Multiple Vehicle License Plates Localization and extraction of Vehicle License Plate Number for Moving Vehicles

Chen-Chung Liu[#1], Zhi-Chun Luo[#2] , Chih-Chin Chang[#3].

Department of Electronic Engineering, National Chin-Yi University of Technology

No. 35, Lane 215, Sec. 1, Chung-Shan Rd., Taiping, Taichung, 41111, Taiwan, R.O.C.

[1] ccl@chinyi.ncut.edu.tw

[2] monkeymk2001@yahoo.com.tw

[3] linked_15@hotmail.com

***Abstract*— Nowadays, vehicle license plate (VLP) recognition system has become a key to lots of traffic related applications, e. g. the road traffic monitoring, the traffic analysis, the parking lots access control etc. Both accurately detecting the VLP from a vehicle image and extracting the VLP number from the detected VLPs are considered to be the most important stage of vehicle license plate recognition (VLPR) system. They greatly influence the overall recognition accuracy and processing speed of the whole system. This paper presents an algorithm to locate the multiple VLPs of moving vehicles from a video traffic image sequence, and adopts the projection scheme to extract the VLP number from the detected VLPs. The shifting of the VLP in the detected image is also studied and then a transformation based on relative position vector to correct the distorted plate image into a calibration standard image is developed. By means of the distortion calibration techniques, the VLP number in a distorted state can also be extracted more correctly. The experiment results show that the presented algorithm can correctly localize the VLPs even in overlapped vehicles situation and can effectively extract the VLP number from a distorted VLP caused by the shifting of relative position between the vehicle and the camera.**

***Keywords*— multiple, VLP, localization, projection, calibration.**

1. INTRODUCTION

The flux and quantity of motor vehicles increase fast along with the rapidly development of the world’s economy. The worsening of social order causes destruction and violence around the world. They have weighted the importance of security, and raised the growing demand for traffic data in regard of traffic flux and automatic identification of motor VLP. Among all the possible schemes, installation of video surveillance systems at streets to record suspected vehicles has become a main tool for police. Whenever criminals committed a crime, it is very possible that they would use vehicle. Hence, the police can get back all the videos recorded around the crime scene to find the possible suspects to follow the vehicle to track the owner. However, to check the enormous volume of video should easily wear down the spirit and efficiency of the pursuit. Therefore, methods that automatically extract the vehicles and recognize their VLPs for identification would be a great help for the police to solve the problem more quickly and efficiently. It leads researchers around the world to develop an automatic system called Intelligence Transportation system (IT system), to monitor motor vehicles and control traffic volume without human interruption [1-6]. So, Intelligence Transportation system is the major development direction of recent transportation management.

In IT system, Vehicle License Plate Recognition system (VLPR system) is one of the most important parts. VLPR system plays a central role in many applications in traffic monitoring; save time and lessen heavy traffic by allowing vehicles to pass crowed plazas or weigh stations, save money and time by collecting and managing vehicle data without human interposition, offer security control of restricted regions, and assist in traffic law enforcement [1-8].

A VLPR system usually consists of four modules; that is the VLP extraction module, the distorted VLP image correction module, the VLP number segmentation module, and the VLP number recognition module. Fig.1 shows four modules of VLPR system. In order to recognize a VLP efficiently, however, the location of the VLP must be detected firstly. Detecting the accurate location of a VLP from a vehicle image is considered to be the most important stage of a VLPR system, which greatly influences the overall recognition accuracy and processing speed of the whole system. In the VLP extraction module, VLP location and extraction from images is always difficult to be located accurately and efficiently, due to following reasons: (1) The size, shape and pose of plate may vary. (2) The lighting condition in the image may vary. (3) The plate may be any color, and the background color may be very similar to that of plate. (4) The image may contain a number of noises. The VLP candidates are decided based on the features of VLPs. Features are commonly derived from the VLP format and alphanumeric symbols constituting VLP number. The features deriving from the VLP format are shape, width to height ratio, color, spatial frequency, texture of grayness, and variance of intensity values [1-8]. Alphanumeric symbols are line, blob, the aspect ratio of alphanumeric symbols, and the sign change of gradient magnitude [1-5]. A set of effective and easy to detect features is adequate usually.

