Automatic License Plate Recognition

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***Abstract*— Automatic license plate recognition (ALPR) is the extraction of vehicle license plate information from an image or a sequence of images. The extracted information can be used with or without a database in many applications, such as electronic payment systems (toll payment, parking fee payment), and freeway and arterial monitoring systems for traffic surveillance. The ALPR uses either a color, black and white, or infrared camera to take images.These plates usually contain different colors, are written in different languages, and use different fonts; some plates may have a single color background and others have background images. In this paper, we present a comprehensive review of the state-of-the-art techniques for ALPR. We categorize different ALPR techniques according to the features they used for each stage, and compare them in terms of pros, cons, recognition accuracy, and processing speed. Future forecasts of ALPR are given at the end.**

***Keywords*— *Automatic license plate recognition (ALPR),automatic number plate recognition (ANPR), car plate recognition (CPR), optical character recognition (OCR) for cars*.**

I. INTRODUCTION

AUTOMATIC license plate recognition (ALPR) plays an important role in numerous real-life applications, such as automatic toll collection, traffic law enforcement, parking lot access control, and road traffic monitoring [1]–[4].

ALPR recognizes a vehicle's license plate number from an image or images taken by either a color, black and white, or infrared camera. It is fulfilled by the combination of a lot of techniques, such as object detection, image processing, and pattern recognition. ALPR is also known as automatic vehicle identification, car plate recognition, automatic number plate recognition, and optical character recognition (OCR) for cars. The variations of the plate types or environments cause challenges in the detection and recognition of license plates.

They are summarized as follows.

A. Plate variations:

- *location*: plates exist in different locations of an image;
- *quantity*: an image may contain no or many plates;
- *size* : plates may have different sizes due to the camera distance and the zoom factor;
- *color* : plates may have various characters and background colors due to different plate types or capturing devices;
- *font*: plates of different nations may be written in different fonts and language;
- *occlusion* : plates may be obscured by dirt;
- *inclination* :plates may be tilted;
- *other*: in addition to characters, a plate may contain frames and screws.

B. Environment variations:

- *illumination* : input images may have different types of illumination, mainly due to environmental lighting and vehicle headlights;
- *background* : the image background may contain patterns similar to plates, such as numbers stamped on a vehicle, bumper with vertical patterns, andtextured floors.

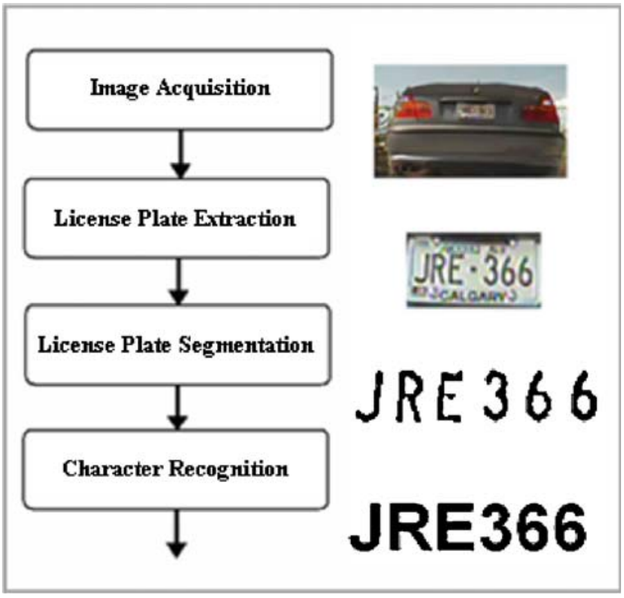

Fig. 1. Four stages of an ALPR system.

Methods	Rationale	Pros	Cons
Using boundary features	The boundary of license plate is rectangular.	Simplest, fast and Straight forward	Hardly be applied to complex images since they are too sensitive to unwanted edges
Using global image features	Find a connected object whose dimension is like a license plate	Straightforward, independent of the license plate position	May generate broken objects
Using texture features	Frequent color transition on license plate	Be able to detect even if the boundary is deformed	Computationally complex when there are many edges
Using color features	Specific color on license plate.	Be able to detect inclined and deformed license plates.	RGB is limited to illumination condition, HLS is sensitive to noise
Using character features	There must be characters on the license plate	Robust to rotation.	Time consuming (processing all binary objects), produce detection errors when other text in the image

The ALPR system that extracts a license plate number from a given image can be composed of four stages . The first stage is to acquire the car image using a camera. Thparameters of the camera, such as the type of camera, camera resolution, shutter speed, orientation, and light, have to be considered. The second stage is to extract the license plate from the image based on some features, such as the boundary, the color, or the existence of the characters. The third stage is to segment the license plate and extract the characters by projecting their color information, labeling them, or matching their positions with templates. The final stage is to recognize the extracted characters by template matching or using classifiers, such as neural networks and fuzzy classifiers. Fig. shows the structure of the ALPR process. The performance of an ALPR system relies on the robustness of each individual stage.

