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# Sample plate based color independent automatic license plate detection

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**ABSTRACT**

Automatic license plate recognition of vehicles is a real time embedded system which identifies the characters directly from the image of the vehicle license plate. In the present research, an efficient method for license plate localization in the images without dependence of the plate color is proposed. After capturing the image of the vehicle, some image-enhancements are done first in order to reduce problems such as low quality and low contrast in the vehicle images. The proposed method extracts edges and then determines the candidate regions by comparing it with a selected plate which has appropriate size for selected capture distance. Finally by connected component elements analysis, the license plate is detected. The proposed system has improved efficiency as compared to earlier methods.



## Introduction

An automated system that can identify vehicle is in demand for reducing the dependency on labor. Automatic number plate recognition (ANPR) has been adopted widely into numerous applications such as access control in unattended parking, security control and stolen vehicle verification. Usually, ANPR systems consist of three main parts: number plate localization, character segmentation, and character recognition. Number plate localization is the most important and difficult stage in all stages.

Most of previous number plate detection algorithms lack efficiency even though they work in certain working conditions, such as fixed backgrounds, known color, or fixed size of the number plates. [1-4] In general, the most common approaches for vehicle license plate detection include texture [5,6], color feature [7], edge extraction [8], combining edge and color [9], morphological operation [7,11] and learning based method [10]. Therefore, it is still a challenging problem to develop an efficient system which detects number plates under areas which require higher efficiency. The reliability of the procedures severely degrades in terms of complexity and noisy pictures. Precise camera adjustment is the best option to attain an efficient system, in which the image of the vehicle must be captured in such a way that the environment is excluded as much as possible and the size of the number plate must be as big as possible. Considering this camera configuration, the proposed system relies on a technique which uses a sample plate to find out the possible plate area and appropriate connected component counter to remove the candidates.

The present paper is organized as follows. The section I deals introduction part whereas section II describes the preprocessing technique used to increase the system efficiency. Section III focuses on plate area searching technique whereas section IV discusses character segmentation and identification. Section V deals with experimental results of the proposed system and conclusions are made in section VI.

## Preprocessing Technique

The proposed system is developed to work in edge based plate area detection without dependence of the plate color. The plate area detection is done in black and white level. It starts with converting the RGB input image into grayscale image which is followed by converting grayscale image into binary form and then edge detection is performed using Sobel's mask operator [11-13]

## Plate Area Detection

The main step of automatic license plate recognition systems is to detect the exact area of the number plate from the captured input image. First it is appropriate to define the number plate as a "rectangular area with increased occurrence of horizontal and vertical edges" [4,5]. The high density of horizontal and vertical edges on a small area caused by contrast characters of a number plate in many cases, but not in every case. This process can sometimes detect a wrong area that does not correspond to a number plate. Therefore, we often detect several candidates for the plate by different algorithms. In general, the captured snapshot can contain several number plate candidates. For this reason, the detection algorithms in many systems always crop several candidate regions, of which the better is selected using another preference algorithm. There is a predefined value for number of candidates, which are detected by analysis of projections (by default this value is equal to nine).

As observed from Fig.1, the original image is converted to grayscale image which is in high contrast in the proposed system . Now, we need to identify the location of the number plate horizontally in which row it is present. The letters and numbers are placed in the same row (i.e. at identical vertical levels) resulting in frequent changes in the horizontal intensity. This provides the reason for detecting the horizontal changes of the intensity, as the rows that contain the number plate are expected to exhibit many sharp variations as shown in Figure 2.

At this point we can see that the highest probability of finding the plate area is around the area where there are many sharp variations which leads to many wrong candidates as other areas also can result in similar frequent fluctuations during edge detection. Our system proposes new technique which can provide a better efficiency by using a fixed sample plate to detect the plate area. That means we can define a plate area as "an area which has good similarity with our selected sample plate area or in other words it is a rectangular area which has

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similar edges to the selected sample plate". Here the sample plate is shown in figure 3 which is selected in accordance to the camera configuration for better efficiency, i.e. the size of the sample plate is selected to match with the plate area of the captured image of the vehicle.

