Heuristic Approach for License Plate Detection

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ABSTRACT - The license plate detection is one of the most important processes in License Plate Recognition (LPR) System. A number of techniques have been proposed in research literatures. Among the most promising techniques is text locating-based technique. However, in a complex scene the technique creates too many candidate regions with noisy background which result in segmentation difficulty. Toward the text locating approach, this paper presents a new license plate detection and segmentation technique. Improving on the existing technique, it creates cleaner connected regions by using our new morphological approach. The searching and segmentation technique proposed here is also efficient for this very application.

1. Introduction

One of the important tasks in the License Plate Recognition (LPR) system is the detection of the plate. It involves locating the area in an image that is considered a license plate. The degree of difficulty varies depending on application that the system is designed for. The simplest case is where cars are forced to stop in a specific spot and the camera points directly toward the plate in a controlled environment. The problem becomes more complex when the car is moving in an open environment with no control over lighting. As the degree of difficulty increases a more complex solution is needed. We propose a plate detection technique for a complex scene, which can operate in real time for slow moving cars. The technique can handle various camera angles and lighting conditions. Our LPR system is designed for Thai license plate which there is not yet commercial product available.

A number of techniques have been proposed for extracting plate region. Among those techniques, the most common approaches include edge and corner extraction[5], plate color[6] and text locating approach[2][3]. The edge or plate boundary detection suffered largely because of uncertainty of the edge, presenting by various types of the plate as well as identifying plate area from incomplete or broken edges. The process also ends up producing too many candidate regions, which is difficult for segmentation. Color-based approaches mainly fail change in lighting conditions. For example, color of an object varies significantly from out door to indoor environment. The text locating-based technique exploits the fact that there is frequent change of the intensity because of the characters in the plate. The edge of the characters are extracted then connected together using morphological operation to represent the plate region. The technique is robust under different lighting and orientation conditions. However, in the complex scene the normal morphological techniques such as closing or dilating produces noisy output and resulting in too many candidate plate regions. In this paper we present an alternative technique that creates cleaner result. Also presented candidate plate searching technique which is more efficient than conventional method for very this application.

2. Candidate Plate Detection

By observing characteristics of the license plate we have found a number of distinguished features. Firstly, intensity change in the plate area is unique because of the appearance of characters on it. Using horizontal projection, uniformity can be observed in intensity peaks as shown in Figure 1. Secondly, the color of the letters on the plate sharply contrasts with the background. And the occurrence of the letters and spacing is also, to some extent, uniform aligned. To obtain this pattern, vertical edge detection is applied on the input image so that only the desired features are exposed. As shown in Figure 2.b, the result image contains only vertical edges. It can be observed that the edges are more uniformly distributed with in the plate area than in other part of the image. Although the pattern of the vertical edges in the plate is unique compared to the other parts, directly searching for this pattern is not an easy task. By connecting these lines together then performing the search, the task becomes simpler. Morphological techniques such as dilation or

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closing are commonly applied to achieve such a result. We have found that it is much more efficient to use a specific algorithm for this task than using a general purpose one. Figure 2 shows the comparison of the closing method and our method. A number of different mask sizes were tested for the closing operation. The best result was achieved with a 9x1 mask.

