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Automatic Localize Iraqi License Plate

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Abstract. A car license plate locator and recognition have gained much interest in recent years in Intelligent Transportation System research. The license plate locator is an important stage in the license plate recognition process. In this paper, a new technique to automatically locate the license plate has been proposed, and then recognize it. The proposed technique is divided into two stages, stage one is to locate and corrupt the license plate, and the second stage focuses on the recognition of the license plate. In the first stage image preprocessing (denoising, convert image to binary image, and detect edges) is implemented, then recognizes the region that may contain the license plate, this is done by finding the connected regions using the mathematical morphology (small and very large regions removed). Then the corners in the image are extracted by using the Harris algorithm. Finally, verifies which one of the nominated regions is a license plate, this is done by eliminating all regions that have less than two separate corners. The license plate is determined according to the candidate region size and vertical/horizontal histogram. While in the second stage the corrupt plate is preprocessing (convert to gray image, enhance contrast, and remove noise). The license plate image converted to the binary image prior to extract the numbers and recognize them based on the number of pixels for each number. The accuracy of the locating plate is up to 96%. And the accuracy of recognizing the number is up to 100%.

Keywords: Car license plate, Corners, License plate locator, Harris, Numbers recognition.

INTRODUCTION

Different countries try to apply Intelligent Transportation Systems that help in traffic management, monitoring, and scheduling. The most important tool in Intelligent Transportation Systems is vehicle License Plate Recognition (LPR) [1]. Image processing is the main technology of many applications for LPR, like road traffic monitoring, vehicle identification, parking, stolen car detection, etc. [2] [3]. To apply the LPR three main phases are needed, namely, license plate locating, character segmentation, and character recognition [1] [2] [4]. License plate locating is the most important and difficult stage of the process [1] [2] [5]. The license plate locator means to identify the position in the image where the license plate is located [2]. Moreover, without the detection of a license plate, character recognition will be a hopeless task [4].

Many unwanted situations affect the LPR system such as image obscuration, size, various illumination, rotation of license plates [1] [5] [6]. Also, there are several issues to get precise findings [6] [7]. So, this research area needs further study to deal with this issue and to provide more solutions, which allow the application of this technology to be useful in many areas of life.

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Previous studies have shown many different techniques in the field of image processing that have been implemented for locating and recognize license plates. For example, researchers investigate the use of transform techniques like Wavelet transform [2] [4]. Other researchers use Fourier transform [8]. While other researchers use different techniques like morphological operations [2] [5] in addition to the use of a Genetic Algorithm [3]. Finally, to detected License positioning some methods are based on median filtering and double edge detection [9].

The rest of the paper includes related works and then introduces the methodology of the suggested algorithm. Results and conclusion are the final sections of this paper.

RELATED WORKS

(Ganapathy, 2008) suggested combining morphological algorithms with Hough transformation, and neural network used to localize and recognition the Malaysian license plate [10].

(Zhenxue Chen et. al., 2009) suggested using salient features to locate the license plate, then separate the seven (LP) characters based on the feature projection estimate, finally, the characters recognize by using template matching and some salient features [11].

(Yang et. al., 2011) suggested locating a license plate based on color and shape information [12].

(Nadir Charniya, 2012) introduced a wavelet transformation method to localize the Indian license plate. Vertical and horizontal clipping was implemented before two-dimensional wavelets [13].

(Bulugu, 2013) works on license plate localization and recognition for Tanzanian License Plates. His work is based on license plate color identification and the characters' orientation [14].

(Gajendra Sharma, 2018) proposed Morphological operations, and edge detection, smoothing, filtering, techniques for plate localization, and character segmentation for Nepali number plates [15].

(Fei Xie, et. al., 2018) Proposed to combine feature extracted model and NN to detect and recognize license plate. In the preprocessing step, the image contrast-enhanced, then checked the candidate region of the license plate to verify the exact plate by integral projection method. Three sets of features combined to use in the NN to recognition the characters of the license plate. Accuracy is up to 97.7%. [16]

(Li Yao, et. al., 2019) suggested using a single shout detector to recognize the license plate. This network used an upper layer classification network to detect license plates and classified and lower layer network used for detection character and classified them.[17]

(YOUNG JUNG, et. al., 2020) Introduce a method based on converting color images to grayscale and then to a binary image. the method locates the license plate and then segment the characters. Finally, recognize the characters by transforming the pixels into meaningful information.[18]

METHODOLOGY

The car license plate locating and recognition method can be a tricky job due to many problems that may cause to degrade the image when acquired image. The plate itself might be tilted, too far, or too near to the camera, and noisy. The proposed method tries to locate the car license plate regardless of the size, tilt angle, noise, etc.

