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A Novel Method for Car License Plate Detection

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Abstract: With an increasing number of vehicles on roads, it is getting difficult to manually enforce laws and traffic rules for their smooth traffic flow. This paper proposes a fast method for car-license plate detection with three major contributions in the real life. The first contribution is that a fast Vertical Edge Detection Algorithm (VEDA) is proposed to detect the contrast between the gray scale values of the image. After binarization the input image using adaptive thresholding (AT), an unnecessary-line elimination algorithm (ULEA) is proposed to enhance the image and then, the VEDA is applied. Very-low-resolution images taken by a web camera is also processed by this method. After the vertical edges have been detected by the VEDA, the desired plate details based on color information are highlighted. Finally, an LP is detected. The third contribution is to compare the VEDA to the principal visual word discovery matching in terms of accuracy and processing time. Results show that the computation time of the CLPD method is 47.7 ms, which meets the real-time requirements.

Key words: Car-license-plate detection (CLPD) · Vertical edge detection algorithm (VEDA) · Adaptive thresholding (AT) · unwanted-line elimination algorithm (ULEA) · LP(license plate)

INTRODUCTION

In the last couple of decades, the number of vehicles has increased drastically. With this increase, it is becoming difficult to keep track of each vehicle for the purpose of law enforcement and traffic management. So Car License Plate Detection and Recognition is an image-processing technology which is used to identify vehicles by their license plates. This technology is used in various security and traffic applications such as access control, tool-booths etc. Also, Traffic Management systems are installed on freeways to check for vehicles moving at speeds not permitted by law. The license plate number can be used to retrieve more information about the vehicle and its owner, which can be used for further processing. Such an automated system should be small in size, portable and be able to process data at a sufficient rate.

Usually, a Car License Plate Recognition system consists of three parts: license plate detection, character segmentation and license plate recognition. Among these, license plate detection is the very significant part because it affects the system's precision significantly. In most cases, however, a license plate detection and extraction part must be performed correctly in order to build a complete and accurate car license plate detection and recognition. So a system is developed for easy identification of vehicles without any inconvenience.

In recent years, there has been an increasing interest in using license plate detection as an important key for solving many problems in various applications. Numerous vehicle tracking and pursue systems are using high performance cameras and this leads to increase the cost of the system hardware and software as well. The robustness and accuracy of the plate detection step are crucial for the success of such systems.

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Vertical edge extraction and detection is an important step in the CLPDRS because it affects the system's accuracy and computation time. Hence, a new vertical edge detection algorithm (VEDA) is proposed here to reduce the computation time of the whole CLPD method. The CLPDRS is usually based on an image acquired at 640 × 480 resolution. This paper proposed a method for CLPD, in which a web camera with 352 × 288 resolution is used instead of a more sophisticated web camera. This paper is organized as follows. Section II introduces a brief of related work. Section III describes two parts. The first part discusses in detail our proposed approach to vertical edge detection, i.e., using an unwanted-line elimination algorithm (ULEA) and the VEDA. The second part discusses the proposed CLPD method. Experimental results and discussion are presented in Section IV. Section V draws the conclusions.

Related Research Works: In the research works, many license plate detection algorithms have been proposed. Although license plate detection has been studied for many years, it is still a challenging task to detect license plates from different angles, partial occlusion, or multiple instances. Generally, it is preferable to extract some features from the images and focus only on those pixels characterized by the license plate. Based on the involved features, traditional license plate detection methods can be classified into three basic categories: color-based, edge-based and texture-based. The Color-based approaches are based on the observation that some countries have specific colors in their license plates. Initially, a test image is checked with a classifier of color model. Then, candidate regions from the classification results are verified with some post-processing to locate the plates.

In the second category, license plate is characterized by a rectangular shape with a specific aspect ratio and can be extracted by checking all possible rectangles in the image. Here edge detection is combined with some morphological operations are exploited to find rectangles of interest for license plate location. The Hough transform is used to detect boundaries of license plates. Bharat Raju Dandu and Abhinav Chopra [1] proposed a framework for Vehicular Number Plate Recognition Using Edge Detection and Characteristic Analysis of National Number Plates.

