Morphology Based Approach for Number Plate Extraction

Chetan Pardeshi and Priti Rege

Abstract Number Plate Recognition identifies vehicle number without human intervention. It is a computer vision application and it has many important applications. The proposed system consists of two parts: number plate area extraction and character identification. In this paper, morphological operation-based approach is presented for number plate area extraction. Effective segmentation of characters is done after plate area extraction. Histogram-based character segmentation is a simple and efficient technique used for segmentation. Template matching approach is used for character extraction. Number plate with variable character length poses limitation on number identification in earlier reported literature. This is taken care of using histogram-based character segmentation method.

Keywords Histogram · Morphological operations · Number plate extraction · Template matching · Thresholding

1 Introduction

Every country has specific vehicle identification system. These systems are used in the traffic control and surveillance systems, security systems, toll collection at toll plaza and parking assistance system, etc. Human eye can easily recognize these number plates, but designing automated system for this task has many challenges. Blur, unequal illumination, background and foreground color and also many natural phenomena like rain fall, dust in air may create problem in number extraction. Also number plate standards are different for each country, therefore large number of variations are obtained in parameters like, location of number plate, area of number plate and characters, font and size used for numbers and characters (standard font is

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Arial Black), background color (white, yellow or black) and foreground color (black or red), etc., which make the task of number plate extraction difficult.

Number of applications of license plate identification can be listed as parking assistance facility during ticket collection, unmanned toll collection at toll booths, traffic surveillance system, tracking vehicles during signal violation, vehicle's marketing research.

Aim of this paper is to implement an efficient method for number plate extraction. Algorithm proposed in this paper identifies characters present on single line number plate with variable character length.

Rege and Chandrakar [1] has separated text image in document images using run length searing algorithm and boundary perimeter detection. Morphological operation and bounding box analysis are used by Patel et al. [2]. Owamoyo et al. [3] used Sobel filter along with morphological operations. Algorithm presented by Gilly and Raimond [4] stresses on connected component analysis. Bulugu [5] used edge finding method to locate the plate in the scene. Kate [6] proposed morphological operation based on area for searching number plate. Kolour [7] has reviewed a number of license plate detection algorithms and compared their performances in his paper. His experimentation gives a basis for selection of the most appropriate technique for their applications. Parasuraman and Kumar [8] extracted the plate region using edge detection followed by vertical projection. Proposed algorithm has four stages: (i) Acquisition of vehicle image and preprocessing includes conversion of image to gray format, resizing of image, etc. (ii) Marking of area covering the number plate in the vehicle image, (iii) Segmentation of characters from the number plate extracted, and (iv) Recognizing and displaying the segmented characters.

2 Proposed Method for Identification of Letters/Numbers from License Plates

This section elucidates the number plate extraction method for single line number plate. Input to the system is a vehicle image (with clear view of number plate in it) which is captured by digital camera and output is the actual characters present in that vehicle image. Each character present on input number plate image should at least have minimum resolution of 24 × 42 pixels and distance of number plate from camera should be such that it guarantees clear view of numbers present on the number plate.

Proposed algorithm consists of following steps:

- Image Preprocessing
- Number plate area extraction
- Segmentation of each character area in image
- Image matching for each character
- Output extracted characters in text format

2.1 Image Preprocessing

Preprocessing is used to enhance the contrast of the image and for resizing of the image. RGB image is converted to grayscale image which carries intensity information. RGB values are converted to grayscale values by forming a weighted sum of the R, G, and B components:

$$\text{Gray} = 0.2989 * \text{R} + 0.587 * \text{G} + 0.114 * \text{B}$$

2.1.1 Contrast Enhancement

Captured image may have unevenly distributed lighting or darkness. During edge detection fine edge details in dark region of the image are eliminated. Also feature edges in bright regions need to be preserved. Top-hat transformation is used to preserve these edge details as well as prominent ones. The main property of top-hat operator can be applied to contrast enhancement. After applying top-hat filtering, image is converted to binary image from gray scale using Otsu's algorithm. Figure 1a–d shows various stages of image preprocessing.

2.2 Number Plate Area Detection

System's speed and accuracy is enhanced using precise number plate area extraction. At this stage, number plate area is extracted from entire preprocessed image. This step reduces processing burden on next stage of identification of numbers from license plate area.

