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CENG 407

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.

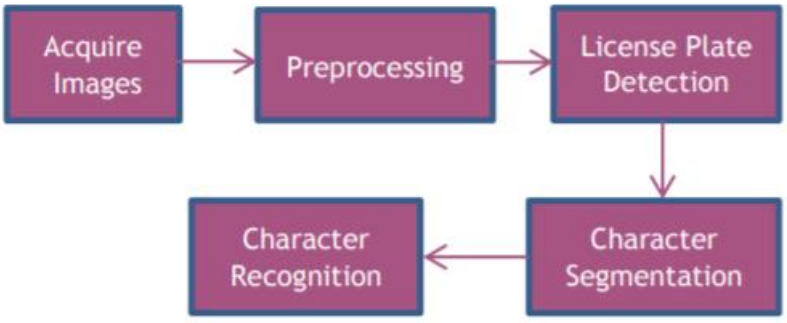

Figure 1 Block diagram of License Plate Recognition

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

The History of ANPR is considerably longer than most people realise. Because of its prolific use in more recent years for a broad range application such as traffic studies, access control and parking, many people, if asked, would guess at it being an invention belonging to this millennium. The history of ANPR stretches into the last century as it was invented in 1976 in the UK at what was then known as the Police Scientific Development Branch (PSDB) (now titled Home Office Scientific Development Branch) and early systems were developed for use from 1979. [2]

Earlier prototypes were premature with low accuracy readings and only functioned under restrictive laboratory conditions that made real world application nearly impractical. Moderate improvements were made and working models were implemented a few years later in Wokingham, England. This subsequently led to the successful development of commercial contracts and applications for early adopter usage. While still crude, with an accuracy that averaged below 60%, the technology was state of the art during its time.

Several decades later, the technology has greatly evolved and prior limitations incurred from vehicle speed, light fluctuation, angular skew, character segmentation and recognition have been solved with today's algorithm technology. Additionally, prior cost prohibitive fees have made way for more reasonably priced implementations allowing application to thrive in multiple industries. [3]

3. Previous Works

Several studies and work has been carried out earlier. In [4], a deep learning model is created to recognize the number plate using the dataset made by them. They used TensorFlow framework with the Keras deep learning library. Since the images were taken from the real time background, they carried out several image processing techniques. After these preparations, the CNN model is trained using the images. In [5], an automatic number plate recognition system using machine learning approach is developed. They got the input from an Infrared camera followed by contrast enhancement and noise reduction as pre-processing steps.

Then they localized the number plate in the image by finding out the Region of Interest (RoI). After that, contour tracing is applied to get the salient features of the image. Then Edge detection is done to find out the edges of the characters in the number plate. Finally, segmentation is applied to separate the characters. The individual characters are recognized using pattern matching by Artificial Neural Networks (ANN). The basic steps in ANPR include vehicle Image capture, number plate detection, Character segmentation and Character recognition.

For number plate detection the factors such as plate size, plate location, plate background and screw must be considered. It is followed by character recognition which is usually done by Artificial Neural Networks, template matching or Optical Character Recognition (OCR) techniques. [6]

4. Methods of Licence Plate Recognition System

4.1. Licence Plate Detection

Computer vision and character recognition, algorithms for license plate recognition play an important role in video analysis of the number plate image. Therefore, they form the core modules in any ANPR system. The system for automatic car license plate recognition includes a camera, a frame grabber, a computer, and custom designed software for image processing, analysis and recognition. Vehicle identification has been an active research for over the last few years. A number of researches have been carried out to identify the type of vehicle such as a car, truck, scooter or motorcycle.

In order to detect a license plate, a definition thatcan be understood by a machine is required. Considering its features, the definition for a license plate can be stated as ‘‘a rectangular area of a vehicle with a high density of horizontal and vertical edges’’ [7]. Based on these features, many algorithms have been put forward to solve the license plate detection task and some of them are rooted in traditional computer vision techniques and some in deep learning. Figure 2 shows a classification of the license plate detection techniques that are used in existing methods.

