A Morphology Based Approach for Car License Plate Extraction

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Abstract – **Locating the car license plate in an image or video frame of a car is an important step in car license plate recognition/identification applications. This problem poses many challenges like location of license plate from images taken in poor illumination and bad weather condition; plates that are partly obscured by dirt and images that have low contrast. This paper presents a new morphology based method for license plate extraction from car images. The algorithm uses morphological operations on the preprocessed, edge images of the vehicles. Characteristic features such as license plate width and height, character height and spacing are considered for defining structural elements for morphological operations. Connected component analysis is used to select the band containing license plate from the candidate segmented. The experimental results with a reasonably large set of car images are very encouraging.**

Keywords – **computer vision system, Hough transform, morphology, Sobel operator, structuring element.**

I. INTRODUCTION

The automatic car license plate recognition/ identification is an important application of computer vision system. The objective is to extract and recognize/ identify vehicle registration numbers from car images without any human intervention. One of its main advantages is the ability to capture information in the plates, at high traffic flow and speeds, under conditions and speeds that human observers may find it difficult to manually record. Some of applications of such license plate recognition/ identification includes vehicular traffic logging, traffic control and law enforcements. The captured registration number can also be subsequently checked against a database of vehicle numbers, containing numbers of vehicles of entirely local interest such as identifying vehicles with access privileges to specified areas, lost or stolen vehicles. These sytems typically have two parts. The first part is to correctly locate and extract the license plate from car images and the next is to recognize/identify the license plate. This paper deals with the first part only.

There exist various approaches to extract license plate such as use of Hough transform, template matching and region growing. However these approaches have certain limitations. The candidate regions that can contain the license plate, as identified using Hough transform [1], often include regions other than those containing just the license plate. Also detecting actual vertical lines using Hough transform is more difficult as they are more prone to noise than horizontal lines. Template matching [2] usually takes more computation time and it is not invariant to scaling. Region growing [3] algorithm requires more memory as it involves recursion and performs satisfactorily only if the images are taken in good ambient lighting conditions.

In this paper, a new morphology based method to extract the licenses plate from the car image, has been proposed. An approach using Morphology has been reported by Martin et al [4]. The difference between our approach and the one used by Martin et al has been presented in Section 5. Our approach consists of mainly three parts viz. vertical edge detection, morphological operations, and connected component analysis. Sobel operator [5] is used to detect edges in vertical direction only since regions in the car image, excluding license plate, usually consists of more horizontal edges [6]. Characteristic features of license plate decide the size of the structuring element in morphological operations. Sequence of closing and opening operations are performed on binarized edge image to eliminate the some of the candidate regions not containing the license plate. However, in some cases, regions other than the one containing the license plate are still present after these operations. These cases are handled by using the number of eight connected components, of specified dimensions, within these candidate regions. The dimension of component is specified based on the height and width of the letters in the license plate. The region with specified number of components is selected as license plate. The basic morphological operations are mentioned in the next section followed by the details of the proposed methodology in section 3. The experimental results and conclusions are discussed in Sections 4 and 5 respectively.

II. MATHEMATICAL MORPHOLOGY

Mathematical morphology [6, 7] is a powerful tool for image analysis based on neighbourhood operations. The mask used for the neighbourhood operations is called structuring element (SE). An SE can have any size and geometrical shape. The shape of SE's widely used is in the form of line

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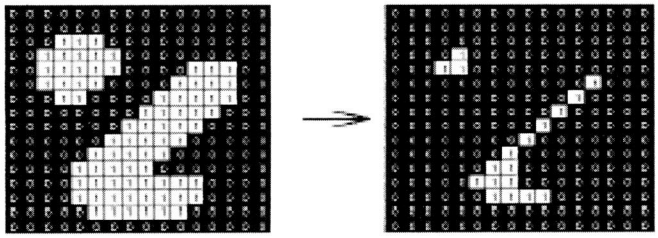

Fig. 1. Erosion (SE is 3x3 square with '1' at all positions)

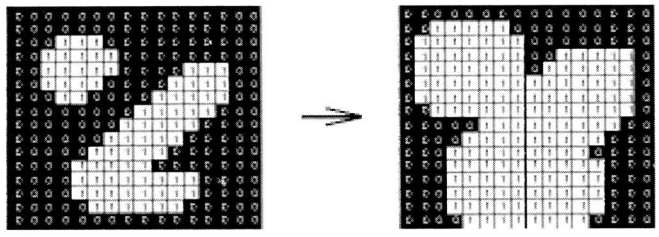

Fig. 2. Dilation (SE is 3x3 square with '1' at all positions)

