IEEE Sponsored 2nd International Conference on Innovations in Information Embedded and Communication Systems
ICIIECS'15

Automatic License Plate Detection using Vertical Edge Detection Method

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***Abstract*— This paper proposes a faster mechanism for license plate detection. Usually license plate has more vertical edges compared to horizontal edge. By focusing on this concept an algorithm called VEDA is used here. First convert the color image into gray image. Then for binarizing the image a technique called adaptive thresholding (AT) is used. The noise in the image is removed by using ULEA algorithm. Then the proposed VEDA is used to extract the vertical edges. Then HDD algorithm is used for highlighting the license plate area. Compared to other edge detection mechanisms such as SOBEL and CANNY, VEDA has lesser complexity. Also the computation time is also less for VEDA when compared against SOBEL.**

***Index Terms*— License plate detection (LPD), adaptive thresholding (AT), unwanted lines elimination algorithm (ULEA), vertical edge detection algorithm (VEDA), highlighting desired details (HDD), candidate region extraction (CRE), plate region selection (PRS).**

I. INTRODUCTION

The license plate recognition (LPR) system is an image processing technology used for identifying the vehicles using their license plate. The applications [1] – [4] of LPR include toll collection, traffic monitoring, border and custom check points, parking fee collection, traffic safety enforcement etc.

Usually a license plate recognition (LPR) system has mainly three phases. First phase is license plate detection. Second one is character segmentation and third phase is character recognition. The important phase is the license plate detection. The accuracy of license plate detection affects the entire system accuracy.

License plate detection is a tedious task due to the following reasons. First one is generally license plate will occupy only small portion of the entire image. Secondly, there are large varieties of license plate formats. Such as difference in color pattern, size and font etc. It varies from country to country. Third problem is the blurry image and also images captured at rain and night. The fourth one is intersection of other text areas over the license plate or overlapped license plates. The fifth section is uneven or low illumination images, damages caused by reflection and dirt. These factors make LPR a challenging task.

Various algorithms are already been developed for license plate detection. But most of them work under certain constraints. Such as the angle of camera, the blurriness rate etc. A good algorithm must work under no constrain.

Most of the LPR applications are real time. So the computational time for LPR should be less. Keeping this in mind a fast edge detection algorithm called VEDA is incorporated here. Usually license plate will have more vertical edges than horizontal edges. So a vertical edge extraction algorithm is used here. Compared with other edge detection algorithms such as SOBEL and CANNY the computation time for VEDA is less. Also the complexity of VEDA algorithm is less compared to SOBEL and CANNY.

Another highlight in this paper is the noise removal algorithm called ULEA. It removes the unwanted lines. It is also a faster algorithm.

The paper is organized as follows. Section II introduces about the related works done so far. Section III describes the proposed method and finally section IV concludes the paper and then follows the references..

II. LITERATURE SURVEY

The accuracy of number plate recognition depends on the accuracy of license plate extraction. There are different methods for License Plate extraction.

In [5] S. Kim *et al.* proposed that the candidate areas are located based on gradient features. The candidates are examined to verify whether it contains the license plate by introducing a template of the license plate. The advantage is it is more robust against noise and tilt. The license plate (LP) templates are difficult to construct. This method fails when there is existence of other text block.

M. Sarfraz *et al.* [6] proposed an LPD algorithm based on edge detection using Sobel operator. Here obtained vertical edges are matched with rectangle. The rectangles which have same aspect ratio like the LP are considered the possible candidates.

According to D. Zheng *et al.* in [7] if only the vertical edges are extracted and if the background edges are also removed, then the LP detection is easier. The block based method is used by H.-J. Lee *et al.* in [8] consider the blocks which have higher magnitude as LP boundary. This methods work with images which have unclear edges.

Boundary based extraction is proposed in [9] by V. Kamat and S. Ganesan. This method use Hough Transform (HT). This method detects straight lines with an inclination up to 30°. The Hough Transform is a memory and time consuming process [10].

In paper [11] D.-S. Kim and S.-I. Chien used generalized symmetric transform (GST) for the extraction of license plate. After edges are extracted the image is scanned to detect the corners. The GST is used for similarity checking of corners.

