An Automatic & Robust Vehicle License Plate Recognition System

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Abstract— An automatic and robust vehicle license plate recognition system has been developed. The proposed method uses scan line evaluation and averaging method to localize the number plate followed by a border removal mechanism combined with character mending and approximation of character height to extract the number plate characters. Finally, a template matching approach is used to recognize the characters. A Graphical User Interface has been created and the algorithm is experimented successfully on a variety of real images, both single as well as double line plates. The sample results obtained on testing with various images are also detailed.

Keywords—Plate localization, Noise removal, Character mending, Character extraction, Pattern recognition, Template matching.

I. INTRODUCTION

The onerousness involved in number plate localization and recognition is very well known in the field of Digital Image Processing and the encumbrance increases as more and more factors are to be taken into consideration. Each vehicle has a unique identification number which is portrayed in its license plate. Number plate recognition system exploits this uniqueness to make it suitable to put in use with a variety of applications such as border crossing monitoring, toll management, parking management etc. With the implementation of such an efficient security system we can put a curb on the increasing crime rate.

But the difficulty in adopting a standard procedure, in approaching this problem, is mainly due to the characteristic features of the number plate which varies widely with the region/area to which the vehicle belongs. This proposed system mainly focuses on number plate localization and character recognition.

The paper is organized as follows. In section 2, we present a literature review that describes a brief summary of some of the techniques that have been used for number plate recognition. Proposed methods for localization of number plate, character extraction and recognition are discussed in Section 3. Finally, the results including sample images and conclusions are drawn in Section 4 and Section 5 respectively.

II. LITERATURE REVIEW

A. Plate localization

Plate localization is done to remove the unwanted background details, and thereby focusing on to the essential details in the image.

To detect the car plate, a method by applying a top-hat filter to the whole image followed by a multiscale region search has been described [4]. Another approach has been proposed to detect the vertical edges, to extract the license plate using sobel operators [3]. A technique using edge detection and hough transforms, to detect the vertical and horizontal edges, by making use of the rectangular shape of the license plate has been presented [6]. Sorin developed an approach to analyse the input image, looking for areas with high contrast gradients at the given scale of about 15 pixels followed by histogram stretching [7].

B. Character extraction

Character extraction is done by segmenting the character portions from the localized number plate. Noise contents that may also be present along with these number plate characters, makes the job a tedious one.

A method has been proposed to remove the frame lines in the number plate followed by digit filtering [5]. A method on color image segmentation, region growing and clustering methods are described in [6]. A simple algorithm for labeling connected components on binary threshold image is detailed, using the elongation and direction to discard the components that do not correspond to digits [4]. A system to solve the character extraction problem on a higher level, by combining the results of various thresholding techniques, also incorporating the feedback from character segmentation and character recognition stages has been proposed [7].

C. Character recognition

Character recognition is an essential and inevitable phase in such an application, where the system is put up to deal with nebulous or distorted characters in the license plate due to environmental hazards.

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A template matching approach using hamming distance has been discussed to recognize the extracted characters [1]. Sorin Draghici solved the character recognition problem using a trainable recognition engine based on neural networks [7], which are often applied.

III. PROPOSED METHOD

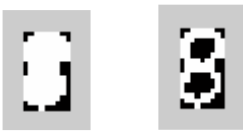
A. License plate localization

As the image may have complex background details, number plate localization is the central issue that demands great attention. Scan line evaluation and averaging method is used here to accomplish this task. The image obtained from the sensor is filtered and binarized and the set of connected components are segmented. Following this step we measure the dimensions; height, width and area; of each of these segmented regions. Only rectangular segmented regions are taken into account.