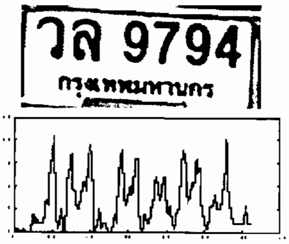

Figure 1. Horizontal projection of the license plate

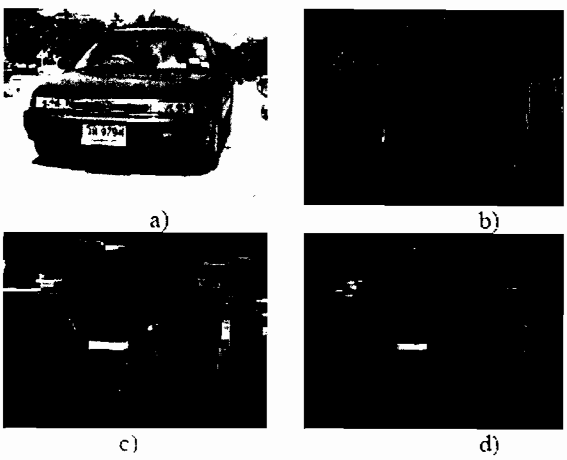

Figure 2. Comparison of closing and the proposed technique a) the original image b) result of vertical edge detection c) result of closing technique using 9x1mask d) result of the proposed technique

Figure 3 shows algorithm of the proposed technique. We call the technique Accumulative Intensity Morphing (AIM). The basic concept of the algorithm is to create a connected region from a group of pixels that conform to our pre-defined conditions. Practically, a pair of pixels, referred to as the start and the end pixel, are considered at a time. A line is then drawn to connect these pixels if the following conditions are satisfied. For any pixel in the input image

- To be a start pixel, its intensity must be higher than a threshold (T) or its corresponding pixel in the output image is non-zero (a part of a line).
- To be an end pixel, it has to have intensity higher than a predefined threshold (T).
- For any start and end pixels to be connected, they must reside within a predefined distance (maxInterval) If there are more than one pixel within the distance the furthest from the start pixel will be chosen.

```
for( y = 0; y < InputImage->height; y++)
{
  for( x = 0; x < InputImage->width; x++)
  {
    int startPixel1  = InputImage[x][y];
    int startPixel2 =  OutputImage[x][y];
    if(startPixel1 > T || startPixel2)
    {
      bool found = false;
      for ( i = x + maxInterval; i > x ; i--)
      {
        endPixel = InputImage[i][y];
        if(endPixel > T)
          found = true;
        if(found)
          OutputImage[i][y] = OutputImage[i][y] + C;
      }
    }
  }
}
```

Figure 3. Algorithm of the proposed region connection technique.

The algorithm can be operated in two directions, horizontal and vertical. In the above figure shows the operation on the horizontal direction. From the algorithm OutputImage will be initialized with black color (zero intensity). Every pixel in the input image will be examined in left-right and top-bottom order. The process start when a starts pixel is found. The image index will be shifted forward by maxInterval. Then pixel will be examined backward. If the end pixel is found, an intensity value (C) will be added to every pixel back to the start pixel. When the operation moves to next pixel, the same procedure will be repeated. This way intensity will be built up as the process advance. See the pattern created by the algorithm in Figure 4.

Figure 4. Result pattern of the algorithm

In equation 1, for explanation purpose, we simplify the algorithm by considering only a pair of start/end pixel. The equation shows how the intensity of a particular pixel in the result image is generated (in horizontal direction) and how the intensity is varied due to distance of pixels. That is, the pixels that lay too close to each other the algorithm will produce lower intensity than the further apart one.

$$OutImage[X_i][Y] = C*(X_i - X_{start});\ X_{start} \leq X_i \leq X_{end} \quad (1)$$

We applied the AIM process in two directions, vertically and horizontally. First the vertical direction is carried out to intensify the vertical line of the edge. This process helps distinguishing the true line and the noise. And as the by product of the vertical AIM process is also act like noise filter operation. This process consequently removes some unwanted and isolated pixels that can cause noisy results. Because the edge pixels of non-plate area are usually scatter around with no pattern as in plate area. Therefore they will fail to comply to some of the rules or forming too low intensity to be qualified for the next process. Figure 5.c shows result of vertical process on the edge image. The output image from the vertical process is then used in the horizontal process to create the final result.

