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Comparative Analysis of Different Segmentation Techniques for Automatic Number Plate Recognition

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***Abstract*— Automatic Number Plate Recognition (ANPR) is an image-processing technology used to identify vehicles by their license plates. This technology is used in various security and traffic applications. Because of the rapid increase of cars and transportation systems, it is very difficult to manage and monitor it by humans because of human limitations. The License plate recognition systems have established a lot of interest from the research community because there is a certain limitation in particular territory, city or countries and lack of equivalence among different license plates. The various stages of ANPR include pre-processing, license plate extraction, segmentation and optical character recognition. This paper mainly introduces an Automatic Number Plate Recognition System which primarily uses morphological operations for plate extraction/localization, different segmentation methods and their comparison.**

***Index Terms*— ANPR, license plate recognition, mathematical morphology, plate region extraction, segmentation.**

I. INTRODUCTION

The Automatic number plate recognition (ANPR) is a mass surveillance method that uses optical character recognition on images to read the license plates on vehicles. Applications of ANPR include traffic monitoring, parking toll management, tracking of stolen cars, border and customs checkpoints security and red-light violation enforcement. ANPR technology tends to be region-specific, owing to plate variation from place to place. The objective of the paper is to successfully locate vehicle number plate, segment characters using different existing methods and compare them given a car image. The system must deal with different angles, distances, scales, resolutions and illumination conditions.

Lots of researches have been done and some systems have been already put into practice. However, the existing algorithms or systems work well only under some controlled conditions.
distortions, different specifications of license plate and multiple license plates detection. It is still a challenging task for us to detect license plates quickly and accurately in varying environments.

The main focus in this research paper is to experiment deeply with, and find best alternative solutions to the image segmentation within the License Plate Recognition framework. First, it is necessary to locate and extract the license plate region from a larger scene image. Second, having a license plate region to work with, segment the alphanumeric characters in the plate needed to be extracted from the background. The variations of the plate types (location, size, occlusion, inclination, colour and font), vehicle speeds or environments cause challenges in the detection and recognition of license plates. Performance can be measured in terms of easier algorithm design and shorter computation times.

The paper is organized as follows. Section I deals with a general introduction about the need and motivation behind the development and implementation of Automatic License Plate Recognition systems. Section II gives a literature survey of the various algorithms which can be utilized to implement one such system under various problems defined. Section III discusses the proposed method in detail. Section IV gives implementation and results on ANPR system. Section V shows the conclusions drawn from the results obtained.

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II. RELATED WORKS

Automatic number plate recognition is an important research field used in computer vision, pattern recognition, image processing and artificial intelligence, which is one of the most important aspects of the intelligent transportation system of human society in the 21st century. Recently, license plate recognition can be widely used in road traffic security monitoring, open tollbooth, road traffic flow monitoring, the scene of the accident investigation, vehicle mounted mobile check, stolen vehicle detection, traffic violation vehicle-mounted mobile automatic recording, parking lot automatic security management, intelligent park management, access control management and etc. [1]-[3]. It has a very important position in the modern traffic management and control system and has good application value. Meanwhile, License plate recognition can also be used in other identification field. So it has become one of the key problems in modem traffic engineering field [4] [5].

A. License Plate Extraction/Localization

As far as extraction of the plate region is concerned, there are several techniques for identification of license plates. The technique based on sliding window method [6] shows good results. The method is developed in order to describe the "local" irregularity in the image using image statistics such as standard deviation and mean value. Techniques based upon combinations of edge statistics and mathematical morphology featured very good results [7]. In these methods, gradient magnitude and their local variance in an image are computed. The paper explains the license plate detection based on color features and mathematical morphology. Since these methods are generally color based, they fail at detecting various license plates with varying colors. The paper [8] proposes a novel license plate localization algorithm for automatic license plate

recognition (LPR) systems. The proposed approach uses color edge information to refine the edge points extracted in a gray-level image. In [9], the paper presents a hybrid license plate location method based on characteristics of characters' connection and projection. This method uses edge detection technique and binarization method.

B. *Character Segmentation*

Number of techniques, to segment each character after localizing the plate in the image has also been developed, such as feature vector extraction and mathematical morphology [6]. An algorithm based on the histogram, automatically detects fragments and merges these fragments before segmenting the fragmented characters. A morphological thickening algorithm automatically locates reference lines for separating the overlapped characters. The paper uses binarization method, proposed by Sauvola [6] [9], to obtain binary image.

