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CENG 407 - 408

LICENCE PLATE RECOGNITION SYSTEM PROJECT

LITERATURE REVIEW

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Abstract

License Plate Recognition System offers a solution that has been needed in recent years and where necessary steps can be taken for the operation of an efficient smart transportation network. Due to the rapid increase in vehicles, it has become a necessity for traffic control management. The main purpose of the License Plate Recognition System is for traffic monitoring and security purposes. License plate recognition uses image processing techniques or OCR techniques and edge detection technology to detect characters on license plates. The model consists of three modules: vehicle detection module, license plate segmentation module and recognition module. The license plate identification system is used in various fields such as police forces, military areas, traffic control and security. By using the License Plate Recognition System, we aim to determine the vehicle brand, model, colour and type to be used in areas such as keeping city entrances and exits under control, city security, and installing smart traffic systems, by using image processing and deep learning methods.

1. Introduction

License Plate Identification System is a method that is frequently used in the identification of vehicles, in parking lots, in urban areas and in places where security is important such as road cameras. A license plate identification system is used to uniquely identify a vehicle. License Plate Recognition system plays an important role in many applications such as electronic payment system (toll payment and parking fee payment), stolen car finding, traffic surveillance. For example, in parking, plates are used to calculate the parking time. When a vehicle enters the door, the license plate is automatically recognized and recorded. When leaving, the license plate is re-recognized and compared to the registered license plates. The time difference is used to calculate the parking fee. License Plate Recognition System is a useful and versatile system as it is automatic.

Various researchers have suggested various techniques for each step, and an individual technique has its positives and negatives. The license plate recognition method includes three main steps. This is the zone of removal of interest, removal of license plate numbers and character recognition. Below is the block diagram for the plate system in Figure 1.

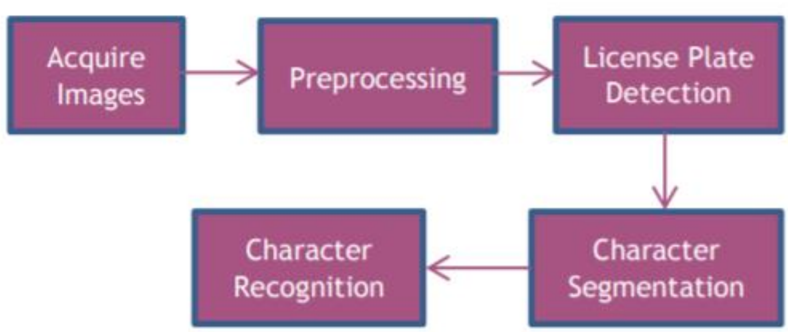

Figure 1 Block Diagram of License Plate Recognition

License plate recognition is provided through the ANPR instrument program. Images captured using cameras show the printout of the license plate. The basic job of ANPR is to read and open the license plate. ANPR is also called ALPR (Automatic License Plate Recognition). The software of this system creates a record of all license plates which it interprets with all relevant data such as date, time and GPS location. It uses OCR technology to recognize the characters of number plates. License Plate Recognition is an important process of automated parking. It will be a feature expected by industry demand for higher commercial parking management projects in smart city areas. It has also been used for security purposes in toll collection systems, traffic control, gas stations and many other exploration opportunities. Intelligent Transportation Systems play a leading role in facilitating smart cities due to its many applications such as highway surveillance, city logistics and traffic law enforcement, and more. [1]

With the License Plate Recognition System, our goal is to determine the license plates of vehicles using image processing methods such as character and segmentation. We aim to determine the characteristics such as the type, type, size and color of the vehicles by using the determined plates. In addition, we aim to use the deep learning method using different vehicle images and datasets of the TensorFlow library in order to be accurate and realistic when defining the license plates in the License Plate Identification System.

2. History of Licence Plate Recognition System

In light of its widespread use in recent years for a variety of purposes such as traffic studies, access control, and parking, many people believe it was invented in this millennium. The Police Scientific Development Branch devised ANPR in 1976 in the United Kingdom, and early devices were composed for use in 1979. [2]

Earlier prototypes were premature, with low precision readings, and only worked in restricted laboratory circumstances, making real-world use practically impossible. A few years later, at Wokingham, England, moderate improvements were made and functioning models were implemented. As a result, business contracts and apps for early adopter use were successfully developed. While still primitive, with an accuracy rate of less than 60%, the technology was cutting-edge at the time.