A number of techniques have been proposed. However, most of these techniques are based on conditions, such as fixed illumination, fixed the relative position between a camera and the VLP, limited car speed, designated routes, and stationary backgrounds [1-8]. The methods based on textures mainly take the aspect ratio, the contrast variations, the uniform distribution of the VLP numbers, and the ratio between background area and VLP number area [9-13]. They process the image as a grayscale image and employ the Sobel edge detection, projection, and seed-filling algorithm to remove the redundant regions. The result is then filtered by the aspect ratio and object connections. These methods are high efficiency, but they are easily undergone by the interference of the lighting effect. The methods based on the colors retrieve the color edge and then enhanced the edge. The object connection is applied to the classified regions separated by the edges and further locates the LP. Yang et al. [14] adopted textures and colors simultaneously to locate the LP, it has the high efficiency and good localization result and the disadvantage is the vulnerability in dealing with low contrast or poor color. The aim of this paper is to lessen many of these restrictions to detect VLPs whose sizes and orientations are slightly different from the original VLP caused by being not shot from exactly the same distance and orientation.

In the distorted VLP image correction module, the pose of VLP image extracted from car picture may distorted, due to the perspective effect of lens or the various combination of visual angles between the camera and the car. It becomes very difficult for segmenting out interior VLP numbers, and decreasing the recognition ability [15-20]. We must correct those distorted plate images before the VLP number segmentation. We propose a smart system using an automated VLP location and distortion calibration to overcome most of the problems with previous approaches. The system can deal with difficulties raised from noise distortion and complex background.

The remainder of this paper is organized as follows: Section 2 – Vehicle License Plate Localization Algorithm. Section 3 –Vehicle License Plate number Extraction Algorithm. Section 4 – Experiment Results. Section 5 – Conclusion.

2. VEHICLE LICENSE PLATE LOCALIZATION ALGORITHM

The first step of a VLP identification algorithm is to extract the VLP image correctly. Our system uses the video sequence images captured by a charge- coupled device digital video camera from a road in Taipein town in a sunny afternoon, in which there are many lighting effects, plate damage, dirties and complex backgrounds as the input. The overall VLPs localization of moving vehicles process of our proposed scheme is shown in Fig. 1. The original input video color image sequence is divided into separated successive frames of color images $C(t_i), i = 1,2,...$ which are presented by RGB planes. A background removal processing discards the useless image part to increase object identification correctly. In addition, VLP extracting and its distortion adjustment (DA) are the most signification roles during the recognition process. However, get the correct VLP location is the condition of exactly identification. The details of our approach are described in the following.

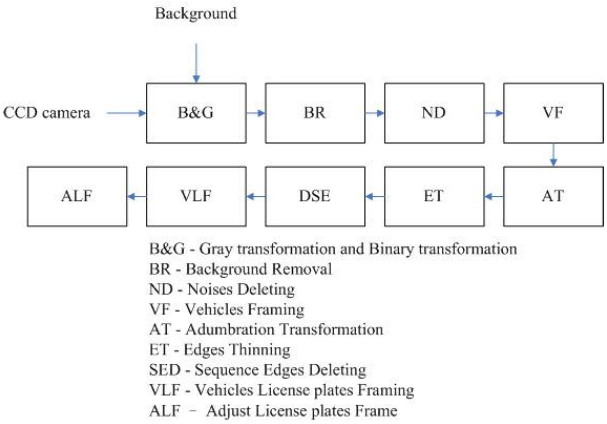


Fig. 1. The flow chart of license plate localization algorithm

2.1. Color mapping RGB to YIQ

The red, green and blue (RGB) are three dimensions of illumination spectrum. They are enough to compose any color adequately, although the spectrum of illumination is infinite dimensional. A common alternation to the RGB representation of an image is the YIQ representation. The YIQ representation of an image is the standard model in the television transmission. The YIQ representation of an image obtained from the RGB representation of an image is given by equation,

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.144 \\ 0.596 & -0.274 & -0.322 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.956 & 0.621 \\ 1.000 & -0.272 & -0.647 \\ 1.000 & -1.106 & 1.703 \end{bmatrix} \begin{bmatrix} Y \\ I \\ Q \end{bmatrix} \quad (2)$$

Where Y is the luminance or brightness which refers to color density, I is the hue which is the dominant such as orange, red or yellow, and Q is the saturation or depth which is the amount of white light mixed with a hue of color. The equation (1) is the inverse transformation of equation (2), to transfer the image in YIQ planes back into the RGB planes.