**Fig. 1: Original image, grayscale image and edge detected image**

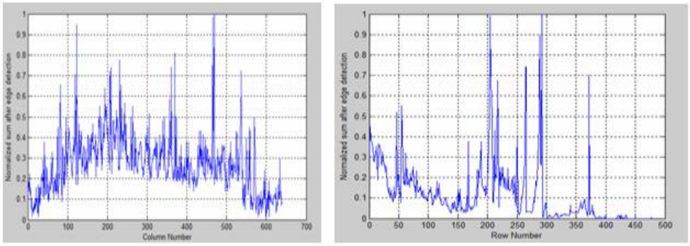


**Fig. 2: Sum of pixel values along rows and columns respectively after edge detection**


**Fig. 3: Selected sample plate used as a filter before and after edge detection**

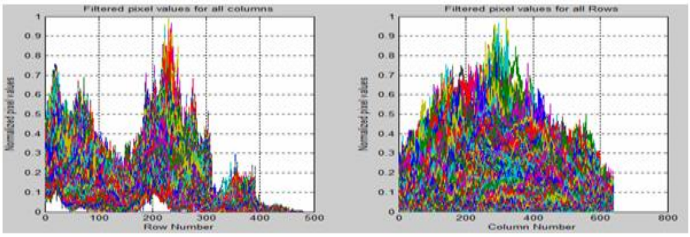


**Fig. 4: Output of the filter using sample plate for all columns and rows respectively**

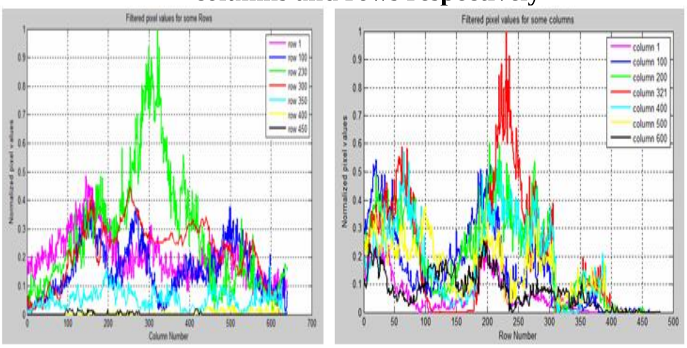

**Fig. 5: Output of the filter using sample plate for some selected rows and columns respectively**

In this technique, the sample plate is used as a filter to find out the plate number of the vehicle. The process is computed by performing two dimensional FIR filter between the edge detection outputs of the captured image and the sample plate. In order to manipulate the correlation of the two edge detected images, the filter matrix (the sample plate after edge detection) is first rotated 180 degree and it is convolved with the captured image (after edge detection). After this the maximum value of correlation will indicate the most probable locations of plate number in the captured image of the vehicle. More visible outputs of this correlation are shown in figure 4 in the plotting for some selected rows and columns only.

After performing the filtering process, the proposed system selects nine top values of the correlation as center point. From Figure 5, it can be seen that row 230(green line in the second plot) and column 321(red line in the first plot) have peak values for the considered input image which suggests that pixel (230,321) is one center point. The other eight center points are selected in a similar fashion. After this nine candidates are cropped out by moving half width to the right and left and half height up and down from each selected point. At this point, the height and width of the candidates are considered to be equal with sample plate.