The purpose of this paper is to provide researchers with a systematic survey of existing ALPR research by categorizing existing methods according to the features they used, analyzing the pros or cons of these features, and comparing them in terms of recognition performance and processing speed, and to open some issues for the future research.

II. LICENSE PLATE EXTRACTION

The license plate extraction stage influences the accuracy of an ALPR system. The input to this stage is a car image, and the output is a portion of the image containing the potential license plate. The license plate can exist anywhere in the image. Instead of processing every pixel in the image, which increases the processing time, the license plate can be distinguished by its features, and therefore the system processes only the pixel that have these features. The features are derived from the license plate format and the characters constituting it.

License plate color is one of the features since some jurisdictions (i.e., countries, states, or provinces) have certain colors for their license plates. The rectangular shape of the license plate boundary is another feature that is used to extract the license plate. The color change between the characters and the license plate background, known as the texture, is used to extractthe license plate region from the image. The existence of the characters can be used as a feature to identify the region of the license plate. Two or more features can be combined toidentify the license plate.

A. License Plate Extraction Using Boundary/Edge Information

Since the license plate normally has a rectangular shape with a known aspect ratio, it can be extracted by finding all possible rectangles in the image. Edge detection methods are commonly used to find these rectangles, Sobel filter is used to detect edges. Due to the color transition between the license plate and the car body, the boundary of the license plate is represented by edges in the image. The edges are two horizontal lines when performing horizontal edge detection, two vertical lines when performing vertical edge detection, and a complete rectangle when performing both at the same time. the license plate rectangle is detected by using the geometric attribute for locating lines forming a rectangle.

Boundary-based extraction that uses Hough transform (HT). It detects straight lines in the image to locate the license plate. The Hough transform has the advantage of detecting straight lines with up to 30° inclination. However, the Hough transform is a time and memory consuming process, a boundary line-based method combining the HT and contour algorithm is presented. It achieved extraction results of 98.8%.

B. License Plate Extraction Using Global Image Information

Connected component analysis (CCA) is an important technique in binary image processing. It scans a binary image and labels its pixels into components based on pixel connectivity. Spatial measurements, such as area and aspect ratio, are commonly used for license plate extraction applied CCA on low resolution video. The correct extraction rate and false alarms are 96.62% and 1.77%, respectively, by using more than 4 h of video, a contour detection algorithm is applied on the binary image to detect connected objects. The connected objects that have the same geometrical features as the plate are chosen to be candidates. This algorithm can fail in the case of bad quality images, which results in distorted contours.

C. License Plate Extraction Using Texture Features

This kind of method depends on the presence of characters in the license plate, which results in significant change in the grey-scale level between characters color and license plate background color. It also results in a high edge density area due to color transition. Different techniques are used in [31]–[39]], scan-line techniques are used. The change of the grey-scale level results in a number of peaks in the scan line. This number equals the number of the characters. In [40], the vector quantization (VQ) is used to locate the text in the image. VQ representation can gives some hints about the contents of image regions, as higher contrast and more details are mapped by smaller blocks. The experimental results showed 98% detection rate and processing time of 200 ms using images of different quality.

D. License Plate Extraction Using Color Features

Since some countries have specific colors for their license plates, some reported work involves the extraction of license plates by locating their colors in the image. The basic idea is that the color combination of a plate and characters is unique, and this combination occurs almost only in a plate region.