After several decades, the technology has advanced significantly, and previous constraints caused by vehicle speed, light fluctuation, angular skew, character segmentation, and recognition have been overcome using today's algorithm technology. Furthermore, previously exorbitant prices have given way to more reasonably priced implementations, allowing the app to thrive in a variety of businesses. [3]

3. Previous Works

Several studies and research projects have already been completed. Using the dataset produced by them, [4] creates a deep learning model to recognize the number plate. They employed the Keras deep learning package in conjunction with the TensorFlow framework. They used a variety of image processing techniques because the photographs were captured against a live scene. Following these steps, the CNN model is trained on the images. In [5] a machine learning method is used to construct an automatic number plate recognition system. They used an infrared camera to gather data, which was then pre-processed with contrast enhancement and noise reduction.

They then used the Region of Interest to locate the number plate in the image (RoI). After that, contour tracing is used to extract the image's key features. Then, to find the edges of the characters on the number plate, edge detection is used. Last but not least, segmentation is used to separate the characters. Artificial Neural Networks use pattern matching to distinguish individual characters (ANN). Vehicle image capture, number plate detection, character segmentation, and character identification are the basic phases in ANPR.

Plate size, plate placement, plate background, and screw must all be considered while detecting number plates. Character recognition follows, which is commonly accomplished via Artificial Neural Networks, template matching, or Optical Character Recognition (OCR) approaches. [6]

4. Methods of Licence Plate Recognition System

4.1. Licence Plate Detection

In video analysis of the number plate image, computer vision and character recognition, as well as algorithms for license plate recognition, play a vital role. As a result, they are the foundation of any ANPR system. A camera, a frame grabber, a computer, and custom created software for image processing, analysis, and recognition make up the system for autonomous car license plate recognition. Over the last few years, vehicle identification has been a hot topic of research. Several studies have been conducted in order to determine the type of vehicle, such as a car, truck, scooter, or motorbike.

A machine-understandable definition is required in order to detect a license plate. A license plate can be defined as "a rectangular area of a vehicle with a high density of horizontal and vertical edges," based on its characteristics. [7]. Many algorithms have been proposed to tackle the license plate detection challenge based on these features, some of which are anchored in standard computer vision techniques and others in deep learning. Figure 2 shows a classification of the license plate identification algorithms now in use.

