Smearing Algorithm for Vehicle Parking Management System

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Abstract - Nowadays, huge shopping malls provide users with larger vehicle parking area. With the extremely large parking area, sometimes the owner of the vehicle could hardly find their own vehicle. Thus, a proper vehicle parking management system is needed to overcome the problem. There are some approaches that used Sobel vertical edge filter and Canny edge detection operator to detect the license plate and implement it in the vehicle parking management system. In the real world application, license plate can come in various forms such as with frame or without frame, one-row or two-rows and so on. Thus, Sobel vertical edge filter and Canny edge operator are not suitable approaches to overcome the limitation of the frameless license plate. This paper investigates the design and implementation of several pre-processing method and Smearing Algorithm to detect and identify a vehicle’s properties such as license plate. Frameless license plate also can be processed by using smearing algorithm. The results obtained can be used for implementation in the vehicle parking management system.

1.0 INTRODUCTION

License plate recognition (LPR) is a form of automatic vehicle identification. It is an image processing based technology used to identify vehicles by only their license plate. The LPR system consists of three steps: license plate location, character segmentation, and character recognition [1]. The numbers of vehicles are always growing. The growth has a positive implication to provide a professional and efficient parking system. Thus, a plate number recognition system is required to support parking management [2].

Every vehicle will carry a unique license plate and there are no external cards, tags or transmitter need to be recognized [3]. Thus implementation of License Plate Recognition can be very useful to develop a vehicle parking management system. Hence, the aim of this project is to develop a system to detect and recognize the license plate from an image of a vehicle. This image processing based system is divided into vehicle detection, pre-processing, license plate detection, character isolation and character recognition.

An overview of image processing techniques and algorithm is given in Section 2. Experimental results and discussion will be presented in Section 3 to demonstrate feasibility of the system. Section 4 will conclude the overall project.

2.0 METHODOLOGY

2.1 Vehicle Detection

Image processing will be used as a sensor to detect the occupancy of the parking lot. Input image is captured using a static camera at the entrance of the vehicle park. Background subtraction will be used to detect the existence of the vehicle at the entrance. Once the vehicle is detected, the image will be subtracted out from the background image so that the contour of the vehicle can be obtained. The distance between the vehicle and the acquisition camera should be fixed at certain distance [4]. This is to ensure that the threshold value set in the program can be applied to all images.

2.2 Pre-processing

Pre-processing is the necessary step to be taken for any image analyzing program. Without a proper pre-processing, the subsequent segmentation and recognition procedure can be very cumbersome and ineffective. The main reason in doing pre-processing is to perform image enhancement to highlight the desired region in the processed image. In this case, it will be the vehicle’s license plate. Figure 1 shows the pre-processing steps applied on a sample image.

Figure 1: Pre-processing Steps
The image will be loaded into the program and converted into a matrix form. The matrix includes information about the coordinates for each pixel and its corresponding colour information. Image will be converted into gray scale to get rid of the unnecessary colour information. The image in gray scale will be further converted into binary image consisting of only 0s and 1s. Then the image will be resized into an appropriate smaller size (300 x 400 pixels). The small objects and noise occurring at the image will be removed by using median filter.

2.3 Vehicle’s License Plate Localization

Vehicle’s license plate localization in the Automatic License Plate Recognition (ALPR) is very crucial to the system. There are many approaches and algorithms that can be implemented to locate the vehicle’s license plate. Effectuation of region of interest is the main concern in detecting the location of the license plate. Generally, vehicle’s license plate is located at the underneath position of the captured image. Hence, the developed program could just crop the region of interest for further processing. This technique could reduce the annoying edges and reduce computation time [5].

There are some approaches that used Sobel vertical edge filter and Canny edge detection operator to detect the edges in the captured images [2]. This operator finds edges by searching for local maxima in the gradient of the image. The gradient is calculated using the derivative of a Gaussian filter. While the vertical edges are detected, filtering and morphology operation will be implemented to remove the unwanted noises. Morphological reconstruction is applied to the filtered image by using a flood-fill algorithm. It is very important to consider accurate bounding boxes along the specified areas by selecting the correct dimension.