Methods in the third category mainly focused on texture features. A covariance descriptor is employed with a neural network to detect license plates. An intensity saliency map is used to segment out the characters on a license plate and then a sliding window is applied to compute some saliency-related features. A license plate detection algorithm using adaptive boosting (Adaboost) on Harr-like features is proposed. Gurjinder Pal Singh and Chhailadeep Kaur [2] introduced a method that deals with extraction of textual information from the number plate of vehicles moving on roads based on image processing techniques and retrieval of details of the vehicle from the data base management system. Here the system may fail if the texture of the plate is not clear, also the license plate region is short of the threshold projection operation.

In addition to the basic methods, there are many several LPD methods that have been used before, such as morphological operations, edge extraction, feature extraction, clustering approach, combination of gradient features, wavelet transform based, salience features, edge finding and window filtering, rank filter, sobel operator, a neural network for color or gray scale classification, Hough transform, hierarchical approach and vector quantization. Zhen-Xue Chen, Cheng-Yun Liu, Fa-Liang Chang and Guo-You Wang [3] introduced a novel method to recognize license plates using local feature extraction. First, the license plates are located using salient features. Then, each of the seven characters in a license plate is segmented. Finally, the character recognizer extracts some salient features of the characters. 32 images out of the 1176 images failed to correctly locate the license plates.

Divya gilly and Dr. Kumudha raimond[4] proposed a mass surveillance method that uses an optical character recognition method to read vehicle registration plates. Reza Azad, Mohammad Baghdadi [5] new and fast method for license plate extraction based on edge analysis. Another method using edge extraction is proposed by Kaushik Deb, Hyun-Uk Chae and Kang-Hyun Jo [6], in which extract license plates from natural properties by finding vertical and horizontal edges from vehicle region. Ronak P Patel, Narendra M Patel and Keyur Brahmbhatt [7] suggest a smart vehicle screening system in which Sobel vertical edge detection and morphology are employed to locate the number plate. Wengang Zhou, Houqiang Li, Yijuan Lu and Qi Tian [8] proposed principal visual word (PVW) discovery and local feature matching for extracting license plate. Saqib Rasheed, Asad Naeem and Omer Ishaq [9] presents a robust method of license plate detection and recognition based on Hough lines using Hough transformation and template matching for Islamabad standardized number plates cars. One of the Morphology Based Number Plate Localization proposed by Thota Sridevi, Chilukuri Sindhu, Pendyala Naga Praveen Kumar and Perupogu.Sagar [10] for Vehicular Surveillance systems is used to monitor the moving vehicles by automatically extracting the number plates.

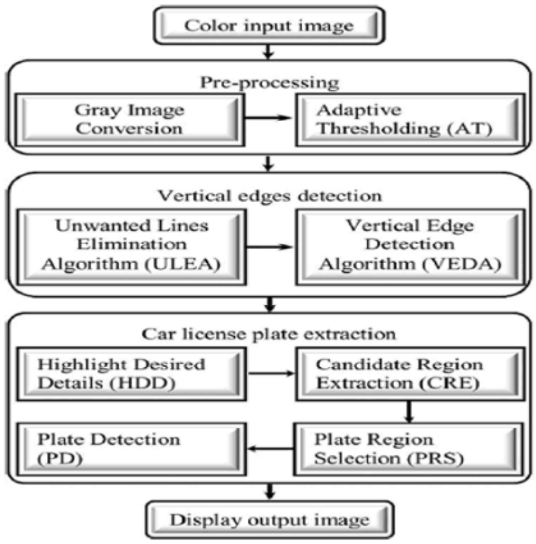

Fig. 1: Proposed Framework

Dongwook Kim and Liu Zheng [11] suggest that in order to accurately detect the various sizes of vehicle license plates which are included in input image a hierarchical approach and overlapped partitioning technique is introduced. Using neural network system proposed by Anuja P. Nagare, Thadomal Shahani [12] the license plate region is recognized and extracted by two Neural Network techniques one is Back Propagation Neural Network(BPNN) and other one is Learning Vector Quantization Neural Network(LVQNN). Fikriye ozturka and Figen ozena [13] proposed a Probabilistic Neural Network that can recognize plates using the pictures.