The image in RGB color space is not suitable for image processing applications, because the image in RGB color space is highly correlated. Other color models like as HIS, L*a*b*, YIQ, YUV, and YCbCr are suitable for image processing applications, they are the reducing redundancy models of the image in RGB color space, obtained by some color transform.

2.2 Background Removal

Fig. 2 shows the flow chart of image processing procedures for obtaining a gray image of moving objects with background removal. The background averaging procedure is used to obtain a background image by averaging more than 30 pictures of a location. Background subtraction is a popular and effective method for detecting moving objects in a scene. Based on the concept of probability, the background image can be constructed from the modified histogram of individual pixel in image sequence. Fig. 3 is an original input image (Y plane) and Fig. 4 shows a constructed background image that is obtained from background averaging procedure. Fig. 5 shows that the objects apart from the background in the scene are extracted by erasing the background from original image

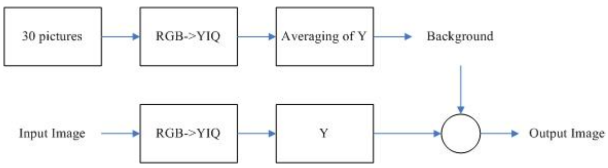


Fig. 2. The background removal flow chart.

Fig. 3. An original input image.

Fig. 4. The constructed background image after background averaging processing.

Fig. 5. The moving vehicles apart from the background in the scene are extracted from original image.

2.3. Noises Deleting

There are many small noises in the gray image of moving objects with background removal. Most of these small noises are generated by the illuminant changes with time due to the input is video image sequence and they are photographed at different time. These noises can be exhibited more obviously on the binary domain. In this paper, we use the erosion of morphology to delete noises from the binary image of moving objects with background removal. In the binary image of moving objects with background removal and noises deleting, vehicles are colored in white (pixel value equals 255) and background is black colored in black (pixel value is zero). We frame the vehicles from the black-white image by finding the seed of vehicle and construct a vehicle by a tree with the seed as the root of the vehicle tree:

1) We find the first white pixel to take as a seed by starting at the left- upper pixel of the black-white image, and shifting from left-to-right and top-to-bottom in the black-white image.

2) A 2X3 window shown in Fig.6 is taken as the mask to filter other white pixels as the leaves of the vehicle hierarchical tree. Each vehicle hierarchical tree represented an object of the black- white image. Fig.7 shows an example of the construction of a vehicle hierarchical tree.

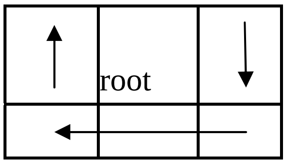
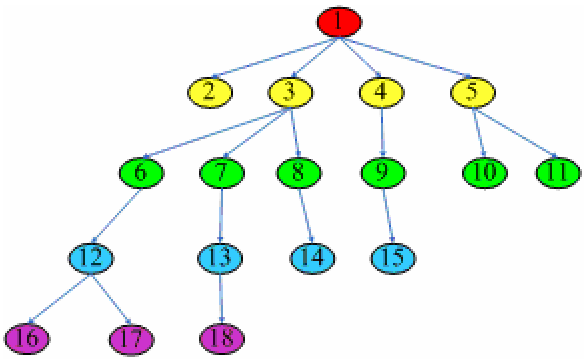


Fig. 6. The 2X3 window used to filter in other white pixels as the leaves of the vehicle hierarchical tree.

0	0	1 (1)	1 (2)	0
1(11)	1 (5)	1 (4)	1 (3)	0
1(10)	1 (9)	1 (8)	1 (7)	1 (6)
1(15)	1(14)	1(13)	1(12)	0
0	1(18)	1(17)	1(16)	0

(a)



(b)

Fig. 7. The construction of a vehicle hierarchical tree. (a) Black- white image with background removed (the number in parentheses represent the order of searching for tree constructing), (b) the corresponding vehicle hierarchical tree of (a).

2.4. License Plates Localization

The localization of VLPs from a traffic images sequence is considered to be the most important stage of VLP recognition system for moving cars, which greatly influences the overall recognition accuracy and processing speed of the whole system. The VLPs location is dealt with following six steps in this paper.

1) For saving the processing time, we segment each object into 3 equal parts from the top to the bottom of the object. The upper part is removed due to the VLP never be placed in the upper part, the middle part and the bottom part are retained as the residual object image. Each residual object image is framed with a suitable outer- connected rectangle to become a residual image of the original image. Fig. 8 shows an example of the framing of the residual image.