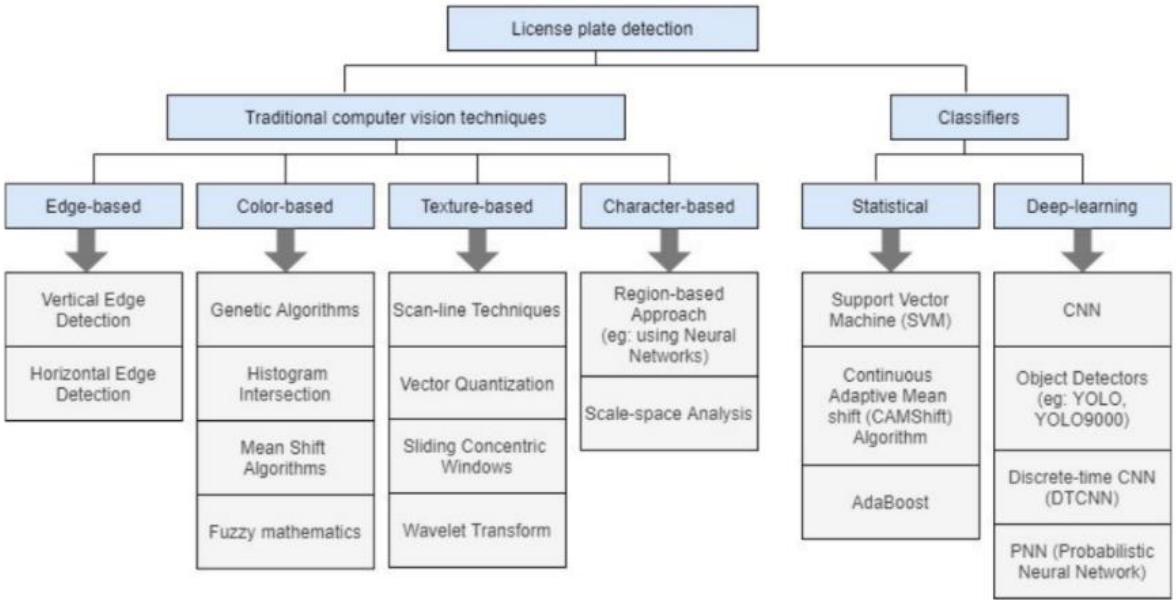

Figure 2 Classification of Related License Plate Detection Techniques

4.1.1. Edge Based Methods

Edge detection is the process of locating edges in an image which is a very important step towards understanding image features. It is believed that edges consist of meaningful features and contains significant information. It significantly reduces the size of the image that will be processed and filters out information that may be regarded as less relevant, preserving and focusing solely on the important structural properties of an image for a business problem.

Edge-based segmentation algorithms work to detect edges in an image, based on various discontinuities in grey level, colour, texture, brightness, saturation, contrast etc. To further enhance the results, supplementary processing steps must follow to concatenate all the edges into edge chains that correspond better with borders in the image. Edge detection algorithms fall primarily into two categories. Gradient based methods and Grey Histograms. Basic edge detection operators like sobel operator, canny, Robert's variable etc. are used in these algorithms. These operators aid in detecting the edge discontinuities and hence mark the edge boundaries. The end goal is to reach at least a partial segmentation using this process, where

we group all the local edges into a new binary image where only edge chains that match the required existing objects or image parts are present. [8]

4.1.2. Colour-Based Methods

Colour-based methods rely on the fact that the colour of a license plate is different from the background colour of the vehicle. Also, the colour combination of the plate and its characters is nowhere found in the image other than the plate region. The Hue, Lightness, and Saturation (HLS) colour model can be used to classify the pixels in an input image against different illuminations. Unlike the Red, Green, and Blue (RGB) model, the HLS model has classified pixels into many categories.

4.1.3. Texture-Based Methods

Tactile texture refers to the tangible feel of a surface and visual texture refers to seeing the shape or contents of the image. In image processing, the texture can be defined as a function of spatial variation of the brightness intensity of the pixels. The texture is the main term used to define objects or concepts of a given image. [9]

Texture-based methods use the presence of characters on the license plate as the base for plate detection. Due to the significant colour difference between the plate and its characters, it creates a frequent colour transition on the license plate. Hence, if the image is grey-scaled there is a notable difference between the characters and the plate background. Thus, it creates a unique pixel intensity distribution around the plate region. Moreover, the colour transition makes the plate region to have a high edge density. [10]

4.1.4. Character-Based Methods

Examining an image for the presence of characters and locating them is also used for license plate detection. These methods are categorized as character-based methods and consider the region with characters as the possible plate region. A neural network classifier is used to classify those extreme regions and if any linear spatial configuration is found, it is assumed as the possible region with the license plate. This method is claimed to be robust against different illumination conditions and viewpoints and the reported detection accuracy is 95%. [11]

4.1.5. Deep-Learning Techniques

According to the recent development in computer vision approaches, most of the statistical methods have been replaced by deep learning neural networks due to their high accuracy in object detection. Embracing this fact, many studies in license plate detection have used different types of neural networks. [12]

4.2. Licence Plate Recognition

As the second stage in a multi-stage automated license plate recognition pipeline, this stage is responsible for ‘‘reading'' the license plate ones the detection stage has localized it. This is a specific case of optical character recognition that considers certain features in the license plate.

