RGB Histogram-Based Filtration to Enhance the Accuracy of Automatic License Plate Recognition

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Summary
This paper proposes a technique to filter out the false negative detection of license plate caused by using edge algorithm to specifying the targeting areas. The proposed technique implements filters bases on the histogram value for the three main channels of the image (RGB). The paper consists of the following three main stages: (a) Detection based on edge detecting method, (b) calculating the histogram values of RGB color model, and (c) finally, verifying and detecting valid license plate regions by applying different histogram- based rules on features extracted out from the calculated histogram values. Experimental results show that the proposed method is very effective in assisting to neglect many noises caused by different conditions such as poor illumination and varied weather

Key words:
License Plate Detection (LPD), Histogram Distribution, Detection Accuracy, False Rejection Rate (FRR)

1. Introduction

The task of detecting objects out of the binarized image with very low false positive detection is one of the most difficult tasks in the field of computer vision or digital image processing. License plate detection (LPD) algorithms are classified under the same topic as it is interesting in finding license plate area from vehicle image. LPD is widely used for facilitating the surveillance, law enforcement, access control and intelligent transportation monitoring with least human intervention. Because of different conditions such as poor illumination and varied weather, the number of the false detected license plate area will increase and will affect negatively in both accuracy and time for the whole LPR system. The challenging part of this system lies in accurately propose a technique which able to separate the plate out of the other noise detected areas to reduce the percentage of false detection.

To find the regions nominated to be plates in the captured image of the plate detection system, many techniques were proposed by different researchers to accomplish the detection task and most of them used edge statistics [1], mathematical morphology methods [2], color classification [3, 4]. Other researchers suggested to use Hough transform in order to detect the lines which considered as one of the major features in the plate regions [5]. Implementing sliding windows as a segmentation technique to extract candidate plate region was also used [6]. Artificial intelligence classifiers such as fuzzy logic [7], neural network [8], adaboost and haar features cascade [9-11] have been also applied in detecting license plates. In the other hand, some researchers prefer a hybrid detection algorithm, where license plate location method based on characteristics of license shape, character connection and projection was presented [12].

In the proposed method, input vehicle images are converted into gray images. After then the candidate regions are found by edge detection. False positive detected regions are filtered out by using histogram values of RGB color model.

2. Proposed LPD Framework

The conventional LPD consists of several standard basic steps of processing the captured image, detecting the regions, and filtering out the noisy locations to get the accurate plate for the recognition stage [13]. Each basic step serves a specific purpose that determines the ultimate accuracy of the LPD system. Error in each step will propagate to next step and lead to inaccurate final result due to accumulated errors or artifacts. The algorithm's complexity in each step influents the overall computational efficiency and therefore requires considerations to assure computational feasibility. In short, each step is critical to the final outcome.

2.1 License Plate Localization

To search for potential license plate in the image or frame grabbed out of the video, Conversion of gray image from color image is executed first, and then Edge detection follows by mathematical morphology are done to specify the nominated plates' regions. Region with high edges variance or change in brightness changes is considered as potential region of being license plate [14]. Edge detectors are kernels used in edge detection operation to measure each pixel's neighborhood and quantify the discrete differentiation of the edge transition include the degree of intensity changes and direction of the changes.

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Specifically, the edge detection operation is a convolution operation. Usually, each pixel is convolved with both a horizontal kernel and a vertical kernel to estimate the gradient in x-direction, Gx and gradient in y-direction, Gy. At each pixel of coordinate (x,y), the outputs of both kernels are then combined to estimate the absolute gradient's magnitude, |G(x,y)|, computed by (1) and its orientation, ϴ computed by (2). These operators can be applied separately to the input image. In the following paragraphs, we discuss several widely applied edge detectors:

$$|G(x,y)| = \sqrt{G_x^2 + G_y^2} \quad (1)$$

$$\Theta = \tan^{-1}\left(\frac{G_y}{G_x}\right) \quad (2)$$

The applied edge detector is Sobel edge detector. The Sobel edge detectors are a pair of 3 x 3 convolution integer kernels to approximate the corresponding gradient in digitized image by using the 8 pixels around the an image point. The kernels are represented as in (3):

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}, G_y = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix} \quad (3)$$

All the output values are compared with specific thresholding values to binarize the image, in order to get the nominated regions; the following pre-processing steps on the binarized image are implemented:

- Remove scattered points by implementing proper pruning (9*9)
- Perform dilation on the vertical edges by using vertical structuring elements where will dilates the vertical edges horizontally.
- Perform pixel connectivity in order to obtain blob information
- Perform filtering on the blobs based on area of the blob, height and width ratio, compactness, and ratio white pixel/black pixel of the binarized blob sub-image.
- Perform another dilation stage to avoid any misdetection caused by splitting plate to two parts due to the big gap between the alphabets and numbers.