M. M. I. Chacon *et al.* used contour detection algorithm in [12] for detecting the connected objects. The connected objects have same geometrical features and thus license plate area is considered as candidate region. This method fails if the image has bad quality.

III. LICENSE PLATE EXTRACTION METHOD

A. Overview

This LP method first converts the color image into gray image and then we binarized the image. After binarization there will be lots of unwanted lines. The next stage will remove those unwanted lines.

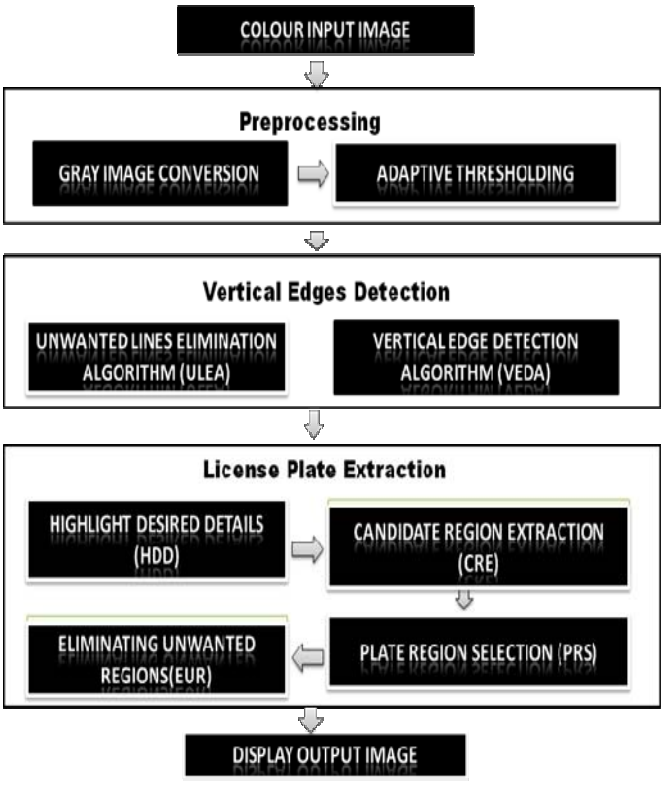

Fig.1. Flowchart of License plate detection

After that the vertical edges from the image is extracted since the LP region consists more vertical edges compared to horizontal edges. The next phase is highlighting the important details. After that the possible LP regions i.e., the candidate regions are formed and out of them one is selected as possible LP region.

In the next phase we need to extract the LP part from the selected candidate region. Before that we need to remove the unwanted lines once more. After that the LP region is extracted.

B. Adaptive Thresholding

After Color image is converted into grayscale image, the grayscale image should be converted into binarized image. The image binarization is done by a method called adaptive thresholding (AT) [13] [14]. Bradely and Roth [15] technique is used for image binarization.

In this method a SxS window around each pixel is taken and the average intensity value of that window is taken. The average along with a threshold is compared along with the current pixel. That is if the value of current pixel is T percentage less than the computed average then the current pixel is set to black or else white.

Algorithm for Adaptive Thresholding

```
1: For each pixel x[i, j]
2:    Do
3:      Calculate the integral image.
4:    End
5: For each pixel x[i, j]
6:    Do
7:      Compute the SxS average using integral image.
8:      If x[i, j] is T percentage lower than SxS average
9:         x[i, j] = black
10:     Else
11:        x[i, j] = white
12:     End
13: End
```

Integral image is used for calculating the SxS average. Integral image is also known as summed – area table. It is a tool that can be used when it is needed to compute the sum of function (which is a function from pixel to real numbers) over a rectangular region.

