Sauvola and Niblack Techniques Analysis for Segmentation of Vehicle License Plate

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Abstract. License plate recognition system is functional to identify the vehicle registration number. This system is popular in image processing field. It’s played important role in transportation system, especially for security system. However, variation condition of image acquisition causes the segmentation of license plate difficult to handle. This paper proposed a methodology for segmentation of license plate number by using thresholding segmentation group. In this study, image segmentation based on threshold has been chosen due to its ability in separating the foreground and the background. Hence, this technique is very useful for segmenting the characters which have tons of noise. Several threshold methods from the most commonly used techniques had been chosen to be compared and analyze the results for license plate detection and recognition. In this research, threshold techniques such as Savoula and Niblack have been select to compare. A total of 100 images captured by using a digital camera has been used the experimental analysis. After segmentation process, unwanted pixel has been removed with fixed value for each technique. Template matching has been used for classification of character recognition. The final result shows that Savoula conquers highest placed with great value in accuracy percentage of license plate recognition.

1. Introduction
License plate recognition system seems easy to found in online but the problem regarding license plate recognition always get attention in the research field. This is because of non-uniform of license plate pattern and displaying numbers [1]. The situation in the image captured also give an impact toward recognition process. As example, developed country have followed the same format or type in displaying their license plate number causes the developed system can work appropriately for image of related countries. However, other countries like Malaysia have different license plate pattern which design by their own government. Instead of work as vehicle identification, this license plate also automatically has been one of the country identity. Moreover, Automatic License Plate Recognition (ALPR) is under Intelligent Transportation System (ITS) and label as the most important application [2]. This is because the system has benefit in tracking the stolen car, car speed control, toll collection, etc. ALPR normally uses for identification purposes such as on elite place or company. Its works by controlling the access vehicle enter the building with only the authorized vehicles can enter the building. This is also for security issues by preventing potential criminal happened [3].
ALPR operating by using image processing techniques and algorithms. Thus, various image processing technique has been proposed to make it suitable with the license plate pattern and situation captured. ALPR generally consist of three parts which are license plate detection, character segmentation and character recognition [4]. Detection of a license plate in the process of identifying or localized the license plate location in the image. From simple methods until the most complex methods have been proposed by multiple researchers in order to extract the license plate. Among overall segmentation proposed, Region-Based segmentation has been highlighted as the most popular method approached. In this paper, threshold segmentation technique in Region-Based was used for analysis. This is because threshold segmentation has been widely used since 1990s to the present with variation threshold techniques introduced over time [5]. Thus, main objective of this paper is to compare and analyses the selected techniques for ALPR segmentation purposed.

This paper nicely arranges as follows: Section 2 simple review are illustrating for previous work and Section 3 briefly explained on dissimilarities of selected threshold technique operating. Section 4 shows the procedure purposed for this research while the result performance of each technique will be discussed in Section 5. Lastly, Section 6 will conclude the outcome of this project.

2. Related Work
Image segmentation is a process of separating the image into a set of pixels. The homogeneity criteria such as texture, colour and intensity have been acting as a guide in separating the pixels into its group [6]. This automatically can extract the interesting object from its background. Image segmentation has been splitting into five categories which are Model-Based, features based clustering, Threshold, Edge Based and Region Based [7]. This paper has been choosing a threshold for analysis segmentation process. Threshold is the simplest method for segment compare to others. Thresholding can create binary image from the greyscale value in order to define their boundary [8, 9]. Plus, this method widely used in ALPR procedure due to the easier splitting in between the foreground and background.

Several reviews have been made to determine the list of threshold method which is used for ALPR. Commonly threshold technique used is Otsu’s method where there widely used in binaries the image. Binarization has been made based on the threshold level which obtained from Otsu’s method. In intention to improve the system, Multi-Scale Adaptive NICK Thresholding method have been used for Binarization aimed. This is because the ability of the method to adapted with degradation types they used. Consequently, this approach can achieve their objective in extracting object of the binary image nicely [10]. This automatically shows that threshold technique has been used in many stages such as in localized the license plate location, extracting the shape of character or some used for both steps [11-13].

In other side, adaptive threshold also quiet famous for segmentation purposed [14,15]. Adaptive threshold has been used in pre-processing stage helping the localized the license plate location process. Then, the same technique has been used again in extracting the character on license plate for character segmentation process [15-17]. Another work, adaptive threshold combined with morphological operation and connected character analysis (CCA) in order to recognize the characters [17]. Even though localization stage has been conquering with edge detection method, segmentation by this thresholding technique still needed to achieve the perfect extraction. In this case, Harris corner have been used for localized the license plate location in the image. After the license plate detected, the adaptive threshold takes over in segment the cropped license plate. This is because to extracting the character in the license plate [18]. This shows that threshold method every useful. Thus, unconscious gives strong evidence that threshold is the right choices to use for image segmentation.

3. Threshold Techniques Review
Thresholding is the simplest method in creating the greyscale image into binary image for image segmentation. Thresholding able to created image segmentation objects to divide an input image into a set of pixel through range value of threshold (T) for compared the pixel values [19]. There are two classes of thresholding scheme which are global thresholding and local (adaptive) thresholding. In
At determining the threshold value(s) T, there might be a failure in finding the most appropriate algorithm for this purpose automatically the result obtained will be as follows:

- The segmented area potential being smaller and larger than the image.
- The edges might not be attached in the segmented area.
- High in possibility, the edges might be either under-segmentation/missing edges or totally finished.

Various threshold technique has been developed from the threshold classes. This is because to succeed in a segment the image between the interesting object and noise. This section discusses the differences between selected threshold method which are Sauvola and Niblack.