For instance, many countries have strict regulation regarding the font and colour of the license plate and usually, they are selected to be easy to read. However, there are some unique issues associated with the license plates [13]. For instance, since the image is taken outdoors, the system designers have to consider aspects such as variable ambient light, uneven brightness, effect of weather. Despite having a standard license plate, they still could be damaged or rotated. Figure 3 shows the recognition pipeline of a typical ALPR system with possible techniques applicable for each stage. However, some of the tasks can be omitted depending on the selected techniques.

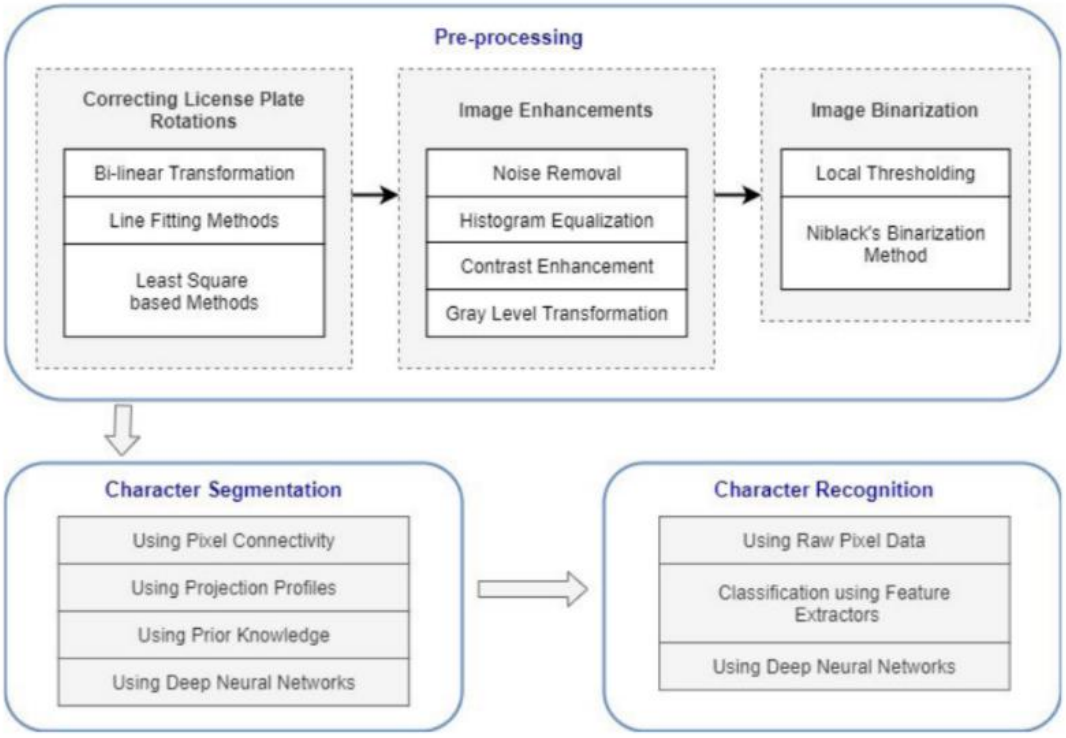

Figure 3 License Plate Recognition Pipeline With Associated Techniques

4.2.1. Pre-processing Techniques

Several pre-processing tasks performs before the character segmentation and recognition to handle unique challenges in license plate recognition. For example, rotation techniques such as bilinear transformations [14], least square-based methods [15] and line fitting methods [16] have been used in related studies. In many classical machine vision-based techniques for character recognition, the image is binarized before segmentation. The process makes it easier to separate the pixels belong to the characters in the image, compared to grey-scale or colour images. However, the threshold for this binarization must be determined correctly, to avoid the combining of the characters or merging with the license plate frame in the binary image, which makes it difficult to segment [17]. The threshold value can be defined using image enhancement techniques such as noise removal, histogram equalization, contrast enhancement and grey level transformation. However, even with these enhancements, it can be hard to get a single threshold.

