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A ROBUST LICENSE PLATE RECOGNITION METHODOLOGY BY APPLYING HYBRID ARTIFICIAL TECHNIQUES

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Abstract. *Intelligent Transportation System (ITS) has been more and more important around the world. License Plate Recognition (LPR) is one of the important technologies for ITS. Meanwhile, LPR provides Real Time and Value-added services with the technology of Cloud computing and database. License plate was used to be recognized by human; however, it is tedious work and easy to make mistakes. The purpose of this research is the development of a robust license plate recognition methodology by applying hybrid artificial techniques including coordinating the angle correction algorithm and the combination of connected component theory. Meanwhile, the Optical Instrument is used as the source of images. The results reveal that about 98% plate images can be recognized by the proposed methodology after angle adjusted, but it takes more time to process the recognition without auxiliary coordinates. The successful plate recognition reached 98% when the image in a horizontal position. However, the successful rate may be greatly reduced when the angle is oblique and without any adjusted. With auxiliary coordinates, the recognition percentage is 95% when angle slope ranges are between 350° and 370°.*
Keywords: Intelligent transportation system, License plate recognition, Connected components, Image coordinates of angle correction algorithm

1. **Introduction.** Traffic management is one of the important issues for traffic control in Taiwan. Hence, many researchers have focused on developing the intelligent transportation system (ITS) since last decade including GPS, radar sensors, or digital cameras to measure average car speed and maximum flow for providing traffic information to avoid congestion. Automatic license plate recognition (LPR) is one of the important fields in ITS where it can be applied in many applications such as automatic parking, searching stolen cars. Moreover, techniques in soft computing and artificial intelligence have been successfully applied to various fields [5-9].

License plate location, license plate segmentation and character recognition are three major parts of a license plate recognition system. Although traditional LPR can do automatic recognition, it has already reached a bottleneck. [15] demonstrated the bottlenecks of traditional LPR:

- Too many spots on the plate will increase the recognition difficulty.
- Color similarity (the color of car and plate) will increase the recognition difficulty.

- The size limit of plate images is also a factor.
- Viewpoint is an influence factor, such as the camera set position.
- Climate – too dark or too light – affects the recognition.

The purpose and contribution of this research is the development of a robust license plate recognition methodology by applying hybrid artificial techniques including coordinating the angle correction algorithm and the combination of connected component theory.

2. **Literatures.** Several tactics have been offered for image of locating license plates victoriously which built a practical application to recognize plate image [1-4,13]. The system catches video edge including a manifest plate image which is different from prior method by using edge detection to detect the edge of a plate and projection method to identify the possible location of license plates. The projection method is to accumulate all non-zero gray values Pixel of X axis to Y axis along the Y axis. Similarly, it accumulates all non-zero gray values Pixel of Y axis to X axis along the X-axis. At this point, the detected image value is not 0 but 255.

Another advantage to detect the edge part of the edge detection techniques is most widely used. After obtaining the images from digital optical equipment, it makes a mask to suppress noise for calculating with image, and then using some edge detection techniques to obtain the license plate location. Mask parameter is shown in Table 1.

FIGURE 1. Original image

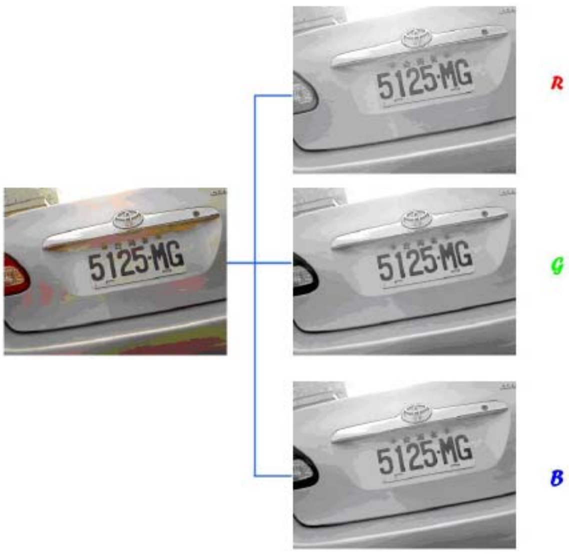

FIGURE 2. RGB value image

FIGURE 3. Gray-level image

Table 1. Most used mask parameters

Mask	Parameter	
Soble	$\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} -1 & -2 & 1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$
Prewitt	$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} -1 & -1 & 1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$
Roberts cross-gradient	$\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$	$\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$

Translating image into gray-level can solve the particularly complex problems such as handwritten documents where the problems contain fluctuating, touching or crossing text lines and low quality image that do not easily to binarization. This technology is adopted to solve the manuscripts [11]. In the vehicle license plate locating process, it also can recognize the license plate image that must use monopoly technology and gray-level algorithm to transform the plate to achieve position. Most binarization methods are based on intuitive observation of the gray level discrimination between characters and backgrounds, minimized of the complexity of the image. To efficiently process the input images, the common image techniques are proposed to extract characters from images with different complexities. [16] The common image skill includes gray-level transformation; binarization and connected components are needed in this study.