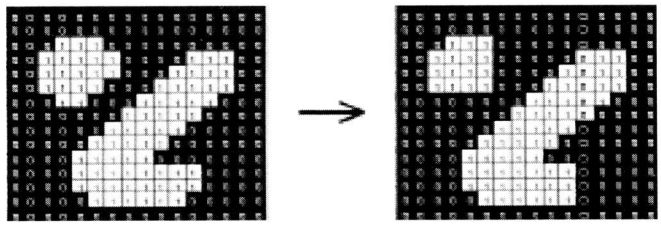

Fig. 3. Opening (SE is 3x3 square with '1' at all positions)

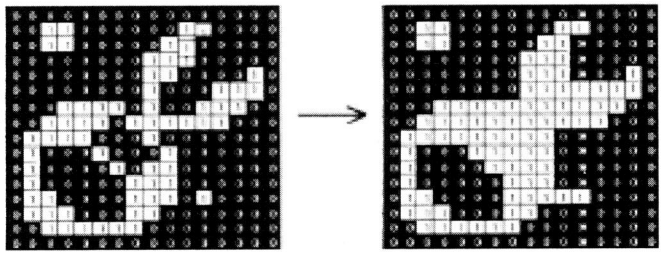

Fig. 4. Closing (SE is 3x3 square with '1' at all positions)

(generally horizontal or vertical). The basic morphological operations are erosion and dilation, which are carried out by convolving the SE with the image. Erosion is often used to remove irrelevant details from binary image and dilation is used to fill the gaps or holes. Erosion and dilation operations are usually combined and result in other two operations *viz.*, Opening, *i.e.,* erosion followed by dilation with the same SE and Closing *i.e.*, dilation followed by erosion with the same SE. Opening can erase white holes on dark objects (or can remove small white objects in a dark background). An object will be erased if the SE does not fit within it. Closing removes black holes on white objects. A hole will be removed if the SE does not fit within it. These operations are illustrated in Figs. 1 - 4. In erosion and dilation the SE is convolved with the image by sliding the SE over the entire image. In the process of convolution the pivotal element in the image (binary) is changed accordingly.

III. Proposed Methodology

The location of license plate can be detected by sequence morphological operations preceded by edge detection. The presence of vertical edges in license plate is highly probable compared to the presence of horizontal edges. Thus by extracting only vertical edges, most of the non license plate regions, predominantly containing horizontal edges, of car image can easily be eliminated. More vertical edges that are observed in license plate region are due to the letters within it have more vertical lines. Morphological operations are used to fill the gaps between characters in edge image to make rectangular regions. Here the use of edge detection eliminates the need of morphological top-hat operations as suggested in [4].

A. Vertical edge detection

An input car image is shown in Fig. 5. Applying an edge detector (vertical Sobel mask [8, 9]) on this image a binary edge image is obtained (Fig. 6) using a suitable threshold. Due to the presence of characters in license plate region, more vertical edges are detected in this region. Suitable threshold is computed using the well-known Otsu's method [10] that is based on gray-level histogram analysis. Inter class variance is selected as discriminant criterion for computing threshold value. The advantage of this method is that the threshold value is adaptively determined from each car image. Morphological operations are then applied on the binary edge image.

B. Morphological operations

To ensure that the license plate is not cropped (*i.e.*, enclose all the license plate characters within a region), the maximum space between characters is considered as one important feature for designing SE. A closing operation is performed on binary edge image using this SE resulting in Fig. 7.

Now, some processing needs to be done to eliminate the regions that do not contain the license plate. Applying an opening operation on the image (Fig. 7) with a vertical SE (whose height is taken as minimum character height) eliminates the regions whose height is less than the minimum character height. The output at this stage is shown in Fig. 8.

Similarly regions with height greater than the maximum character height are eliminated by performing sequence of two opening operations. First opening the image (Fig. 8) using a SE designed considering maximum license plate height. The output obtained after this opening operation is shown in Fig. 9. Note that performing the opening operation with SE eliminates the regions whose height is less than (or equal to) the maximum license plate height. This step eliminates the li-

cense plate region also as shown in Fig. 9. This is followed by subtracting the output of this process from Fig. 9. This results in the elimination of regions with height greater than the maximum license plate height. The resultant image containing the

Fig. 5. Original car image

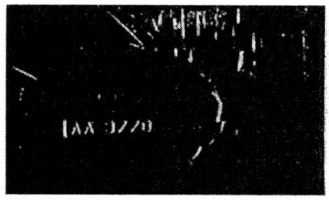

Fig. 6. Vertical edge detection

license plate region along with some small noise blobs is shown in Fig. 10. Finally, an image opening operation with horizontal SE (SE width is less than minimum license plate width) eliminates the noise blobs whose width is less than minimum width of license plate. The result is shown in Fig. 11. Using Fig. 11, the corresponding regions of original car image are obtained as shown in Fig. 12.

