Vehicle plate localization and extraction based on hough transform and bilinear operations

Masar Abed Uthaib¹, Muayad Sadik Croock²
¹Iraqi Commission for Computers and Informatics (ICCI), Informatics Institute for Postgraduate Studies, Iraq
²Computer Engineering Department, University of Technology, Iraq

ABSTRACT

In general, the extraction of the vehicle plate is a previous step of plate recognition, and it actively studied for several decades. Plate localization is used in various security and traffic applications. In this paper, the proposed method is efficient to localize a plate for the multinational countries. The proposed method consists of three levels. The first level is the preprocessing that contains several steps. The digital camera capture images have been taken about twenty meters from the car with zooming two to three meters. Images are resampled using the zooming technique (bilinear interpolation) that makes the dimension of image (1024 x 768) pixels. The resampled images are resized to (940 x 730). These images are converted to grayscale (green channel), and the bilateral filter is applied for removing noise. The second level is plate detection that adopts morphological operations, image subtraction, and vertical edge detection (Sobel). At the last Connected component analysis and Hough transform are used. The third level is the Deskew plate that notifies the plate may skew so that Hough transform is used to detect the largest line segment. Then, the images are rotated using bilinear interpolation. About 860 images are tested for different countries (Iraq, Belarus, Armenia, Hungary), and the accuracy is 98.99 % for extraction of the plate and 100% for the Deskew plate. Thus, the proposed system shows high efficiency in achievement.

Keywords: Hough transform, Hough transform, Image processing, Sobel and bilinear operations, morphological operation, Vehicle plate localization

1. INTRODUCTION

The human population increase, and the vehicle control takes considerable space. The extraction of a license plate is very significant in the monitoring of borders, intelligent transportation systems, and controlling of traffic flow. The security enforcement makes the use of car detection is essential, in case of detection of stolen cars, terrorist activities, and parking violations. It is a technology uses the image processing to recognize vehicles by their car plates. License plate detection approaches aim to discover rectangular regions in the image where the plates found. License plate recognition accuracy relies on the License plate detection efficiency. Several drawbacks effect on the localization of license plate, including noise, weather conditions, places of the plate in the car, non-prorate camera, complex of the scene, unwanted characters, the effectiveness of the plate, backgrounds of plates[1].

Several techniques have been developed for the license plate localization from the vehicle image in recent years. In [2], authors proposed a way to extract plate; they used Sliding Concentric Window for division the interested region and morphological (dilation and erosion); the accuracy of the system was 86.5 %. In [3], the haze removal technique was employed to enhance the images. Then the improved image
Vehicle plate localization and extraction based on hough transform and bilinear... (Masar Abed Uthaib)
i) The other added operations are removing pixels less than 200 pixels after that morphological open and erosion, removing all objects except the six-biggest objects, analyzing the connected component to know the number of connected objects, extracting the license plate, Deskewing car plate using Hough transform for line detection and bilinear interpolation to rotate the plate.

Figure 2. Flow chart of the proposed system
For clarifying the working phases of the proposed method in detail, the steps are explained as follows.

2.1. Preprocessing

The preprocessing phase includes different steps that can be explained as follows.

2.1.1. Image acquisition

Firstly, the image of a vehicle is obtained by a digital camera with high resolution in various sizes, illumination conditions, and angles. Figure 3 illustrated an example.

![Figure 3. Original image](image)

2.1.2. Resampling and resizing images

We must deal with the different dimensions of car images (Width x Height), where there are enormous numbers of pixels to be processed, and the run-time is increased. It is crucial to reduce the dimension and save the quality of the image. Image resampling technique (bilinear interpolation) is used to decrease the dimensions to (1024 x 768) pixels and keep the quality of the picture. It is used widely in the computer vision field to get pixel values for positions which it is not located in the pixel grid. Four neighbor values are adopted to compute the interpolated value in each sub-pixel [13]. Figure 4 stated the interpolation grid, while Figure 5 displays the resampling image. Then, after the image is resampled, it is resized to concentrate on the license plate region with dimensions of 940x 730, as shown in Figure 6.

