Detection of License Plates of Vehicles

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ABSTRACT

This paper presents an image processing approach for the detection of the vehicle license plate area in digitized photographic images. The algorithm takes a raster image of the rear view of a vehicle as input and yields the segment of the photograph that contains the plate as the output. The developed algorithm is based on three basic processing stages; yellow regions extraction, dilation of yellow regions and extraction of the plate region. The performance of the developed algorithm has been tested on a set of real images of vehicles. Preliminary tests show that the algorithm performs quite well in accurately locating the license plates (with 97% efficiency). The results of this work can be extended for the automatic detection and recognition of vehicle license plates for vehicle identification.

1. INTRODUCTION

Vehicle identification is a research area where image processing methods are used to identify vehicles by detecting and identifying the license plate numbers. Typical vehicle identification systems consist of three main stages. They are the identification and tracking of vehicles through motion, locating the license plate and accurately identifying the numbers in the license plate.

Although many intensive research studies have been conducted in other countries in the area of automatic vehicle identification, to our knowledge, there is virtually no research studies conducted in Sri Lanka in this area. However, vehicle identification is an essential area in the development of intelligent traffic systems and surveillance. Given the current security situation in the country due to ethnic conflicts, this is one of the areas where there is an urgent need for the development of devices that could be used in variety of situations to ease the security concerns. In addition, the use of vehicles in Sri Lanka has increased rapidly due to urbanization and modernization, especially in recent years, and thus, traffic congestion in cities has become a major issue due to inadequate road infrastructure. Therefore, control of vehicles and identification of traffic violators to maintain discipline, is becoming a big problem in many cities. Automatic vehicle identification systems can be used effectively for this purpose [1, 2].

This paper presents, results of a preliminary study carried out to extract the location of license plates from the still images of rear view of cars.

From the variety of number plate systems introduced over the years by local authorities, there are several types that are still accepted as valid number plates on the roads. In this project, it was decided to concentrate on the new number plate system, introduced about five years ago by the Department of Motor Traffic in Sri Lanka. Essentially, it consists of plates with white background at the front and yellow background at the rear, and letters in black in both cases. The arrangement of numbers consists of two English letters followed by four digits, separated by a dash (example, GA-1234). In addition, two more smaller letters are placed on plate to identify the Province of issue, namely, CP (Central Province) EP (Eastern Province), NC (North Central), NE (North Eastern), NW (North Western), SG (Sabaragamuwa), SP (Southern Province), WP (Western Province) and UP (Uva Province). As a security feature, a small circular hologram, about the size of a penny coin, is imprinted over the dash between the numbers [3]. In addition, the government seal is imprinted on the license plates above the Provincial identification label.

Many methods have been proposed to detect number plates from vehicle images; ranging from simple statistical methods to neural network algorithms and genetic algorithms. However, in real-time monitoring systems, simple procedures have advantages over complex procedures. Thus, in this work, performance of a simple procedure to extract the plate region of images of rear side of vehicles (yellow number plate) was tested. The basic method for extracting the plate region can be described by the following steps.

1. input of the original (RGB) image
2. identification of the yellow regions
3. edge detection
4. morphological operation
5. finding the license plate region
6. outputting the extracted plate region image (RGB)

Each of these steps is discussed in the proceeding sections of this paper.

2. METHODOLOGY

The only inputs to the system were the images of vehicles captured by a digital camera. The captured images were taken from approximately 3-5 meters away from the rear of the vehicle so that the number plates were clearly visible in the view. Most of the past research studies in the area of number plate identification have been carried out by converting the RGB original image to other colour spaces such as NTSC, HSV or CIE [4, 5]. In this study, RGB colour space was directly handled by extracting the yellow regions. Since there are pattern recognition problems arising due to poor image quality caused by varying ambient lighting conditions, number plates are often difficult to detect accurately and efficiently in real situations. Based on the pilot tests carried out with several test runs, it was found that the range of yellow colour range in RGB colour space varies between images taken under different light conditions as shown in table 1.

Table 1: Yellow colour range in RGB space

Red	Green	Blue
130 - 255	80 - 255	0 - 85

The captured images were first converted to binary images where the yellow regions were assigned as 1's and others were assigned as 0's.

Figure 1(a) shows one of the original input images and Figure 1(b) shows the binarized extracted yellow regions of the original image. It was seen that yellow regions outside the number plate also remained in the binarized image. This is undesirable since ideally we are interested only in identifying the yellow region where the number plate is located. This problem could become much severe if the images are taken in a yellow background or if the vehicle colour itself is yellow. Problem due to the yellow colour vehicle or yellow background was not investigated in this initial work.

Figure 1: (a) Captured RGB image (b) Binarized extracted yellow regions

After the initial preprocessing to identify the yellow regions, the next step was to find the edges of the identified regions. Edge detection is a process for detecting discontinuities in intensity values. Such discontinuities can be detected by using standard first or second order edge detection operators [6]. In this work, Canny edge detection operator was used to detect the edges in the captured images. 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. First, the image is smoothed using a Gaussian filter with a specified standard deviation to reduce noise. Then the local gradient and edge detection is computed at each point. An edge point is defined to be a point whose strength is a local maximum. Thereafter the edge points give rise to ridges in the magnitude image. The algorithm then tracks along the top of these ridges and sets all pixels that are not on the ridge top's to zero to produce a thin line as the output - a process known as non-maximal suppression. Finally, the algorithm performs edge linking by incorporating the weak pixels that are 8-connected to the strong pixels [6]. Therefore, this method is more likely to detect true weak edges. Figure 2(a) shows the binarized extracted yellow regions of the image after processing through the edge detection operator.

