New Method for Optimization of License Plate Recognition system with Use of Edge Detection and Connected Component

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Abstract—License Plate recognition plays an important role on the traffic monitoring and parking management systems. In this paper, a fast and real time method has been proposed which has an appropriate application to find tilt and poor quality plates. In the proposed method, at the beginning, the image is converted into binary mode using adaptive threshold. Then, by using some edge detection and morphology operations, plate number location has been specified. Finally, if the plate has tilt, its tilt is removed away. This method has been tested on another paper data set that has different images of the background, considering distance, and angle of view so that the correct extraction rate of plate reached at 98.66%.

Keywords—license plate recognition; Adaptive thresholding; edge detection; connected component; plates correction

I. INTRODUCTION

Recently, transportation tools, such as public transport vehicles, personal cars, motorcycles and even electronic bicycles, are playing and will play more and more impressive roles on every aspect of human life and public environments. Administration and Monitoring of those transportation tools for the better service, becomes very essential. Due to the uniqueness (each car has its own license plate number) and simplicity (easy to identify and record compared with the other external characteristics) of license plate number, the application of license plate recognition on transportation monitoring tools have already shown its greatest importance on the area of unattended parking lots [1], [2], security control of restricted areas [3], traffic law enforcement [4],[6], congestion pricing [7], and automatic toll collection [8], [9].

Due to many complex conditions such as illumination situation, vehicles speeds, backgrounds conditions, and distances between image acquisition device and the transportation tool, the accuracy of license plate recognition is not as high as expected.

A license plate recognition system generally consists of three main parts: 1) license plate recognition 2) characters segmentation 3) characters recognition [10], [11]. Among these stages, the license plate recognition has a special sensitivity and is one of the most difficult stages in this process. Some of the related works in the field of automatic car plate recognition are as follows. In [12], the combination of morphology, edge detection and the analysis of the histogram have been used. Primarily, by means of sober operator, obtains the edges of plate image, then these edges are clarified by the analysis of repeated histogram and it considers the most frequent point as a candidate and for detecting the exact location of license plate, the obtained image extended horizontally and vertically, in frequency; then the license plate is obtained by sharing of this development.

In [13] to determine the edges of the image, a new algorithm has been used that, unlike the Sobel and Canny methods, has less time complexity. To find the plate, the number of the drawn lines in each row are counted and then saved in one matrix. Also, the image is divided into several subgroups of 10 rows and the number of the horizontal lines in every group is counted. Then a group is chosen which has less number as candidate and omits the non-candidate points by means of a threshold function and the location of plate is extracted.

In [14], firstly, they takes the input image into a grayscale, then for analyzing the location of plate the operations of morphology such as erosion and dilation are applied. Then, the plate is extracted with use of vertical and horizontal projection among various candidates.

In [15] the plate has a location with the black background and white writings. In this way, firstly, the image converts into the HIS. Then, due to applying the capability of black color of its background, it uses a mask and segments the image according to HSI color intensity parameter and creates a binary image. For canceling probable noises, it uses the operation of erosion and dilation, and then labels the existing candidates. For canceling the candidates which aren’t the location of plate, it applies the geometric capability of the plate and other characters, then for recognizing a primary candidate, it uses the color intensity histogram, and recognizes the location of plate.

In this paper a new method based on edge detection and connected components is presented which in comparison with other similar methods has better operation on a situation that plate is tilt in the images or ambient light is low. In section II, the proposed method is elaborated, in section III, the practical result of the paper and in section IV, conclusions are presented, respectively.
II. PROPOSED METHOD

General block diagram of the proposed method is shown in Fig. 1. In the proposed method, the input image is reconstructed at the first time and then plate location is specified by edge detection and morphology operations. Then, plate tilt is corrected and finally vehicle license plate is extracted.

A. Image reconstruction

Pre-processing is carried out on the image to improve the quality of the image which leads to the main processing becomes easier. This step involves image converting to grayscale and Gaussian filter applying.

1) Grayscale conversion

From the 24-bit color value of each pixel (i,j), the R, G and B components are separated and the 8-bit gray value is calculated. Fig. 2(a) shows the input image in RGB mode and Fig. 2(b) shows the grayscale of input image.