(a) (b)

(c)

Fig. 8. The framed vehicle in (a) original image, (b) background- removed black- white image, (c) the residual object image framed with a rectangle.

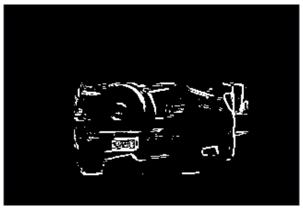
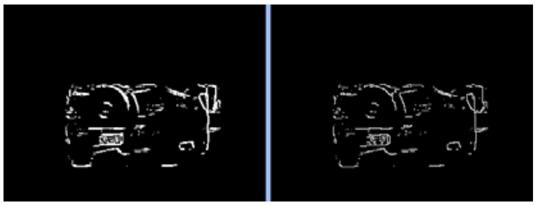


Fig. 9. The edge image of a residual image of Fig. 8.

2) To take each residual color image of original image by extracting the object image from the residual image's corresponding position in the original color image. Then, we transform each residual color image of original image into gray image; the residual gray image is then transformed into binary image with the median filter. Edge features of the car image are very important, and edge density can be used to successfully detect a number plate location. Since most edges in the residual binary image are horizontal or vertical edges, and we want to avoid taking too much redundancy edges to extract license correctly, we find the 45 or -45 degree edges from the residual image with Sobel filter. Fig.9 shows an example of the edge image of a residual image.

3) For extracting VLP correctly, the edges in the edge image are thinned to take the one pixel width skeleton of edge by ZS thinning method [21]. Fig.10 shows an example of the edge thinning.



(a) (b)

Fig. 10. The residual edge image (a) before thinning, (b) after thinning.

4) In the image of edge skeleton, we delete these over- size skeletons due to that the VLP number skeleton size of the VLP in skeleton image has its limitation. Then, the residual skeleton should concentrate in the VLP region. Fig. 11 shows an example of the residual skeleton image.

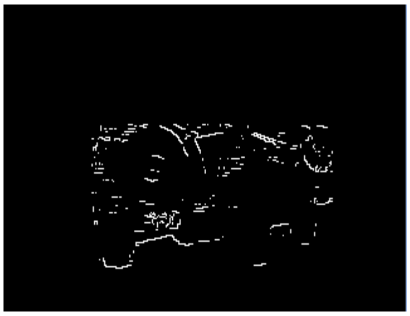


Fig. 11. The residual skeleton image after deleting over- size skeletons

5) We use a plate- frame with height h equals the 1/8 height of the residual image and width w is (8/5)* h as the mask to extract the VLPs from the residual skeleton image, and shifting from left-to-right and top-to-bottom in the residual skeleton image to calculate the number of edge pixels in the mask. The first extracting VLP located at the frame that has the maximum number of edge pixels $N_M(e)$ in the mask. If the second large number of edge pixels of another masked region that does not overlapped with the first extracted VLP is not less than 80% of $N_M(e)$, then the second masked region is extracted as the second VLP (the object is composed by two

overlapped vehicles). Fig.12 shows an example of the VLP localization.

(a) (b)

Fig. 12. (a) The framed overlapped vehicles in background- removed black- white image, (b) the framed vehicle license plates in an overlapped vehicles color image with background- removed.

6) From Fig. 12, we can see the plate-frame size framed in step 5) is much greater than real VLP size. We need to adjust the size of the frame rectangle to increase the framing precision. The size adjustment of the framing rectangle is the same as the method of locating VLP in residual image. We take a plate-frame as a residual image and take a rectangle with size equals to the size of plate-frame times 0.9 as a mask each time, and shifting the mask from left-to-right and top-to-bottom in the plate-frame to calculate the number of edge pixels $N_M(e)'$ in the mask. We find a rectangular region that has the maximum number of $N_M(e)'$, and then calculate the edge pixels density of the region. We stop the iteration and take the rectangular region as the final VLP region if density is greater than 0.6, we repeat step (6) otherwise.

3. VLP Number Extraction Algorithm

In the proposed algorithm of VLP number extracting from an extracted VLP in the previous section, the VLP number is extracted with a rectangular block. This algorithm consists of five major processes: the preprocessing process, Horizontal projection process, Horizontal segmentation process, Vertical projection process, Vertical segmentation process. Fig. 13. illustrates the outline the proposed algorithm for VLP number extraction, and each process is described detail as Fig. 13.

