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A novel and robust method for automatic license plate recognition system based on pattern recognition

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Abstract

In this paper, for finding the place of plate, a real time and fast method is expressed. In our suggested method, the image is taken to HSV color space; then, it is broken into blocks in a stable size. In frequent process, each block, in special pattern is probed. With the appearance of pattern, its neighboring blocks according to geometry of plate as a candidate are considered and increase blocks, are omitted. This operation is done for all of the uncontrolled blocks of images. First, all of the probable candidates are exploited; then, the place of plate is obtained among exploited candidates as density and geometry rate. In probing every block, only its lip pixel is studied which consists 23.44% of block area. From the features of suggestive method, we can mention the lack of use of expensive operation in image process and its low dynamic that it increases image process speed. This method is examined on the group of picture in background, distance and point of view. The rate of exploited plate reached at 99.33% and character recognition rate achieved 97%.

Keywords: *license plate recognition, HSV, Character segmentation, Character recognition.*

1. Introduction

Automatic license plate recognition plays an important role in numerous real-life applications, such as 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]. In the most of present methods, the conditions of environment and plate, effect on the performance of the method, therefore these methods have limitations. So, reaching the methods that offer the acceptable results is 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. To detect the region of car license plate, many techniques have been used. In [12] and [13] combination of edge statistics and mathematical morphology showed very good results, but it is time consuming and because of this problem, [14] uses block-base algorithm. In [15] a novel method called "N row distance" is implemented. This method scans an image with N row distance and counts the existent edges. If the number of the edges is greater than a threshold then the license plate is recognized, if not threshold have to be reduced and algorithm will be repeated. This method is fast and has good results for simple images. Disadvantage of this paper is that the edge based algorithms are sensitive to unwanted edges such as noise edges, and they fail when they are applied to complex images. A wavelet transform-based algorithm is used in [16] for extraction of the important features to be used for license plate location. This method can locate more than one license plate in an image. Methods which are symmetry based are mentioned in [17].

In [18], firstly, it takes the input image into a grayscale, then for analyzing the location of plate the operation of morphology such as erosion and dilation is applied, and the plate is extracted with use of vertical and horizontal projection among various candidates. In [19] the plate is a location with the black background and white writings. In this way that, firstly, takes the image into the HSI and applies the capability of being black color of its background for this purpose, 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, then labels the existing candidates and 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. The current paper aims at investigation into and identification of the novel Iranian plate characterized by both inclusion of blue area on it and its geometric shape. Obviously, the suggested system contains suitable velocity due to not making use of heavy pre-processing operation such as image-improving filters, edge-detection operation and omission of noise at the beginning stages. So, the recommended method of ours is compatible with model-adaptation, i.e., the very blue section of the plate so that the present method indicated the fact that if several plates are included in the image, the method can successfully manage to detect it. In section 2, the proposed method is elaborated, in section 3, the character segmentation and recognition, in section 4, the practical result of the paper and in section 5, conclusion is presented.

2. Proposed method

Proposed method, consisted of 2 parts which in the first part, the entire candidate of plate place is exploited and in the second part, the real place of plate is determined among exploited candidates with use of plate geometry and characters density. If there are several plates in image, the proposed method will find it. General diagram of first part is shown in Figure 1.

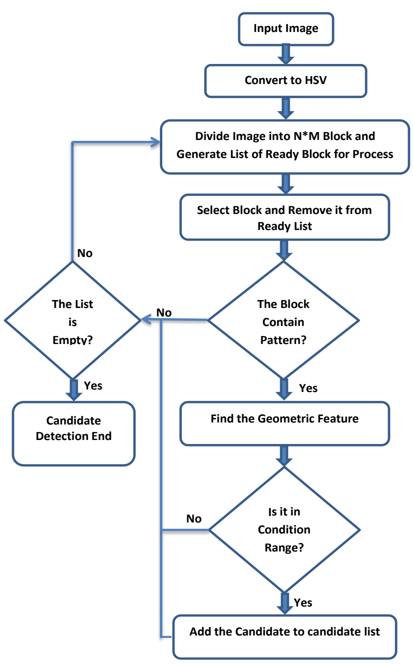

Fig. 1 First part of proposed method

In the proposed method at first time, entrance image is taken to HSV color space for recognizing pattern. Then instead of processing the entire image, the image is broken to list of preparatory blocks and in order during frequent process, blocks are selected. The existence a blue area is investigated in it. For investigate of blocks only its lip pixel used, that are consisted of 23.44% of block pixels. Whenever a block with blue area is found, by investigation its top, down and side blocks and geometry ratio of plate, the considerable place is selected as a candidate and is added to list of the candidates. Upper operation is continued to finishing of all blocks.

