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Vehicle License Plate Localization in Image Using Edge Statistical Features and Morphology

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Abstract: This study presents an algorithm based on edge statistical characteristics and morphology for license plate detection in images. The proposed method is highly efficient using edge statistical characteristics. The method is subdivided into four steps. Firstly, the proposed method is majorly characterized with vertical edging, as several numbers of license plate may resemble vertical lines like a 1D barcode. Next, the edges are statistically analyzed; then, license plate is hieratically located and finally, the license plate is extracted from image by morphology. The proposed algorithm accurately and rapidly locates license plates. The 9786 of 9825 license plate images in a real database were identified with the accuracy of 99.6%.

Key words: License plate location, statistical features, edge detection, hierarchical license plate location, morphology

INTRODUCTION

In modern societies, highways significantly contribute in transportation. Smart transportation is largely interested and developed throughout the world. License plate recognition is considered as critical research titles. License plate recognition is mainly used in traffic monitoring system such as traffic volume control, vehicle automate labeling and the like. License plate recognition system generally consists of three parts including license plate recognition, characters partitioning and characters identification. The most important of which is license plate location. To attain rapid and successful extraction process, it requires many problems such as poor quality images resulted from improper lighting as well as license plate angle in image are removed. In past, multiple approaches were applied for license location such as morphologic operations (Bai *et al*., 2003; Hsieh *et al*., 2002) edge extraction (Yu and Yong, 2002; Parker and Federl, 1996; Rovetta and Zunino, 1999; Lee *et al*., 1994) gradient feature composition (Kim *et al*., 2002) neural network for colored images and vector quantization (Martin *et al*., 2002).

Lee *et al*. (1994) used standard recurrent neural network for extracting Korean license plate through using HLS color space. However, improper results obtained due to major faults of neural network and color impermanent characteristics. Vector quantization depends on rough lighting, glim and hit-strike like spots. Figure 1 represents the proposed system consisting of four parts. Vertical edging is initially completed; then, edge statistical features are processed. Next, license plate is hierarchically identified and finally, license plate location is extracted. The 9825 images were used in experiments for lightings in various directions in 9786 images of which license plates were accurately located at the precision level of 99.6%.

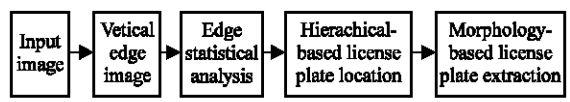

Fig. 1: The proposed method algorithm

MATERIALS AND METHODS

License plate location: As seen in Fig. 1, license plate is automatically extracted in 4 steps of vertical edge detection, edge statistical feature analysis, license plate hierarchical localization and morphological operation discussed as follows.

Vertical edge detection: If there is a high contrast between the subject and the background, the edge is where changing from background to the subject. There are several edge detection approaches including Laplacian, Robert, Kenny and Zoble edge detectors. However, license plate images maintain many horizontal

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edges greatly influencing license plate localization. Horizontal edges by Eq. 1 and vertical edges by Eq. 2 are shown in Fig. 2. It is observed that vertical edge detector outperforms horizontal detectors. A linear filter is used prior vertical edge detector for image smoothing; in addition, image brightness is also normalized to decrease light and shadow effects in image:

$$G_H(i,j) = \left| \begin{matrix} \left[f(i-1,j-1) + 2f(i-1,j) + f(i-1,j+1) \right] - \\ \left[f(i+1,j-1) + 2f(i+1,j) + f(i+1,j+1) \right] \end{matrix} \right| \quad (1)$$

$$Gv(i,j) = \left| \begin{matrix} \left[f(i-1,j-1) + 2f(i,j-1) + f(i+1,j-1) \right] - \\ \left[f(i-1,j+1) + 2f(i,j+1) + f(i+1,j+1) \right] \end{matrix} \right| \quad (2)$$

Where:

$f(i, j)$ = Input grey image after smoothing and normalization

$G_H(i,j)$ and $G_V(i,j)$ = Horizontal and vertical edge detecting

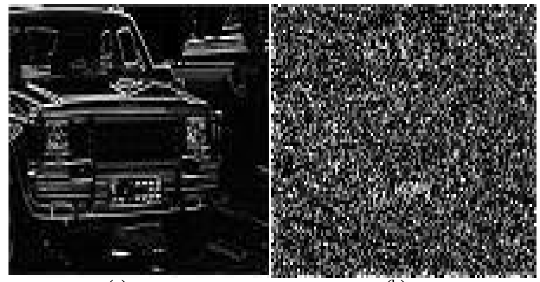
Edge feature statistical analysis: Highway images show large changes such as change in brightness level, context and background and changes in license plate surfaces, etc. Therefore, edge threshold may not be randomly identified. The 4 various thresholds were selected following a license plate features. Candidate areas are recognized step by step including point to line conversion, lines to polygon conversion and finally, removing or combining the polygons. Therefore, there are 3 steps here.