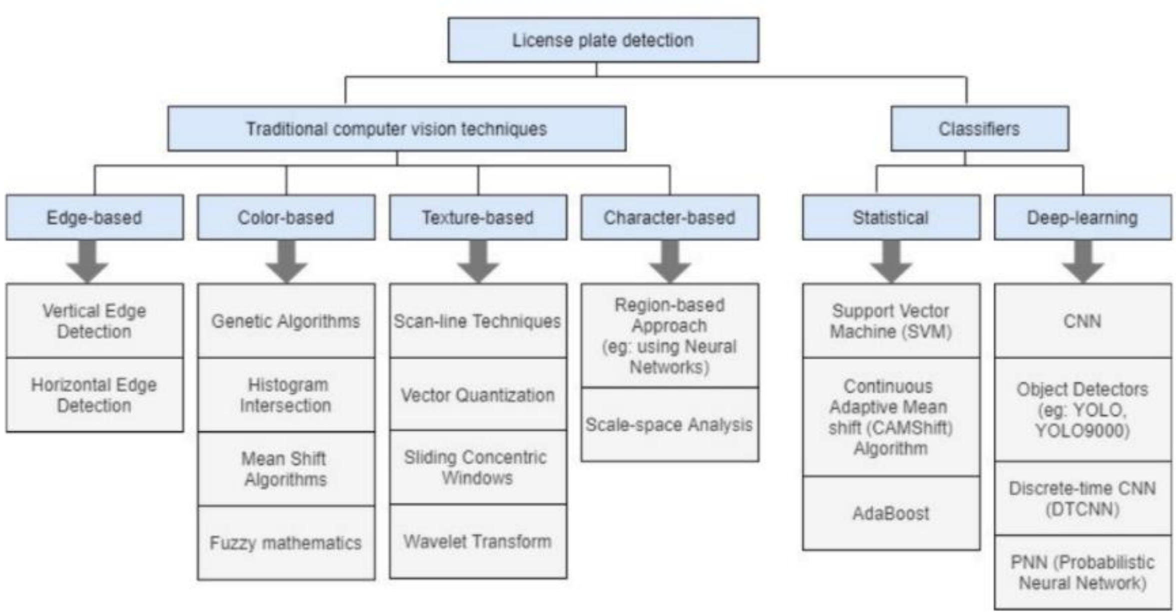

Figure 2 Categorization of Related License Plate Detection Techniques

4.1.1. Edge Based Methods

Edge detection is the process of finding edges in an image and is an important step in understanding visual features. Edges are regarded to provide important information and have distinguishing characteristics. It considerably reduces the size of the image to be analyzed and filters away extraneous data, leaving only the structural features of an image for a business problem to be solved.

To find edges in an image, edge-based segmentation algorithms exploit a variety of discontinuities in grey level, color, texture, brightness, saturation, contrast, and other characteristics. Additional processing procedures must be undertaken to concatenate all of the edges into edge chains that better fit the image's borders to improve the findings even more. Edge detection techniques are divided into two categories. Grey histograms and gradient-based approaches These methods employ basic edge detection operators such as the sobel operator, the canny operator, and Robert's variable, among others. These operators help detect edge discontinuities and, as a result, designate edge boundaries. The end goal is to achieve at least a partial segmentation using this method, in which we combine all of the local edges into a new binary picture that only contains edge chains that match the required existing objects or image sections. [8]

4.1.2. Colour-Based Methods

Colour-based approaches rely on the fact that a license plate's colour differs from the vehicle's background colour. In addition, the colour combination of the plate and its characters is only present in the plate portion of the image. To identify pixels in an input image against different illuminations, the Hue, Lightness, and Saturation (HLS) colour model can be utilized. Unlike the RGB model, which divides pixels into three categories, the HLS model divides pixels into several categories.

4.1.3. Texture-Based Methods

Tactile texture refers to the real feel of a surface, and visual texture refers to observing the shape or contents of an image. In image processing, the texture of an image may be defined as a function of the spatial variation of the brightness intensity of the pixels. Texture is the most common phrase used to describe objects or concepts in a picture. [9]

In texture-based techniques, the presence of characters on the license plate is employed as the foundation for plate detection. Due to the substantial colour difference between the plate and its characters, a regular colour transition appears on the license plate. As a result, when the image is grey-scaled, there is a clear inequality between the characters and the plate backdrop. As a result, a distinctive pixel intensity distribution is formed around the plate region. Furthermore, the plate region has a high edge density due to the colour shift. [10]

4.1.4. Character-Based Methods

License plate detection also involves examining an image for the presence of characters and locating them. These approaches are classified as character-based methods because they consider the region containing characters to be a suitable plate region. To categorize those extreme locations, a neural network classifier is utilized, and if any linear spatial configuration is identified, it is assumed to be the potential region containing the license plate. This approach is said to be resistant to a variety of lighting situations and views, with a stated detection accuracy of 95%. [11]

4.1.5. Deep-Learning Techniques

Most statistical methods have been substituted by deep learning neural networks due to their excellent accuracy in object detection, according to current developments in computer vision technologies. Many studies in license plate detection have used various forms of neural networks as a result of this fact. [12]

4.2. Licence Plate Recognition

This stage, which is the second in a multi-step automatic license plate recognition pipeline, is in charge of "reading" the license plate once the detection stage has located it. This is a type of optical character recognition that takes into account specific characteristics of the license plate.

Many countries, for example, have tight regulations concerning the font and color of license plates, which are normally chosen to be easy to see. The license plates, on the other hand, have certain peculiarities [13]. For example, when the photograph is shot outside, the system designers must account for variables such as ambient light, uneven brightness, and weather effects. Even if you have a regular license plate, it is possible that it will be damaged or rotated. Figure 3 depicts a typical ALPR system's recognition pipeline, along with the strategies that can be used at each stage. However, depending on the methodology used, some of the chores may be skipped.