2.1 HSV color space

Even although RGB color space is ideal for monitor, it is unnatural for human being. For stance, recognizing how to make a color lighter in RGB color space is more difficult work. It is easier for human to use hue, saturation and brightness features for explanation [20]. The superior of this color space to RGB, is lack of relation between producer elements hue, saturation with brightness amount. Whereas plate number recognition system is made by subjectivity that human has from colors. So, use of suitable color space is necessary for carefulness in work. In Figure 2 is shown 2 different faces of HSV color space. Figure 3 shows the result of operation of HSV color space for entrant picture.

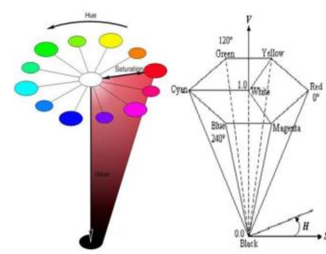

Fig. 2 HSV color space

Fig. 3 (a) Entrance image in RGB mode and (b) Image in HSV mode

2.2 Determination of plate candidates

For determine plate location after changing an image to HSV color space, the image is broken to blocks in N*M size, that N and M amount as practical result and data set from [21], is obtained in order 16, 16. After creation of lists from blocks in order bottom corner and left hand are being started to evaluate because of blue area in left hand and bottom. In evaluating every blocks only its lip pixels that it consist 23.44% of it, reevaluated. If in evaluating, the blue pixel is found the evaluating will be done for whole pixel of blocks. Then with evaluating of it’s up and down blocks we can find the steady blue area height then the width of blue area is measured. If the width and height

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of blue area that is selected as a pattern be in standard limit, plate height is obtained equally with the blue area height. And its width is obtained by increasing the height 8 times. Amount of HSV is obtained from below relation as practical results.

```
For   Each Pixel of Blocks
If (0.58<=H<= 0.74) and (S>0.45) and (V>= 0.5)
 Pixel color is BLUE
End
```

By finding candidate area this area is added to plate candidates list and increase blocks that are in this area are omitted from preparatory blocks list and operation is done on reminder blocks. In this algorithm the worst state is happened if the plate isn't in image or it is scratched. In this state all blocks will be studied and therefor 23.44% of image will be processed.

2.3 Detection plate places

The total diagram of algorithm of plate recognition is show in Figure 4. In this algorithm, first the exploited candidates from last step are numbered. And in a repeated process are evaluated the number of color change. If evaluation of a candidate is successful, the plate tilt will be solved. And its plate kind such as governmental, public, private will specify.