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3.1. Preprocessing

Due to the fact that most of the extracted VLP images are not good enough to be progressed the VLP number extracting process. For example the extracted VLP image contains too much car body, or the VLP part in the extracted VLP image is distorted. So, they are need to be improved by preprocessing process. The preprocessing process of extracted VLP improves the VLP image to make the VLP number extracting effectively and precisely. As shown in Fig. 14., the preprocessing process of extracted VLP according to five steps as Fig. 14.

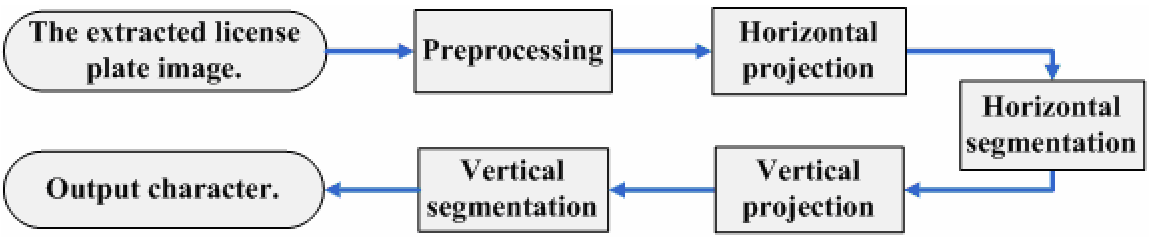


Fig. 13. The flow chart of VLP number extraction algorithm.

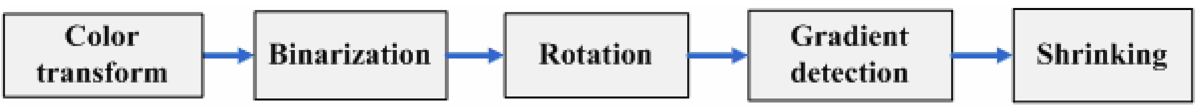


Fig. 14. The flow chart of VLP number extraction algorithm of license plate.

Step 1.Color transform: Due to the input extracted VLP image is a RGB color image and the image in RGB color space is not suitable for image processing applications, because the image in RGB color space is highly correlated., thus it is needed to be transferred into a gray level image to go onto the following black-white processing. In this paper, the RGB extracted VLP region is transformed in to YIQ color space described in section 2.1. Then, the Y component is taken as the gray level image of the extracted VLP region. Within the OpenCV image reading function, threshold will be defined to transform the extracted VLP region to gray level image. From the results of the experiment, the scheme that to define the gray level threshold is to select the YIQ color space's Y value.

Step 2.Binarization: Once the gray level image has been extracted, black-white binarization will starts processing. Black-white threshold is the average pixels of all the gray level image's pixels. Using this threshold can solve the problems of too dark or too bright of the whole image.

Step 3.Distored plate calibration: The main defects in the VLP images can be summarized as follows: geometric distortion, noise presence, out of focus and so on. Some geometric distortion of VLP images is caused by the perspective effect of lens. It skews the interior VLP numbers of the license. It is very difficult for segmenting out those skewed interior VLP numbers, and then causes complications for us in the VLP number recognition. In order to increase the ability of VLPR system, it is necessary to develop an algorithm to handle those distorted VLP images caused by the perspective effect of lens. Many researches have presented various techniques to solve it. T .Naito et al. constructed a templates table of the inclined VLP numbers in advanced, and then took template matching [6]. The pose of a VLP image is a function of the position vector of the VLP with respect to the camera frame. Two points that are near from the camera center appear more departure in the image than the same two points when they are far to the camera center .The unique imaging orientation that does not have distortion, is when all points on the VLP are the same position vector with respect to the center of camera lens. Since cars motion, the place position restriction of camera, and camera is a projective transformation engine in nature, it is nearly impossible to take an undistorted VLP image. Correcting distorted VLP becomes an important and inevitability process in VLPR system. The VLP image distortion due to the camera– VLP interaction can be modeled as a shift of the position within the image, that is the distortion can be modeled and corrected without prior knowledge of the camera's intrinsic parameters (the focal length of camera, true image center and pixel scale) and extrinsic parameters (camera position and orientation in three dimension space). We analyze the relation between the VLP shifting in the image and the relative position vector of the VLP with respect to the camera, and then develop a transformation to correct the distorted plate image into a calibrated standard image. In our system, we don't correct the full image. We only correct the sub-image that contains the VLP. The transformation must include rotating and translating operation. Since a rotation can be decomposed into a sequence of one-dimensional translations, we recompose and simplify the rotating and translating operations into shearing along x-axis and shearing along y-axis. Fig. 15. demonstrates the geometry of shearing operation. Fig. 17. is the flow chart of distorted image calibration.