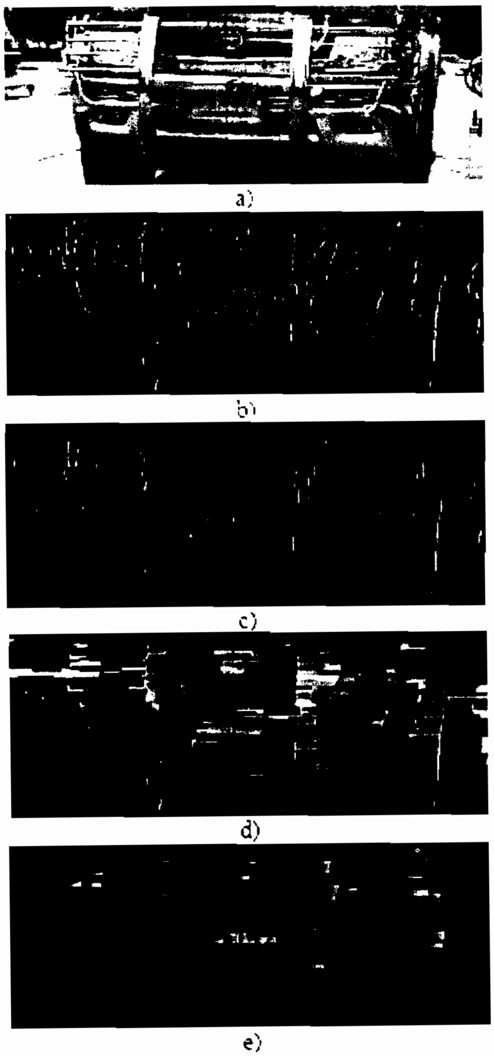

Figure 5. Output of each steps in the AIM process a) the input image b) result of the vertical edge detection c) result of the algorithm on vertical AIM d) result of closing technique e) the final result

In term of implementation of the algorithm, these processes are done on separate images. There are some parameters that their values are determined emperically such as maximum distance between pixels in the same group (maxInterval). It was set to 5 and 35 for vertical and horizontal processing respectively. The intensity, C, of the line for connecting pixels together is 10. The threshold T, for the valid start and end pixel, is 100. Figure 6 shows comparison between closing and the proposed technique from different camera angles and lighting.

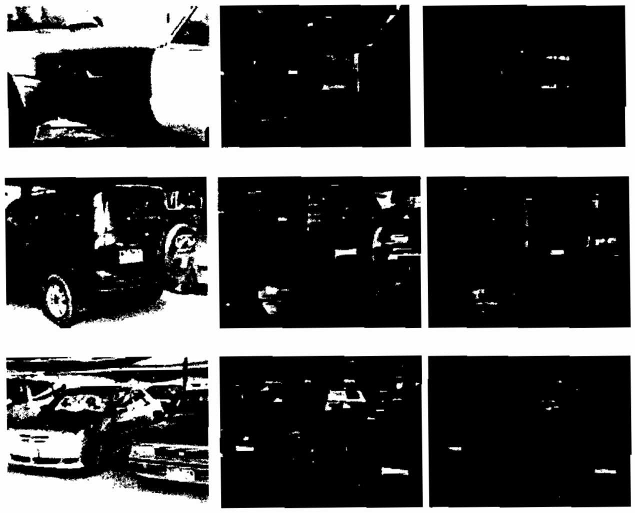

Figure 6. Comparison result images between closing (second column) and the proposed technique (last column).

The parameters setting depend largely on the distance from the car to the camera. For the plate detection algorithm +/-1 meter misplace is still acceptable. The result of the improper setting, mostly, effects on character recognition process instead. Since too small characters will result in less accurate recognition. Therefore some calibration is required for each installation. Usually some kind of trigger is need for the system to start taking a snap shot of the plate. In our case, a row of pixel in video frames is used as a trigger line. For every incoming frame it will be tested to see if there is a jump of variance of pixels intensity. If the variance is higher than a threshold that mean there is a car move into the operating area and the detection operation is started using current video frames. By doing so, we can assure that the size of the plate will be approximately as require.