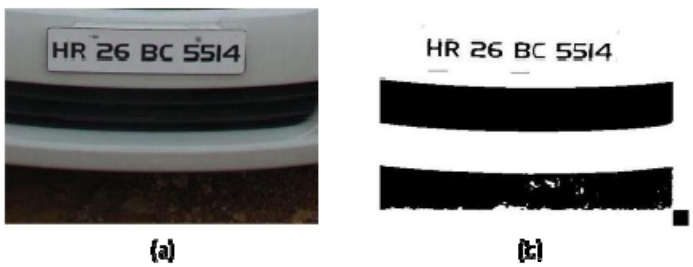

Fig.2. Adaptive Thresholding (a) Original image (b) Thresholded image

C. Unwanted Lines Elimination Algorithm

After thresholding, the image will have lots of thin lines which are not the part of LP. There will be lots of foreground lines and noise present in the image. The unwanted lines may interfere in the LP region. Presence of such lines makes the LP region detection a tedious task. ULEA eliminates these noises from the image. This step is considered as morphological operation and it is also an enhancement process. Unwanted lines can occur in 4 different ways.

1) Line is horizontal 0^0 (—)
2) Line is vertical 90^0 (|)
3) Line is inclined 45^0(/)
4) Line is inclined 135^0 (\ )

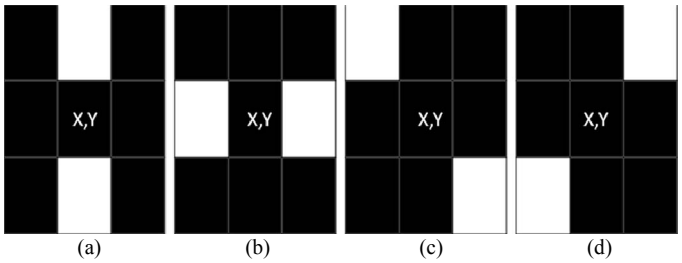

Fig.3. Four conditions for converting the central black pixel in to white pixel. (a) Horizontal (b) Vertical (c) Right inclined (d) Left inclined

For identifying the unwanted lines 3x3 mask is used. The 3x3 mask is moved throughout the image. Once the central pixel is identified as black, the remaining 8 neighbor pixels are tested. If any two pixels are white together (as shown in fig. 3) then the central black pixel will be converted into white pixel. The image after performing lines elimination is shown in figure 5(a).

D. Vertical Edge Detection

In this step the vertical edges in the image is extracted [16]. It is noticed that most of vehicles usually have more horizontal lines compared to vertical lines [17]. Usually the LP will be in a rectangular box. So that box will have two vertical lines as boundaries. So by finding out two vertical edges of a LP, four corners of the plate can then be located.

The main advantage of VEDA is it distinguishes the starting and ending of each character in the LP region. After Adaptive Thresholding and ULEA there will be only black and white regions in the image. VEDA focuses on the black-white and white-black intersection regions.

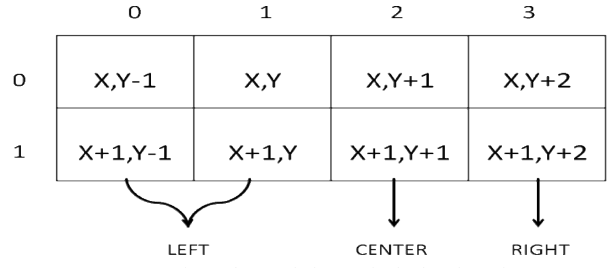

Fig.4.The mask for vertical edge detection

A 2x4 mask as shown in figure 4 is used for processing. The x, y shows rows and columns of the image respectively. The center pixel of mask is located at point (0,1) and (1,1). Using this mask when we scan the image from left to right black-white regions will be found. In that case first two black pixels will only kept. In the case of white-black region only the last black pixel will be kept. The output after vertical edge detection is shown in figure 5(b).

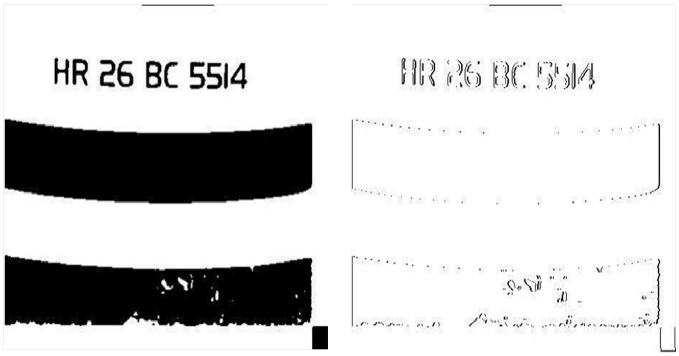

Fig.5. Vertical Edge detection (a) ULEA (b) VEDA

E. Highlighting Desired Details

After vertical edges are extracted from the image, next phase is highlighting the required regions. Here we need to highlight the LP region. After vertical edge extraction stage, more number of edges is extracted probably from the desired LP region. But there may be edges from other areas also. The vertical edge extracted has a particular format. It has two pixel width at the starting and one pixel width at the ending side.