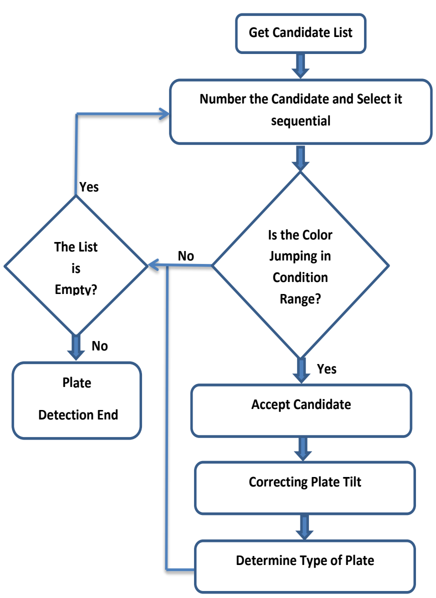

Fig. 4 Detection plate places algorithm

2.4 Color jump Testing

In this step for determining that whether candidate is considered as place or not, with regard to the plate area consists of successive 8 characters and its color violence change rate is more than to other area these features are used for the plate specifying. For determining of a color change range, in every line the number of color change is counted from white color to black color or inverse. If the number of color change is more than K amount and successive line numbered more than T, this area as a plate area is considered. T and K amount as practical result is obtained in order 11, 15. Below code shows the color change testing algorithm for plate recognition.

```
Function Candidate Plate Color_Jump Testing (Candidate Plate)
 [n, m]=size (Candidate Plate)
 For i=1: n
  Test= Candidate Plate (i, 1);
  Count=0;
          For j=1: m
            If Test~= 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: n
          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)   }
```

After the candidate validated as a plate, it located in oblong and if it consist tilt it will be solved. Figure 5 shows exploited plate from entrance image of Figure 3.

Fig. 5 The image of extracted candidate

2.5 Correction the plate tilt

In the process of the vehicle license plate recognition, the tilt of license plate has significant influence on the

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character segmentation, identification of patterns and the final recognition results [22]. So at this stage, first, by using the plate features that is determined by the candidate, the image of plate is extracted of 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 is 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. In this paper this method is used to remove the plate rotating that shows the good result about 45 degrees.

2.6 Determine type of plate

For specifying the kind of Iran country plates that are in three categories: 1) the public in yellow background, 2) the government in red background and 3) private cars in white background, are known. The below algorithm is used, that it recognize the most of the color frequencies as a plate kind.

```
For each pixel in Plate
Start
If (S>=0.45 and V>=0.5)
        {
          If (0.8<=H) OR (H>=0.94)
            {     Pixel color is RED
            }
          Else if (0.58<=H<=0.74)
            {
                  Pixel color is YELLOW
            }
        }
Else if (S<=0.15 AND V>=0.8)
        {
        Pixel color is White
        }
End
Type=max (RED, YELLOW, WHITE)
Show ("Type of Plate Color is (Type)");
```

3. Character segmentation and recognition

At this stage the plate characters are distinguished and then, recognized by the normal factoring.

3.1 Character segmentation

To isolate the characters of car license plate, many techniques have been used. In [23], the extracted license plate is resized into a known template size. In this template, all character positions are known. After resizing, the same positions are extracted to be the characters. This method has the advantage of simplicity. However, in the case of any shift in the extracted license plate, the extraction results in background instead of characters. Since characters and license plate backgrounds have different colors, they have opposite binary values in the binary image. Therefore, some proposed methods as in [24]-[35] project the binary extracted license plate vertically to determine the starting and the ending positions of the characters, and then project the extracted characters horizontally to extract each character alone. Segmentation is performed in [36]–[41] by labeling the connected pixels in the binary license plate image. The labeled pixels are analyzed and those which have the same size and aspect ratio of the characters are considered as license plate characters. This method fails to extract all the characters when there are joined or broken characters.

In this paper from last step, the area that is exploited as a plate, first probable noising are solved, then plate image is complemented till its writing of plate inside is seen such white violence. Figure 6 show the works of operation on Figure 5. Then this area is labeled and through the available regions, the regions that are bigger are stored as exploited characters. Figure 7 shows histograms of Figure 6 witches the most space are relevant characters.