3. Segmentation and Searching

The result from the previous process creates connected regions. Usually there are more than one regions that are possible to be the license plate area. Before the actual plate region can be determined, all the candidate regions have to be located. The task involves image segmentation and searching for all possible regions. Using one of the most obvious characteristics of the license plate that is it has a rectangular shape. Therefore our searching task is to looking for regions that have some degree of rectangular shape. Because of the camera angle, poor contrast on the plate and noisy background we can hardly expect perfect rectangular blob. Therefore the process has be highly tolerant to distortion both from noise and camera perspective.

A number of segmentation techniques have been proposed in the research literature, e.g., edge and contour technique, thresholding technique, and regions splitting and merging technique. These techniques were designed for general segmentation purposes. To achieve higher accuracy as well as efficiency some form of customization is often required. In this paper, we propose a new segmentation technique that is designed specifically for the rectangular shape object like license plate. Although there might be some distortion due to the camera angle, the system should be tolerant to some tilt. That is the plate pan and tilt around -30° to +30° should be acceptable. The proposed technique is more robust and faster compared to the aforementioned one.

In order to represent the propose technique more clearly, we define a rectangular object as a region that composes of a number of continuous vertical lines. Our task is to search for a sequence of lines that can form such a region. The search process is done by scanning image in top-down direction from left to right. As scanning down each column, a number of vertical line segment might be passed through. These lines will be recorded as part of a new candidate region if: firstly it has intensity higher than a threshold and secondly its length is within acceptable range. The range represents the expected height of the license plate. For any following line to become part of a region it has to be check for the length of intersection with the previous member of the region. To be qualified as the member of the same region, it must have less than 50% of their length outside intersection area as in following equations:

$$I(x\text{-}1, i) > T;\ s_{x\text{-}1} <= i <= e_{x\text{-}1} \quad (2)$$

$$I(x, j) > T;\ s_x <= j <= e_x \quad (3)$$

When $I(x, i)$ is intensity of a pixel at current column, x, and row i. This pixel locates between the start pixel s_x and the end pixel e_x which is a vertical line interval at column x that has value exceed threshold T. $I(x\text{-}1, j)$ is intensity a pixel at previous column at row j.

$$L_x = e_x - s_x \quad (4)$$

$$L_{x\text{-}1} = e_{x\text{-}1} - s_{x\text{-}1} \quad (5)$$

$$L_{ins} = Min(e_{x\text{-}1}, e_x) - MAX(s_{x\text{-}1}, s_x) \quad (6)$$

$$L_{ins} - 0.5 * L_{x\text{-}1} > 0\ AND\ L_{ins} - 0.5 * L_x > 0 \quad (7)$$

When $L_{x\text{-}1}$ is the length of the previous line in the region. L_x is the length of the new line. And L_{ins} is length of intersection between $L_{x\text{-}1}$ and L_x. The equation 7 is the condition used to include a new line in a region. With this method all the objects that has approximately rectangular shape will be recorded for final identifying of the actual plate. It should be noted that the perfect rectangular object, intersection must be 100% to each other. In practice there is always slant or perspective distortion that the intersection is hardly perfect so 50% intersection should be flexible enough to detect the distorted plate. Figure 7 shows an example of a region can be extracted by our algorithm.

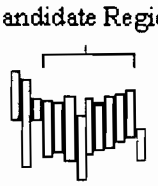

Figure 7. Shows a sample of a candidate region detected by the algorithm

4. Plate verification

Since there can be more than one candidate regions, it is required to verify the most likely one. There are 2 steps in plate verification. First region size and ratio of width and height is checked to reduce the number of candidate regions. The region size is calculated by using width x height. The value used for the region size is in the range of 1000 – 6000 pixels. For the ratio of width/height should be in the range of 2-5. It should be noted that these values is chosen according to an expected camera distance (or image resolution) including some variation tolerance. If the condition differ too much these number have to be change as well. The second step, the final verification, is done by analyzing projection of output from vertical AIM process on each region (Figure 8). By summing up peaks from the projection, we have found that the real plate region usually have higher sum value than non-plate regions. Practically only the values that are not higher than 2 time of the mean of the peaks are used in order to avoid outlier. Therefore the candidate plate that has the highest sum of peak value will be selected as the real plate.