2) Gaussian filter

After converting the image into gray level, image is improved to remove the possible noises on it. To this end, a Gaussian filter with a 3*3 mask is used. Fig. 3 shows mask of Gaussian filter.

| 0.0113 | 0.0638 | 0.0113 |
|-------|-------|-------|
| 0.0878 | 0.6197 | 0.0878 |
| 0.0113 | 0.0828 | 0.0113 |

B. Vertical edge detection

Edge is a sudden change in image brightness. The plate number of vehicle due to written numbers and letters on it has many vertical edges. We use these features to find plate location in the picture. There are different approaches and algorithm to find out the edge in image processing that, in the meantime, sobel operator has a more favorable performance compared to other methods due to high speed and low processing volume. Sobel edge detection method causes to both vertical and horizontal edge detection. In the proposed method both of them are used. Fig. 4(a) shows the sobel vertical mask and Fig. 4(b) shows the sobel horizontal mask.

Before applying this filter, first of all, the gray image is converted into binary image with use of statistical features. To this end, at first, the mean and standard variances of the image are calculated. Then the threshold level is placed equal to the sum of the mean and variance. Then, the level of the image that is more than threshold is converted into intensity values 1, and other values are converted into intensity values zero. The following equation shows the threshold applying way:

\[
P_m = \frac{1}{W} \sum_{i} P_i
\]

\[
P_o = \frac{1}{W} \sum_{i} |P_i - P_m|
\]

\[
B[i,j] = \begin{cases} 1, & \text{if } P_i > T \\ 0, & \text{otherwise} \end{cases}, \quad 1 \leq i \leq W
\]

\[
T = P_m + P_o
\]

In the above-mentioned equation, \( P_i \) the image pixel, \( P_o \) standard variance, \( P_m \) average of image, \( T \) threshold considered and \( B[i,j] \) is the binary image. Fig. 5 shows the image of edge detection of Fig. 2, after applying the Gaussian filter.
C. Care license plate extraction

In this part, the candidate region has been identified and among these areas, plate area is extracted.

1) Mathematical morphology

Mathematical morphology is one of the branches of image processing that argues about shape and appearance of object in images. The erosion and dilation operators are basically operators of mathematical morphology that are used in this part to improve the edge detection image.

a) Image erosion

At this step, erosion action is applied in the edge detection image. The erosion action is defined as follows:

\[ A \ominus B = \{ x \mid (B)_x \subseteq A \} \]

A and B erosion is a collection of all points of X; if B is replaced in the size of X, A and B erosion is still placed in A.

b) Horizontal expansion of Image

After erosion action on image, the dilation action is done. The dilation action is defined by the following equation:

\[ A \oplus B = \{ x \mid (\hat{B})_x \cap A \subseteq A \} \]

A and B dilations are the collection of all X (es) that B\_x and at least A have overlap in a non-zero element. B\_x is B symmetric around its own axis. And then it transfers the symmetry of X.

c) Filling the probable holes

Since the plate area is a compact area, the holes are filled in this stage. Fig. 6 shows the result of three simultaneous acts on Fig. 5 to enhance the edges and holes. The result of this step is more coherent than lines which create closed space in the image.

2) Candidate region extraction

As is clear from Fig. 6, in the place of candidate plate, there are several interconnected areas. First, the length of each of these areas is obtained and an area that has the greatest length and is in the geometry range of plate and was accepted by the density testing, is considered as the exact location of license plate and is placed inside a rectangle; then the rest area is eliminated. Following function show the density testing and Fig. 7 shows the results.

```
Function Candidate Plate Density Testing (Candidate Plate)

[m, n]=size (Candidate Plate)
For i=1: m
    Test= Candidate Plate (i, 1);
    Count=0;
    For j=1: n
        If Test\_a= Candidate Plate (i, j+1)
            Count=Count+1;
            Test= Candidate Plate (i, j+1);
        End
    End
    Check (i) =count;
End
Flag=0; continuous =0;
For i=1: m
    If Check (i)>15
        Continuous =0; j=i;
        While (Check (j)>15) && (j<n) j++;   continuous++; 
    End
End
If continuous >11
    Flag=1;
End
End
If Flag==1 {    Accept (Candidate Plate) }
End Function
```

The image of extracted candidate

At this stage, license plate space can be an unequal figure that causes an error in the reading of the characters. So, since the license plate is located in a 4-point rectangle and determines the license plate corners information, this feature is used to remove the plate tilt.
3) Correction the plate tilt
In the process of the vehicle license plate recognition, the tilt of license plate has significant influence on the character segmentation, identification of patterns and the final recognition results [16]. So, at this stage, by using the pate features that are determined by the candidate, the image of plate is extracted from original image; then it is improved in contrast and is converted into the binary level. To remove tilt of plate, the features of pixels arrangements are used in a digital image. To this end, in image without tilt, the path that goes from one corner to another corner of the image must include only pixels that are connected together from one corner. Fig. 8 shows the image plate that has tilt. According to the zoom part, the tilt angle of the plate is specified by original diameter to fit the horizontal axis. This method is used to remove the plate rotating in this paper and shows the good result about 45 degrees.