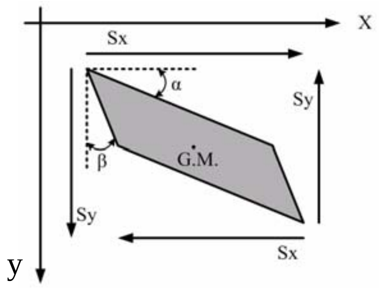
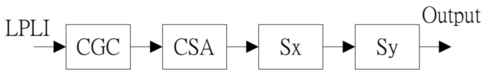


Fig. 15. The geometry of shearing operation.

	Original image	Color transform	Binarization	Rotation	Gradient detection	Shrinking
Image						
Size	337*251	337*251	337*251	337*251	337*251	305*251

Fig. 16 Preprocessing result



LPLI:License Plate Location Input
CGC: Calculate Geometry Center
CSA:Calculate Shearing Angles
Sx:Shearing Along the x-axis
Sy:Shearing Along the y-axis

Fig. 17. The flow chart of distorted license plate correction.

Referring to Fig. 14, If we denote $[S_x]$ as the matrix of shearing transformation along x-axis, and $[S_y]$ as the matrix of shearing transformation along y-axis, then we get a calibration transform matrix, $[T]$, composed with two matrices as following:

$$[S_y] = \begin{pmatrix} 1 & 0 \\ -\tan(\alpha/2) & 1 \end{pmatrix} \quad (3)$$

$$[S_x] = \begin{pmatrix} 1 & -\tan(\beta/2) \\ 0 & 1 \end{pmatrix} \quad (4)$$

$$[T] = [S_y][S_x] \quad (5)$$

Step 4.Gradient detection: This processing is to solve the problem that while extract VLP, it may also extract some parts of the car other than only the VLP and thus, cause unnecessary noises which occurs during VLP localization processing. Therefore, to solve this problem while during this procession is to calculate the times of each straight line's black-white edges transformations, if the result is not satisfied the threshold then the whole straight line will be deleted and setup to be highlighted white.

Step 5: Shrinking: Most of the uneasy to handle noises will be modified once the previous processing was completed. Most of the VLP image which extracted from the VLP allocation is not perfect; therefore, we can re-circle the preprocessing image. The main reason for this is to ungroup the unnecessary parts of the both sides of the VLP image, and thus, preprocessing has been fully completed, and the results are as shown on Fig. 16.

3.2. Horizontal projection and Horizontal Segmentation

These paper using projections to processing segmentation that include the VLP numbers of VLP horizontal segmentation and the VLP numbers segmentation. Before the horizontal segmentation starts, the accumulation of pixel values in each row is calculated as shown on the Figure 18. Figure 18-(a) is the image that has been preprocessing, and Figure 18-(b) shows the accumulation of pixel values in a row after the horizontal projection has completed. As shown on the Figure 18-(b), the accumulation of pixel values of VLP number is within the specified range which is the range between the two red lines. And thus, using two different thresholds can divide the horizontal histogram into three non- overlapping parallel regions in vertical direction. Due to the characteristic of VLP number distribution, the sub-region of the middle region having maximum width will be the horizontal region of VLP numbers.

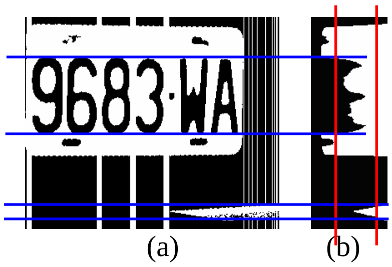


Fig. 18. Horizontal projection Example. (a) The image after preprocessing. (b) Horizontal projection of (a).

