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Original Research

Detection License Plates on Spatial Digital Pictures for Smart Car Parking with a New Morphology

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Abstract

Vehicle license plate identification technology is the key technology of intelligent transport system, finding a stolen vehicle, monitoring traffic flow, in town management and highway tolls. The major issue in such applications is to detect the exact location of plate, because finding the location of number plate could vary and as well as its size and color. So that many of the vehicles have an uncertain difference in license plate position, location and unclean license plate. In this paper we have conducted a very fresh survey of most authentic techniques of license plate detection from a car. We studied different techniques and compared them, and figured out every technique has its own limitations, every method gives best results under some certain conditions so do bad results. This paper will lead to choose the best technique for detection just according to circumstance that wouldn't have to waste much more time in order to figuring out the suitable algorithm, as well as will informed with its accuracy percentage. Also, we present a real time and robust method of license plate detection and recognition based on the morphology and template matching. Such that main stage is the isolation of the license plate, from the digital image of the car obtained by a digital camera under different circumstances such as illumination, slop, distance, and angle. Proposed algorithm starts with preprocessing and signal conditioning, and it has the correct location rate of 83.50%.

Keywords: Transport Information Systems, License Plate Recognition, Localization, Discrete Wavelet Transform, Morphology, Segmentation, ANN.

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Introduction

License plate detection and recognition system is an image-processing technique used to identify a vehicle by its license plate. In fact this system is one kind of automatic inspection of transport, traffic and security systems and is of considerable interest because of its potential applications to areas such as automatic toll collection, traffic law enforcement and security control of restricted areas [1]. Vehicles license plate recognition is a technology of image processing. Vehicles license plate detection is a type of automatic vehicle recognition. The important role of license plate detection is to control traffic rules automatically and managing law enforcement on public roads. Since every vehicle carries a unique license plate, no external cards, tags or transmitters need to be recognizable, only license plate [2, 3].

While the first industrial automatic system for car license plate recognition (LPR) was introduced in the 80's, an outburst of commercial systems occurred in the 90s. Although that a lot of LPR systems are available in the market, the research and development still continues and new sophisticated solutions to plate localization, character segmentation and recognition appear [4, 5, 6]. This is due to the growing demand for the automatic vehicle identification required for traffic control, border control, access control, calculation of parking time and payment, search for stolen cars or unpaid fees, and the requirement for reliable identification at different lighting conditions, presence of random or structured noise in the plate, and nationality specific features, concerning plate's size and type of characters [7, 8, 9, 10].

Previously the popular technologies were used to identify vehicles are VIN technologies and e-tags which were expensive and had a big issue in common. If a new car comes than first you would have to install any of these technology in that car then you would be able to identify that car so to eliminate that factor the best way to identify a vehicle is to identify it's number plate with a simple camera. Different detection algorithm for detecting license plate is presented. We shall give brief description, functionality how a method works in different environment [11]. Numerous methods exist in license plate location but we shall discuss those methods which will give the most accurate results in critical situations like lighting distance effects etc. Some methods work for still images, some for videos and some for sequence images. We shall also discuss which method is best for lighting, distance, and other invariant. Below in figure1 there is a representation of different techniques [12, 13, 14, 15]:

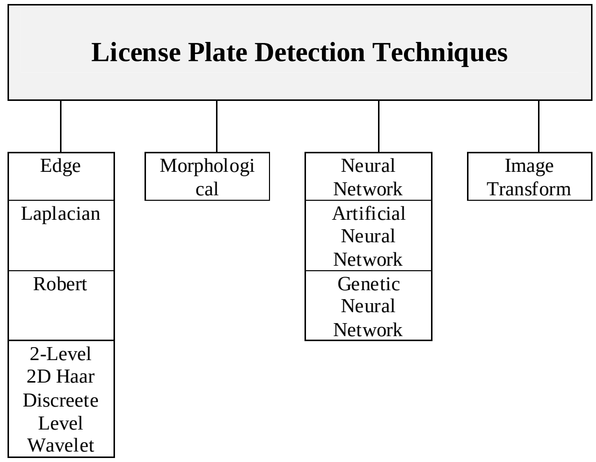

Figure 1. Classification Diagram

Some of the related works in the field of automatic car plate recognition are as follows. Lotufo, Morgan and Johnson [16] proposed automatic number-plate recognition using optical character recognition techniques. Abolghasemi and Ahmadifard [17] proposed an IFT-based fast method for extracting the license plate. Zamani and Movahedi [18] proposed a morphologic method for extracting the license plate using some simple constant templates. In this paper, we introduce a novel method for license plate. Figure 2 illustrates a typical license plate recognition system.

