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3—17 A system for locating license-plate area from images taken under complex conditions

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Abstract

In this paper, an efficient edge-based approach, including implementation of a hardware system, for locating car license plate area from images taken under relatively complex conditions is presented. The proposed method is divided into three steps: 1) *preprocessing* - edges are detected from the input image and thresholded, 2) *global search* - candidate areas are sought from the edge images, and 3) *local search* - exact plate area is determined based on the structural properties of the plate. For many images collected from a large underground parking place, the accuracy of the global search is 98% when the first and the second candidates are considered. And the local search algorithm correctly locates the plate area for 97% of the images.

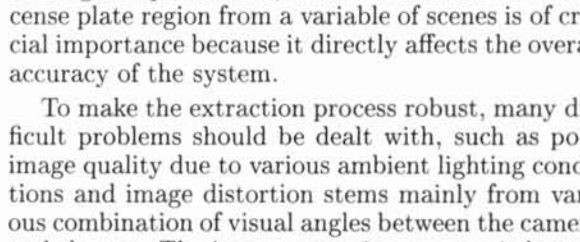
1 Introduction

Automatic vehicle identification plays an important role as the ITS(Intelligent Transport Systems) becomes getting bigger attention [1]. In general, the technologies for identifying a vehicle can be classified into two categories: first one is to use of electromagnetic devices to identify each individual vehicle. The RF tag, which is attached to a car for the purpose, is a typical and popular example. When microwave signal arrives, the unique information stored in the tag is decoded and used for identifying the car. The second one is to retrieve the information on the license plate attached to each car. In the approach, a camera captures the image of a car and a computer processes the image to locate the plate area and recognizes the information on the plate by applying various image processing and optical pattern recognition techniques [2].

Computer vision-based vehicle identification technologies that have been reported in previous researches generally consist of several procedures, including extraction of a license plate region (or a number of candidate areas), segmenting characters from the region and recognizing the characters. Among the procedures, accurate location of the license plate region from a variable of scenes is of crucial importance because it directly affects the overall accuracy of the system.

To make the extraction process robust, many difficult problems should be dealt with, such as poor image quality due to various ambient lighting conditions and image distortion stems mainly from various combination of visual angles between the camera and the car. The image capturing process is largely depending on several aspects, including camera angle, dynamic range of the camera, ambient lighting condition, background complexity, existence of reflection and plate fracture [3]. Therefore, it is necessary to make the extraction process robust so that it can work under any situation in the real world environment. Several approaches have been applied for extracting the plate region, including edge extraction [4][5], Hough transform [6], histogram analysis [7] and morphological operators [8].

A robust approach, including hardware implementation, for extracting car license plate from images with complex background, variable plate size



(a) (b)

Figure 1: Car images taken in an indoor parking place: (a) with light beams and (b) various ambient lighting condition

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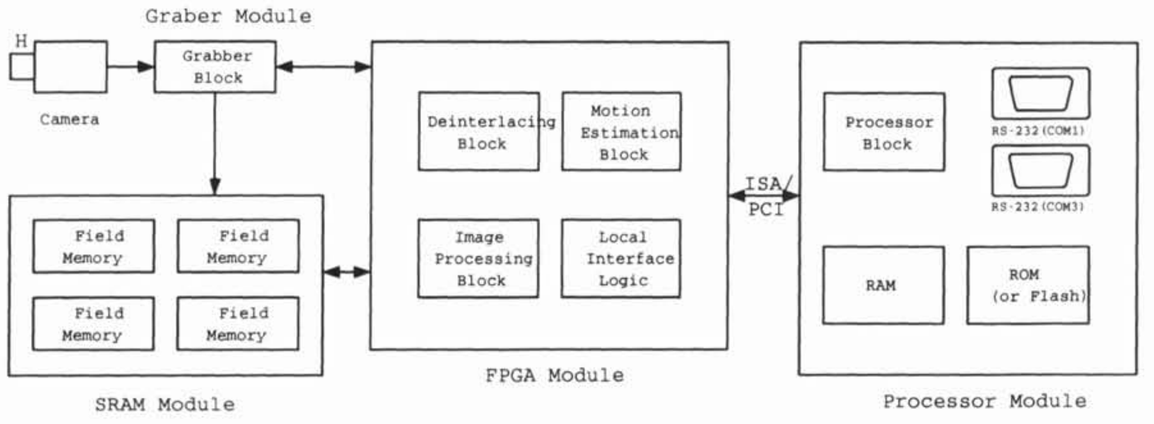

Figure 2: Block diagram of the hardware implementation

and skew/tilt angles, and relatively poor lighting conditions is presented in this paper. Figure 1 shows two example images that the system deals with.