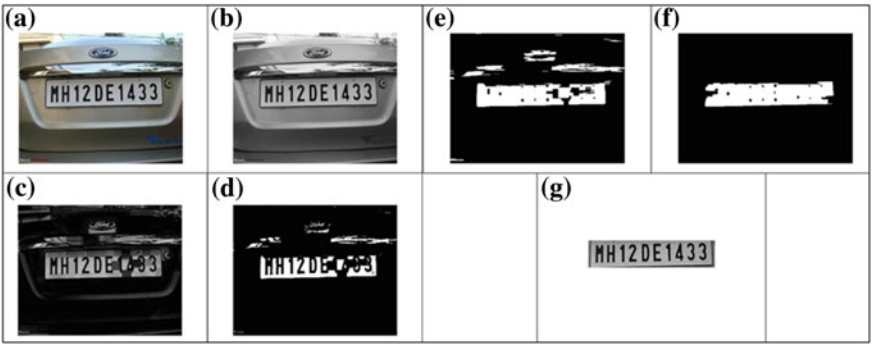

Fig. 1 **a** Original image, **b** Gray image, **c** Top-hat filtered image, **d** Binary image, **e** Dilated image, **f** Selected object, **g** Extracted plate

2.2.1 Plate Area Detection

A morphological operator is employed to the preprocessed image for extracting the plate area. Morphological operator that suits the rectangular shape of number plate is used for this purpose. Binary image is dilated with rectangular box as structuring element.

After dilation operation, horizontal object with Aspect Ratio(R) > 3 is filtered out from dilated image. As number plate generally have larger lengths as compared to its width. Aspect Ratio = width/height and R defines the region of interest.

Upon detection of plate area, top left and bottom right coordinates are extracted and further these coefficients are used for selecting plate area from original image. Figure 1e–g shows various stages involved in plate area extraction. Figure 1e shows dilated image. Filtered region (selected object) from unwanted region is shown in Fig. 1f. Figure 1g shows extracted plate area.

2.3 Character Segmentation

In this step, number plate is segmented to obtain characters present in it.

Morphological operations are used in segmentation process. Dilation of an image I by the structure element H is given by the set operation

$$I \oplus H = \{(p+q) \mid p \in I, q \in H\}$$

Erosion of an image I by the structure element H is given by the set operation

$$I \Theta H = \{(p \in Z^2) \mid (p+q) \in I, \text{for every } q \in H\}$$

Algorithm for segmentation process is as follows:

- Convert extracted plate image is into gray scale image (Fig. 2a).

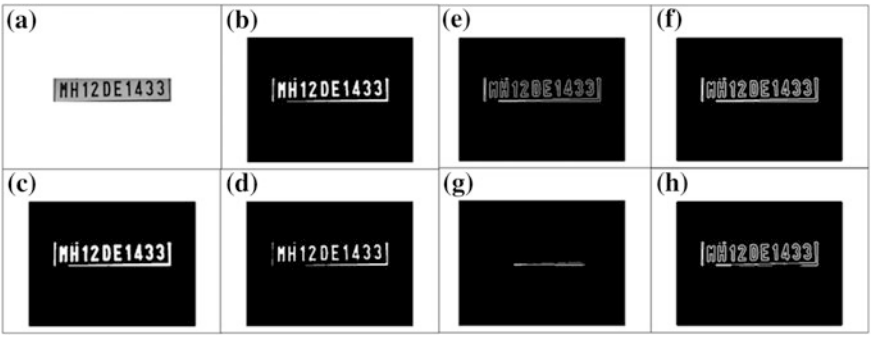

Fig. 2 **a** Gray image, **b** Inverted binary image, **c** Dilated image, **d** Eroded image, **e** Subtracted image, **f** Convolved Image, **g** Erosion with horizontal structuring element, **h** Subtracted after erosion

- Binarized image is using Ostu's algorithm. Invert pixel values of binarized image, i.e., make 0 to 1 and 1 to 0 for further processing. Result of binarization is shown in Fig. 2b.
- Apply morphological gradient for edges enhancement. Figure 2c shows dilated image with disk as structuring element. Figure 2d shows results of erosion on binary image Fig. 2b, e shows result of image subtraction of eroded image from dilated image.
- Convolve subtracted image with [1 1; 1 1] for brightening the edges (Fig. 2f).
- Erode with horizontal line as structuring element to eliminate the possible horizontal lines from the output image after subtraction operation (Fig. 2g).
- Subtract eroded image from convolved image (Fig. 2h).
- Fill all the regions of the image (Fig. 3a).
- Do thinning on the image to ensure character isolation (Fig. 3b).
- Calculated properties of connected components, i.e., objects present in image using 4 and 8 neighborhood labeling algorithms. Following properties of each object are calculated, (i) [x y] which specifies the upper left corner of the object. (ii) [x_width y_width] which specifies the width of the object along each dimension.
- Calculate histogram of all objects based on y-dimensions and y-width. Find intersection of number of objects in histogram based on y-dimensions and histogram based on y-width, to know exact number of characters present in image. Use 4, 8 neighborhood connectivity algorithms to find out bounding box for individual objects in image. Using result of histogram analysis, only those objects which have been identified in intersection of histogram are proposed for further processing. The result of object segmentation is as shown in Fig. 3c.