Proposed Framework

A.Overview: The framework of this approach consists of two main stages: vertical edges detection and car license plate extraction. The first stage is a preprocessing stage in which an Adaptive Thresholding(AT) is performed to binarize the image. The first main stage is used for the detection of vertical edges for that an Unwanted Line Elimination Algorithm(ULEA) and Vertical Edge Detection Algorithm (VEDA) is performed. The last stage is a car license plate extraction stage, here the desired details are highlighted for candidate region extraction from that plate region are selected for license plate detection as shown in Figure 1.

This paper has three main contributions to the real life: The VEDA is proposed and used for detecting vertical edges; the proposed CLPD method processes low-quality images produced by a web camera, which has a resolution of 352 × 288 with 30 fps; and the computation time of the CLPD method is less than several methods. The color input image is first converted to a gray scale image and then, adaptive thresholding (AT) is applied on the image to constitute the binarized image. After that, the ULEA is applied to remove noise and to enhance the binarized image. Next, the vertical edges are extracted by using the VEDA. The next process is to detect the LP; the plate details are highlighted based on the pixel value with the help of the VEDA output. Then, some statistical and logical operations are used to detect candidate regions and to search for the true candidate region. Finally, the true plate region is detected in the original image.

Adaptive Thresholding (AT): Thresholding is the simplest method of image segmentation. From a gray scale image, thresholding can be used to create binary images. Before going to the adaptive thresholding in the pre-processing stage, first of all the input color image is converted into black and white image. The converted black and white image again undergoes gray scale operation using the consequent operation and this helps to upgrade the method used. After the color input image is converted to grayscale, an AT process is applied to constitute the binarized image. Bradley and Roth recently proposed real-time AT using the mean of a local window, where local mean is computed using an integral image. For getting a proper adaptive threshold value, the above said method is used. The AT technique used in this paper is just a simple extension of Bradley, Roth's and Wellner's methods. The idea in Wellner's algorithm is that the pixel is compared with an average of neighbouring pixels. If the value of the current pixel is T percent lower than the average, then it is set to black; otherwise, it is set to white.

$$o(i,j) = \begin{cases} 0, & g(i,j)*s^2 < t(i,j) \\ 255, & \text{otherwise} \end{cases} \quad (1)$$

where o(i, j) represents the adaptive threshold output value of pixel, g(i, j) and s^2 represents the computed area of the local window for the selected region and t(i, j) represents the threshold for each pixel at location (i, j).

$$t(i,j)=(1-T)*sum_{window} \quad (2)$$

where T is a constant with value 0.15 and sum $_{window}$ represents the summation of the intensities of the gray values for a specified local window, in which the currently binarized pixel is centering in. The advantage of this technique is that only a single pass through the image is required. As a result, the decrement of T below 0.15 will affect in constituting new black regions the increment of T above 0.15 will affect in eliminating important details.