Depending on applications, it is often desirable to make the system running stand-alone with minimum connections with other systems. To make the system simpler and more compact and to make up the processing power a specialized hardware which includes a large scale programmable component is introduced. The programmable component contains some image processing algorithms.

This paper is organized as follows: Section 2 is on brief description on the hardware implementation and Section 3 describes overview of the proposed search algorithms. Section 4 is on experimental results and performance analysis. Section 5 provides a summary of the work with conclusion.

2 Hardware Implementation

The proposed system consists of several hardware modules for grabbing images and fast processing of the images in efficient manner. Figure 2 shows the block diagram of the implementation. A deinterlaced image is formed using four field images captured using a normal video camera and saved in the memory module. While the deinterlacing is performed, to minimize visual artifacts, the motion is analyzed from the field images and interpolated based on the advanced edge-based line average method. Also, several basic image processing operators, such as ones for producing gradient and edge images, are implemented in a large scale FPGA. The FPGA module is controlled by the processor module which is a single board PC and connected via standard bus systems.

Performance and efficiency of the motion estimation and compensation algorithm which resides in the FPGA module is compared with several existing software implementations using typical test images. And the images captured by the implemented hardware compared with the ones taken by a progressive camera in a subjective manner. Also, functionality of the image processing operators are checked with ones produced by the corresponding software counter parts. The preliminary results show that high quality images can be captured using a conventional camera and prove that hardware implementation of a number of basic image processing operators can be effectively employed for the various applications. Figure 3 shows the edge images of ones shown in Figure 1 using the hardware implementation.

(a) (b)

Figure 3: Edge images obtained using the hardware implemented

3 License plate searches

Once a vehicle image is captured, a sequence of *pre-processing* steps is applied. A two-stage search process is performed in the subsequent steps: *the global search* in which candidates of the plate region are sought from the edge images, and *the local search* where the correct plate region is selected from the candidates and the boundary of the region is adjusted using the structural properties of the plate. Figure 4 shows the flow of the search process and details on each step in Figure 4 are described in this section.

3.1 Pre-processing

To obtain edge images, the Canny operator [9] is applied. Based on the fact that the plate area contains more components with vertical strokes the operator is designed to detect vertical edges. Figure 5(a) and (b) show the edge images of Fig-