Here the filling is to be done inside the characters. The boundary of each letter can be identified from the above mentioned property of vertical edges.

For implementing this additional measure called horizontal distance is required. This is the width of each letter. When the scanning is processed from left to right and top to bottom, if there are two pixels black together and after that there are white pixel, then the horizontal distance is calculated from the second black pixel to the next seen black pixel. If it falls under the range then those pixels are converted to black. The result after highlighting the desired details is shown in figure 6(a).

F. Candidate Region Extraction

After highlighting the desired details the next phase is selecting the possible LP area. For performing this step, the image is divided into two half upper part and lower part. The count of black pixels is taken in both parts separately. The part where the LP region is present will have maximum number of black pixel because the LP part is highlighted using black pixels.

So the part where the count of black pixel is more is the probable area where the LP should present. Then the boundary of the selected part is extracted. The result after candidate region extracted is shown in figure 6(b). After candidate region is extracted, the black pixels in other part are converted into

white pixels. So in the figure the candidate region will be highlighted.

Fig 6.Outputs of two stages (a) HDD (b) CRE

G. Plate Region Selection

After candidate region is extracted from the image the next and final step is extracting the license plate area from the candidate region. In the image the blackness density is more in the LP part. A scanning is performed from left to right and top to bottom manner in the candidate region. If there are there or more continuous black pixel present in a line then the starting black pixels position is noted.

Fig. 7 After Plate region is detected.

Similarly a scanning is performed from right to left and bottom to top of the candidate region. If there are there or more continuous black pixel present in a line then the starting black pixels position is noted. These two positions that are obtained are the two diagonal corners of the license plate. Then using these two positions a rectangular is drawn and thus the plate region is extracted. The result of plate region selection is shown in figure 7.

IV. Results and Discussion

The experimental conditions are mentioned in Table 1. This method require images that are captured with succifient light. So the capturing of images is done between 8am to 6pm. Similerly the experiment is carried out with different type of license plate as well as different size of license plate. This experiment takes not only Indian vehicle images but also took different countires license plate images for making this algorithm working globally.

TABLE I
Experimental conditions

Database types	Normal, Blur, Indian, Indian taxi, With multiple text, Malaysian
Capturing time	8am – 6pm
Camera specs	30 fps
Camera distance to LP	2m – 4m
License plate size	Different
License plate design	Different
Colors of vehicle	Various

For making result analysis, several types of samples were taken. The entire database is grouped into 6 different groups. The group 1 deals with the normal license plates. That is images that are clear and the license plate details are legible. The second one that is group 2 includes blur images. That is the LP region has high blurriness factor. The third group (group 3) includes Indian vehicles (Privately owned). These LPs have white background and the letters are in black. Most of the European countries follow the same pattern.

Fig 8. Different group of the database (a) Normal (b) Blur (c) Indian Private (d) Indian Taxi (e) Malaysian (f) Multiple Text

The next group is Indian Taxis (group 4). The Indian taxis have yellow background and black letters. The fifth group (group 5) is the collection of images of Malaysian vehicles. These vehicles have number plates with black background and white letters. The final group (group 6) is the images with multiple text areas. There are other texts on the image that are either above or below the LP. Sample images from each set are shown in figure 8.

The detection rate for each group of database is shown in figure 9 as a graph. It is noted that group 6 shows higher

detection rate it is the sample of images taken at normal condition. Group 3 shows sample images of Indian private vehicles. It shows an average detection rate of 90%.