After extracting edges a morphological operation – dilation - is applied to the images for specifying the plate location. Dilation is an operation that "grows" or "thickens" objects in a binary image. The specific manner and the extent of this thickening is controlled by a shape referred to as a structuring element. Mathematical morphology is a tool for extracting image components that are useful in the representation and description of shape regions such as boundaries [6]. The method dilates the yellow regions appearing on the previous picture (see Figure 2(a)). A diamond shaped structure element was chosen to dilate the binary image. Generally, this permits identification of yellow regions better than the pure edge detection operation, ignoring for example, the holes (empty regions) inside the plate as shown in Figure 2(b). The grouping yellow regions in separate filled components and accentuating the separation between them are very useful for the next steps.

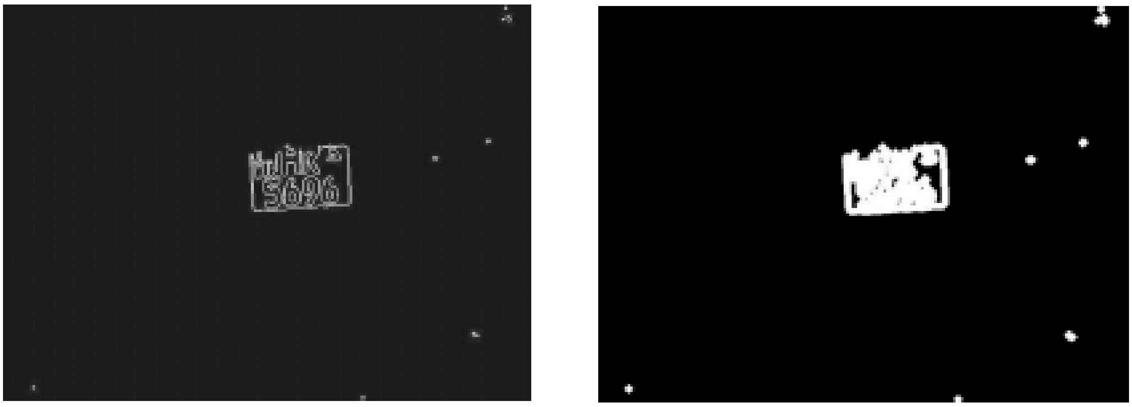

Figure 2: (a) Edges found by the edge detector operator (b) After applying the morphology

Next, morphological reconstruction was applied to the dilate images by using a flood-fill algorithm. Figure 3(a) shows an image after applying the flood-fill algorithm. It is very important to consider accurate bounding boxes along the specified areas by selecting the correct dimension. As shown in Figure 3(a), some yellow components well outside the license plate area still appear on the image and one must use a cropping process to separate other yellow regions from the license plate region. In order to do that, bounding boxes for each region was computed. It was found that the smallest rectangle that can contain the region is 1-by-4 vector. By choosing the maximum area which is covered by the bounding boxes, the license plate location was found. In the final step, license plate region was extracted and generated as the output (see Figure 3(b)) which is the main objective of this study.

Figure 3: (a) Flood-filled image (b) Extracted license plate region

3. PERFORMANCE

Pilot tests were carried out to test the performance of the developed system based on the accuracy of identification of sub-components by the image processing algorithms and to study the processing time of the system against the image resolution. The system was designed and developed in Matlab using the image processing toolbox. The test images were taken under various illumination conditions. The input images were colour images with a maximum resolution of 1600×1200 pixels. The results of the test are given in Tables 2 and 3.

Table 2: Test results of license plate detection module

Sub-component	Accuracy	Percentage
Extraction of yellow regions	30/30	100%
Extraction of plate region	29/30	97%

The proposed algorithm shows 100% accuracy in extraction of yellow regions and 97% accuracy in extraction of plate regions. Table 3, shows the time taken to execute the complete code in an Intel Celeron A6R notebook computer running at 1.6 GHz clock speed. According to the results, the developed algorithm takes 3±1 sec to identify and produce the plate region as the output for images taken with 640×480 resolution. About 70% of the execution time has been consumed in the extraction of the yellow regions.

Table 3: Test results of execution time

Image Quality	Average execution time
1600 × 1200	50 ± 1 sec
640 × 480	03 ± 1 sec

4. CONCLUSIONS

In this paper, we presented an image processing technique, designed for the extraction of plate regions of newly introduced yellow colour rear vehicle license plates with black letters from photographs of vehicles. First the yellow regions were extracted, and then through a mathematical morphological operation, the plate region was extracted. Based on the experimental results, criteria to identify the yellow regions in RGB colour system were discussed.

As expected, the execution time of the system was highly depended on the resolution of the captured images converted to gray levels. The method discussed here fails in locating a license plate if the colour of the vehicle itself or the background is yellow. However, pilot tests showed that the algorithm was highly successful in finding a plate under various illumination conditions. Most of the yellow regions could also be eliminated by investigating the relationship between the length and the width of areas.

Future work could focus on character recognition to extract the numbers in the plate region and locating the plate under any vehicle colour or the background irrespective of the environment.

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