3.1 Niblack Method

Niblack is under a local thresholding class. Sliding window surrounds the pixel location is a technique used in this algorithm to calculates the threshold value of local standard deviation and local mean [19]. Any pixel (x,y) is calculated in order to define the local threshold. Size of the window has been determined by the application. The quality of segmentation is based on the value of k and sliding window sizes. A smaller value of k used may produce thick and unclear stroke, and large k value creates slim and broken stroke. The local mean represents in m(x,y) while σ(x,y) stands for local standard deviation. However, Niblack still has a weakness, especially in document images. This method unsuccessful to familiarize large variation in illumination.

3.2 Sauvola Method

Sauvola development is inspiration from Niblack method. The objective of this method is to solve the problem of noise by using a range of grey-level values in order to analyses the impact of the standard deviation value [19]. In addition, developed of this method spontaneously solve the noise problem great another level. However, it weak in a segment the image if the contrast of foreground and background is low. The values of the factors k and the window size are needed in Sauvola method to determine manually.

4. The Proposed Procedure for License Plate Recognition

A simple procedure approach in order to identify which technique is the best approached for ALPR system. Mainly, there are three steps for ALPR process which are license plate detection, character segmentation and character recognition. From the flowchart in figure 1, the original image containing color element known as RGB image is the input. RGB is represented as Red (R), Green (G) and Blue (B). The image has been captured with 14 megapixels of Fujifilm Digital Camera. The image captured in three different three angles which are 45°, 90° and 135° with car as the centre. The distance used during this capturing process is between 1.5m – 2.0m distance used.

After that, the original image converts into a greyscale image. This can make the process running easily and cut the time processing. Then, the segmentation process proceeds on grayscale image. Segmentation process running by using all the selected techniques that have been discussed before. This algorithm operating with separating the alphanumeric from the background and prepared the image for recognition stage.

The unwanted region has been removed by using region method. This removing process is based on a specific width, height and area of alphanumeric pixels. A region which not in specific categories value will be removed from the image. Thus, the remain region will proceed for recognition process.

Lastly, Optical Character Recognition (OCR) is a process to identify and classify the alphanumeric characters. OCR technique used for recognition purposed is matching technique. This evaluation made by using bounding box technique to highlight the target object by finding the similarity between the database and obtained pixels. Template Matching is an algorithm used in matching technique process. The user of this algorithm due to the most famous, fastest and simplest working process that has been purposed in OCR field.
5. Results and discussions

The research has been tested on a set of 100 variation angle of the vehicle license plate. Three different angles of parked vehicle license plate image have been captured. All the image was captured during day and night with deviation of lightening received. Figure 1 illustrates the output of every step in the research methodology.

![Figure 1](image-url)

**Figure 1.** The output of segmentation based on procedure approach.

Figure 1 (a) shows the Malaysian car license plate as the input image for this analysis. The input image is in a colored image with size 1932 x 2576 pixels. Figure 1 (b) shows the greyscale image as a result of converting of input image into greyscale. The conversion result of greyscale image was obtained from the weighted average of sum RGB scales. Next, Figure 1 (c) shows the segmentation image produced right after region-based techniques were applied and Figure 1 (d) shows the image after applying region growing for noise removing purposed. In this stage, noise was identified based on the height, width and area of target object. The object which not achieve the highlight characteristic will be considered as noise and automatically eliminated from the image. Figure 1 (e) shows the image with bounding box technique boxing the object for recognition purposed. Character recognition have been classified by using template matching technique. Then, the result produced from template matching was illustrated as shown in Figure 1 (f). The analysis has been made based on the accuracy of the template matching recognition.

The image result of Savoula method was shown in Figure 2 and Niblack method in Figure 3. From Figure 2 and Figure 3, the differences in segmentation produce of each technique give nice segmentation result. It seems like both methods have been produced a good segmentation process and not easy to identify superior method through manually. Thus, analysis by mathematical calculation have been made basd on template matching recognition in order to finalized which method give the best segmentation result. Table 1 shows an example of the evaluation for Sauvola technique performance. Plus, Niblack technique also has been evaluating with the same process.
Thresholding Technique

Average accuracy

Sauvola 83.17%
Niblack 67.01%

Table 1 shows the comparison of percentage average accuracy for recognition performance of 100 car images for each technique.

Table 2 shows the comparison of percentage average accuracy for threshold techniques. From the table, the highest accuracy obtained was Sauvola with 83.17% while Niblack was produce 67.01% of accuracy. This average accuracy was calculated from overall accuracy evaluation over 100 car images from table.
1. Template matching technique works efficiently towards almost all character obtained. Nevertheless, some character has given the technical complications in matching the characters. These characters were ‘B’, ‘D’, ‘E’, ‘G’, ‘J’, ‘I’, ‘O’, ‘Q’, ‘Z’ and ‘1’, ‘2’, ‘5’, ‘9’ was the numbers that contribute in mismatching the characters. Thus, recognition technology will be another focus for next work in order to face the problem obtained.

6. Conclusion
As a conclusion, this paper was aiming to analysis suitable threshold method for segmentation of the ALPR system. The threshold used were Sauvola and Niblack Method. A simple procedure has been proposed nicely to test the selected techniques suit with the objective of this project. The procedure starts by input the original image. Then, input image was converted into greyscale image and forward to segmentation process. After segmentation, the noise on the image was removed before proceeding into recognition stage. Recognition process was operated by using template matching technique. The result from template matching has been used to evaluate the performance. The overall evaluation shows that Sauvola achieves an accuracy of 83.17%. However, recognition technique for this procedure was the simplest and unstable for recognized the character. In future, the template matching technique needs to change for better recognition results.

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