4.2.2. Character Segmentation

In many optical character recognition techniques, the characters are first segmented before the classification. License plate character segmentation techniques consider the attribute of having contrasting colours for the background and characters. Binarization of the image makes this separation easier, as the foreground (character) and background pixels get the opposite ‘‘colours’’ in binarization.

Character Segmentation Using Pixel Connectivity:

Pixel connectivity is a simple method for character segmentation. Here, the connected pixels are labelled and if the pixels of the same label for an object of predetermined size or aspect ratio, then they are extracted as a character. One problem with pixel connectivity based methods is that they fail with broken characters or when characters are joined due to binarization threshold selection. However, pixel connectivity based methods are robust against rotated license plates and relatively simple to implement. Lack of need for pre-processing to compensate for license plate rotation further simplifies the license plate recognition pipeline.

Character Segmentation Using Projection Profiles:

Projection profiles methods use the fact that having opposite colours for the character and background pixels in the license plate image after image binarization. Typically, vertical projections are used to detect the starting and ending positions of the character and then horizontal projects are used to extract the character. However, project-based techniques are sensitive to image quality and image noise. As a result, a de-noising stage has to be included in the pre-processing stage of the recognition pipeline. Although these methods give low robust values compared to pixel connectivity based methods for rotations, the projection-based methods are still robust to rotations and independent on character positions.

Character Segmentation Using Prior Knowledge:

Prior knowledge about the license plate such as the aspect ratio of the characters, the ratio of various coloured pixels in the image is used for character segmentation. Approaches based on prior knowledge tend to be simple to implement; however, these methods are usually specific to the regions where they were designed to operate and do not generalize in other instances.

Character Segmentation Using Deep Learning:

Neural network has become a recent approach for character segmentation, which uses CNN (Convolutional Neural Networks) for the task associated with computer vision. A localized license plate is given as the input for the CNN and the bounding boxes of each character are produced as the output. However, depending on the dataset, the CNN execution consumes more time and resources compared to the traditional computer vision-based techniques. In addition, several deep learning-based license plate recognition pipelines have omitted explicit character segmentation in favour of implicit character segmentation in later stages, which leads to reduce the number of parameters and the computational cost. [18]

4.2.3. Character Recognition

Many classification techniques require fixed-size inputs to the learning model. Since the output from the segmentation stage is vary in size, the input segments are re-scaled before the classification. Because the number of characters, their relative position and possible values are known in most cases, each segment is classified individually to be of one of the possible values. This can be considered in three cases, (A) Com-pare all the pixel values of the raw image data directly with the predefined templates, (B) Use different image processing and machine learning techniques to extract features before classifying the segments, (C) Use deep learning techniques to classify segments.

A) Template and Pattern Matching Techniques:

Given that license plate usually have a known font and character size, one popular option is to use template matching techniques to classify characters. Template matching is typically used with binarized images. For each possible character, a predefined template is created and each segment is matched with each template to find the most similar tem-plate. In order to handle the rotations in characters, additional templates have to be stored which further increases computation time and processing memory.

B) Character Recognition Using Feature Extractors:

In general, all the pixels are not required to recognize a character. Thus, feature extractors are used to distinct simpler features from the images by reducing the computational costs. Some feature extraction techniques can extract features, which are robust against rotations and image noise. In these methods, a feature vector is generated using a transformation on each segment and then classifies using a machine learning model. Some of the feature extractors techniques are eigenvector transformation, Gabor filter, Kirsch edge detection. Machine learning models are used to classify the extracted features.

C) Character Recognition Using Deep Learning:

Advantage of using neural networks is that they can be given the raw pixel data directly and act as both feature extractors and classifiers on their own. Various forms of neural networks ranging from simple multilayer perceptrons to Probabilistic Neural Networks (PNN) [26] and discrete-time cellular networks have been used for this task. However, many recent studies have used CNN (Convolutional Neural Networks), which have shown great potential in many computer vision tasks. Another recent approach is to directly use object detection based technique such as YOLO (real-time vehicle detection using deep learning methods). [19] Although deep learning-based approaches are relatively computationally expensive than the alternative methods like template matching and statistical feature extractors, they provide better accuracy in general.

5. Potential Problems and Alternative Solutions

Licence Plate Recognition System is exploited in various applications that involve vehicle identification, such as controlling limited access to restricted areas, automating parking systems and payments, monitoring toll fee payments, controlling state border pass and security measures in countries, traffic management and law enforcement.

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 characteristics such as the type, colour and size of the vehicles 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 License Plate Recognition System by using the deep learning method with libraries such as TensorFlow and Keras.

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