III. AUTOMATIC NUMBER PLATE RECOGNITION SYSTEM

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. The parameters 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, support vector machines, HMMs and fuzzy classifiers. Figure 1 shows the structure of the ANPR process. The performance of an ALPR system relies on the robustness of each individual stage.

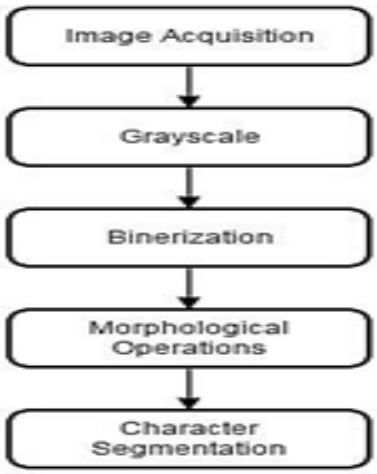

Figure 1: Stages of an ANPR System

A. *Image Acquisition*

Image Acquisition is the first step in an ANPR system and there are a number of ways to acquire images. For this project, readily available image database is used, which uses a 5-10MP digital camera at a distance of 3-5 meters. The format of the image has been exported or generated to .JPEG or .JPG. This is because .JPEG or .JPG format picture is the best, most suitable, easy and widely used based on the format compatibility with computer languages and systems.

B. *Pre-processing*

Pre-processing of an input image includes Grayscaling & Binarization. A binary image is a digital image that has only two possible values for each pixel. Typically the two colors used for a binary image are black and white though any two colors can be used. Binary images are also called bi-level or two-level. This means that each pixel is stored as a single bit (0 or 1). Binarized image is exactly referred as combination of any two colors with each pixel is stored as a single bit either 0 or 1.

C. *License Plate Extraction*

The purpose of this part is to extract the License Plate from a captured image. The output of this module is the RGB picture of the LP precisely cropped from the captured image, and a binary image which contains the normalized LP. The most important principle in this part is to use a conservative algorithm which, as we get closer to the license plate step by step, becomes less conservative, and avoid losing information in it, i.e. cutting digits and so on.

- *Morphological Operations*

Morphology is a broad set of image processing operations that process images based on shapes. Morphological operations apply a structuring element to an input image, creating an output image of the same size. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors. By choosing the size and shape of the neighborhood, we can construct a morphological operation that is sensitive to specific shapes in the input image.

The most basic morphological operations are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the *structuring element* used to process the image.

D. *Image Segmentation*

In image processing, Segmentation is the process of partitioning a digital image into multiple segments. Segmentation is used to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries such as lines, curves, objects etc. in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

a) Using Pixel Connectivity

Segmentation is performed 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.

Here, we are going to use horizontal and vertical edge processing. While we convert the image to gray scale, as the difference in gray value between successive pixels exceeds a certain limit, we count on the total of such at given column. Eventually, all column totals are stored in a matrix. If we were to plot the matrix, we get a result as in Figure 2.

Detecting the correct region at horizontal edge processing is as follows: when the number of white pixels (an edge is white) per column remains fluctuating for a long time over the calculated threshold, we assume that these certain regions indicate the approximate horizontal position of the number plate. In case, if there are multiple possible selected regions, we continue to work with the widest. For vertical edge processing same method is used; only we do not look now to the number of white pixels per column, but the number of times a pixel relative to its neighbor in a row going from high to low or vice versa.

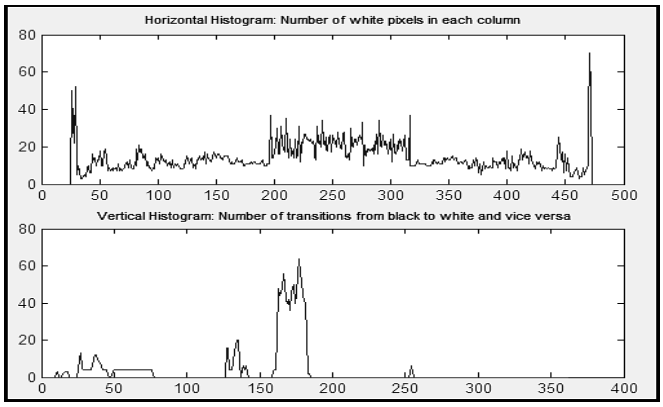

Figure 2: Horizontal & Vertical Histograms

b) Using Character Smearing Algorithm

The smearing algorithm is a kind of special algorithm constructed by using specific parameter design. It is used to smear the binarized image in horizontal and vertical way by reading the pixel of the image. This will apply to each character as the character smearing process is to identify the actual location of the character and to separate every character from one another by reading the white pixels in every character. If the number of white pixels is less than a desired threshold or greater than any other desired threshold, white pixels are converted to black.

