A Vertical Edge Detection Algorithm for Car License Plate Detection

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ABSTRACT
Edges characterize boundaries and are therefore a problem of fundamental importance in image processing. Edge detection is one of the most critical tasks in automatic image analysis. There exists no universal edge detection method which works well under all conditions. This paper shows the new approach based on the one of the most efficient techniques for edge detection, which has advantages of its robustness and its flexibility. Edge detection is a very important process for many image processing applications, especially in Car License Plate Detection and Recognition Systems (CLPDRS). The need to distinguish the desired details is a very important pre-process in order to give good results in short time processing. We proposed a new and fast Vertical Edge Detection Algorithm (VEDA) which is based on the contrast between the gray scale values. After binarizing the input image using adaptive thresholding (AT), an unwanted-line elimination algorithm (ULEA) is proposed to enhance the image, and then, the VEDA is applied. The results revealed accurate edge detection performance and demonstrated the great efficiency of using VEDA in order to highlight license plate details.

Keywords
Image acquisition, Image pre-processing, Unwanted line elimination algorithm, Vertical edge detection algorithm(VEDA).

1. INTRODUCTION
Edge detection is an important issue in image processing. Edges constitute a significant portion of the information contained in images, and thus, it is useful to extract these features from a complete image. An edge map has vastly reduced complexity and retains important structure present in the original image [1]. Edge detection is in the forefront of image processing for object detection, it is crucial to have a good understanding of edge detection algorithms.

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions.

Vertical Edge Extraction (VEE) is a basic process in CLPDRS where VEE can display car plate characters and details; therefore, it is useful to be used in order to distinguish these details. Literature showed that VEE had been used for license plate detection such as [4] [5] [6]. VEE is one of the most crucial steps in Car License Plate Detection (CLPD) and influences the whole system in locating the plate efficiently [7]. Car license plate details always have a lot of vertical edges that can be used to generate the candidate regions for classification [4]. Most edge detectors do not perform well on images that have been blurred and do not contain “sharp” edges. For this reason, it is often useful to pre-filter an image prior to performing edge detection [1]. To detect car license plate automatically, many difficulties have to be overcame, such as the background details, the poor image quality, the processing time, the plate sizes and designs.

Sobel operator is one of the most important algorithms that has been widely used to detect the vertical edges in many CLPD methods [8] [9] [10]. Therefore, this paper proposes a Vertical Edge Detection Algorithm (VEDA) to be faster than Sobel operator with an accurate performance of showing the vertical edges. Furthermore, the use of VEDA in CLPD would enhance the system performance.

This paper is organized as follows: Section II describes Adaptive Thresholding Algorithm. Section III Describes our algorithm of vertical edge detection, and it contains two parts: Unwanted Lines Elimination Algorithm (ULEA) process and VEDA process. Experimental results and discussion are given in section IV. Section V draws the conclusion.

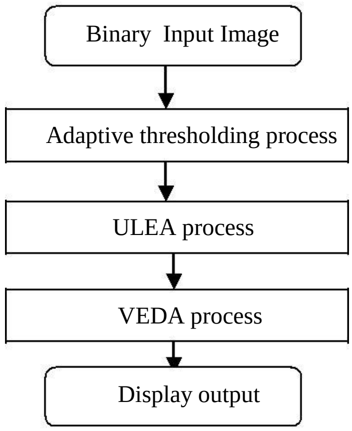


Fig. 1: The flowchart of proposed approach

2. ADAPTIVE THRESHOLDING PROCESS
Our adaptive thresholding technique is a simple extension of Wellner’s method [Wellner 1993]. The main idea in Wellner’s algorithm is that each pixel is compared to an

average of the surrounding pixels. Specifically, an approximate moving average of the last s pixels seen is calculated while traversing the image. 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. This method works because comparing a pixel to the average of nearby pixels will preserve hard contrast lines and ignores soft gradient changes. The advantage of this method is that only a single pass through the image is required. Wellner uses 1/8th of the image width for the value of s and 15 for the value of t. However, a problem with this method is that it is dependent on the scanning order of the pixels. In addition, the moving average is not a good representation of the surrounding pixels at each step because the neighborhood samples are not evenly distributed in all directions.

In this technique we calculate the integral image in the first pass through the input image. In a second pass, we compute the s x s average using the integral image for each pixel in constant time and then perform the comparison. If the value of the current pixel is t percent less than this average then it is set to black, otherwise it is set to white. The following pseudocode demonstrates our technique for input image in, output binary image out, image width w and image height h.

Fig. 2 (a): Input image

Fig. 2 (b): Thresholded image

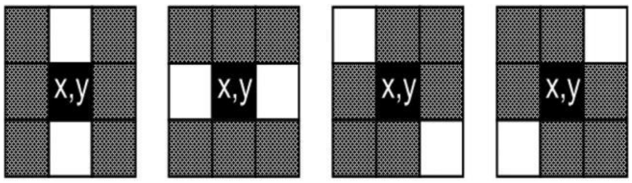
3. VERTICAL EDGE DETECTION ALGORITHM

3.1 ULEA Process

Thresholding process in general produces many thin lines that do not belong to the LP region. In Fig. 2(b), we can see that there are many long foreground lines and short random noise edges beside the LP region. These background and noise edges are unwanted lines. These lines may interfere in the LP location. Therefore, we have proposed an algorithm to eliminate them from the image. This step can be considered as a morphological operation and enhancement process.

