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A Simple Skew Correction Method of Sudanese License Plate

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Abstract:*License plate character segmentation is an important phase of vehicle license plate recognition systems. The skewed license plate negatively affects the accuracy and efficiency of character segmentation. This paper presents a simple skew correction method; which is mainly designed for Sudanese vehicle license plates recognition. The propose method involves several steps: contrast enhancement and binary conversion, filtering unwanted regions, and computing skew angle. In order to analyze the performance and efficiency of the proposed method, number of experiments was carried out over a new dataset of images. The test results, demonstrate that the proposed method is efficient to be used for license plate recognition system.*

Keywords:*Contrast-Limited Adaptive Histogram Equalization; Morphological Operation; Binary Conversion; Vehicle License Plate Recognition.*

1. Introduction

Vehicle License Plate Recognition (VLPR) systems are an important component for automating many control and surveillance systems, such as road traffic monitoring, parking lots, access control, highway electronic toll collection, red light violation enforcement, finding stolen cars and gathering traffic flow statistics [1]. License plate character segmentation is a significant phase in VLPR system; its aim is to find the individual characters (digits and alphabets) and extracting those characters from the plate image. Since the skewed License Plate (LP) considerably has a great influence on the accurate character segmentation and recognition [9, 11, 12], it is important to implement an additional method, which detects and corrects skewed LP.

The LP can be rotated and skewed in many ways due to the position of the vehicle towards the camera. According to the state of the art of VLPR system, the basic problem of skew correction is to determine an angle, under which the LP is skewed. Many eff orts have been reported for solving the problem of calculating the skew angle.

Chen et al. proposed the least square skew detection method, which starts with finding all the connected regions in the License Plate and calculating the centered of each region. Afterwards, skew angle detects by least square [6]. Mansour performed the skew correction by least squares based on the centroid [2]. Moghassemi applied similar techniques based on connected component analysis to compute the centroids of all characters in license plate, then with coordination's of left and right characters, the skew angle is computed [14].

Dashtban et al. used Canny line detection algorithm and Hough Transform to find the longest line in the plate image. Then the slope of the line is used to rotate the plate [4]. Arulmozhi et al. proposed polar Hough Transform [10].

Shapiro et al. Randon Transform (RT) function is used in conjunction with Dirac's delta function to eliminate the skew position in a license plate [3]. In addition, Azam et al. used Radon Transform to detect the skew angle. But before that, Bernsenbinarization method with a local window of 15 × 15 is applied to the grayscale candidate license plate images, then generating the perimeter image from the binarized image [8].

Kaushik Deb et al. proposed least square fitting with perpendicular offsets (LSFPO) for skew correction in horizontal direction and estimating the rotation angle of the license plate region. Then the whole image is rotated for skew correction in the horizontal direction by this angle. Skew correction in vertical direction is implemented by reorientation of the titled LP candidate through inverse affine transformation [5].

Cheng and Bai introduced an approach based on of self-organizing map (SOM) to find the skew angle of the license plate. Regarding the aim of correcting the skew plate and segmenting 7 characters subsequently, authors choose a SOM network with 7 output points and take the coordinates of white pixels as the input vectors. Then initializing the weight matrix. After training the SOM, white pixels are classified and new weight vectors are got. Finally, the skew angle is calculated [7].

Renlong Pan et al. proposed an approach for license plate skew correction. First, the plate image is divided into a set of 5×5 non-overlapping blocks. The local orientation of each block is estimated by gradients of pixels in the block. The horizontal incline angle of license plate is detected by the local maximum of the direction angle histogram. The plate image is rotated according to this angle. Then, the vertical distortion of the license plate image is corrected by the single character projection method [9].