Results for two more samples are shown in Figs. 4 and 5.

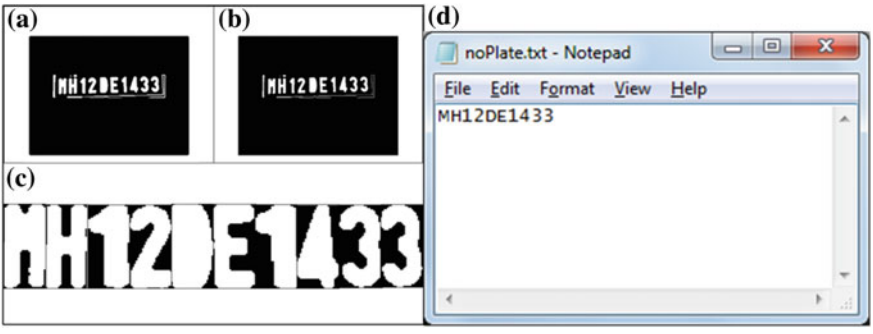

Fig. 3 **a** Holes filled, **b** Thinning, **c** Segmented characters, **d** Extracted characters stored in text file

Fig. 4 **a** Sample image Fig. 2, **b** Extracted plate, **c** Processed image, **d** Extracted letters, **e** Extracted characters in text file

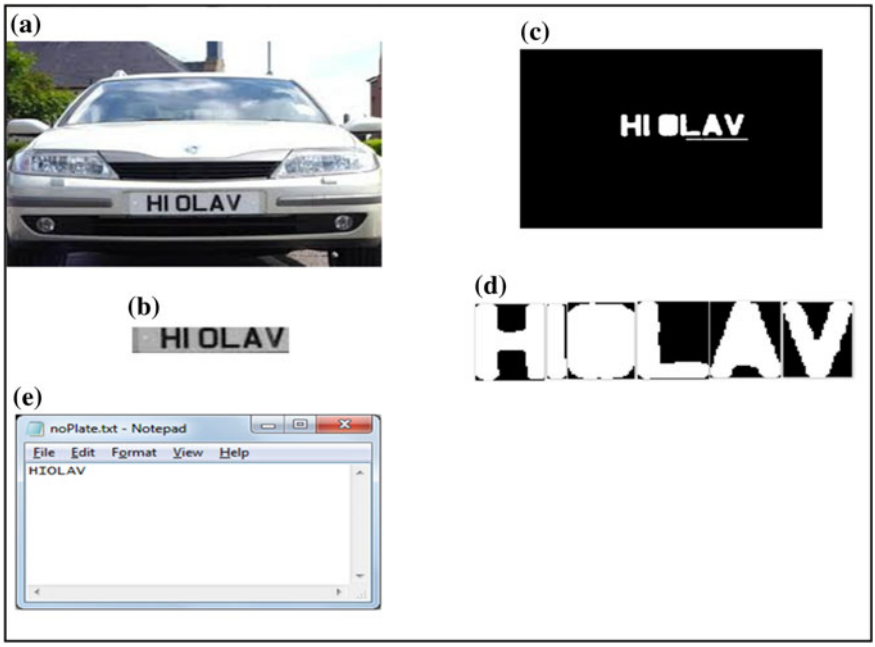

Fig. 5 **a** Sample image Fig. 3, **b** Extracted plate, **c** Processed image, **d** Extracted letters, **e** Extracted characters in text file

2.4 Image Matching

Each segmented character image is then compared against database image (database is set of few samples of character images of different fonts and different style of holes fillings in them) and correlation between test character image and database images is found.

Correlation coefficient between image A and image B can be calculated using

$$r = \frac{\sum_m \sum_n (A_{mn} - \overline{A})(B_{mn} - \overline{B})}{\sqrt{\left(\sum_m \sum_n (A_{mn} - \overline{A})^2\right)\left(\sum_m \sum_n (B_{mn} - \overline{B})^2\right)}},$$

where $\bar{A} = \text{mean}(A)$, and $\bar{B} = \text{mean}(B)$.

The database image for which maximum correlation is obtained is the identified character. This identified character is then stored in text file as shown in Fig. 3(d).

3 Conclusion and Future Works

Algorithm proposed in this paper identifies characters present on single line number plate with variable character length. In future, the extraction of number plate can be integrated with video-based surveillance system for automatic detection of various objects from video sequences.

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