Figure 2 shows an input image of a license plate with frame. Sobel vertical edge filter is applied to find the vertical edges. The result is further processed by implementing flood-filled algorithm. As shown in Figure 2(b), pixel with value ‘1’ that is connected to the image border will be cleared hence leaving the region of license plate with pixel value ‘1’ (rectangular white region) as shown in Figure 2(c). The developed program will assume the white region as the license plate region and calculate its basic properties. These basic properties are Area, Centroid, and Bounding Box. Information of this bounding box will be used to crop the region of the binary license plate. The process of the license plate extraction is shown in Figure 3.

Figure 3: Extracting License Plate

Figure 4 shows an implementation of Sobel vertical edge filter on a frameless license plate. Sobel operator finds all the edges in the binary image. Without a proper frame of a license plate, the edges that have been detected and flood-filled cannot form a proper rectangular white region. A proper rectangular white region is very important since it is going to be used to determine the coordinates of the license plate. As can be seen in Figure 4(c), there is no license plate region detected because all the pixel with value ‘1’ (refer Figure 4(b)) that is connected to the image border had been cleared.

Figure 4: Locating Region of a Frameless License Plate by Using Sobel Vertical Edge

To overcome this limitation, smearing algorithm has been investigated in this paper. Smearing algorithm will be used to detect the location of a license plate on a vehicle. This method will detect the spaces in between each
character on the license plate. Firstly, the gray scale image will be processed along horizontal scan. Two threshold values are required in the smearing algorithm. If the numbers of white pixels are less than a desired or greater than the second desired threshold, white pixels will be converted to black. The threshold values for horizontal scan are preferable to set as 10 and 100 for horizontal and vertical smearing [3]. After the horizontal scan, the image will be further processed through vertical scan. Same concept in horizontal scan is applied in the vertical scan except for the threshold selected as 20 and 100 for vertical scan. Figure 5 illustrates the idea of Smearing algorithm in both vertical scan and horizontal scan.

![Figure 5: Smearing Algorithm](image1)

The result obtained from the smearing algorithm will be further processed by morphological image processing technique. It is done by dilation via a suitable structuring element. A flat linear ('line') structuring element is implemented in this program. This technique is used to compensate the small gap in the vertical scan and highlight the area holding the license plate.

AND function is used for the dilating image and binary image to extract the characters out. After that, median filter (7x7) is applied to remove the small noise while preserving the sharpness of the image. Then, image’s colour will be inverted to make the characters in the image in black colour. This is because the database used for template matching consists of characters in black colour.

After that, AND function and median filter will be used to remove the noise in the image. Then, the image will be eroded, to prevent disconnection which might occur on a single character. The purpose of cropping images is to reduce the unwanted distortion from the desired area. Normalization is used to refine the characters into a block containing no extra white spaces (pixels) in all four sides of the characters. The purpose of normalization is to make sure that each character is fit to equal size. This approach is necessary for template matching. Figure 6 shows the steps applied to detect the license plate.

![Figure 6: Extracting License Plate](image2)

### 2.4 Character Isolation

To ease the process of identifying the characters, it is preferable to divide the extracted plate into several images. After the process of normalization (as in Figure 6(f)), the characters will be complemented, so that it can be labelled and stored in an array. Each character will be classified as a connected component. This is done by assuming a character should not have discontinuity. Every isolated character image will be normalized and resized to the equal size of the template being used which is 24 x 42.

Every connected component in the binary image will be labelled with 1, 2, 3 and so on until every component has been labelled. The label process will start from left to right. The program will be looped until all the characters have been isolated. Figure 7 shows the isolation of all the characters.