Figure 1. Segmented region with three scan lines

Further analysis is done using a set of scan lines, say three scan lines through ¼ H, H H and ¼ H; where H is the height of the segmented region. Through these scan lines each of these segmented regions are evaluated (scan lines are shown with yellow color in figure 1). The idea is to set a counter for each of these scan lines to count on the number of times a toggling in binary value (1/0 or 0/1) is encountered. This is done by comparing every i^{th} pixel, with the $(i+1)^{th}$ pixel. The average of these counter values are taken and is stored in a vector. Finally, an index is set to find the largest value in the vector, which will be pointing towards the segmented portion of the number plate. As more scan lines are used, the accuracy of finding the license plate also increases, which depends upon the application for which the system is designed.

As this step determines the overall efficacy of the system, it is quite important to localize the plate with all the details in it. For example, segmenting certain connected components, such as '8', '9' etc, can cause information loss, since the inner circular region in these characters may get lost during the localization process as shown in figure 2 (a). This may end up with wrong character recognition results; '8' may be recognized as '0' or 'D'. Hence a procedure has been adopted to gather every fine detail within this region by comparing it with the binarized image of the original input image so as to obtain the character shown in figure 2 (b). Likewise the whole localized number plate region can be restored to obtain an image as in figure 3 (d) which is given as input to the next step to extract the license plate characters from it.

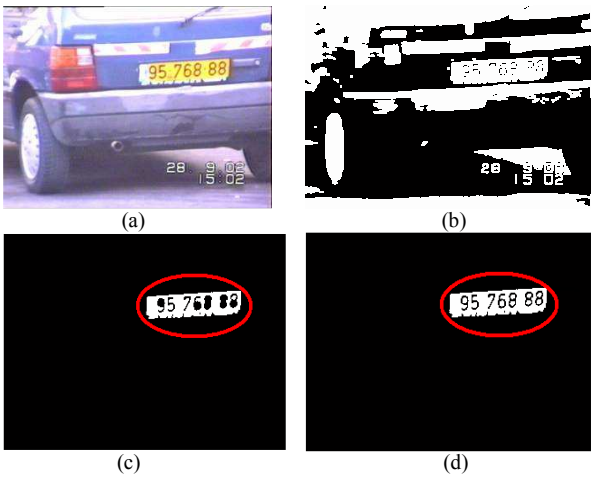


(a) (b)

Figure 2. (a) Character '8' with information loss, (b) Character '8' after restoration

B. License plate character extraction

To extract the characters from the localized number plate, the image obtained from the previous step is complemented. The contents in this image will either be trivial noise components or characters to be identified. A border removal mechanism followed by the approximation of character height is performed to extract the characters. This border removal process considers the unwanted white region around the number plate portion as a single noise component which can be easily eliminated (figure 4). Now the image will be left out with the number plate characters along with any foreground design (-which again is to be considered as a noise component-) as shown in figure 5 (a). The next step involves the approximation of the character height by finding out one 'integral' component among the set of connected components in the plate. The 'integral' component is chosen in such a manner that it will be having a height greater than any other connected component in the border removed plate region. Afterwards the character components can be stripped out of the plate keeping the height of this 'integral' component as its base condition. Only those components within a narrow range of this base condition are considered as the number plate characters. This procedure underscores the fact that the characters inscribed in a number plate will have uniform height [8]. All other components are discarded.



(a) (b)

(c) (d)

Figure 3. (a) Original image, (b) Binarized image, (c) Localized plate region with information loss, (d) Localized plate region after restoration

Figure 4. Border removed

But character breakage due to improper illumination can thwart the above mentioned procedure of character extraction. So in order to surmount this problem a character mending procedure is adopted as illustrated in figure 5. This process strengthens the white pixels in the border removed number plate by turning its adjacent left and top black pixels to white. This again is done by scanning through the image for a white pixel. Proceeding with character stripping after this mending process proved to provide better results as the extraction of this kind of mended character is quite easier when compared to the extraction and recognition of a distorted character shown in figure 5 (c).