3.3. Vertical projection and Vertical Segmentation

After getting the VLP region with horizontal projection and horizontal segmentation, the presented algorithm uses the vertical projection process to accumulate the pixel values in each column as shown on the Figure 19. Figure 20-(a) is the vertical projection of a horizontal segmented VLP, where also shows the accumulation of pixel values in each column after the vertical projection has completed. As shown on the Figure 20-(a), the accumulation of pixel values of each VLP number of VLP is larger than zero and the accumulation of pixel value of each gap between two adjacent VLP numbers of VLP is zero. And thus, the VLP number will be extracted by extracted the region between two zero accumulation pixel values. Figure 20-(b) shows the result block after Vertical projection.

(a)
(b)

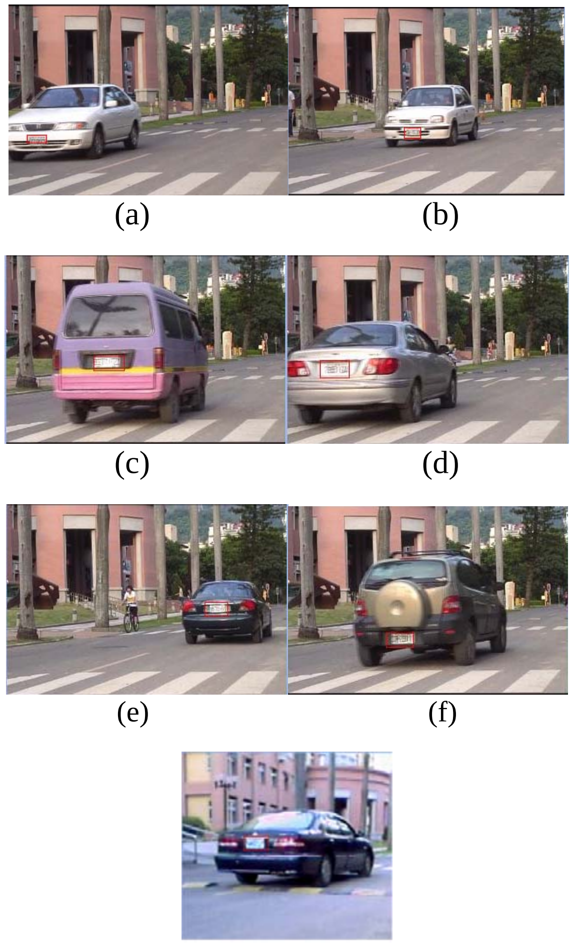
Fig. 19. Vertical projection example.

(a)
(b)

Fig. 20. The result after vertical projection. (a) Vertical projection example, (b) Result block after Vertical projection.

4. EXPERIMENT RESULTS

In order to demonstrate the performance of the proposed scheme, a series video sequence images of traffic scene captured by a charge-coupled device digital video camera from a road in Taipein town in a sunny afternoon, in which there are many lighting effects, plate damage, dirties and complex backgrounds were used in simulation. There are 126 cars in the video series; there 120 VLPs are located successfully and 6 cars driving too fast to locate them successfully. The results images were obtained by through several processes and describing as following. The proposed algorithm can accurately locate VLPs for those vehicle images whatever the background color of VLP is different from that of the vehicle body or not and whatever the background complexity. Fig. 21 shows our real experiment results on the road. This experiment results show that our scheme can locate the VLP precisely of moving vehicle from the image sequence captured by a CCD digital video camera wherever the VLP is adhered on the head or on the tail of a car.



(a) (b) (c) (d) (e) (f) (g)

Fig. 21. Experiment results of license plate location for moving vehicle; (a) successive locating the front VLP of a white car; (b) successive locating the front VLP of a white car; (c) successive locating the back VLP of a pink car; (d) successive locating the back VLP of a car colored in silver; (e) successive locating the back VLP of a black car; (f) successive locating the back VLP of a green car ; (g) successive locating the back VLP of a blue car .