2.2 Rule-based Histogram Filtration Stage

As we can notice from the figure below, two blobs are nominated to be plates as they are overriding the filtering conditions and having properties similar to the plates (compactness, size, ratio, …..), unfortunately one of them is an accurate plate but the other one is false blob which has to be filtered by suggesting another filter based on different features. Based on the fact that plates have standard colors and all the input images for the LPD system are represented as red (R), green (G) and blue (B) or RGB images, new condition should be proposed based on the color properties.

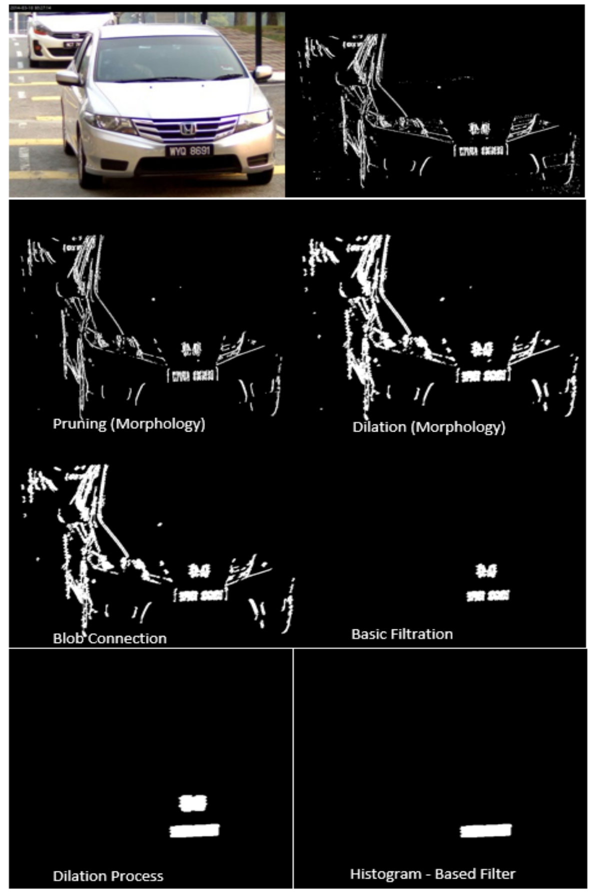

Fig. 1 Proposed LPD stages.

By using Histogram values for all three RGB channels, we analyze that specific conditions might be applied to filter out noise based on studying the intensity distribution of Histogram values for license plate available in our database. This is illustrated in Figure 2.

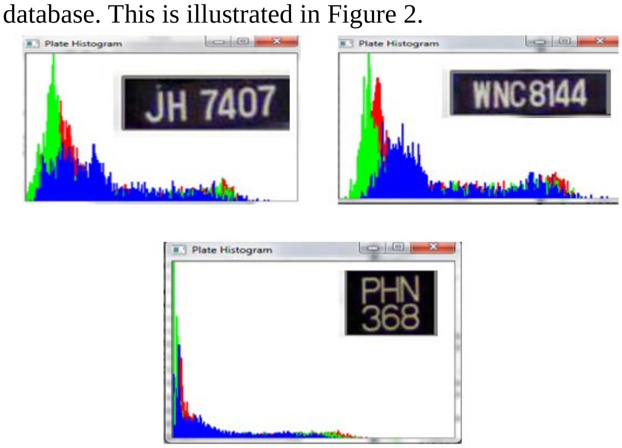

Fig. 2 RGB histogram distribution for car plates.

Histogram distribution for each channel is divided into five ranges S1[0,50] , S2[50,100] , S3[100,150], S4[150,200], and S5[200, 255]. Following values are calculated for each channel to be used later in the filtration process:

- ($PeakR_i$, $PeakG_i$, $PeakB_i$) Number of peaks values that exceed 100 for each range.
- ($IndR_i$, $IndG_i$, $IndB_i$) Index of max value for each range.
- (MaxIndR, MaxIndG, MaxIndB) Index of max value among all the ranges.

Where i has a value [1,5]

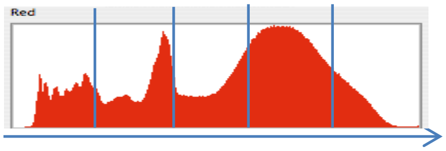

Fig. 3 Ranges of each histogram channel.