Fig. 7. Character fusion into rectangle

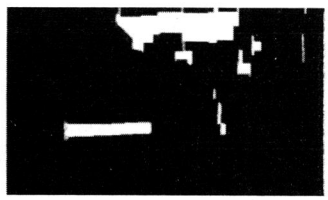

Fig. 8. Eliminating the regions with height less than minimum. character height.

Fig. 9. Noise blobs taller than the plate

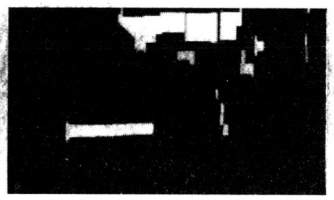

Fig. 10. Taller noise blobs are eliminated

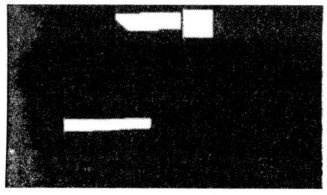

Fig. 11. Plate with some noise blobs

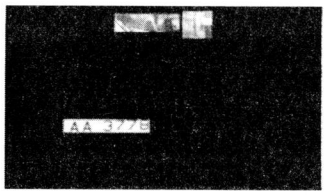

Fig. 12. Regions from original images

C. Connected component analysis

Now the task is to eliminate the remaining candidate regions not containing the license plate. The license plate consists of thick characters that are well separated from background. An eight-connected-component extraction algorithm [11] is used for this purpose. For each candidate region (Fig. 11) the corresponding regions from the edge image is used as input to the connected component extraction algorithm. The number of connected components along with the width and height of each component are obtained for all candidate regions. The license plate region consists of characters of well-defined dimension (width and height) and number of such connected components is bounded within a well-defined range for each

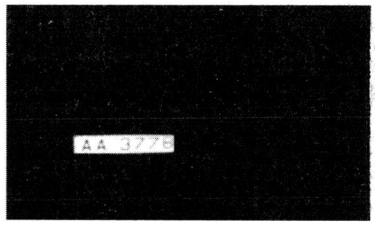

Fig. 13. Final detected plate

country. So the region with specified number of components and of specified dimension will be picked as region containing the license plate (Fig. 13).

IV. Results

The methodology discussed in earlier section has been implemented on a reasonably large database of car images consisting of 342 samples. Car images from eight countries viz. India (19 images), China (31 images), Hong Kong (25 images), South Africa (19 images), Spain (98 images), Europe (54 images), Brazil (75 images) and Japan (21 images) form the database used to test the current system. Here each country with number of test images, indicated above, varies in scaling, lighting conditions and contrast. The distance between camera and car considered is not fixed. The system is tested in two ways. 1) The dimension of SE is designed for each country individually and achieved 100% accuracy. 2) All of 342 samples are considered as one set and SEs are constructed for various morphological operations. In this case 95% accuracy is obtained. The system is developed in Matlab 6.1. Few examples of car images with extracted number plates tested following first way are shown in Fig.14

V. Discussions & Conclusion

An effective algorithm has been proposed to extract license plate from various complicated scenes with non-uniform

(a)

(b)

Fig.14. Tested car images and extracted License plates. (a) simple test images (good lighting conditions & contrast). (b) complex test images (poor contrast, obscured and dirty plates, plate containing two lines)

lighting conditions. Moreover the license plates consist of characters of variable size. The algorithm considers features like minimum and maximum character heights, license plate width and height based on which structuring elements for morphological opening and closing are designed.

The advantage of the proposed system is that it works for all types of license plates having either white or black background with black or white characters respectively. Note that the algorithm discussed in [4] had used two top- hat operations to get white characters on black background. The present method requires no morphological top-hat operations unlike [4]. Though we have used connected-component analysis to get the correct region for license plate after a sequence of morphological operations, however all morphological operations used in [4] are not required here.

Experimental results show that the performance of the algorithm is very accurate when the algorithm is applied using country dependent parameters. The overall performance is also encouraging for global parameters (SEs are same for all 342 images). The database (car images of spain) used in [4] is also included in our test data set and 100% accuracy is achieved for this data set.

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