After the image has been smeared with the smearing algorithm function, the next algorithm used is morphological algorithm. Morphological algorithm consists of two major algorithms which are dilation and erosion. In this approach, it seems to use the dilation algorithm after the image has been processed with smearing algorithm. The dilation process is actually to dilate and extract out the detected plate region in this experiment. With dilation process, the plate region area will be carried out and then the image involving will be only the plate region with segmented characters.

c) Using Projection Profiles (Peak-to-Valley Method)

Since characters and license plate backgrounds have different colors, they have opposite binary values in the binary image. Therefore, some proposed methods project the binary extracted license plate vertically to determine the starting and the ending positions of the characters, and then project the extracted characters horizontally to extract each character alone.

In order to segment the characters in the binary license plate image, the method named peak-to-valley is used. The methods first segments the picture in digit images getting the two bounds of the each digit segment according to the statistical parameters, Digit Width and Min Area. For that purpose, it uses a recursive function which uses the graph of the sums of the columns in the LP binary image. This function passes over the graph from left to right, bottom-up, incrementing at each recursive step the height that is examined on the graph.

It checks the bandwidth of the first part of the signal, if it is greater than Digit Width, the function is recursively called after incrementing the height which is examined on the graph. Otherwise, if the bandwidth is good, the two bounds of the signal with this bandwidth are taken as a digit segment, and the function is recursively called for the part of the image which is at the right side of the digit segment just found. This is done until the whole width of the picture has been passed over.

Once this segmentation has finished, the method keeps in the result only segment for which the area of the smallest rectangle containing them is more than Min Area; then, it keeps only the pre-defined number of segments in the result with largest area, and in case less segments were found, it attempts to recall the whole method, after making the separation between the already found segments clearer (by cleaning the bits which are there).

The pro of the peak-to-valley method is that the extraction of characters is independent of their positions. The license plate can be slightly rotated. However, it depends on the image quality. Any noise affects the projection value. Moreover, it requires prior knowledge of the number of plate characters. In some rare cases, digit may be cut or two digits may appear in the same segment; this is especially the case when the image is blurred due to motion or when the contrast of the LP is very poor.

IV. EXPERIMENTAL RESULTS

In this section, we have simulated the Matlab program for all the three segmentation techniques and presented their simulation results (Figure 3-8). The performance of the system can be evaluated on the basis of complexity, processing time and accuracy. The results are shown in Table I.

A. Using Pixel Connectivity

Figure 3: Input Image 1

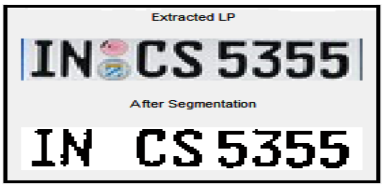

Figure 4: Output using Pixel Connectivity

B. *Using Character Smearing Algorithm*

Figure 5: Input Image 2

Figure 6: Output using Character Smearing Algorithm

C. *Using Projection Profiles (Peak-to-Valley Method)*

Figure 7: Input Image 3

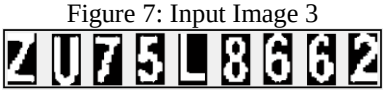

Figure 8: Output using Projection Profiles (Peak-to-Valley Method)

D. *Comparison*

Table I: Comparison of Different Segmentation Methods

Sr. No.	Method	Complexity	Processing Time	Accuracy
1.	Pixel connectivity	Very simple	2-3 seconds	Low
2.	Smearing algorithm	Moderately complex	0.8 seconds	Moderate
3.	Peak-to-valley method	Simple	Less than 0.2 seconds	High

V. CONCLUSION

Automatic Number Plate Recognition is a rapidly evolving area of research and development in the field of Intelligent Transportation System. Different researchers provided different methods and techniques for this system. However, every technique has its own advantages and disadvantages. Furthermore, each country has its own license plate numbering system, colors, language of characters, style (font) and sizes. Even within the same country the license plate differs from state to state and in terms of types of License plate. In this report, three different techniques for image segmentation are analysed. The experimental results for the three techniques clearly demonstrate the following conclusions:

Segmentation using Pixel connectivity is a simple process, but it not very accurate and requires more processing time. Segmentation using Smearing algorithm yields moderate accuracy but requires more processing time. Peak-to-valley method is a simple method with highest accuracy & takes less time as compared to other methods. Hence, it is most suitable for the real-time applications.

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