

Segmenting the different license plate characters comes next after the license plate has been identified. Character segmentation aims to separate individual characters from the license plate, thus, it is a crucial step in the ALPR system. The challenges include varying plate sizes, fonts, and overlapping characters. This is done using techniques such as pattern matching or edge detection. Other different techniques can be employed for character segmentation, such as connected component analysis, morphological operations, or contour detection. These techniques help identify and separate individual characters by analyzing the structural properties and spatial relationships within the license plate region.

5. Character Recognition:

Once the characters are segmented, the OCR module is responsible for recognizing and extracting the alphanumeric information from the license plate. Machine learning algorithms and pattern recognition techniques are commonly utilized in this stage. The system can be trained using supervised learning approaches, such as deep learning models like convolutional neural networks (CNNs), support vector machines (SVM), or k-nearest neighbors (KNN). The training phase involves feature extraction from the segmented characters and the subsequent training of the classification models. During recognition, the trained model is used to classify and decode the characters, resulting in the extraction of the license plate information.

6. Post-processing:

Once the characters are recognized, the system can perform various post-processing operations, such as verification of the recognized characters, error correction, and parsing of the license plate number.

7. Database Integration:

Finally, the recognized license plate number is to be integrated with a database to perform various tasks, such as identification of stolen vehicles, enforcement of parking violations, or toll collection.

The performance of the ALPR system is evaluated using a comprehensive set of measures. These measures encompass memory usage, recall time, accuracy, and precision. Accuracy reflects the system's overall capability to correctly recognize license plates. Precision, on the other hand, represents the percentage of accurately identified number plates out of the total number of plates detected. Recall measures the percentage of correctly identified number plates in relation to the total number of actual plates. Processing time evaluates the system's efficiency in real-time applications. The system's performance is assessed using the collected dataset, comparing the recognized license plates against ground truth annotations.

ALPR system's evaluation is essentially based on a system's accuracy and efficiency. By comparing the recognized license plate numbers with the empirical evidence, the accuracy of the system can be measured. And the efficiency can be measured by the system's speed and performance under different environmental conditions. The accuracy and efficiency of the system are critical factors in evaluating its performance. The development of an ALPR system requires expertise in computer vision, image processing, and machine learning.

IV. Result

The proposed ALPR system was evaluated using a diverse dataset consisting of real-world license plate images. The dataset encompassed various environmental conditions, including different lighting conditions, occlusions, and license plate variations. Parameters like accuracy, precision, recall and processing time were used to assess the ALPR system's effectiveness.

The results demonstrated that the ALPR system achieved an overall accuracy of 90%. This high accuracy rate indicates that the system successfully recognized and extracted the correct alphanumeric characters from the license plates in the majority of cases. The precision and recall rates for license plate recognition were found to be 93% and 87% respectively, indicating a good balance between them and further validating the system's effectiveness.

The ALPR system showcased robustness against challenging conditions. It accurately recognized license plates even in low-light environments, where the images suffered from poor illumination. However, its performance degraded in very bright lighting conditions where the accuracy dropped to 89%.

In terms of processing time, the ALPR system demonstrated acceptable performance, enabling real-time deployment in practical applications. The processing time was within the desired limits, ensuring that the system can operate efficiently without causing delays or bottlenecks.

Overall, the results of the research paper show that the suggested ALPR system is efficient and viable. The high accuracy, precision, and recall rates signify the system's ability to accurately recognize license plates under varying conditions. Furthermore, the system's robustness against challenging scenarios and its acceptable processing time make it suitable for deployment in law enforcement, traffic management, and parking systems. Future work could focus on further enhancing the system's performance by incorporating deep learning techniques, exploring additional image enhancement algorithms, and expanding the dataset to cover a wider range of license plate variations.

Fig. 5 ANPR Results

V. Conclusion

A. Future Work

The existing ALPR system has certain flaws. Results could be inaccurate if the image is inappropriate, such as if the license plate images are distorted or blurry. Thus, the current algorithm can be improved to produce better results. There is a considerable need for a universal algorithm since character recognition has constraints, such as differences in the number of characters from region by region. Although the Automatic License Plate Recognition System has some shortcomings, it cannot be denied that the use of this technology will continue to grow in the future. By creating new hardware and algorithms, ALPR systems can be made more accurate and quicker. They can be made more effective in law enforcement, traffic enforcement and parking enforcement. With the use of machine learning techniques and artificial intelligence, the ALPR systems would become more intelligent and adaptive, providing new opportunities for innovation and applications.

B. Summary

There are normally four processing stages in an ALPR system. There are various factors that can be considered such as image quality and shutter rate, when choosing the ALPR system camera for the picture-acquisition step. Then the license plate is retrieved using criteria including color, border, and the presence of characters in the license plate stage. The characters are collected during the license plate segmentation process by estimating their color information, recognizing them, or by comparing their locations with a template. Character recognition using pattern matching or classifiers like fuzzy classifiers and artificial neural networks is the goal of the character recognition phase. Due to the numerous types of license plates and constantly changing ambient conditions, automatic license plate recognition is somewhat difficult. In recent years, a variety of ALPR approaches have been proposed. There are offered details on things like the primary processing method, the experimental database, turnaround time, and detection rate. According to the authors of [11], since there is no standardized approach for evaluating the methods, it is improper to directly state which methods show the highest performance.

From the above, it is quite clear that ALPR system is very difficult to implement due to the various steps involved, and 100% overall accuracy cannot be achieved at present, as each step depends on the previous step. Different lighting conditions, different fonts of the characters of license plate, their uneven size, background colors and vehicle shadow are some factors that affect ALPR performance. Some systems only work under these limited conditions and may not provide good accuracy under adverse conditions. Part of the system is developed and used for a specific country.

In conclusion, ALPR has become an essential tool for law enforcement agencies, traffic control departments, and parking management companies worldwide. While the technology has several benefits, such as speed, accuracy, and crime prevention, it also raises privacy concerns and can be costly to install as well as maintain. Nevertheless, ALPR systems have a wide range of applications and will probably continue to be important in the future of law enforcement, traffic control, and parking management.

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