According to the specific formats of Chinese license plate proposed that all the pixels in the input image are classified using the hue, lightness, and saturation (HLS) color model into 13 categories. A neural network is used to classify the color of each pixel after converting the RGB image into HLS. Neural network outputs, green, red, and white are the license platecolors in Korea. The same license plate color is projected vertically and horizontally to determine the highest color density region that is the license plate region.since only four colors (white, black, red, and green) are utilized in the license plates, the color edge detector focuses only on three kinds of edges (i.e., black–white, red– white, and green–white edges). In the experiment, 1088 imagestaken from various scenes and under different conditions are employed. The license plate localization rate is 97.9%

E. License Plate Extraction Using Character Features

License plate extraction methods based on locating its characters have also been proposed. These methods examine the image for the presence of characters. If the characters are found, their region is extracted as the license plate region. Instead of using properties of the license plate directly, the algorithm tries to find all character-like regions in the image. This is achieved by using a region-based approach. Regions are enumerated and classified using a neural network. If a linear combination of character-like regions is found, the presence of a whole license plate is assumed.

The approach used is to horizontally scan the image, looking for repeating contrast changes on a scale of 15 pixels or more. It assumes that the contrast between the characters and the background is sufficiently good and there are at least three to four characters whose minimum vertical size is 15 pixels. A differential gradient edge detection approach is made and 99% accuracy was achieved in outdoor conditions, binary objects that have the same aspect ratio as characters and more than 30 pixels are labeled. The Hough transform is applied on the upper side of these labeled objects to detect straight lines. The same happens on the lower part of these connected objects. If two straight lines are parallel within a certain range and the number of the connected objects between them is similar to the characters, the area between them is considered as the license plate area.

III. License Plate Segmentation

The isolated license plate is then segmented to extract the characters for recognition. An extracted license plate from the previous stage may have some problems, such as tilt and non uniform brightness. The segmentation algorithms should overcome all of these problems in a preprocessing step and the bilinear transformation is used to map the tilted extracted license plate to a straight rectangle. A least-squares method is used to treat horizontal tilt and vertical tilt in license plate images.

A. License Plate Segmentation Using Pixel Connectivity

Segmentation is by labeling the connected pixels in the binary license plate image. The labeled pixels are analyzed and those which have the same size and aspect ratio of the characters are considered as license plate characters. This method fails to extract all the characters when there are joined or broken characters.

B. License Plate Segmentation Using Prior Knowledge of Characters

Prior knowledge of characters can help the segmentation of the license plate. The binary image is scanned by a horizontal line to find the starting and ending positions of the characters. When the ratio between characters pixels to background pixels in this line exceeds a certain threshold after being lower than this threshold, this is considered as the starting position of the characters. The opposite is done to find the ending position of the characters.

The extracted license plate is resized into a known template size. In this template, all character positions are known. After resizing, the same positions are extracted to be the characters. This method has the advantage of simplicity.

However, in the case of any shift in the extracted license plate, the extraction results in background instead of characters. The proposed approach provides a solution for the vehicle license plates that are degraded severely. Color collocation is used to locate the license plate in the image. Dimensions of each character are used to segment the character. The layout of the Chinese license plate is used to construct a classifier for recognition.

IV. Character Recognition

The extracted characters are then recognized and the output is the license plate number. Character recognition in ALPR systems may have some difficulties. Due to the camera zoom factor , the extracted characters do not have the same size and the same thickness. Resizing the characters into one size before recognition helps overcome this problem. The characters' font is not the same all the time since different countries' license plates use different fonts. Extracted characters may have some noise or they may be broken. The extracted characters may also be tilted. In the following, we categorize the existing character recognition methods based on the features they used.

V. SUMMARY

In general, an ALPR system consists of four processing stages. In the image acquisition stage, some points have to be considered when choosing the ALPR system camera, such as the camera resolution and the shutter speed. In the license plate extraction stage, the license plate is extracted based on some features such as the color, the boundary, or the existence of the characters. In the license plate segmentation stage, the characters are extracted by projecting their color information ,by labeling them, or by matching their positions with template .Finally, the characters are recognized in the character recognition stage by template matching, or by classifiers such as neural networks and fuzzy classifiers. Automatic license plate recognition is quite challenging due to the different license plate formats and the varying environmental conditions. There are numerous ALPR techniques that have been proposed in recent years.

VI. CONCLUSION

This paper presented a comprehensive survey on existing ALPR techniques by categorizing them according to the features used in each stage. Comparisons of them in terms of pros, cons, recognition results, and processing speed were addressed. A future forecast for ALPR was also given at the end. The future research of ALPR should concentrate on multi style plate recognition, video-based ALPR using temporal information, multi plates processing, high definition plate image processing, ambiguous-character recognition and so on.

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