**Fig. 6: Best candidate localization and selection respectively using sample plate as a filter**

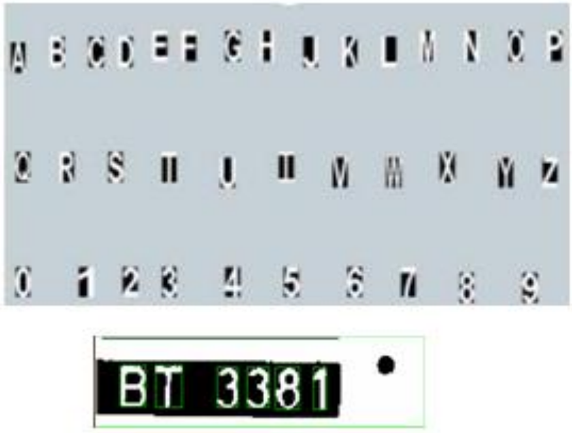


**Fig.7: Saved templates and the connected components respectively**

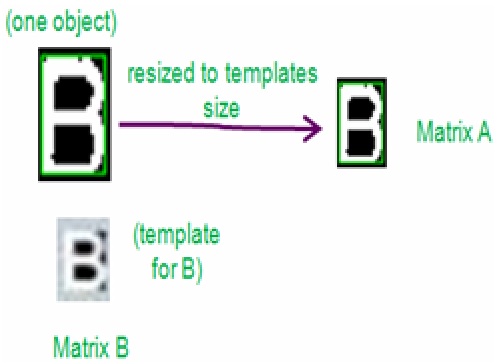


**Fig. 8 Character recognition pre-process**

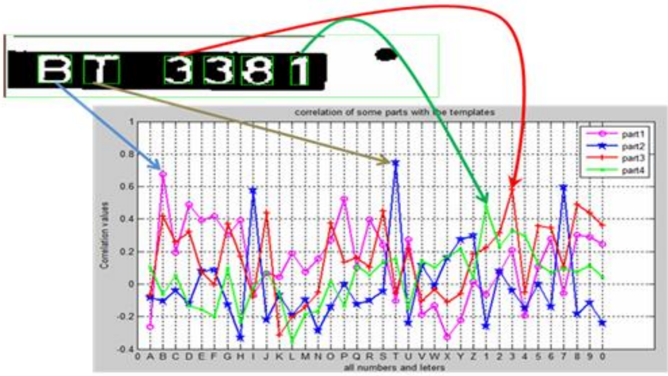


**Fig.9: The correlation result for some connected parts**

After this candidate removal is performed using connected component counter in which the connected components whose pixel numbers are close to the characters in the sample plate are counted. During counting process, connected components which are too small or too large than the threshold size, will be neglected. The threshold pixel numbers are selected to match our camera configuration as our sample plate does. Finally a candidate which has around six or seven (depends on the country of implementation) connected components within the required pixel number range is selected as a best candidate.

**Fig. 10. Some of the input images used in the experiment**

**Character segmentation and character identification**

Character segmentation is the first step of license plate detection after the plate area is isolated. Image noise, plate frame, space mark, plate's rotation and light variance are among the diverse aspects that make the character segmentation task complicated. The approach used in this work for character segmentation is based on total pixel number thresholding in Connected Component Analysis(CCA). In binary image processing, CCA is an important technique that scans and labels the pixels of a binarized image into components based on pixel connectivity. Using thresholding connected components that have higher or lower threshold pixel number are not considered. Therefore at this step, plate borders and other noises are removed. After the segmentation of characters and numbers, the final step is character recognition. In present study, the technique applied for character recognition is template matching in which each segmented element is compared with all saved templates and the one which yields maximum correlation is assumed to be the belonging character. In character recognition process, the size of the connected component is changed into saved templates as shown in Figure 8. Then each connected components is correlated with the entire saved templates. Here the correlation of the matrix A and matrix B is computed by

$$r = \frac{\sum_m \sum_n \left( (A_{mn} - A_{mean})(B_{mn} - B_{mean}) \right)}{\sqrt{\left( \sum_m \sum_n (A_{mn} - A_{mean})^2 \right) \left( \sum_m \sum_n (B_{mn} - B_{mean})^2 \right)}}$$

where $A_{mean}$ and $B_{mean}$ are the mean values of the matrices A and B. In this manipulation matrix A is fixed to one of the connected components while matrix B will have variable values as it will represent all the saved templates and the same process will be repeated for all connected components that satisfy the thresholding range. The result of correlation for some of the connected components for the considered specific input is shown in Figure 9. From this figure, it can be seen that the connected component objects produce highest correlation result with the template belonging to them.

**Experimental Results**

The newly proposed algorithm is run on laptop Core i3 CPU 2.10 GHz with 4 GB of RAM under MAT-LAB R2008b environment. Some sample images of our database are shown in Figure 10. Now, in order to evaluate the accuracy of proposed method, we have categorized the provided database into different categories based upon size and plate color. The proposed approach has been tested on 180 images of license plate of different cars. Table 1 shows the accuracy of the system for small, medium and large vehicle sizes which shows that the proposed system have 95.3%, 99% and 93.7% number plate detection, character segmentation and license plate recognition efficiencies respectively for small size vehicles while the accuracy values for medium size vehicles are 97%, 99% and 96% for number plate detection, character segmentation and license plate recognition respectively. Similarly the accuracy values for large vehicles are found to be are 96%, 99% and 94.4% for number plate detection, character segmentation and license plate recognition respectively.

**Table 1: Experimental results for different sized vehicles**

| Size | Number of samples | Accuracy | | |
|---|---|---|---|---|
| | | Plate detection | Segment-ation | Recognition |
| Small | 50 | 95.3 | 99 | 93.7 |
| Medium | 50 | 97 | 99 | 96 |
| Large | 50 | 96 | 99 | 94.4 |

Table 2 shows the results for different plate colors namely yellow and white. The accuracy results are found to be 97%, 99% and 94% for number plate detection, character segmentation and license plate recognition respectively for yellow plate vehicles. In the other case the accuracy values for white plate vehicles are 94.6%, 98% and 92.8% for number plate detection, character segmentation and license plate recognition respectively.

**Table 2: Experimental results for different plate colors**

| Plate Color | Number of Samples | Accuracy | | |
|---|---|---|---|---|
| | | Plate Detection | Segment-ation | Recognition |
| Yellow | 50 | 97 | 99 | 94 |
| White | 50 | 94.6 | 98 | 92.8 |

**Conclusions**

The present method extracts edges and then determines the candidate regions by comparing it with a selected plate which has appropriate size for selected capture distance. Finally by connected component elements analysis, the license plate is detected. The system works in high efficiency without dependence of plate color and vehicle size.

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