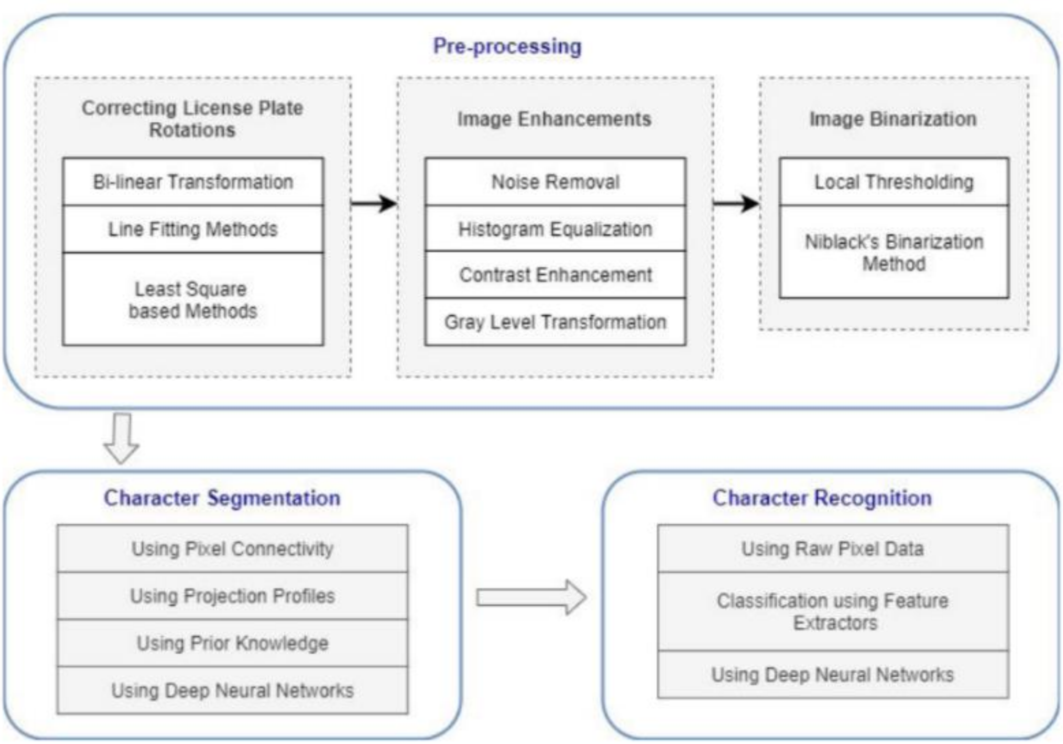

Figure 3 Pipeline for License Plate Recognition and Related Techniques

4.2.1. Pre-processing Techniques

To manage particular obstacles in license plate identification, certain pre-processing operations are performed before character segmentation and recognition. Bilinear transformations [14], least square-based methods [15], and line fitting methods [16] are examples of rotation techniques that have been employed in related investigations. The image is binarized before segmentation in several traditional machine vision-based character recognition systems. In comparison to grey-scale or color images, the method makes it easier to differentiate the pixels that belong to the characters in the image. However, the binarization threshold must be calculated correctly to avoid character blending or merging with the license plate frame in the binary image, which makes segmentation difficult [17]. Image improvement techniques such as noise reduction, histogram equalization, contrast enhancement, and grey level transformation can be used to define the threshold value. Even with these improvements, getting a single threshold might be difficult.

4.2.2. Character Segmentation

Characters are segmented before classification in various optical character recognition systems. The feature of having distinct colours for the backdrop and characters is taken into account by license plate character segmentation algorithms. Binarization of the image facilitates this separation by assigning opposite "colours" to the foreground (character) and background pixels.

Character Segmentation Using Pixel Connectivity:

For character segmentation, pixel connection is a straightforward method. The connected pixels are tagged here, and if they have the same label for an item of a certain size or aspect ratio, they are extracted as a character. One issue with pixel connectivity-based approaches is that they fail when characters are damaged or when binarization threshold selection causes characters to be connected. Pixel connectivity-based techniques, on the other hand, are resistant to rotating license plates and are reasonably easy to deploy. The license plate identification pipeline is further simplified by the absence of the necessity for pre-processing to correct for license plate rotation.

Character Segmentation Using Projection Profiles:

After image binarization, projection profiles methods take advantage of the fact that the character and background pixels in the license plate image have different colors. Vertical projections are usually utilized to detect the character's beginning and ending points, and then horizontal projects are used to extract the character. Project-based approaches, on the other hand, are susceptible to image quality and noise. As a result, a de-noising stage must be added in the recognition pipeline's pre-processing stage. Although the projection-based approaches have lower resilient values for rotations than pixel connectivity-based methods, they are nonetheless robust to rotations and independent of character placements.