The suggested method consists of two parts, detecting the car license plate and recognize the characters on the license plate.

First Part

In the first part, we focus on the detection of the license plate by using corner placement and morphological operations. The proposed method has been divided into two stages. The first stage recognizes the candidate regions that may contain the license plate (LP) (the suggested algorithm is shown in Fig. 1, while the second stage verifies that the selected region has the LP. These processes are necessary to make the method more robust.

At the first stage, the captured image is enhanced and de-noised to eliminate any particles that may not belong to the LP region. The next step is to detect edges for the whole image.

A morphological operation has been done on the image to get the connection object and get the nominated LP. By eliminating very small and very large objects we can get objects that may only belong to the vehicle itself. Each object

in the image may have certain corners, these corners will be extracted by using Harris corners, hence, the corners of the license plate may appear. The nominated LP is the object with two corresponding corners horizontally and tilted by an angle less than 3° vertically and horizontally, all the other objects are neglected.

The final nominated regions are determined by using the candidate size and vertical/ horizontal histograms. The second stage will process the nominated areas from stage 1. The process in stage 2 focuses on verifying that the nominated region is a license plate. In this stage, the images are processed to find objects in the image that its centroids spaced by equal spaces, this came from the fact that the LP contains at least three equally spaced characters, Fig. 2 shows the equal spaces between characters in the license plate.

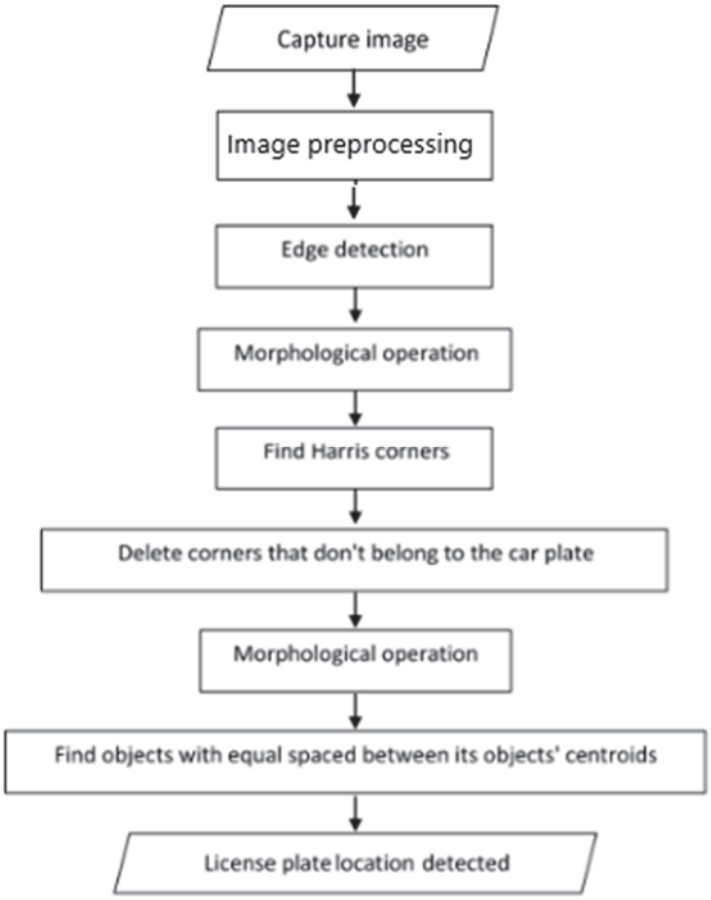

FIGURE 1. Methodology Flow Chart for the first part.

FIGURE 2. Equally Spaced Characters' Centroids

Morphological Operations

Some morphological operations have been done during the process such as dilation and erosion, which are important processes needed in some pattern recognition systems to eliminate unwanted objects. The open morphological operation (erosion followed by dilation) is performed after finding the edges of the objects at the first stage by using the Prewitt method. The open morphological operation is applied to remove objects that might not

belong to the LP. This process is very important in locating the LP because it minimizes the number of candidates to find its corners in the next step.