On the other hand, the performances of VLP number extraction from the detected VLP region are described with the following figures. Fig. 22 shows a VLP number extracting process from a distorted VLP without distortion calibration: Fig. 22-(a) is the original RGB VLP region image,

Step	Original RGB image	Color transform	Binarization	Distortion Calibration	Gradient detection	Shrinking
VLP Image						
Size	337*251	337*251	337*251	337*251	337*251	305*251
	(a)	(b)	(c)	(d)	(e)	(f)

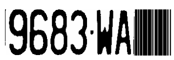
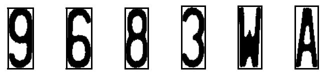
Step	Horizontal projection	Horizontal segmentation	Vertical projection	Vertical segmentation
VLP Image				
Size	409*251	305*92	305*133	(12~40)*(>40)
	(g)	(h)	(i)	(j)

Fig. 22. Experiment result of VLP number extraction without distortion calibration process, (a) is an original RGB image of an extracted VLP. (b) the Y- component of EVLPR after RGB to YIQ transformation; (c) the white- black image of EVLPR after binarization process; (d) the result EVLPR image after distortion calibration process; (e) the result EVLPR image after gradient detection process; (f) the result EVLPR image after shrinking process; (g) the result EVLPR image of horizontal projection process; (h) the result EVLPR image after horizontal segmentation process; (i) the result EVLPR image of vertical projection process; (j) the extracted VLP numbers after vertical segmentation process.

Fig. 22-(b) is the Y-component of extracted region (EVLPR) after RGB to YIQ transformation; Fig. 22-(c) is the white- black image of EVLPR after binarization process; Fig. 22-(d) is the result EVLPR image after distortion calibration process; Fig. 22-(e) is the result EVLPR image after gradient detection process; Fig. 22-(f) is the result EVLPR image after shrinking process; Fig. 22-(g) is the result EVLPR image of horizontal projection process; Fig. 22-(h) is the result EVLPR image after horizontal segmentation process; Fig. 22-(i) is the result EVLPR image of vertical projection process; Fig. 22-(j) is the extracted VLP numbers after vertical segmentation process.

And, Fig. 23 shows a VLP number extracting process from a distorted VLP without distortion calibration: Fig. 23-(a) is an original RGB image of an extracted VLP region. Fig. 23-(b) is the Y-component of an extracted VLP region after RGB to YIQ transformation; Fig. 23-(c) is the white- black image of an extracted VLP region after binarization process; Fig. 23-(d) is the result an extracted VLP region image after gradient detection process; Fig. 23-(e) is the result an extracted VLP region image after shrinking process; Fig. 23-(f) is the result an extracted VLP region image of horizontal projection process; Fig. 23-(g) is the result an extracted VLP region image after horizontal segmentation process; Fig. 23-(h) is the result an extracted VLP region image of vertical projection process; Fig. 23-(i) is the extracted VLP numbers after vertical segmentation process.

5. CONCLUSION

Nowadays, vehicle license plate (VLP) recognition system has become a key to lots of traffic related applications. Both the accurately detecting the VLP from a vehicle image and the extracting the VLP number from the detected VLPs are the most important stages of vehicle license plate recognition (VLPR) system. This paper presents a algorithm to localize the multi-

Step	Original RGB image	Color transform	Binarization	Gradient detection	Shrinking
License Plate Image					
Size	337*251	337*251	337*251	337*251	305*251
	(a)	(b)	(c)	(d)	(e)

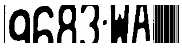
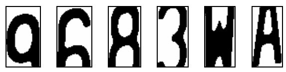
Step	Horizontal projection	Horizontal segmentation	Vertical projection	Vertical segmentation
License Plate Image				
Size	409*251	305*67	305*133	(12~40)*(>40)
	(f)	(g)	(h)	(i)

Fig. 23. Experiment result of VLP number extraction without distortion calibration process, (a) is an original RGB image of an extracted vehicle license plate(EVLPR). (b) the Y- component of EVLPR after RGB to YIQ transformation; (c) the white- black image of EVLPR after binarization process; (d) the result EVLPR image after gradient detection process; (e) the result EVLPR image after shrinking process; (f) the result EVLPR image of horizontal projection process; (g) the result EVLPR image after horizontal segmentation process; (h) the result EVLPR image of vertical projection process; (i) the extracted VLP numbers after vertical segmentation process.

ple vehicle license plates of moving vehicles from a video image sequence even though vehicles are overlapped in a complex surrounding, and to extract VLP number from the detected VLP regions. The algorithm also analyzes the shifting of the VLP in the image, and then develops a transformation based on relative position vector to correct the distorted plate image into a calibration standard image. By means of the distortion calibration techniques, the VLP number in a distorted EVLPR can also be extracted accurately. The experiment results showed that our method can correctly localize the VLPs even in overlapped vehicles situation. From the experiment results, reveal the presented method can correctly extract the VLP number even in a distortion VLP.

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