Character Segmentation Using Prior Knowledge:

For character segmentation, prior knowledge of the license plate is employed, such as the aspect ratio of the characters and the ratio of various colored pixels in the image. Prior knowledge-based approaches are usually simple to execute; nevertheless, these methods are frequently specific to the regions in which they were meant to work and do not apply in other situations.

Character Segmentation Using Deep Learning:

The use of CNN (Convolutional Neural Networks) for the task related with computer vision has become a current strategy for character segmentation. The CNN is given a localized license plate as input, and the bounding boxes of each character are produced as output. However, compared to standard computer vision-based algorithms, CNN execution consumes more time and resources depending on the dataset. In addition, in later stages of various deep learning-based license plate recognition pipelines, explicit character segmentation was skipped in favour of implicit character segmentation, resulting in a reduction in the number of parameters and computing cost. [18]

4.2.3. Character Recognition

Many classification approaches necessitate fixed-size learning model inputs. The input segments are re-scaled before classification since the output from the segmentation stage varies in size. Because the amount of characters, their relative positions, and possible values are usually known, each segment is classified as one of the possible values. There are three scenarios in which this can be evaluated. (A) Compare all the pixel values in the raw image data directly with the predefined templates, (B) extract features using various image processing and machine learning approaches before categorizing the segments, and (C) classify segments using deep learning techniques.

A) Template and Pattern Matching Techniques:

Given that license plates often have a consistent font and character size, using template matching techniques to identify characters is a popular choice. Binarized images are commonly used for template matching. A predefined template is constructed for each possible character, and each segment is matched with each template to find the most comparable template. Additional templates must be kept in order to support character rotations, which increases computation time and processing memory.

B) Character Recognition Using Feature Extractors:

In general, recognizing a character does not necessitate the use of all pixels. Feature extractors are thus used to separate basic features from images while lowering computing expenses. Some feature extraction algorithms can extract features that are resistant to image noise and rotation. In these methods, each segment is transformed into a feature vector, which is subsequently classified using a machine learning model. Eigenvector transformation, Gabor filter, and Kirsch edge detection are examples of feature extractor algorithms. The extracted features are classified using machine learning algorithms.

C) Character Recognition Using Deep Learning:

The benefit of adopting neural networks is that they can be fed raw pixel data and function as feature extractors and classifiers on their own. This goal has been achieved utilizing a variety of neural networks, including simple multilayer perceptrons, Probabilistic Neural Networks (PNN) [26], and discrete-time cellular networks. However, CNN (Convolutional Neural Networks) have been employed in a number of recent research and have showed significant promise in a variety of computer vision applications. Another current approach is to use an object detection-based technology like YOLO directly (real-time vehicle detection using deep learning methods). [19] Although deep learning-based algorithms are more computationally expensive than alternative methods such as template matching and statistical feature extractors, they often yield superior accuracy.

5. Potential Problems and Alternative Solutions

Controlling limited access to restricted locations, automating parking systems and payments, monitoring toll tax payments, controlling state border pass and security measures in countries, traffic management, and law enforcement are all applications that use a license plate recognition system.

Since it is aimed to use deep learning, image optimization, camera adjustment and image processing method, data processing speeds and the resulting delay times can be seen as potential problems. Since the type of car will be determined with different vehicle images, the teaching time may vary. There may also be issues such as camera-related lags.

With more specific algorithms and methods, the license plate recognition system can be made in accordance with speed and time. Thus, problems such as camera optimization can be solved.

6. Conclusion

The design and development of an automated license plate recognition system (ALPR) require careful selection of specifications and techniques to work with different operational and hardware constraints. In Literature Review we briefly summarized the history of the License Plate Recognition System. Thus, we observed how and why the Plate Identification System came from the past to the present. In Literature Review, we reviewed in detail the research and analysis of current approaches and techniques used in the solution of the License Plate Recognition System. We discussed in detail the main methods required for the License Plate Recognition System. We explained these methods in detail under the titles of License Plate Detection and License Plate Recognition. We also discussed the open challenges for the License Plate Recognition System and suggested solutions to these challenges.

Based on our research, we aim to determine the features required for the recognition of license plates by using image processing, image detection and recognition methods for the License Plate Recognition System. In addition to these methods, we aim to make the Plate Recognition System by using the deep learning method with libraries such as TensorFlow and Keras.

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