4) Plate detection
Fig. 7 is the exact location of license plate that is extracted of original image by eliminating the fines. Fig. 9 shows the result. The extracted plate at this stage can be saved in a separate file to identify characters.

III. PRACTICAL RESULT
In this part, first, we will express the difference of threshold amount selection with adaptive state and stable state. Then, proportion success rate of edge detection will be computed by Sobel operator and other operators that they were tested on different images practically. Also, the success rate of plate tilt removal that are tested on images, will express. At the end, the results which are gained from the different images will express. Our proposed method has been implemented on Intel Core i3-2330M CPU, 2.20 GHz with 2 GB RAM under Matlab environment.

A. Adaptive thresholding
In this part threshold values, are shown with different amount for rising system efficiency on all images with different amount. The sample of practical result is shown on the image in fig. 10. Fig. 10(a) shows the state that the threshold amount is equal to 0.4. This amount may destroy some points in some images due to the lights existence. It causes some problems in recognizing step of the plate faces. Fig. 10(b) shows the state that the threshold amount is 0.7. In this situation extra points of image are made that they don't belong to plate area. Fig. 10(c) shows the state that the threshold mound is selected by proposed method. So, in the situation that the threshold amounts select the image statistics information base, it expresses a better result in comparison with the situation that image light is less or more. Table 1 shows success rate, selection of different amount of threshold for finding plate place on the image [17].

| Total image | Threshold value | Rate of success |
|-------------|-----------------|-----------------|
| 150         | 0.4             | 40%             |
|             | 0.7             | 50%             |
|             | adaptive        | 98.66           |

B. Edge detection method
There are different approaches and algorithms to find out the edge in image processing that, in the meantime, Sobel operator due to high speed and low processing volume has more favorable performance in comparison with other methods. Table 2 shows the success rate of different methods for edge detection in [17] dataset.

| Method      | prewitt | Log   | canny  | Sobel | Robert | Zero cross |
|-------------|---------|-------|--------|-------|--------|------------|
| Success rate| 83%     | 60%   | 85%    | 98.66%| 88.22% | 70%        |

| Total image | 150 | 150 | 150 | 150 | 150 | 150 |

C. Plate title solving
When the vehicle plate has tilted our proposed method recognizes it and removes it. For removing plate tilt in this paper, the object orientation method is used. According to results, for the images with the correct plate recognition, the success rate of this operator has been gained to 100%. Fig.11 shows sample image that the plate has tilt but the system has known and solved it correctly.

Figure 8. The image of plate with title

Table 1. Rate of success according to threshold value

Table 2. Rate of success according to edge detection method

Figure 8. The image of plate with title
D. Analysis of the experiment result

The data set that is used in this paper consists of 150 colorful images in different sizes [17]. These images are varied in point of view, good light balance, various distances and various backgrounds. The result of the proposed method for license plate recognition compared with [17] is shown in Table 3.

| Method     | Total image | correct identification | Wrong identification | Percent efficiency |
|------------|-------------|------------------------|-----------------------|--------------------|
| Our Method | 150         | 148                    | 2                     | 98.66              |
| [17]       | 150         | 147                    | 3                     | 98.20              |

The case which the system isn't able to recognize plate location occurs due to the background complexity. Fig. 9 shows the sample of images from [17] that the system be able to recognize them.

![Figure 9. The sample of images that system is able to recognize them successfully](image)

In general, the advantages of the proposed method in this paper in comparison with other methods include the following:

- Lower computational complexity,
- Fast response and operation,
- Ability to correct plate tilt,
- Ability to implementation on microprocessors,
- Usability in real time work,
- Detect minimum candidates as car plates. In most images, the proposed method detects a candidate that is in fact an original license plate,
- Scale invariant.

IV. CONCLUSION

This paper suggests a quick method for license plate recognition. In this method, at first, by using the statistical features, an appropriate threshold will be obtained for the input image and converts it into the binary. Sobel operator extracts the vertical edges of the image, then using of morphology operation and the geometric ratio the location of plate is extracted and as result of this process, tilt of plate is set away. It causes that when the system reads the characters, no problem will ultimately arise. The proposed method has been examined on the image with different background, different distance and view point, various light and atmospheric conditions and also is accurate in some situation when the image quality is low. The experimental results from the examination of the method show that the rate of correct extraction of the plate reaches approximately to 98.66%.

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