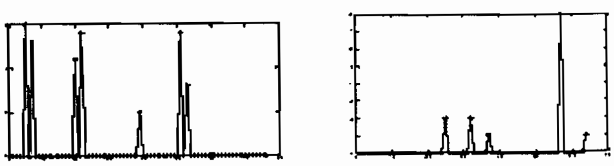

Figure 8. Shows project of intensity from output of vertical AIM process. Left graph is from plate region and non-plate region on the right.

5. Experimental result

Since there is no standard test corpus, the technique has been tested with about 150 test samples of Thai license plate from both video and still images collected by the research team. These samples were captured with different camera angles and lighting conditions from both indoor and outdoor environments. The resolution used for both video and still image is 640x480 pixels. From the experiment, the proposed technique proves to be robust under various complex scenes. It achieved 97% correct plate detection. Mostly, the error is caused by poor contrast in the plate as a result of very dim lighting or the plates with dark color background e.g. black character on red background. In this case, the detection process fails at the very beginning when it tries to extract vertical edges. In terms of processing time, the proposed technique is twice as fast as the conventional morphological closing operation.

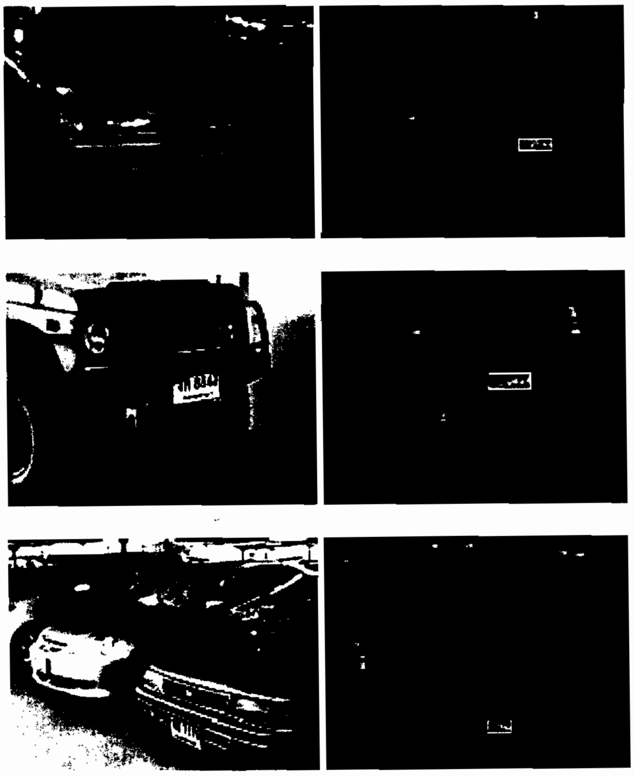

Figure 9. Shows experimental result from various camera angles and lighting conditions.

6. Conclusion

This paper presents a new license plate detection technique. The proposed technique is divided into two main processes, namely the candidate plate detection and the plate segmentation. The proposed method has shown better results, in terms of candidate plate detection, as compared to conventional approaches. We have achieved significantly less noisy results. The technique is robust to undesirable connections with non-plate components – leading to difficulty in segmentation. The result image is cleaner and easier for plate location search. On average, the processing time of our technique is also twice as fast as the conventional morphological closing operation. The segmentation and searching parts also perform efficiently in locating license plate even with noisy input image and distorted plate. The overall processing time is fast and the proposed system is capable of real time operation.

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