![Figure 7: Isolating Connected Component](image3)

After all the characters have been successfully isolated, it will be inverted so that the character is in black colour instead of white. This is due to the characters used for template matching are in black colour. The isolated character will be inverted and normalized to get rid of the extra white spaces (pixel with value ‘1’) in all four sides of the characters. Figure 8(b) shows the inverted and normalized character that is ready for template matching.
2.5 Character Recognition

Template matching is used for the character recognition. Before the matching process, the input image must be resized in order to be equal-sized with the template. After that, the isolated character can be identified by comparing with the ones in the template and the best similarity is measured. To measure the similarity and find the best match, a 2-dimension correlation method is used. Two perfectly matched characters will have a correlation which is equals to 1. Finally, the license plate number will be recognized and saved in database.

2.6 Template Matching

The developed program used template matching to identify the segmented character. Template matching method must have character images as template stored in memory [6]. The segmented character will be identified by calculating the correlation coefficient. The idea behind the implementation of a correlation based identification scheme is when two template pools, one consisting of all the possible values of letters, and of all values of the digits, are constructed. Generally, once the license plate has been segmented into the several characters, each image that containing a single character is evaluated. The correlation coefficient between the image of the character and the appropriate template pool is computed. The template that yields the highest coefficient will indicate what character is depicted in the input images.

For matching characters with the template, input images must be equal sized with the template’s characters. In this program, the characters are fit to the size of 24 x 42. The extracted characters are obtained from plate and the characters on database are now equal sized. After that, the character image is compared with each component in the database and the best similarity is measured.

Figure 9 shows the template which consists of 24 alphabets and 10 numerals with the size of 24 x 42. The template formed is based on the real font of the license plate. To measure the similarity and find the best match, a 2-dimensional correlation coefficient is used. This method measures the correlation coefficient between a number of known images with the same size unknown images or parts of an image with the highest coefficient between the images producing the best match. The equation for calculate the coefficient is as shown in Equation (1).

\[
r = \frac{\sum_{m} \sum_{n} (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{\sum_{m} \sum_{n} (A_{mn} - \bar{A})^2 \sum_{m} \sum_{n} (B_{mn} - \bar{B})^2}}
\]

Where \( \bar{A} \) = mean value of A, and \( \bar{B} \) = mean value of B.

\[ \text{corr2} = \text{corr2}([\text{templates}[1:n], \text{imag}]); \]

Figure 10 shows one of the segmented characters. The developed program will calculate the correlation coefficient between the input image and the images in the template. The value of correlation coefficient is then return in a table as shown in Figure 11. Since the template created consists of 34 images, thus there are 34 values of correlation coefficient were calculated and return under the position of the images in the template respectively. The measured values of correlation coefficient allow the developed program to find the best match for the input character.

The position of the images in the template is set by the developer as shown in Equations (2) and (3). The position of the images in the template will be arranged sequentially. This means that the character ‘A’ will be placed at position 1, character ‘B’ at position 2 and so on. There are 34 images in the template and hence the maximum number of the position is 34.

\[
\text{letter} = [A B C D E F G H J K L M N P Q R S T U V W X Y Z];
\]

\[
\text{number} = [\text{one two three four five six seven eight nine zero}];
\]
The program will find the maximum value of the correlation coefficient as shown in Figure 11. Then the program will locate the location of the maximum value of the correlation coefficient. The location of the correlation coefficient will feed as the recognition result and store in the database.

### 3.0 EXPERIMENTAL RESULTS & DISCUSSIONS

The proposed system has been prototyped using Matlab 7.6 and MySQL Community Server Version 5.1.29. The architectures of this simulation test include CPU Intel Core 2 Duo and memory is 1GB in the server. There is no specific limitation on camera. The system developed works well for a clear image taken from a minima 2 Megapixel camera. Dimension of the sample image is 1632 x 1224 pixels.

The database developed will save the current date and current time of the particular vehicle entering the parking area. License plate can come in many patterns such as one-row license plate, two-rows license plate, frame or frameless license plate and etc. Frame of a license plate can play a vital role in locating and segmenting the region of interest in a mixed image.

The system developed with smearing algorithm approach works well with one-row license plate and frameless license plate. Successful experimental results are shown in Figure 12.