Modi et al. developed a combined method for skew correction of plate's image based on the Harris corner detector and principal component analysis (PCA). First, corner points are extracted as features using the Harris corner detector. PCA is applied onto these features to find out the principal component in the direction of maximum Eigen value. This principal component reflects the skew angle of the plate, which is used to rotate the plate image [11]. Paunwala et al. proposed a combined method based on wavelet transform and PCA. Extraction of Feature points, which are considered as the edge of characters on the LP are extracted by using the two level wavelet transform. The PCA gives the information about skewed angle of the plate, with the help of feature points [12].

In this paper, a simple and fast method to compute the skew angle is proposed, which based on detecting the starting and ending points of the middle horizontal line that split the LP into upper and lower parts as illustrated in Figure 1.

Figure 1. The Middle Horizontal Line.

The remainder of this paper is structured as follows: Section 2, describes the proposed method. The experimental results are provided along with discussion in section 3. Section 4 concludes the paper.

2. The Proposed Skew Correction Method

The proposed method composed of three of steps, including contrast enhancement and binary conversion, filtering unwanted region, and computing skew angle, as shown in Figure 2.

The input of the method is the LP image in grayscale, which had been extracted from the vehicle image by a method reported in [18]. Each step of the proposed method is presented in the following subsections.

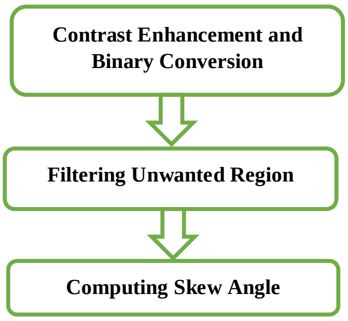


Figure 2. The Proposed Method.

2.1 Contrast Enhancement and Binary Conversion

Contrast Enhancement and Binary Conversion are the first step and considered as a pre-processing step. This step receives the LP image as illustrated in Figure 3 (a). In order to improve the contrast in the LP image Contrast-Limited Adaptive Histogram Equalization (CLAHE) is used as illustrate in Figure 3 (b). CLAHE operates in small regions in the image, called tiles, rather than the entire image [13, 15, 16]. Each individual tile's is processed using histogram specification. In our experiments, CLAHE provides better results for enhancing low-illumination LP images than other contrast enhancement techniques.

In binary conversion, the enhanced grayscale image is converted into binary scale image (Black & White). It is important to use an effective technique for binarization in order to clearly separate the plate contents in the LP image from the background. Therefore, our method performs this task using a well-known Otsu's method [17]. The Otsu's method calculates the optimal global threshold value for binarization process [13]. As a result, the plate characters and boundaries are properly segmented and appeared clearly after binarization, as shown in Figure 3 (c).

(a)

(b)

(c)

Figure 3. Contrast Enhancement and Binary Conversion (a) Gray-scaled Image. (b) Contrast Enhancement by CLAHE. (c) Binary-scaled Image.

2.2 Filtering Unwanted Regions

The main aim of this step is to eliminate plate characters and it is four side boundaries (Upper, Lower, Left and Right) and keep the middle horizontal line as the region of interest. Based on the size of the LP image being processed, LP boundaries are eliminated by replacing white pixels by black pixels in specific parts of the LP image as follows:

- Upper Boundary: Scan the First fifth part of the LP image horizontally, and change pixel values to Zero.
- Lower Boundary: Scan the last third part of the LP image, and change pixel value to Zero.
- Left Boundary: Scan the first fifteenth columns in the LP image, and change pixel values to Zero.
- Right Boundary: Scan the last fifteenth columns in the LP image, and change pixel values to Zero.

Working on the complement of the binary-scaled image as in Figure 4 (a). The resultant image after eliminating the four boundaries is shown in Figure 4 (b). In addition, it is clear that, most of the characters or considerable parts of characters have been reduced.

As obvious in Figure 4 (b), above and below the middle line, there are some regions belong to the plate characters, which will be handled as unwanted regions. So, in order to filter out those unwanted regions, morphological opening operation with the linear Structuring Element (SE) of length 20 is implemented. Then, based on the number of pixels (Region Area) that forming each region in the result image, regions smaller than m pixels are removed. The value of m has been set during the experiments to 160 pixels. Figure 4 (c) illustrated the resultant image.