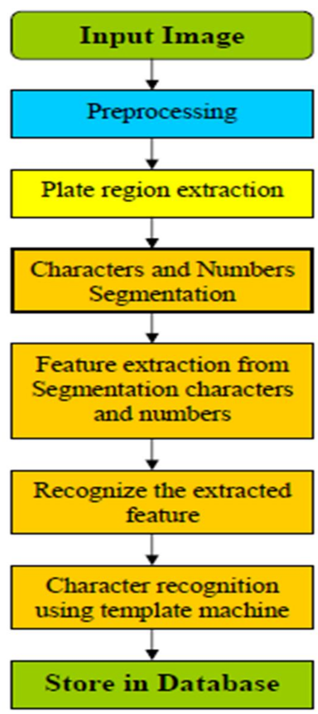

Figure 2. An automatic vehicles License Plates Recognition system

In the recognition from a gray scale image of the car, first use a preprocessing stage that contains a certain number of transforms established heuristically for reduces the extra information of car picture. Input of the car plate detection and recognition system is the binary image that obtains form preprocessing stage. Next, start a process for identifying and isolation of the car's license plate from the image, then the result of this process send to segmentation part. Segmentation part separates the characters individually. Finally recognition part recognizes the characters giving the result as the plate number.

License plate location is an important stage in vehicle license plate recognition for automated transport system. We present a real time and robust method of license plate detection and recognition based on the morphology and template matching. In this system the main stage is isolation of the license plate, from the digital image of the car obtained by a digital camera under different circumstances such as illumination, slop, distance, and angle. The algorithm starts with preprocessing and signal conditioning. Next license plate is localized using morphological operators. Then a template matching scheme will be used to recognize the digits and characters within the plate. The system is tested on Iranian car plate images, and the performance was 97.3% of correct plates identification and localization and 92% of correct recognized characters. The results regarding the complexity of the problem and diversity of the test cases show the high accuracy and robustness of the proposed method. The method could also be applicable for other applications in the transport information systems, where automatic recognition of registration plates, shields, signs, and so on is often necessary.

In this paper we have total of 10 sections, in section 2, 3, 4, 5 and 6 each sub-section elaborates the technique for license plate detection and its limitations; in section 7, 8 and 9 our methods is proposed, implemented and comparison in form of table is given with previous of them. In the section number 10 we have provided conclusion.

2. Edge Detection Approaches

2.1. Sobel Operator

It is one of the most useful techniques in image processing very popular in image processing as shown in the application of License Plate Detection [19, 20, 21, 22, 23, 24]. Sobel Operator is a classical edge detector. With the License Plate of small integer valued filter into vertical and horizontal directions by using of (3x3) mask to convolve the image. The mask preferred is applied to the whole image and this mask process square pixel at a time on image. It represents a two dimensional spatial gradient measurement. Due to small integer values the Sobel operator is relatively expensive.

Level 2D Haar Discrete Wavelet

2-level 2D Haar DWT method is an excellent method for detecting edges. It gives more detail about the vertical edge density and intensity of License Plate separately. It also removes that object which contains less information that causes the noise in the vertical edges background. In short, it differentiates between vertical edges and background noise. It works based on the gray scale image, first of all gray scale images converted and divided into four sub band images through 1-level 2D Haar DWT. After completing the whole process it detects the license plate [25].

Canny Operator

First of all convert the RGB image to gray scale image and then remove noise from the image then apply the canny edge detector on the image. The canny edge detection provides an exact detection of the License Plate and provides better

Localization with very minute difference within the actual and provided edge [11]. The boundary of the object is represented by edges. Edges are also used to identify areas and shapes of the object.