2.1. **Grayscale conversion.** First, convert a full-color image into a 256 gray level image, gray value from 0 to 255. The color of image turns whiter with higher gray value; in contrary, blacker with lower gray value [3]. As the human eye's structure, the color was divided into red, blue and green and constitutes a RGB color image, so the use of two-dimensional matrix to represent the image of the RGB values of each pixel changes. One RGB 8bit, the depth ranges from 0 (black) to 255 (white), so there are 24 bits of a total RGB image, a total of 16777216 colors change. Signals are used YIQ color model, which Y stands for luminance, I stands for hue and Q stands for saturation. The higher values bring higher sensitivity. Y is used to turn a gray-level image into a color image. An original color image, its RGB vales, and the gray-level image are shown in Figures 1-3 respectively where the gray-level images can be obtained by $Y(luminance)$ in the following equation.

$$Y(luminance) = 0.299R + 0.587G + 0.114B \tag{1}$$

$$I(saturation) = 0.595716R - 0.274453G - 0.321263B \tag{2}$$

$$Q(saturation) = 0.211456R - 0.522591G - 0.311135B \tag{3}$$

2.2. **Image binarization.** Binarization is mainly used to decrease information and image complexity; however, binarization cannot work well when the license plate under uneven illuminations. For example, strong lightness affects the plate image blacker than normal bright region [12]. It needs a threshold (T) to let an original color image or a gray-level image f(x, y) change to a black or white image T(x, y), which way can be used in character recognition and fingerprint recognition. Also, binarization can simplify the color images; for example, the color of gray-level image is between 0 and 255, but the binarization image is only 0 to 1.

$$g(x, y) = \begin{cases} 0 & \mathrm{f} < \mathrm{T}_1 \\ 1 & \mathrm{f} \geq \mathrm{T}_1 \end{cases} \tag{4}$$

Although Binarization simplify calculation, it loses image information at the same time. Therefore, how to use binarization to decrease information but keep the recognized information is very important.

2.3. **Angle correction.** Hsieh [10] developed different ways for angle correction including dual-camera. However, it takes time and cost to catch the license plate images after relocation. In the research, auxiliary coordinates algorithm is used to recognize license plates.

3. **Methods.** The image was first converted into gray-scale. Then, license plates were positioned and components segment characters were connected to revise angles for recognizing plates. Captured specimens must be performed in pre-processing including removing noise, deleting interlacing, transferring the color space to gray color, masking unnecessary background and segmenting the foreground. Factors may affect the images captured by different types of camera and environments such as the edge resolution, the scanning method, edge rate and the depth of color [14].

3.1. **Image preprocessing.** Input mage is first turned into gray-level image and binarization is applied to turn gray-level images into black and white images as shown in Figures 4 and 5. These processes all cooperate with connected components.

3.2. **License plate recognition.** License plate locating (LPL) method of the research is based on two pixels corresponded to gray-level values, such as white and black color. More boundary points present larger difference values corresponding to gray-level. For example, drawing a straight line from left to right in a white plate with black numbers can appear many boundary points of white turning to black or back turning to white. In normal situation, there is single color of car so most boundary points gather in the plate (Figure 6).

The ratio of plate is 1 : 3.5 which is used to draw a rectangle from left to right, top to bottom for calculating the most boundary points in the rectangle area (Figure 7). Furthermore, the characters of plates are obtained and then extend 50% to get the plate image for avoiding inaccuracy (Figure 8).

Figure 4. Gray-level image

Figure 5. Black and white image

Figure 6. A stright lines over 12 boundary points

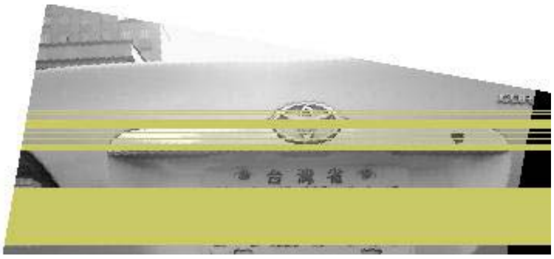

Figure 7. The area of most boundary points

Figure 8. First license plate location

3.3. **Connected components.** The connected pixel in an image is called the same component where the connected components labeling algorithm are used to segment characters of license plates containing a combination of edge statistics. There are two categories of components labeling: 8-connectivity and 4-connectivity. Image must be binarization image and it is divided into foreground (value = 0) and background (value = 1). Foreground is the target component. Here, we set foreground value 0, and treat pixel areas with the number same as component area. The calculative process is shown in the following:

(1) The first scan

- Screen the image from left to right and up to down. Each pixel value is zero to indicate an N mark of non-zero value. The marked value should consider other pixel number; the connecting data is by 4-connectivity or 8-connectivity.
- If connecting points are background, dealing element will become a new N value.
- If one non-zero value is in connecting points, the dealing element marks and connecting non-zero value are the same symbol.
- If the non-zero value is not one point of combining points, the connecting points are the same as Mark N, also dealing elements are as N Value. If the sign value is different, the dealing element is the same value as the smallest Mark N.

(2) The second screen

All elements are first marked and one element may be determined by to different marks. The process should calibrate more. The research adopts 4 and 8 connectivity methods and the second screen is from left to right and up to down. If non-zero N value is combining the points, the smallest N value is used to replace it.

4. **Results.**

4.1. **Test of plate images recognition.** 500 images from the camera are used in ANGLE OF the system test. The result reveals that 492 are recognized faultless, 8 are mistakes and rate of recognition is 98%. Meanwhile, 500 samples are tested in the angle

Table 2. Pros and cons between normal plate recognition and the one of this study

	Normal plate recognition	This study
Advantages	• The recognition rate is between 85% and 98%. • The recognition time is one second when plate is in horizontal position. • Even slight slope plate can be recognized.	• Most horizontal position plate with a slope between 350 and 370 degree can be recognized. • Oblique plate can be recognized.
Disadvantages	• Oblique plate can be barely recognized. • Characters can be easily recognized with mistake when the angle tolerance is between ±2 degree.	• The recognition time is longer.

Figure 9. Without auxiliary coordinates

Figure 10. With auxiliary coordinates

oblique of system test. The result reveals that 477 are recognized faultless, 23 are mistakes and rate of recognition is 95%.

4.2. **Validation of plate images recognition.** It takes 1.75 sec from original image to angle adjusted and recognized, and turns the angle from 350 degree to 370 degree. The advantages and disadvantages between normal plate recognition and the methods proposed in the current research is shown in Table 2.

With images in horizontal position and recognized faultless, the comparison of the system without auxiliary coordinates and the system of the current study are shown in Figures 9 and 10 respectively.

Next, the images took in a slop angle were recognized by two methods and their results are shown in Figures 11 and 12 respectively. In a normal recognition system, it cannot recognize the plate in oblique position. However, the plate can be positioned after the angle adjusted to 366 degree with auxiliary coordinate.

Although there is no mistake in the process of plate locating, it still cannot be recognized because it may segment other noises resulting in unrecognized characters as shown in

Figure 11. Without auxiliary coordinates

Figure 12. With auxiliary coordinates

Figure 13. Without auxiliary coordinates

Figure 14. With auxiliary coordinates

Figure 13. The result reveals that the oblique plate cannot be positioned without auxiliary coordinates (Figure 14). Therefore, connected components cannot successfully segment characters in this situation.

The study adopts Webcam from different angle to take the plate images in daytime in views of 366° and 358° as shown in Figures 15 and 16 respectively, where the horizontal plate images are difficult to be recognized.

Figures 17 and 18 show horizontal plate images took in views of 369° and 363° respectively. The height of the first character in Figure 17 has three unit differences with the last one where the horizontal plate image cannot be found. However, the height of the first character in Figure 18 has only one unit difference with the last one where the horizontal plate image is recognized successfully.

5. **Conclusions.** A robust license plate recognition methodology by applying hybrid artificial techniques including coordinating the angle correction algorithm and the combination of connected component theory is developed successfully in the research. Meanwhile, it was applied to recognize plate images took by the Optical Instrument. The successful plate recognition reaches 98% when the image in a horizontal position. Meanwhile, it

Figure 15. The image took in a view of 366°

Figure 16. The image took in a view of 358°

Figure 17. The image took in a view of 369°

Figure 18. The image took in a view of 363°

takes more time to process and adjust the image without auxiliary coordinates and the rate will be about 98%. However, the successful rate may be greatly reduced when the angle is oblique and without any adjusted. With auxiliary coordinates, the recognition percentage is 95% when angle slope ranges are between 350° and 370°.

According to cases studied in the research, researchers can focus on developing methodologies to recognize images under different situations including strong bright, light reflection of the car color, fuzzy or raining weather condition and so on. Meanwhile, the license plate recognition system can adopt scrutiny cameras in the roadside and an immediate recognition system for providing automatic real-time roadside scrutiny in the future.

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