Harris Corner

Harri's corner point discovery is found by Chris Harris, Mike, and Stephens in 1988. The Harris corner detection algorithm is established along with the point feature extraction of the signal. It draws the window to move infinitesimal displacement in any direction, and the variation of gray can be defined as:

$$E(u,v) = \sum_{x,y} w(x,y)[I(x+u, y+v) - I(x,y)]^2$$

E(u,v) is the Harris corner at point (u,v)
w(x,y) is the shifted value from u and v.
Finding corners will not detect the LP location because there are a lot of other corners in the image that belongs to other objects. The number of corners needs to be reduced to the minimum to show only the LP, this can be done by finding the Euclidean distance between every two corners in the image:

$$D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Where D is the distance between any two corners in the image
(x_1, y_1) is the first corner coordinates
(x_2, y_2) is the second corner coordinates

From different tested images (by experiment) we found that if the distance D is < 20 then the object might not be an LP and the process will eliminate the second corner. Other than that, from several LP images that have been tested the tilt angle between two corners shouldn't exceed 3°, as illustrated in Fig. 3.

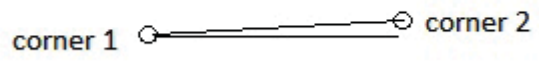

FIGURE 3. Tilted Angle between Two Corners

Nominate a License Plate

The remaining set of corners are cropped and nominated as a license plate mini-image. The new images have been processed separately by determining the sum of row values and the sum of column values. The result of the column and row values will determine if there is a large mass object in the image which may include an LP.

Finalization Process

The final process is to assume that the detected objects are an LP. The process will map the large object that is detected in the previous step on the original image. The resulted image will be processed to find any spaced objects that may represent the characters in the LP. The equally spaced objects inside this image will indicate that the nominated image is an LP image because every object in the LP (numbers and letters) is equally spaced from centroid to centroid. If this verification succeeds to find equally spaced objects, then the cropped image represents a license plate.

The Second Part

1. The cropped license plate can suffer from noise, low contrast, and maybe non-uniform illumination. So the contrast enhancement and denoise are a very important step. At this step contrast of the grayscale image is enhanced by transforming the image values using contrast-limited adaptive histogram equalization, this process is local contrast enhancement which enhances the contrast of small regions by histogram equalization.
2. Also, denoising is implemented on the license plate image after the contrast enhancement. The denoising process included two steps, the first one is removing the bright details based on area opening, while the second

step is reducing the noise by using a Gaussian filter. Combining the opening operation and Gaussian filter tries to reduce all unwanted details that are not belonging to numbers but some noise in the image.

3. Image intensities will be adjusted to increase the contrast of the numbers, this can be achieved by using a threshold. The result of this step is a binary image.
4. Numbers will be separated from text in the license plate image by dividing the image into two separated images (top and bottom parts). We found that the top 92 rows of the Iraqi license plate can be regards as the numbers while the remaining bottom rows of the image are specified for the text (The name of the province).
5. Now the skeleton operation is implemented on the number part of the image, then the image produces a thining image for the number part.
6. Because the numbers and texts on the car plate are organized and arranged so that each number has a specific size in the image and are equal distances from each other, so this will facilitate the process of separating the numbers from each other. Numbers image scanned from right to left, at each case when the value of a scanned pixel is equal to one, the location of this pixel is recorded, then fetch thirteen pixels before and after that location for all rows of the image (vertical strip with 27 pixels width) from the image of numbers before skeleton, and store them in a new image for one number.
7. The new image resulted from the previous step will be divided horizontally into two equal images, then the number of pixels for each part will be determined. The numbers of pixels will be used to recognize each number according to the table.

RESULTS

The method has been tested on different datasets with different weather and light conditions. Collected datasets are taken from a moving vehicle with different distances. Corners for the tested image will be determined as shown in Fig. 4.

FIGURE 4. Corners of the car.

The proposed system has a good ability to differentiate between the image with a license plate from that that has no license plate as shown in Fig.5.

FIGURE 5. Detecting license plate as in the first two images, and no plate as in the third image.

When the license plate is tilted with an angle of more than 3° the system will not discover the license plate as shown in Fig. 6.

FIGURE 6. License Plate is not detected.

Detection and localization of the license plate are tested with 200 images, and the result was summarized in table 1.

TABLE 1. Detection statistics

No. of Images	True positive (TP)	False-positive (FP)	True negative (TN)	False-negative (FN)
200	96	4	97	3

Performance of the suggested algorithm for detection and localize the license plate are determined according to the following equation and the results were

the accuracy =96.5%, recall = 97% and precision = 96%

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FN + FP} \qquad precision = \frac{TP}{TP + FP} \qquad recall = \frac{TP}{TP + FN}$$

For the second part of this method, we will adjust the corrupted image of the Iraqi License plate and implement all the recognition steps, the results were as follow:

First, the image converted to the grayscale image, enhance the image contrast and denoising as shown in Fig. 7 while the result of intensity adjustment and converting image to binary shown in Fig. 8.