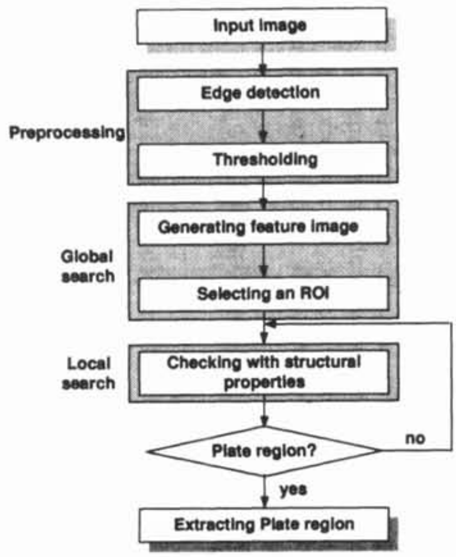

Figure 4: The overview of the search algorithm

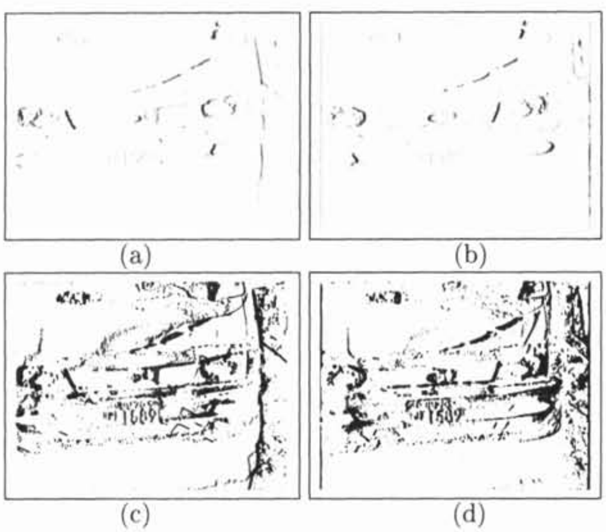

Figure 5: Edge images: with (a) positive- and (b)negative- gradient, and (c,d) after thresholding

ure 1(a) with positive- and negative-gradient respectively. Then the edge images are thresholded to discard edges with trivial strength. Figure 5(c) and (d) show the edge images of Figure 5(a) and (b) after thresholding.

3.2 Global search

Step 1: obtaining the feature image

As we can see in Figure 5, when a type of gradient is observed in one side of a stroke it is natural to expect the other type of gradient nearby. The property can be used as a clue for locating the candidate regions. Since the both edge images with positive- and negative gradients are obtained in the pre-processing stage, a feature image can be created by preserving edges with such property (Figure 6(a)).

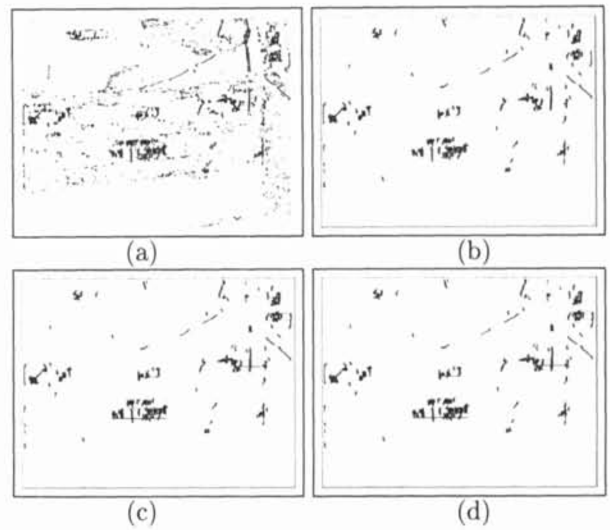

Figure 6: Global search: (a) feature image, (b) labeled image, (c) lines are merged, and (d) candidate areas.

Step 2: labeling edges

In this step, labeling the edges is performed. During the labeling, relatively longer ones in both horizontal and vertical directions and smaller ones which can be regarded as noise are eliminated. Figure 6(b) shows the result.

Step 3: locating candidate regions

Edges remaining are examined and merged based on its relationships. As shown in Figure 6(c), boxes are formed by merging edges with similar length and directions. Distance between the edges are considered as well. Then, the boxes are also merged according to their relative horizontal positions and the vertical distance between them. Figure 6(d) shows the merged boxes.

Among the regions, three candidates are selected and ranked based on the size and the edge density inside the box.

3.3 Local search

Even the candidate areas are determined, as we can see in Figure 6(d), no candidate contains the whole plate area. Therefore, it is necessary to enlarge the area under examination in all directions as shown in Figure 7(a). Once the ROIs are selected, it is necessary to make sure which one contains the license plate. Binarization [10] is applied to the area and the objects inside are labeled (Figure 7(b)). Among them, objects which can be regarded as (bigger) numbers are identified using the aspect ratio of the digits, edge density, and so on. Using the identified objects, the size and the tilt angle of plate are estimated and confirmed based on the structural properties of the plate.