Fig. 2: Intersection Of Black-White And White -Black Regions

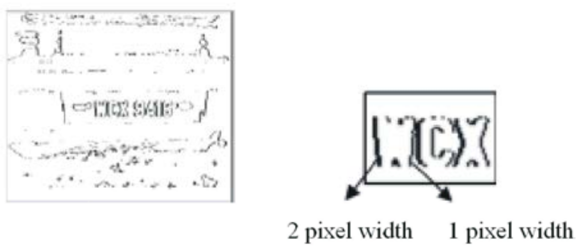

Fig. 3: VEDA Output

Unwanted Line Elimination Algorithm (ULEA): As many thin lines are produced during the adaptive Thresholding process, that do not belong to the LP region. These lines may interfere with the LP location. So an algorithm is used to eliminate them from the image. This step can be considered as a morphological operation and enhancement process. The unwanted lines formed are, the line is horizontal with an angle equal to 0, the line is vertical with an angle equal to 90, the line is inclined with an angle equal to 45, the line is inclined by an angle equal to 135.In this step, while processing a binary image, the black pixel values are the background and the white pixel values are in the foreground. A 3 × 3 mask is used throughout all image pixels. Only black pixel values in the thresholded image are tested. To retain the small details of the LP, only the lines whose widths equal to 1 pixel are checked. Suppose that b(x, y) are the values for thresholded image. Once, the current pixel value located at the mask center is black, the eight-neighbour pixel values are tested. If two corresponding values are white together, then the current pixel is converted to a white value as a foreground pixel value (i.e., white pixel).

Vertical Edge Detection Algorithm (VEDA): In order to distinguish the plate detail region, particularly the beginning and the end of each character VEDA is most suitable. Then the plate details will be easily detected and the character recognition process will be done faster. After the thresholding and ULEA processes, the image will only have black and white regions and the VEDA can easily processing these regions. In an image, ROIs are rectangular regions with white background and dark characters. The most important characteristic of these rectangles is the existence of lots of edges. The idea of the VEDA concentrates on intersections of black–white and white–black as shown in Figure 2.

A 2 × 4 mask is proposed for this process. The center pixel of the mask is located at points (0, 1) and (1, 1). By moving the mask from left to right, the black–white regions will be found. Therefore, the last two black pixels will only be kept. Similarly, the first black pixel in the case of white–black regions will be kept. This process is performed for both of the edges at the left and right sides of the object-of-interest. For the VEDA, there are two- and one-pixel thicknesses for each detected object as shown in Figure 3.

The first edge can have a black-pixel width of 2 and the second edge can have a black-pixel width of 1. The number “2” points out the number of rows that are checked at once. The consumed time in this case can be less twice in case each row is individually checked. VEDA has less complexity than the Sobel operator by k^2 times. Also VEDA has less complexity than canny edge detection. The searching process for the LP details could be faster and easier because this process searches for the availability of a 2 pixel width followed by a 1 pixel width to stand for a vertical edge. This mechanism of searching could save more processing time. In addition, there is no need to search again once the 1 pixel width is faced. These two features could make the searching process faster and easier.

Car License Plate Detection (CLPD): To extract plate region and characters four steps are involved. They are Highlight Desired Details(HDD),Candidate Region Extraction(CRE), Plate Region Selection(PRS) and Plate Detection(PD). By Performing NAND-AND operation for each two corresponding pixels values taken from ULEA &VEDA, also Connecting to vertical edges with black background the desired details become highlighted.

Candidate region extraction is to find exact LP region from the image. So the Process is divided into four steps. First of all count the drawn lines per each row, then divide the image into multi groups also count satisfied group indexes and boundaries finally select boundaries of candidate region in the image. After the candidate region extraction two steps are used to extract one correct LP i.e., the selection of LP region and then making a vote. For plate region selection(PRS), check blackness ratio of each pixels lies in candidate region. After detecting region, the region will replaced by vertical lines. Column with top and bottom neighbor have a high blackness ratio will give a vote. After voting section, the candidate region, which has highest vote will be selected. Finally, plate will be detected and extracted.