FIGURE 7. Results of the first two steps in the suggested method for recognizing the characters.

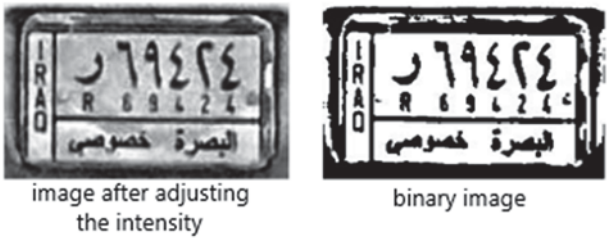

FIGURE 8. Results of the image after intensity adjustment and converting to binary by using a threshold.

The result of separation numbers from text is shown in Fig. 9

FIGURE 9. Two images separated from the binary image.

Thinning the image and separation the numbers is shown in Fig. 10.

From this image, the number can be separated as shown in Fig. 10, it is very clear that the numbers are separated accurately and clear.

FIGURE 10. Results of thinning image and separation of numbers in the image.

The results of dividing the numbers horizontally are shown in Fig. 11.

FIGURE 11. The result of dividing the numbers into two parts.

The relation between the upper and lower parts of the image resulted from Fig. and the number of pixels for each number and part is shown in Fig. 12 and table 2.

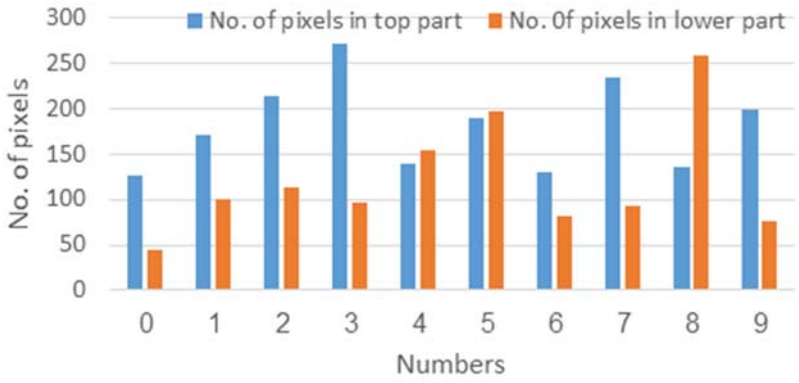

FIGURE 12. The relation between numbers and number of pixels for top and lower parts.

TABLE 2. Number of pixels for top and lower parts of numbers.

Numbers	No. of pixels in the upper part	No. of pixels in the lower part
0	127	44
1	171	101
2	213	114
3	271	96
4	140	154
5	190	196
6	130	82
7	233	93
8	135	258
9	198	76

The accuracy of recognition of the numbers and the text is up to 100%.
Also, we compare the results of this proposal with other similar works, the results summarized in table 3.

TABLE 3. Compare the proposed method with other works.

Papers	Detection method	Accuracy rate %
Hsieh et al. [17]	wavelet transform	92.4
Al-Ghaili et al. [18]	the vertical edge detection algorithm Sobel-based	91.4
Abbas et al. [19]	edge detection technique and region growing technique	95
Jabar et al. [20]	Mathematical morphology	84.19
Babu K et al. [21]	Sobel mask	93.33
Roy et al. [22]	Boundary-based contour algorithm	93
Panchal et al. [23]	Harris corner detection	93.84
Do et al. [24]	Neural network	96
Abdul Hadi et al. [25]	Morphological transformation	91.5
Yuan et al. [26]	line density filter	96.62
Yimyam et al. [27]	Edge detection and noise reduction	82
Corneto et al. [28]	Haar classifier	92.55
Choong et al. [29]	Sobel mask	89
Yaseen et al. [30]	Histogram of Oriented Gradients (HOG) feature	89.66
Tadic et al. [31]	Gabor Filter Bank with Crisp Parameters	94
Proposed method	Mathematical morphology and Harris corner detection	96.5

CONCLUSION

This paper proposes a method that locates the LP using corner location and confirmation methodology to determine whether the detected corners belong to LP or it is something else. Also, recognize the characters in the images. The accuracy of locating the LP is 96.5% while it recognizes all the characters.

Very tilted LPs or very far may affect the accuracy. The main focus of this method is to create a fast, robust, and high accuracy method to detect and recognize the license plates.

The results of the proposed method are compared with the results of other works and give promised results.

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