(a) (b) (c)

Figure 5. (a) Localized number plate with distorted character within the box, (b) Mended character, (c) Segmentation result of the distorted character (the three sections constitute to form the distorted character '5')

C. License plate character recognition

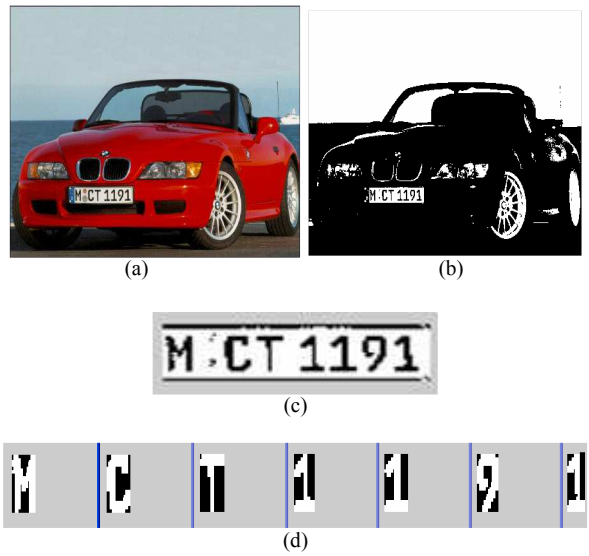
Recognition is done through a template matching approach. The set of templates previously stored in the database are compared with this extracted character set. Correlation coefficient is used to define the relationship between the templates and the character in hand. The template onto which the character has got the maximum correlation will be provided as output onto the output screen. To perform template matching the extracted characters are resized to 40*55 to tally it with the characters in the database.

IV. EXPERIMENTAL RESULTS

The concept used for coding the system does not limit it's workability to any specific image format or size. The input to the system can either be a color or grayscale image. Sample results obtained on working with jpeg and bmp formats are presented here in figure 6 and figure 7. The system is designed in Matlab 7 for recognizing the number plate characters of vehicles.

V. CONCLUSION AND FUTURE WORK

The paper explicates on license plate recognition emphasizing a scan line evaluation method to localize the license plate and a border removal mechanism combined with character mending & character height approximation to draw out the characters from the license plate without much distortion. An effort has been taken to make the proposed method work with variety of number plates of different kind of vehicles of various countries. The success rate on plate localization is about 93% and the success rate on character extraction is about 96%. This can be taken as a feasible result when the cost of implementation of the system is considered. This method works for those images having a number plate with the characters inscribed in a single row or in double row. The GUI provides a proper environment for the system to provide promising results with white and black background number plates.

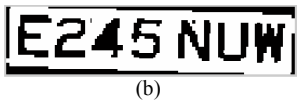


(a) (b) (c) (d)

Figure 6. (a) Original image, (b) Binarized image, (c) Localized number plate, (d) Extracted character set

Depending upon the application for which the system is to be used, the distance between the car plate & the camera unit is adjusted, to make it work properly. Design of the number plate must be in such a manner that, their properties like the color and reflective coatings etc, is to be within the bounds of the jurisdiction. Intricate designs, that may be present in the foreground of the plate introduces a higher dimension of complexity. This design complexity can be tackled if enough information can be obtained about the foreground designs with respect to the region where the system is deployed. The vehicle may have any number of characters in its license plate and the system does not readily depend upon the number of characters in the plate (-even, a prior knowledge about the number of expected digits only enhances the workability-). The effectiveness of the system is directly proportional to the readability of the number plate. The system assumes that the characters inscribed in the license plate are of uniform height. Finally, adequate amount of light energy and fine weather conditions are preferred for better results.

(a)



(b)

(c)

Figure 7. (a) Original image, (b) Localized number plate, (c) Extracted character set

Different standards for license plates are found all over the world and as the system is supposed to work with number plates independent of its place of origin, the character database requires an update with respect to the region where it is installed, which can be done with a reference to the character specification legally documented by the jurisdiction.

A highly sophisticated sensor coupled with adaptive neural networks based recognition engine can be suggested as a part of future enhancement work.

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