Forming line: The points obtained by edge detection are known as feature points horizontally scanned; then, if the distance between 2 feature points is smaller than the maximum length, the points are joined together forming a line. Finally, a set of lines is obtained. Density of points is measured by Eq. 3. If the obtained density is within the given minimum and maximum, the line is maintained; otherwise, it is removed. Minimum and maximum are determined according to license plate characters.

$$\text{Poi nt density online} = \frac{\text{Line length}}{\text{Points on line}} \quad (3)$$

The remaining lines of this phase are called feature lines.

Polygons: Polygons are formed like step 1. The shortest line is firstly identified in input image; next, if vertical distance of the two lines is smaller than maximum



(a) (b)

Fig. 2: a) Horizontal edge detection; b) vertical edge detection

distance, it may joint to the original line and an angle is formed; then, it is iterated for another line that may be added to the angle if it satisfies. Finally, multiple angles and polygons are attained. If line density is higher than the given minimum, the line is saved; otherwise, deleted.

$$\text{Line density in polygon} = \frac{\text{Polygonarera}}{\text{Lines in the polygon}} \quad (4)$$

The polygons obtained at this step are called feature polygon.

Combined polygons: The polygons are combined together due to roughness. There defined four communication positions for R1 and R2 as shown in Fig. 3. The candidate points are combined if they share equal width and orientation and a short distance. About 5 indicates polygons connection density.

$$D = \frac{\text{overlap}_v}{\min(h_1, h_2)} - \frac{\text{dis}_H}{\sqrt{w_1 \times w_2}} \quad (5)$$

where, overlap represents how much the two polygons vertically overlaps and this shows horizontal distance; h1, h2, w1 and w2 are the length and width of the polygon. If connection density is larger than threshold, the two polygons are combined.

License plate hierarchal localization: In a system, various thresholds are used for different scales in images to localize license plate (Fig. 4). Thresholds 64, 32, 16 and 8 are determined for 4 different scales. Feature points are less in the largest scale and system runtime is short; however, license plate is hardly located. Whereas, in the smallest scale, there are multiple feature points, long running time as well as many areas; however, most areas are wrongly detected as license plate.

As many candidates may be selected as license plate area, wrong candidates are removed through hierarchical

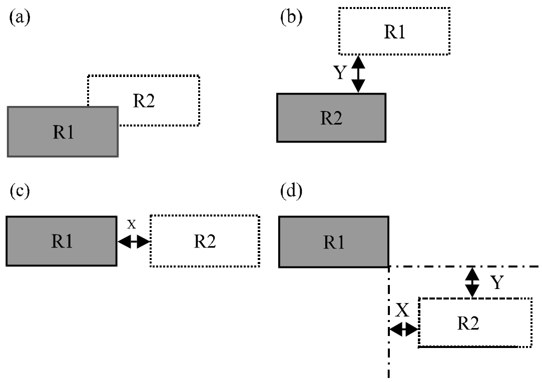


Fig. 3: Combined polygons: a) Internal relation; b) Vertical relation; c) Horizontal relation; d) Diagonal relation

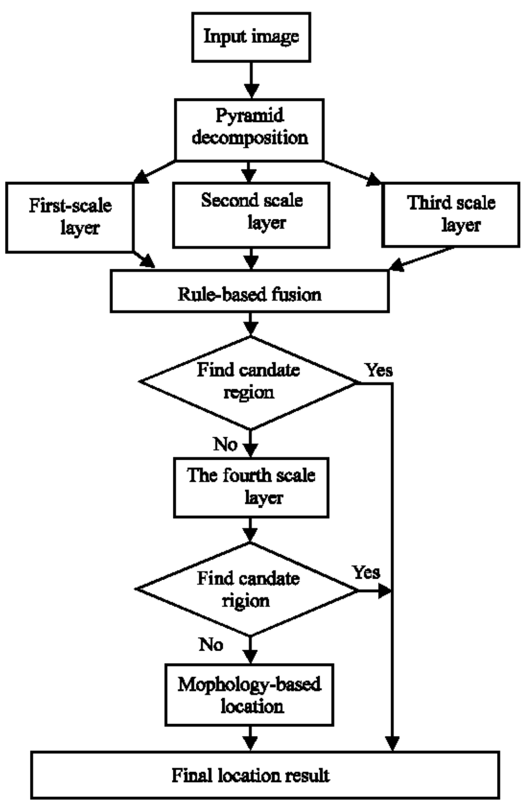


Fig. 4: Hierarchical localization flowchart

method. Clearly, the result of the 1st, 2nd and 3rd scales are integrated. Since, if license plate is identified in the 1st scale, it may necessarily be detected in the 2nd and 3rd scales. The 7-8 candidate areas remain following integration step; applying the following rules, 3 regions are only remained at the end:

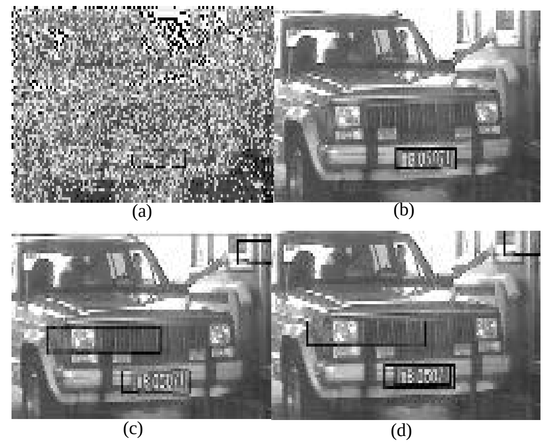


Fig. 5: Results of hierarchical step

- The 1st polygon in the first scale is prioritized
- The polygons at the lower parts of image are prioritized
- Polygons are prioritized that the length to width ratio is proportional to the license plate length to width ratio
- Internal areas go to step 2-2

If no candidate region after 3 scales is selected yet; then the 4th scale is used by hierarchical method. As there are many feature points in the fourth scale; so, multiple candidates will attain. Figure 5 shows candidate regions in 4 different scales. As seen, several undesired regions are detected as license plate in the 4th plate. In some images, license plate is worn or defected which is solved by morphological operations.

Morphological operations: The region where the license plate is located shows a high density edge. Thus, edge density is computed by adding all edge pixels using Eq. 6 in a 15×3 block centered at g (i,j). Figure 6a shows density of Fig. 2:

$$d(i,j) = \frac{1}{45}\sum_{x=-1}^{x=1}\sum_{y=-7}^{y=7} g_v(i+x, j+y)\,\text{Mask}(i+x, j+y)$$

where, d (i, j) shows edge density. Prior developing, using binary and non-linear filter, narrow horizontal lines are removed as these are selected through vertical edge detectors which are undesired. Otsu threshold method was applied for edge density thresholding by Eq. 6 as shown in Fig. 6b. Upper and lower edges are detected for any white pixels; if the height between higher and lower edges is smaller than T threshold value, the white pixel became black as background as shown in Fig. 6c. Then, the image is developed (extended) using a horizontal

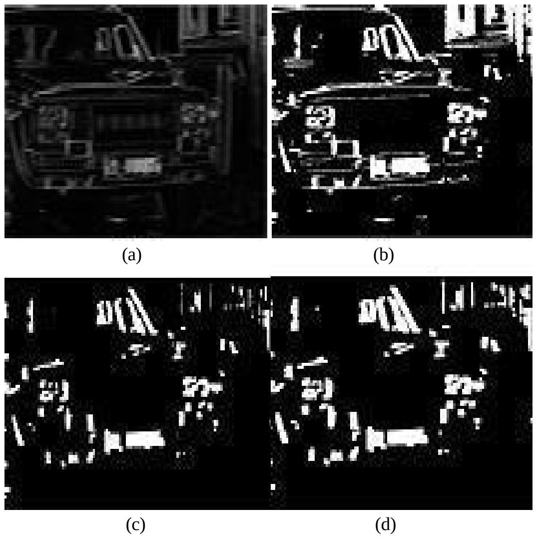


Fig. 6: a) Edge density; b) Binary; c) Non-linear filter; d) Expanding

Fig. 7: Experimental results

mask. The mask size is 1×9. At this step small blocks are connected to large blocks which is efficient for

Fig. 8: Experimental results and license plate extraction

next step. Figure 6d represents expanding results. After pre-processing, candidate regions are detected through following steps: analysis of interconnected components. This step is employed on prior processed images; in this regard, polygon boundary and inside pixels are obtained.

Feature extraction. According to aforementioned, some features of the region such as length to depth ratio, region area and density are obtained. According to obtained results, many regions are removed at this step and 1-5 candidate regions remain. Combining candidate regions, It is done like step 2-2. Obtaining the final region embracing license plate (Fig. 7 and 8).

RESULTS AND DISCUSSION

To evaluate the proposed method, the algorithm was implemented on 9825 color images and grey scale of 534×768. Images of highway cameras at different lightings (cloudy, sunny, day and night) and various vehicles were used for proper evaluation. Experimental results revealed that the proposed method could properly localize 99.6% of the license plates. The results are shown in.

CONCLUSION

This study introduced a method for vehicle license plate detection based on edge statistical features and morphology. The proposed method was subdivided into 4 studies of vertical edge detection, analysis of edge detection statistical features, hierarchical localization and morphology. Algorithm showed proper results and was resistant to intensity and various vehicles. Experimental results were also desired. It is recommended that license plates at different angles, hidden in some parts are investigated for further studies.

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