(a)

(b)

(c)

Figure 4. Filtering Unwanted Regions Step (a) Complement of the Image. (b) The Plate's Four Boundaries Elimination. (c) Open Operation and Removing Specific Regions

2.3 Computing Skew Angle

The main goal of this step is to compute the skew angle (Slope Angle). According to the prior knowledge in mathematical concepts about the Linear Function, the slope of a line is defined as follows: Let (x_1, y_1), and (x_2, y_2) be distinct points on the line. Then the slope (m) of the line is given by:

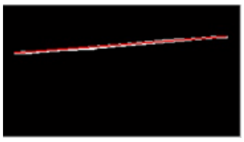
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{changeiny}{changinx} \quad (1)$$

Then the slope angle Θ is given by

$$\Theta = tan^{-1} m = tan^{-1} \frac{y_2 - y_1}{x_2 - x_1} \quad (2)$$

The image in Figure 4 (c) is processed in this step to detect the two points on the horizontal middle line, which represent its starting and ending points. Consequently, the entire image has been fully scanned vertically from the first column up to the last column, and recording the coordinate of the first pixel and the coordinate of the last pixel.

Figure 5 (a) shows the line that connects the two detected points on the middle line and Figure 5 (b) shows the corresponding line on the original gray-scaled image. By detecting the two points, the skew angle Θ was computed directly from Equation (2). Finally, rotate the entire original input image in reverse direction by the computed angle, as shown in Figure 5 (c).



(a)

(b)

(c)

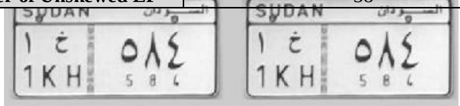
Figure 5. Computing Skew Angle Step (a) The Red Line Connects The Two Points. (b) The Red Line on the Original Gray Image. (c) Skew Corrected Image.

3. Result Analysis

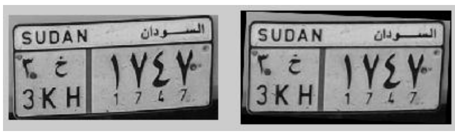
The Skew correction increase the success of character segmentation. Different gray images in size and illumination were taken for testing, which are received from the LP detection and extraction phase [18]. Results show that the method works very well on positive and negative skewed images. Moreover, it gives reliable results with less computation complexity as presented in Table 1. It is shown that, the skew correction method accuracy is 100%.

Table 1. LP Skew Correction Experiments Results

Total Number Of LP Images	Successful Skew Correction	Unsuccessful Skew Correction
370	370	0
%	100.0 %	0.0 %
Number of Unskewed LP	38	
Number of Positive Skew	197	
Number of Negative Skew	135	
Processing Time	0.017 to 0.035 Seconds	



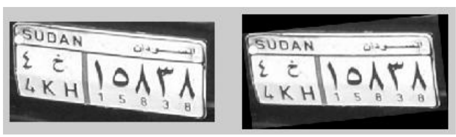
(a)



(b)

(c)

(d)



(e)

Figure 6. Several Results of Skew Correction Method.

Some of the representative images shown in Figure 6 are successfully corrected even though some difficulties, such as, variation in contrast and size. Unskewed images were left unchanged as shown in Figure 6 (a). Positive skewed images were accurately corrected as illustrated in Figure 6 (b) and (c), as well as negative skewed images shown in Figure 6 (d) and (e).

4. Conclusion

According to the state of the art of VLPR system a suitable collection of that techniques has been chosen to implement the proposed method: CLAHE and Otsu method are chosen for contrast enhancement and binary conversion respectively; morphological opening operation is found suitable for unwanted regions elimination; detecting the starting and ending points of the middle horizontal line for computing skew angle. Our method is straightforward and simple. Experimental results inthis paper facilitate the subsequent segmentation process.

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