If an area under examination does not satisfy the conditions, the process is repeated until the candi-

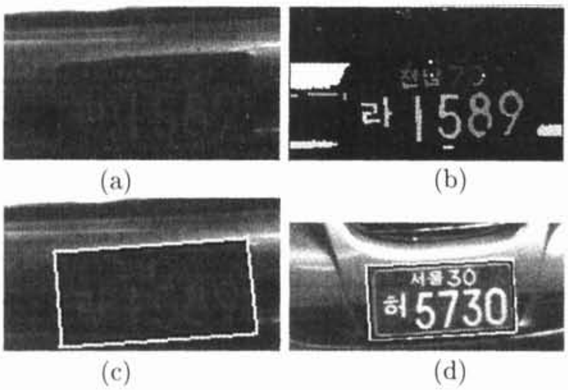

Figure 7: Local search: (a) the enlarged ROI, (b) objects are labeled after thresholding, (c) the plate area is located, and (d) plate extraction result of Figure 1(b)

dates are consumed. Figure 7(c) shows the final result after the local search, and Figure 7(d) shows the result of image shown in Figure 1(b).

4 Experiments

Many images with various types of vehicles, not only passenger cars but also vans and trucks, were collected from a large indoor parking place with different angles and different lightening conditions. The image acquisition system consists of a CCD camera, a photo sensor to detect presence of a car, and a personal computer with a image grabber in it. Size of the image is 640×492.

The experimental result shows that the global search algorithm correctly locate the plate area for 92%, 98%, and 99% of the images used when we consider 1st, 2nd and 3rd candidates respectively. And the local search algorithm exactly extract the plate area for 97% of the images.

Sources of the failure can be classified into three major categories: 1) existence of other text blocks which are very similar to the license plate, 2) bounding box containing the plate is merged into other box(es), and (3) weak gradient information from the plate area.

Figure 8 shows additional correct results: in (a) the first candidate is ignored by evaluating the structural properties and the second candidate is selected (left light is selected as the first candidate) and in (b) other text area with similar size is ignored.

5 Summary and Conclusion

An edge-based efficient and robust approach, including a hardware implementation, for locating license plate from a car image is presented in this paper. The three-step approach is designed to deal with images taken under various real world conditions. In the first step, edges are detected and thresholded. In the second step, the whole edge image is searched and candidate areas are located. In

Figure 8: Additional results: (a) the 2nd candidate is selected and (b) text are is ignored

the last stage, the candidates are examined to verify whether it contains the license plate based on the structural properties of the license plate. Based on the experimental result, the performance of the proposed approach is promising. Ways to make the approach more robust and faster are being sought by combining a couple of techniques and fully utilizing the hardware implementation.

References

[1] D. Gao and J. Zhou, "Car license plate detection from complex scene," in *Proceedings of International Conference on Signal Processing, Washington D.C.*, pp. 1409–1414, 2000.

[2] P. Hu, Y. Zhao, J. Zhu, and J. Wang, "An effective automatic license plate recognition system," in *Proceedings of CISST 2000*, pp. 80–84, 2000.

[3] M. W. Burke, *Image acquisition*. Chapman & Hall, 1996.

[4] D. H. Ballard, *Computer Vision*. Prentice-Hall Inc., 1991.

[5] K. Kanayama, Y. Fujikawa, K. Fujimoto, and M. Horino, "Development of vehicle-license number recognition system using real-time image processing and its application to travel-time measurement," in *Proceedings of IEEE Vehicular Technology Conference*, pp. 798–804, 1991.

[6] K. M. Kim, B. J. Lee, K. Lyou, and G. T. Park, "The automatic recognition of the plate of vehicle using the correlation coefficient and Hough transform," *Journal of Control, Automation and System Engineering*, vol. 3, no. 5, pp. 511–519, 1997.

[7] D. U. Cho and Y. H. Cho, "Implementation of preprocessing independent of environment and recognition of car number plate using histogram and template matching," *The Journal of the Korean Institute of Communication Sciences*, vol. 23, no. 1, pp. 94–100, 1998.

[8] M. Shridhar, J. W. Miller, G. Houle, and L. Bijnagte, "Recognition of license plate images: Issues and perspectives," in *Proceedings of International Conference on Document Analysis and Recognition*, pp. 17–20, 1999.

[9] J. Canny, "A computational approach to edge detection," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. PAMI-8, pp. 679–698, November 1986.

[10] N. Otsu, "A Threshold Selection Method from Gray-Level Histograms," *IEEE Transactions on Systems, Man, and Cybernetics*, vol. SMC-9, pp. 62–66, 1979.