Robert Operator

It computes the 2-D spatial gradient measurement and also highlights the high spatial gradient region corresponds to edges. It consists of a 2x2 convolution mask. In [3] it detects the license plate of the input image by down sampling. In [12] Robert operator first starts to detect the vertical edges of the input image and then it filters the image to get its horizontal edges.

Laplacian Edge Detection

The Laplacian is a 2D isotropic measure of the 2nd spatial derivative of an image. It is similar to as Sobel operator. The only difference among them is that the Laplacian uses only one mask for both horizontal and vertical direction as in [12, 13]. The mask approximates second derivate of the image and is very sensitive to noise. Noise reduction LOG is used which first smoothens the image with Gaussian filter and then applies Laplacian operator [12].

3. LPL System

Since our approach does not need color information, the system is able to locate license plates with different colors. The overview of the algorithm is shown in figure 3. Figure 4 depicts a sample of input image, which is gray-scale (figure 5).

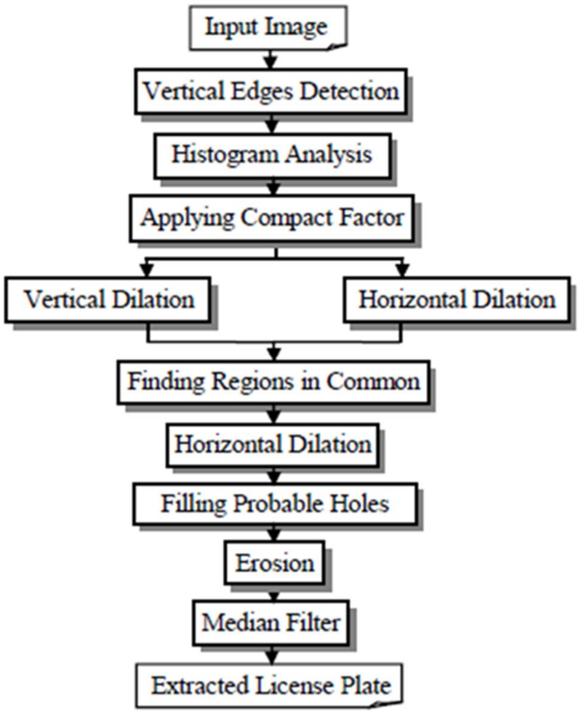

Figure 3. License plate recognition process

4. Vertical Edges Detection

Due to digits and characters, a license plate contains many vertical edges. This feature is employed for locating the plate in an image. Many approaches has been proposed for edge detection. Sobel mask has a good performance compared with others; indeed, it is fast and simple. In general, there are two masks for Sobel, horizontal mask and vertical one. Figure 3 shows these masks. We just use the vertical mask of Sobel. Supposing that the input image is not highly tilted, vertical edge detecting plays its role well enough. The result of edge detection is depicted in figure 6.

5. Histogram Analysis

Now we employ histogram analysis and find vertical projection of the edge image. To do this, we calculate the number of "ones" for each row of the image. Vertical projection is a diagram with two axes; vertical axis is the rows of the image, and horizontal axis shows the number of white pixels in each row. Figure 5 shows the vertical projection of the edge image too. Figure 6 illustrates candidate regions without considering compact factor. The above region is omitted if we consider this criterion. The rows corresponding to the license plate usually have the highest values in the vertical projection. For this reason, the next step is finding the rows with the c% highest values in the projection. These are candidates for license plate. For reducing noise effects, a row is considered as a candidate, not only when its value is c% above, but also when the value of the next row is d% the value of the row. Simulations find values for c and d. We consider f rows before and after each candidate row as candidates too, and we continue processing on the regions determined by them.

Figure 4. A sample of database, input image

Figure 5. Vertical edge detection result

Figure 6. Candidate regions in vertical edge image

Figure 7 is the resulted candidate image, and Figure 8 is for comparison with the input image.