Fig. 6 License Plate after removing the available noise and complementation

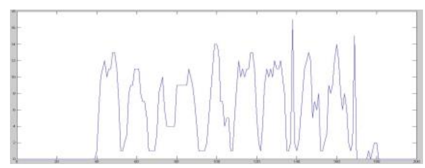

Fig. 7 Histogram of extracted plate

3.2 Character recognition

The extracted characters are then recognized and the output is the license plate number. To recognition the characters of car license plate, many techniques have been used. In [42], the feature vector is generated by dividing the binary character into blocks of 3×3 pixels. Then, the number of black pixels in each block is counted. In [43], the feature vector is generated by dividing the binary character after a thinning operation into 3 × 3 blocks and counting the number of elements that have 0°, 45°, 90°, and 135° inclination. In [44], the character is scanned along a central axis. This central axis is the connection between the upper bound horizontal central moment and lower bound horizontal central moment. Then the number of transitions from character to background and spacing between them form a feature vector for each character. This method is invariant to the rotation of the character because the same feature vector is generated. Template matching is performed in [45] - [48] after resizing the extracted character into the same size. Several similarity measuring techniques are defined in the literature. Some of them are Mahalanobis distance and the Bayes decision technique [46], Jaccard value [47], Hausdorff distance [48]. The method is used in this paper is a function as normal factor that studies the features of characters deposit. Based on this features the exploited character image is compared with the prepared sample that were known before. By rely on this base, two similar images in the same weight upon each other can deposit. So the normal factor is introduced in below shape:

$$NF = \frac{\sum_{i=0}^{m}\sum_{j=0}^{n} T_{i,j} \cdot M_{i,j}}{\sum_{i=0}^{m}\sum_{j=0}^{n} T_{i,j}}$$

$T_{i,j}$ is the weight of sample characters and the model that was known. $M_{i,j}$ the binary image is extracted characters of plate. NF is the number between 0 and 1 that more amounts shows more similarity.

4. PRACTICAL RESULT

Our suggestive method have been done on Intel Core i3-2330M CPU, 2.20 GHz with 2 GB RAM under Matlab environment. Figure 8 shows the face of worked systems.

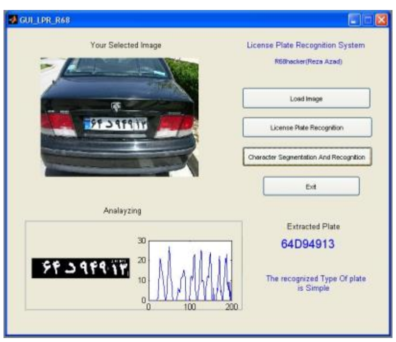

Fig. 8 License plate recognition system

That implemented by Matlab graphical interface. The suggestive method is robustness against parameters such as: the different size and situation of plate in image, the view of videotaping and different light situation in videotaping, injuries and pollution of plate. In suggestive method when vehicle plate has tilt, the system is able to identify and solve it. For solving the plate tilt in this paper, the object orientation method is used. As practical results that are done on the images, in the image that plate area is recognized correctly the success rate of this operator has been gained to 100%. Figure 9 shows sample image that the plate has tilt but the system has known and solved it correctly.

Fig. 9 the image of vehicle's plate with title

The data set that is used in this paper consists of 150 colorful images in 640*480 sizes from [21]. These images are variety in point of view, good light balance, various distances and various backgrounds. The result of the proposed method for license plate recognition compared with [21] is shown in table 1.

Table 1: The result of license plate recognition

Method	**Total**	**Correct plate recognition**	**Correct character recognition**	**Percent efficiency for each part**	
Our Method	150	149	145	99.33	97
[21]	150	147	138	98.20	92

The case which the system isn't able to recognize plate location it is because of lack of light. Figure 10 shows the sample of images from [21] that the system be able to recognize them.

Fig. 10 Sample of images that system recognized correctly

In general, the advantages that are presented in this paper compared to 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,
- Ability to detect multi plates in an image,
- Detecting all plate types of Iran e.g. public plates with yellow background and governmental plates with red background,
- Recognizing private, governmental and public plates.

5. Conclusions

In this paper, for vehicle plate recognition, the fast method in comparison with methods that are in the same rank is presented, the owe showing the best result. In this method first, for recognizing, the pattern of entrance image is taken to HVS color space; then by image blocking and exploiting the pattern area, a candidate of exploited image was evaluated. This method is formed on the features of standard Iranian plate -8 writing in plate, plate writing in 3 colors white, red, yellow; the blue area is in the left hand-in regard to probing 23.44%, whole image whose border is the investigated blocks. The operation burden is reduced remarkably. In suggestive system, if the plate had a tilt, its tilt would be solved. And it will be recognized correctly. The suggestive methods expressed in this paper is tested on[21] that the success rate of plate place is received to 99.33% and character recognition reached to 97%; so, this state shows the high efficiency rate of top expressed method.

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