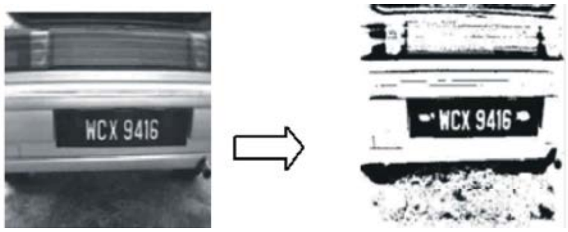

Fig. 4: Output Of Adaptive Thresholding

Fig. 5: ULEA Output

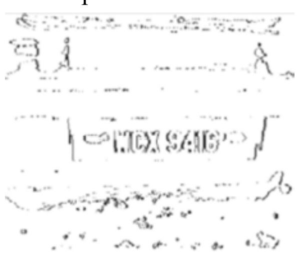

Fig. 6: VEDA Output

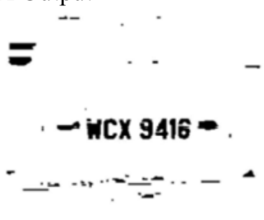

Fig. 7: Output Of Highlight Desired Details

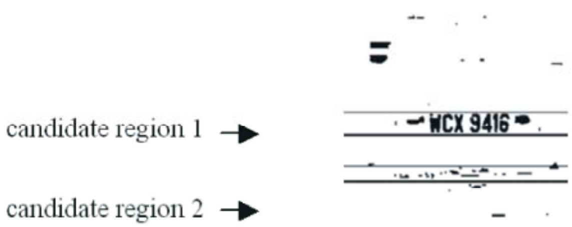

Fig. 8: Output Of Candidate Region Selection

RESULTS AND DISCUSSIONS

Pre-Processing: The input color image is converted into gray scale using gray scale conversion in the first stage of pre-processing. Then after performing the adaptive thresholding the gray scale is converted to binary image as shown in Figure 4.

Fig. 9: Detected License Plate

Table 1: Computation Time Of Each Stages

LP	Color to gray	AT	ULEA	VEDA	HDD	CRE	PRS & PD	Total time
1	1.1	20	5.1	7	7	2.5	8.4	51.1
2	1.0	10	5.3	6.9	6.5	5	8	42.7
3	1.0	15	5.4	7.1	7.1	2.5	8.6	46.7
4	1.6	17	5.2	6.7	7.4	1.5	7.8	47.2
5	0.8	13	5	7.3	7.5	5	8.2	46.8
AVG(ms)	1.1	15	5.2	7	7.9	3.3	8.2	47.7

Table 2: Comparison With Other Methods

Methods Used	No.Of Correctly Detected Plates	Detection Rate	Computation Time
VEDA based	607/664	91.4%	47.7ms
Sobel based	591/664	89%	101.7ms
PVW based	580/664	84.8%	298ms

Vertical Edge Detection: In the vertical edge detection stage, the thin lines produced during the adaptive thresholding process that do not belong to the LP region are eliminated by using Unwanted Line Elimination Algorithm(ULEA) as shown in the below Figure 5.

After the ULEA process, the output image used to find all the vertical edges using the Vertical Edge Detection Algorithm(VEDA).The idea of the VEDA concentrates on intersections of black–white and white–black is clearly visible on the obtained output as shown in Figure 6.

Car License Plate Extraction: The car license plate extraction is done with the help of four associated stages such as highlight desired details, candidate region extraction, plate region selection and plate detection.

Connecting to vertical edges with black background the desired details become highlighted as shown in the above Figure 7.

The horizontal line is drawn above and below each candidate region to extract the license plate as shown in figure 8.After plate region selection the license plate is detected as shown in Figure 9.

By calculating the time in each computation stages of this method the total processing time needed is about 47.7ms. Out of these stages the adaptive thresholding stage only requires more time for computation as shown in Table 1.

The VEDA contributes to make the whole proposed CLPD method faster. The accuracy is higher than other LPD and algorithm is useful for real time application.

CONCLUSION

Based on these results, it is concluded that using the VEDA for detecting vertical edges could have enhanced the performance of the proposed CLPD in terms of the computation time and the detection rate. Also a new and fast method is formulated using vertical edge detection, in which its performance is faster than the performance of Sobel by five to nine times depending on image resolution. This paper proposed a method for CLPD, in which a web camera with 352 * 288 resolution is used instead of a more sophisticated web camera.By comparing this method with the principal visual word(PVW) discovery method, it is found that it can only process the image with higher resolutions (640*480) also the computation time is very high. In the experiment, the rate of correctly detected LPs is high in addition, the computation time of the CLPD method is low, it is about 47.7ms which meets all the real-time requirements.

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