![Figure 4. Interpolation grid](image)

![Figure 5. Resampling image](image)

![Figure 6. Resizing the resampling image](image)
2.1.3. RGB to grayscale (green channel)

The resized image in the previous step is RGB image contains three channels red, green, and blue. The value of each channel in the range 0-256, whereas the grayscale image contains just one channel. Thus, the extraction of one channel decreases the run time, as well as the storage space. We use the green channel because it gives adequate contrast for the image by experiments. Thus, we take the green channel as a proposed method for gray conversion[14, 15]. Thus, the green channel is extracted, as apparent in Figure 7.

![Figure 7. Green channel](image)

2.1.4. Bilateral filtering

This filter smooths the car image while preserving its edges, through a non-linear mixture of adjacent values to an image. The way is non-iterative, straightforward, and local. It combines gray range or colors depend on both their geometric adjacency and their photometric hassling. It produces no illusion colors through edges in RGB-images [16]. Figure 8 explains this process.

![Figure 8. Bilateral filtering](image)

2.1.5. Image histogram and adaptive histogram

The image histogram is a diagram in which the pixel's intensity (x-axis coordinate), which represents obtainable gray range against no. of the pixels (y-axis coordinate) that refers to a specific pixels number to gray-range value. According to the adaptive-histogram, the total histogram of an image may have an extensive division, where local regions histogram is extremely skewed to once of the grey spectrum end. Therefore, we use adaptive histogram equalization in which processing differently for different areas [17]. Figure 9 clarifies the histogram of the image, while Figure 10 explains the adaptive histogram.

![Figure 9. Image histogram](image)  ![Figure 10. Adaptive histogram](image)
2.2. License plate detection

The detection of the plate is the important phase in the proposed method. The steps of the workflow of this phase are explained as follows.

2.2.1. Morphological open and image subtraction

Morphological operations are simple to use and based on set of theories. The objective of using morphological-operations is to remove the imperfections in the image structure. Morphological-open is applied to the (Adaptive-Histogram) images using a structuring element (disk), where the morphological-open performs erosion and then dilation operation. It smooths the object's outline. The morphological open is subtracted from the images of the Adaptive Histogram. Image subtraction is useful to remove the parts that are out dominated the images, such as a car body. This is to easy the localization of the plate in the next step. The image subtraction results are called the candidate images because the objects that remained from this step are areas that became a candidate location of a license plate [18, 19]. Figure 11 and Figure 12 identifies morphological-open and image-subtraction.

![Figure 11. Morphological open](image)

![Figure 12. Image subtraction](image)

2.2.2. Sobel edge detection

Vertical Sobel operator used to identify the edges in images. It generates two-dimensions spatial gradient measurement on the image and affirms higher spatial frequency regions that are corresponding to the edge [20]. The operator involves a twice 3×3 kernels, as illustrated in Figure 13.

![Figure 13. Sobel convolution kernels](image)

For getting distinct gradient component measurements in both orientations, Gx and Gy kernels can be applied to the image separately. The gradient magnitude and an approximate magnitude computed by the following equations [21]:

\[
|G| = \sqrt{G_x^2 + G_y^2} \\
|G| = |G_x| + |G_y|
\]

After first order Sobel edge detection, Dilation operation shows visibility and the small's holes filled in objects. It is applied to Sobel edge detected images for more precise and comfortable to extract the License Plate. Figure 14 clarifies Sobel detection, while Figure 15 represents the dilation.
2.2.3. Morphological open

We apply another morphological-open on the dilated images, as shown in Figure 16.

2.2.4. Fill holes

Filled Holes operation was used after the previous step, as shown in Figure 17, and then the proposed method removes objects less than 200 pixels, as shown in Figure 18. Then, morphological open is applied and passed to erosion, as shown in Figure 19 and Figure 20, respectively.

2.2.5. Removing unwanted objects

In this stage, only six-biggest objects are remained. After that, we used the connected component analysis to get the interested zone, which is the car plate, as apparent in Figure 21.
2.2.6. Plate segmentation

The connected component analysis is used for detecting the connected regions (white parts) in the binary-image. Connected Component labels are based on the given heuristic [22]. Then, the adopted conditions to extract a plate, which are the size and dimensions of the plate area, filling area, and the aspect ratio (Height/Width), to find the accurate license plate. Then, the proposed method cuts this area from the adaptive histogram image according to those dimensions, as shown in Figure 22.