Figure 7. Candidate regions in input image

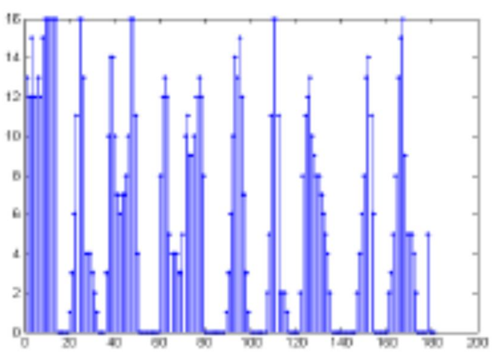

Figure 8. Histogram brightness of pixels of row 325

6. Definition of compact factor

Due to vertical edges of structures such as fences or some parts of the vehicles, they can be selected as candidate regions. To prevent this, we propose the compact factor. A License plate has vertical edges in a narrow range, but those structures have vertical edges in a wide range. This feature is used in compact factor. This means that if we can calculate the quantity of compactness of the vertical edges, we can easily classify them. A simple criterion for this purpose is the number of deviations between “ones” and “zeros” and vice versa for each candidate row. The rows with e% minimum values belong to plate, so we omit the other rows from candidate regions. Vertical edges of the plate are close to each other, so for a row in the plate region, there so many cases in which consequent points are totally “ones” or “zeros” and this makes the deviations minimum. Simulations find the acceptable value of e. For evaluating the performance of compact factor, refer to figure 9. As it is shown in its vertical projection, fence structure of the vehicle is also considered as a candidate region. Local maximum in the row 116 is due to this fence structure, as maximum in the row 325 is because of the plate. These two rows are shown in figure 10 and 11.

Figure 9. Resulted image after employing median filter

Figure 10. The extracted license plate of figure 2

7. Experimental

The proposed method in the case of very low resolution and contrast is unable to perform its task well. There are some probable faults listed here:

- Fault No. 1: Extracting a region larger than the plate
- Fault No. 2: Extracting a region smaller than the plate
- Fault No. 3: Extracting a wrong region as the plate
- Fault No. 4: Being unable to extract any region

7.1. Dilations

Now we use a morphological operator. The image of figure 4 is once dilated horizontally and the other time vertically. Another horizontal dilation is employed on the common bright pixels of these two dilated images. The structuring elements of dilations are 6-pixel horizontal or vertical lines.

8. Result

The Database contains 400 images different in size, background, camera angle, distance, and illumination conditions. The performance of the system for c=15, d=70, f=20 and e=10 are shown in table 1. The performance of the method of [12] with our database is also illustrated in this table. Table 1 also shows the computational time needed by these methods for a typical 384*288 image [13]. We use a personal computer, Pentium-4 2.4 GHz, 256 MB RAM, for implementation. As it is shown, the proposed method is not only faster than the method of [12], but also it has a better performance on our database. The enhanced image undergoes the process of segmentation done using morphological operators. The segmentation is the process of partitioning the image into multiple segments. It is to simplify the representation of the image. The enhanced image is been segmented using morphological gradient operators.

Table 1. Comparison of the performance of two methods

		Correct location	Fault No. 1	Fault No. 2	Fault No. 3	Fault No. 4
No. of samples	Proposed method	334	31	17	11	7
	Method of [13]	307	23	61	9	0
Rate of correct location (%)	Proposed method	83.50	7.75	4.25	2.75	1.75
	Method of [13]	76.75	5.75	15.25	2.25	0.00
Computational time (ms)	Proposed method	32.4				
	Method of [13]	47.9				