<u>Filter1</u>: Non Standard color detector based on color variance

- MaxDiff > 70
- where MaxDiff = abs (MaxIndR – MaxIndG)

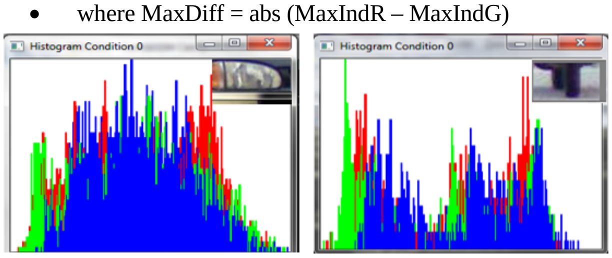

Fig. 4 Non-standard rule filtration rule.

<u>Filter2</u>: Multi-colors detector based on extreme color

- ((SumPR > 15) && (SumPG > 15) && (SumPB > 15)
- &&
- ((PeakR5> 2) || (PeakG5> 2) || (PeakB5 > 2))
- Where
- SumPR = PeakR1 + PeakR2 + PeakR3 + PeakR4 + PeakR5
- SumPG = PeakG1 + PeakG2 + PeakG3 + PeakG4 + PeakG5
- SumPB = PeakB1 + PeakB2 + PeakB3 + PeakB4 + PeakB5

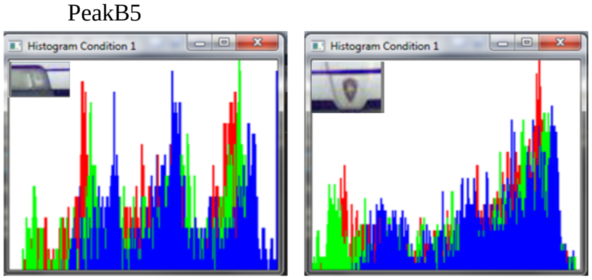

Fig. 5 Extreme color filtration rule.

<u>Filter3</u>: Beams detector based on dominant color

- (MaxIndR > 200 && MaxIndR < 235 && PeakR2 == 0 && PeakR2 == 0)
- OR
- (MaxIndG > 200 && MaxIndG < 235 && PeakG2 == 0 && PeakG2 == 0)
- OR
- (MaxIndB > 200 && MaxIndB < 235 && PeakB2 == 0 && PeakB2 == 0)

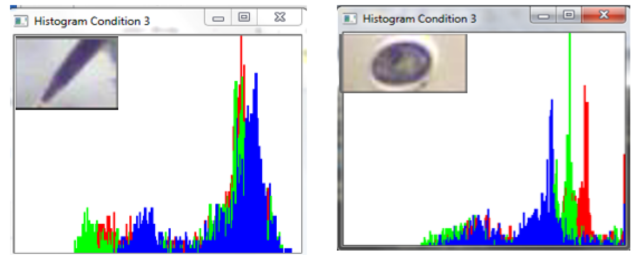

Fig. 6 Beams detector filtration rule.

3. Result and Analysis

We have tested the algorithm with a video which contains 522 cars captured during daylight as shown in the figure below. The resolution of the frame is 800 times 600. The over noise kicked by the three histogram filtration rules is shown in the table below tacking into consideration that the total number of noise caused by the edge detection over the whole video is 2445 blobs:

Table 1: Results of histogram-based filtrations.

Filter	*Positive Detection*	*Negative Detection*	*FRR*	*Accuracy*
Filter 1	117	2	1.7 % (2/117)	4.7% (117/2445)
Filter 2	154	1	0.64%	6.2%
Filter 3	989	12	1.2%	40.4%

Fig. 7 Sample of frame grabbed from the testing video (600 * 800).

4. Conclusions

License plate detection (LPD) involves cascaded procedures of image processing. During the processes, techniques that are required range from low level spatial image processing to high level image analysis; each of them is interconnected with the subsequent processing and hence increases the error rate. The difficulties that are regarded as impediments to the accuracy of ALPR come from unpredictable and ever-changing variations in scene environments and the non-standard format of license plate. Our algorithm tends to deal with the caused noise by proposing a method based on the calculation of histogram distributions for three channels RGB. Using RGB color features to determine the noise out of the plate is an important feature for enhancing the detection rate. In future works, we will focus to enhance the detection method in order to decrease the number of noise as much as we can.

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