Group 2 consists of sample images of Malaysian number plate. They have about 88% of detection rate. The group 1 shows the sample images of Indian taxis. It also shows a good detection rate of 85%. Group 5 shows the sample of images that consists of other text area other than license plate. Even then a detection rate of 80% is obtained. The case where the detection rate is low is the case with sample set consists of blur images. It is shown in group 4. The detection rate is 75%. Here the blurriness up to 40% is considered.

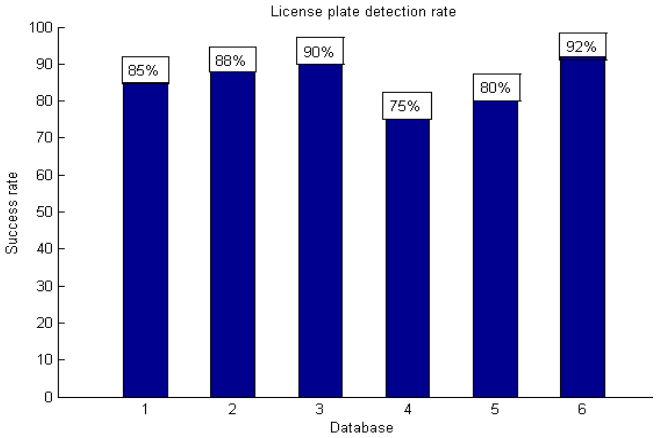

Fig 9. The comparitive analysis of detection rate for different database.

The table II describes the comparative analysis of the proposed system with some existing system. By analyzing the table it can be concluded that the proposed method has lesser computational time and this method detects LP even in the presence of multiple text area. In [5] even though it is more robust against noise and tilt, the creation of license plate template is required and this is a tedious job. The method in [17] is also robust against tilt. But sometime it even eliminates critical edges by considering them as noise.

TABLE II
Comparison with existing system

Methods	Advantages	Disadvantages
Gradient Features and plate template based [5]	-More robust against noise and tilt.	-LP templates are difficult to construct. -Fails with the existence of other text blocks
Vertical edge matching based [17]	-More robust against tilt.	-Sometimes edges are eliminated by considering it as noise.
VEDA based	- Less computational time -Detect LP even there is other text blocks are present.	-Fails to detect highly blurred image.

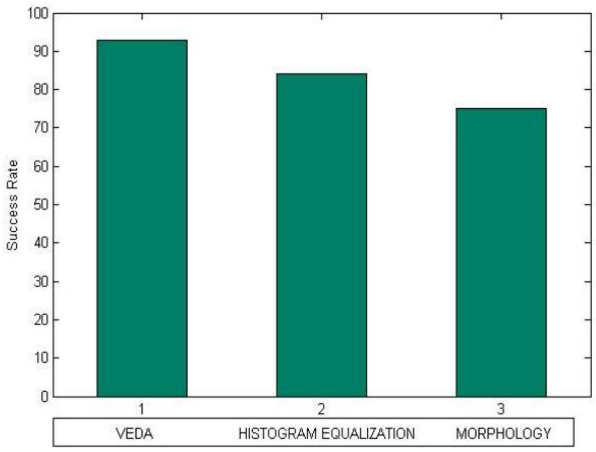

Fig 10. Comparative analysis of detection rate

The detection rate is compared in figure 10. The method that uses histogram equalization has detection rate of about 84%. Similarly the license plate detection using morphology has a lower detection rate of 76%. But the proposed method that use VEDA for vertical edge detection has a detection rate of about 92%. So comparing these we can finalize that the proposed method is better when compared with these two techniques.

ACKNOWLEDGMENT

The authors are thankful to Media Lab LPR database for providing the database for research work. They are also thankful to Royal College of Engineering, C.S.E Department, Calicut University, for providing necessary infrastructural facilities during the progress of the work.

CONCLUSION

In this paper a fast method for license plate detection is mentioned. In India an efficient license plate detection method is not provided until now. This method can detect private Indian vehicle number plate as well as number plates of Indian taxis. This method can be used for detecting license plates of different countries including India, Malaysia, European countries etc. Another great achievement is that this method detects the license plate even in the presence of other text area in the image.

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