9. New Morphology

In this part, we firstly convert the RGB color input image to a 256 gray scale image. Applying the closing operation on edge image in the horizontal direction yields several connected regions which are plate candidates. With respect to a license plate shape, a rectangular structural element is used. The main motivation to focus on morphology was the rectangle shape of the plates. However, there may be more than one candidate region as plate location in the image after closing. To find the correct region and discard the others, some features such as shape, aspect ratio, and size of the plate are tested for all regions where this filter considerably reduces the noise. The processed image on input image (figure 11) after these stages is as shown in Figure 12, while Figure 13 illustrates some Iranian care plates. Character segmentation is an important stage in many license plate recognition systems. There are many factors that cause the character segmentation task difficult, such as image noise, plate frame, rivet, and rotation and illumination variance [26, 27]. Preprocessing is very important for the good performance of character segmentation. Firstly, image is filtered for enhancing the image and removing the noises and unwanted spots. During the threshold processing on a gray scale Image, many small objects or points accrue in the threshold image due to the problem of different illumination, low quality cameras and motion effect. This kind of noise gives direct effect on segmentation and recognition process. We have used a morphological process which search the entire image for small connected elements and remove it. Then dilation operator is applied to the image for separating the characters from each other if the characters are close. After this stage, partition scanning is proposed to extract characters from plate. This method is conducted by checking the mean of each partition in image (the size of partition of a character or background. In this process, the background is defined as white (1) and characters are defined as black (0). After some experiments, it is concluded that the optimum threshold value is nearly 0.7-0.8. Partition value larger than 0.7-0.8 is considered as background, otherwise it is considered as character. Then the plate is divided into two blocks. The first block contains digits, and the second block contains the letter (Figure 13).

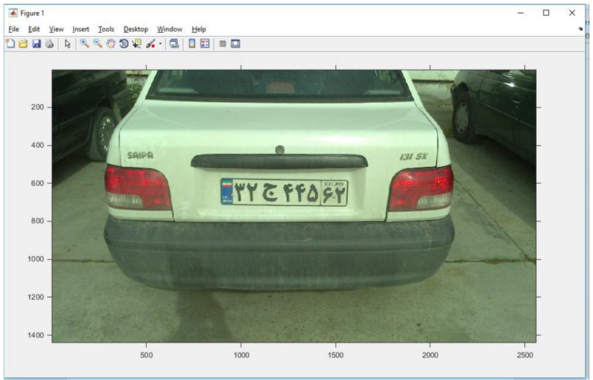

Figure 11. input image

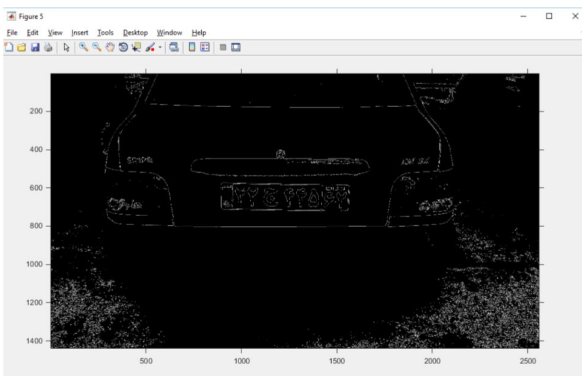

Figure 12. morphology method

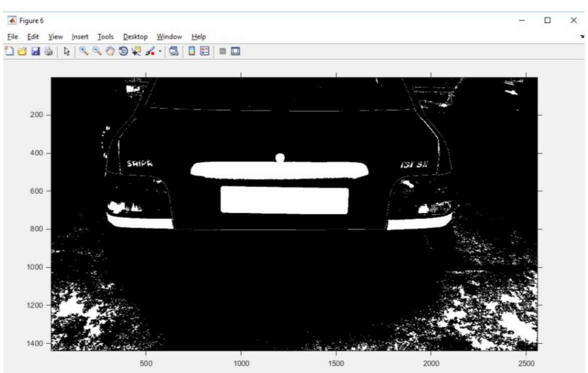

Figure 13. Detection location of plate

Before employment of the recognition algorithm, the characters would be normalized. Normalization is to refine the characters into a block containing no extra white spaces (pixels) in all the borders of the characters. Then each character is fit to a 38x20 block as shown in figure 14. Fitting approach is also necessary for template matching. For matching the characters with the database, input images must be equalizing to a 38×20 block with the database characters. In this system the characters are fit to 38×20. The extracted characters cut from plate and the characters on database are now equalized. The next step is template matching. Template matching is an effective algorithm for recognition of characters. The characters' image is compared to the ones in the database and the best similarity is considered. To measure the similarity and find the best match, a statistical method correlation based is used. Correlation is an effective technique for image recognition. This method measures the correlation coefficient between a number of known images with the same size unknown images or parts of an image with the highest correlation coefficient between the images producing the best match. This system used the database as the Iranian license plates characters all 25 alphanumeric characters (16 alphabets and 9 numerals) with the size of 38x20.