2.2.7. Rotate the skew plate

The previous result of a segmented plate can be a skew plate, so we use the Hough transform for line detection and bilinear interpolation to rotate the plate. We use the canny edge detector to discover edges, as shown in Figure 23.

For line detection, we used the Hough transform, which is the most famous technique for the detection of the straight line in a digital image, where it is a linear transform. Hough space uses two parametric for detection of a line in the image and represented as follows [23, 24]:

Where \( L \) is a straightforward-line in the space of the image. The variable \( \theta \) is the angle to the straight-line that crosses through the origin being orthogonal to the straight line \( L \). The variable \( \rho \) considered the area from the origin to the line \( L \). The straight- line is available to use the polar coordinate system as shown in Figure 24.

\[
p = x \cos \theta + y \sin \theta
\]  

(3)
The peaks are identified by the Hough Space Accumulator. Hough Space accumulator is used to locate the regions in which most Hough space lines are intersected at a common point in the $(\rho, \theta)$ as illustrated in Figure 25. Then, the proposed method finds the longest-line segment, as shown in Figure 26 [25-27]. After determining the most extended line angle, we rotate the plate using the Bilinear interpolation technique, which is used to deskew the car plate without losing the quality of the image[28]. Figure 27 displays the rotation of the plate using Bilinear interpolation.

![Figure 25. Accumulator space](image)

![Figure 26. The most extended-line segment (the line with blue color)](image)

![Figure 27. Deskew license plate](image)

3. RESULTS AND DISCUSSION

In order to test the proposed method, four groups of vehicle plates are considered. These groups are collected from four countries, which are Iraq, Armenia, Hungarian, and Belarus, with a total number of 860 images with different illumination conditions and orientations.

MATLAB 2019a simulator is adopted in this paper to represent the proposed method as well as testing it with numerous case studies. The reason behind adopting this simulator is the availability of software components regarding image processing.

Table 1 show the result obtained of the proposed method. It can be seen that the suggested method shows an excellent performance in terms of computed accuracy (extraction percentage). The diversity of accuracy percentage between the adopted image groups is the result of the resolution of them as well as the angle of the image capturing in addition to noise and surrounding circumstances. It is essential to note that the proposed method works well even under difficult conditions of import images with little contrast, noisy and low-resolution in addition to various distances.

| ID | The type of license plate | Total images | No. of extracted license plate | No. of not extracted license plate | The percentage of deskew plate % | Run time in Sec. | License plate Extraction percentage |
|----|----------------------------|--------------|-------------------------------|----------------------------------|---------------------------------|-----------------|-----------------------------------|
| 1  | Iraqi plate                | 104          | 102                           | 2                               | 100%                            | 8               | 102/104~98.07%                    |
| 2  | Armenia plate              | 333          | 331                           | 2                               | 100%                            | 8               | 331/333~99.39%                    |
| 3  | Hungarian plate            | 188          | 186                           | 2                               | 100%                            | 8               | 186/188~98.93%                    |
| 4  | Belarus plate              | 235          | 234                           | 1                               | 100%                            | 8               | 234/235~99.57%                    |
| Total |                         | 860          | 853                           | 7                               | 100%                            |                 | 98.99%                            |

4. CONCLUSION

We proposed an efficacious approach for the vehicle plate extraction using Bilateral filter and Hough transform. It was based on the presented algorithm of [12] that has been modified. The modification was focused on the resizing of images without affecting the resolution. The proposed method consisted of three stages: preprocessing, license plate detection, and Deskew plate. The proposed method was tested with four different multinationals car images from the following countries: Iraq, Armenia, Belarus, Hungary. It had been proved as an efficient method in performing the plate extraction and localization. It is efficient with different weather conditions, such as sunny, mud, cloudy, night, rainy, and different orientations. The accuracy for extraction and rotation plates is 98.99% and 100% for rotation images.
Vehicle plate localization and extraction based on hough transform and bilinear... (Masar Abed Uthaib)