It is clear from Fig. 2 (b) that the image has some unwanted lines in angles 00, 900, 450, and 1350 with width of one pixel. Therefore, ULEA has been proposed in order to eliminate these lines. In order to keep small plate details, one pixel width is selected to be used for this process. A 3x3 mask is used throughout all image pixels. Only black pixel values in the thresholded image are tested. Supposed that g(x,y) are the values for thresholded image. Once, the current pixel value located at center of the mask (x,y) is black, the 8-neighbor pixel values are tested. If two corresponding values are white in the same time, then the current pixel is converted to white value as background pixel.

Fig. 3(a) shows the possible cases in which the current pixel is converted to background pixel. Each case of a,b,c and d represents two corresponding values in each time the mask moves through the g(x,y) values.



(a) 0° (b) 90° (c) 45° (d) 135°

Fig. 3(a): The 4-cases for converting center pixel to background value, (a) horizontal lines (0^0), (b) vertical lines (90^0), (c) inclined lines with (45^0), (d) inclined lines with (135^0)

The pseudocode for this process can be summarized as illustrated in Algorithm 1

```
For every pixel in thresholded image
If(g(x,y)=0)

   If[ (g(x-1,y)=255 AND
     g(x+1,y)=255) OR
       (g(x,y-1)=255 AND
     g(x,y+1)=255) OR
      (g(x-1,y+1)=255 AND g(x+1,y-
   1)=255) OR
      (g(x-1,y-1)=255 AND g(x+1,y+1)=255) ]

     Then
          O(x,y)=255;
  End if
End for
```

Algorithm1: ULEA pseudocode

Fig. 3(b): ULEA output

3.2 VEDA Process

After eliminating the unwanted lines in the binary image the Vertical Edge Detection Algorithm (VEDA) is to distinguish the plate detail region, particularly the beginning and the end of each character. The idea of the VEDA concentrates on intersections of black – white region. The VEDA is to distinguish the plate details region, especially, the beginning and the end of each character therefore, the plate details will be easily detected and character recognition process will be done faster.

A VEDA will make the black-white and the white-black regions edges have two and one black pixels, respectively. A mask 2X4 is proposed for this process, where (x,y) represents the current processed pixel location at point (0,1) as center of our mask as shown in Fig. 5 (a). Basically, the proposed mask consists of 3 smaller masks, which are left mask 2X1, center mask 2X2, and right mask 2X1. Fig. 5 shows the design of the proposed mask, where x represents the rows or the height of the image and y represents the columns or the width of the image.

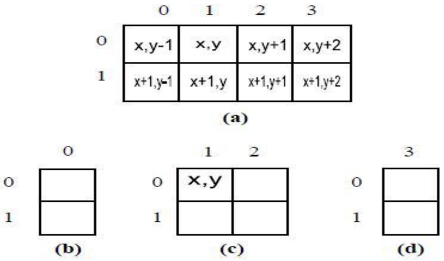


Fig.3(c): The design of the proposed mask:

(a) moving mask, (b) left mask (0,0), (1,0), (c) center mask (0,1), (0,2), (1,1), (1,2), (d) right mask (0,3), (1,3)

The selection of the column at the locations (0,1) and (1,1) to be a center of our proposed mask, is to keep the last two black pixel values located at the intersection of black-white regions, and to keep the first black pixel value located at the intersection of white-black regions as well. The 2X4 mask moves from top to bottom and from left to right. The abundance availability of black pixel values inside the plate itself and because plate characters are white color which is considered as background in our

work, therefore, our proposed mask can keep the last two black pixel values, which are located at the end of intersection of plate region with the beginning of the character (black-white regions).

Algorithm 2 shows the pseudocode for VEDA process-
Create a white blank image as *Img(x,y)*;

```
Create a white blank image as Img(x,y);
For every pixel in ULEA image
    output center=1; left=1;
    right=1;
  If(four center mask values
        = black)
        center=0;
  End if
  If(two right mask values
        = black)
        right=0;
  End if
  If(two left mask values
        = black)
        left=0;
  End if
  If(!center AND !right AND !left)
      two center column values of Img =white;
  /* Img(x,y)=255;
  Img(x+1,y)=255; */ End if
```

Algorithm2: VEDA pseudocode

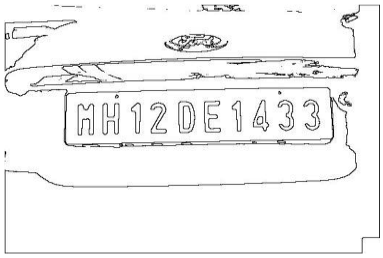


Fig.3(d): VEDA output

4. EXPERIMENTAL RESULTS AND DISCUSSION

Here, the AT process will be evaluated first. Then, the accuracy and the computation time of the VEDA are compared with that of the Sobel operator. We can notice that car license plate vertical edges are distinguished and clear to be extracted easily, the two pixel width and the one pixel width are clear too. It is important to say the first edge of the plate character is darker than the second one. The computational time in VEDA is much less than Sobel which gives a strong advantage to VEDA.

5. CONCLUSION

In this paper, we have proposed a new algorithm in order to detect vertical edges. Before VEDA was applied, ULEA was done in order to enhance the binarized image. This enhancement process makes VEDA works faster than Sobel. The experimental results demonstrated that VEDA is faster than Sobel operator for extracting vertical edges, yet the accuracy of edge detection is nearly similar. Our proposed approach is able to work with motion blurred images for detecting the vertical edges. The advantage of VEDA is that this algorithm gives two pixel width for black-white region edges and one pixel width for the white-black region edges. This advantage helps to detect plate details easily and faster during next processing steps and suitable for real-time processing.

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