According to Faisal Shafait, Daniel Keysers, and Thomas M. Breuel [7], the smearing algorithm classified text lines merged with the noise block as non-text, resulting in a large number of errors. Thus classification and image filter steps are very important to avoid merge errors from occurring.

#### 3.1 Limitation of Smearing Algorithm

Smearing algorithm depends on the pixel of the gap between the characters horizontally and vertically. Range of gap to be detected by smearing algorithm is manually set in the program as the threshold value. Hence, the pixel of gap in the image must be restricted to a certain value. Another error that might occur is due to the connected object which will be calculated from left to right and it cannot differentiate the upper and lower part of the license plate.

The advantages of this algorithm are it is independent to the rotation and the bounds found are quite precise. Its disadvantage is that it requires a good image quality and good conversion from the original image to binary image, to avoid making two characters appear as one connected region [8].

#### 3.2 Limitation of Two-Rows License Plate

Figure 13 shows the failure process of the two-rows license plate where error occurs due to inappropriate selection of threshold value for the horizontal smearing. When vertical smearing took place, it will cause all the white pixels (pixel with value 1) to be wiped off. Thus the program cannot be finished as all the characters had been cleared.

Even the license plate provided with frame and location of the license plate can be easily located using Sobel or Canny edge operator, but somehow the characters of the license plate cannot be accurately extracted. The method used such as ‘labelling connected component’ will label each character started from left to the right. It cannot differentiate upper and lower part of the license plate. Thus, the extracted character may carry some errors.
3.3 Limitation of Labelling Connected Component

As mentioned previously, connected component will be labelled starting from left to right. If there are two characters that stay too close to each other, it will be labelled as one component.

Figure 14 shows two characters that are very close to each other. Even the license plate is successfully located, but somehow error occurs during the labelling process. The first character ‘S’ and the second character ‘A’ are identified as one component.

3.4 Limitation of Template Matching

Template matching is one of the convenient methods that can be used to recognize the character. The extracted character from the license plate is compared with each component in the database and the best similarity is measured. Because of the similarities of some characters, there may be some errors during the recognition as shown in Figure 15. The confused characters mainly are B and 8, E and F, D and 0, S and 5, and Z and 2 [3]. High accuracy and fast recognition speed are two requirements for real time and automatic license plate recognition system [6].

To increase the recognition rate, some criteria tests can be used in the program for confused characters defining the special features of the characters. With these feature of characters and applied test during the recognition algorithm, recognition rate is able to be increased with minimum error [3].

3.5 Effect of Intensities

The main difficulty of the license plate localization is the environment. For example, image taken from outdoor parking spaces and indoor parking spaces will be influenced by the sunlight and fluorescent light. The surrounding light intensity might cause reflection on a license plate. This may lead to distortion during license plate segmentation.

Figure 16 shows the error occurred due to intensity effect. Intensity effect will cause the program unable to filter the unwanted noise. Besides that, intensity also will cause the characters to be connected together. Hence, the efficiency of the system will be reduced due to the intensities effect.

4.0 CONCLUSIONS

There are many methods that can be used to detect and recognize the license plate. In this paper, the flow of procedure is vehicle’s detection, pre-processing, vehicle’s license plate localization, character isolation and template matching. The pre-processing step plays a vital role in preparing the mixed image to be segmented. Smearing algorithm is used in extracting the license plate. Then the characters on the license plate are separated by isolating every connected component obtained from the vehicle plate. Finally, template matching is applied with the use of correlation for recognition of the characters.

From the results and discussion, it can be concluded that the license plate recognition via Smearing algorithm is not hundred percent precise. This may be caused by many factors such as brightness effect, image quality, camera position, distance between the camera and the vehicle and distance between the characters and the insignificant parts of the vehicle’s plate. Besides that, the labelling of connected component method causes a limitation for the two-rows license plate. In the real world application, there are also many distortions and noises exist due to the environment. Hence, enhancements need to be added to ensure that the system may run smoothly to overcome the limitations. Further improvements are still needed to be done in order to increase the accuracy and reliability of the system.
5.0 REFERENCES