Figure 14. Extract plate using morphology method

Due to the similarities of some characters, there may be some errors during the recognition phase. The confused characters mainly are "ب" and "ت". To increase the recognition rate, some properties of each character are used in the system for the confused one to define their special feature of vectors. With these feature the applied tests show a serious increase in the correct recognition rate.

9.1. Result

Experiments have been performed to test the proposed system and to measure the accuracy of the system. The input images are colored images with the size of 640x480. The test images were taken under various illumination conditions and distance. The results of the tests are presented in Table 1. It is shown that accuracy for the extraction of plate region is %97.3; %94 for the segmentation of the characters and %92 is the percentage of accuracy of the recognition unit. Tested on ten different cars, Figure 15 shows the outcomes of the system.

Table 1. Experiments Results

Applied stages	Number of correct detection	Percentage of Accuracy (%)
Extraction of Plate Region	12/30	48%
Segmentation	15/30	50%
Recognition of Characters	18/30	97%

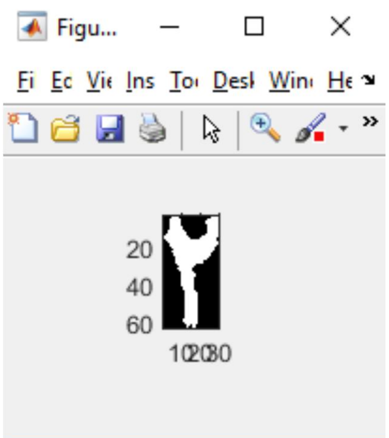

Figure 15. Segmentation, Normalization, and the final Character Recognition

The basic elements of a CLPR (Car License Plate Recognition) system are presented in this paper, generally accenting on the problems of LPL (License Plate Localization) instead of the LPCR (License Plate Character Recognition) therein. This reflects the LPL specifics of CLPR application, where the problems of LPCR are usually considered priori resolved by usage of conventional OCR (Optical Character Recognition) software. The goal of the research is to investigate the possibility to create a comprehensive system for multinational vehicle identification based on the license plate recognition. In that case no additional hardware such as transmitters mounted on the vehicle or additional sensors are required. The preliminary results obtained on real data are quite satisfactory. They could be summarized as follows:

- Reliable verification of the plate candidate generated at the phase of localization is achieved.
- Accurate plate segmentation under varying illumination and various image distortions is obtained.

In vast majority of classes the plate was contained into one of the detected prospective horizontal strips (plate candidates). Only few images of extremely poor quality (poor contrast and missing part of the plate) attempted more than three prospective strips.

10. Conclusion and Future Work

In this paper, we presented a novel method of identifying and recognizing of Iranian car license plates. Firstly we extracted the plate location, and then we separated the plate characters by segmentation and applied a correlation based template matching scheme for recognition of plate characters. This system is customized for the identification of Iranian license plates. The system is tested over a large number (more than 150) of images, where this algorithm performs well on different types of vehicles including Iranian car and motorcycle plates as well as diverse circumstances. Finally it is proved to be 48% correct in the extraction of plate region and 50% correct in the segmentation of the characters and 97% in the recognition of the characters. We believe that this system can be redesigned and tested for multinational car license plates in the future time regarding their own attributes.

Also In this paper, we proposed a real time and robust method for license plate location. Images of our database are complex and different in size, background, camera angle, distance etc. Considering all of these, the proposed method has the correct location rate of 83.50%. Preparing and introducing a standard database for making comparisons between proposed methods in this field is an essential work for future. Relating to the proposed method, finding some ways to calculate the optimum values for parameters such as *c*, *d*, *e* and *f* can be another future work.

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