Moving License Plate Segmentation

José María Lezcano Romero
Abilio Mancuello Petters
Dr. Horacio A. Legal Ayala
FIUNA, FPUNA
Universidad Nacional de Asunción
San Lorenzo, Paraguay
hlegal@pol.una.py

Dr. Jacques Facon
PPGIa
Pontifícia Universidade Católica do Paraná
Curitiba-PR, Brazil
facon@ppgia.pucpr.br

Abstract—This document presents an approach for vehicle's license plate segmentation from images acquired during the day. The presented methodology is based on a connected component analysis. The images were acquired by a digital camera mounted on the front of the car through moving traffic. The approach was tested in 500 images with a success rate of 91.8%; these results show that this method proves to be an efficient alternative for license plate segmentation.

Keywords-Image processing; license plate segmentation.

I. Introduction

License plate segmentation is an integral part in the development of license plate recognition method. License plate recognition is important since it provides a means to identify a vehicle by its license plate and it can be an important tool for law enforcement, marketing, toll, traffic, and access control among others.

Several different license plate recognition methods are available in the literature and most of them follow the same scheme. The general scheme is composed of three modules: license plate location, license plate characters location, and character recognition.

This paper presents an approach for Paraguayan license plate segmentation with the following steps. First, there is a pre-processing step to extract candidates. Then, the image is filtered using descriptors to reject false positives. Finally, the best candidate is selected using a qualification process.

The rest of the paper is organized as follows. Section II reviews the state of art. Section III describes the license plate segmentation. Experimental results over 500 image database are discussed in Section IV.

II. State of Art

License plate detection has been one of the mainstream applications of computer vision in the last decade. This functionality is present in many traffic control systems. Therefore numerous methods have been developed for different countries and target applications.

X. He, H. Zhang, W. Jia, Q. Wu, and T. Hintz have presented in [1] a license plate detection algorithm based on two kinds of features for region classification: edge features as a global feature and Haar-like features as local. Global classifiers are formed by using common learning-based processes and global statistics. Local features and AdaBoost are used to create the local classifiers.

Another approach is the one proposed by B. Remus [2]. This approach consists of the use of the Prewitt edge detector, a low-pass filtering for noise reduction, and a maximum entropy criterion for thresholding, as a preprocessing procedure. Then the Hough transform is calculated from the binary image. The vertical and horizontal lines are extracted to form rectangles with them. The license plate is detected by selecting a rectangle and comparing it against a template and considering its aspect ratio.

A similar approach was presented by T. D. Duan, D. A. Duc, and T. L. H. Du in [3]. The aim of this method is to segment the license plate by searching its border lines using Hough transform and contour algorithm. As preprocessing stages they use the Sobel edge detector and a thresholding procedure. Many parallelograms are formed with the lines identified by the Hough transform. Then a candidate is selected by its geometric characteristics. The software IDE and the camera manufacturer used in this approach are the same as the ones used for our method.

Another approach is exposed [4] by K. Halina, and W. Bartosz. The license plate segmentation procedure is based on two steps. Firstly, a connected component analysis localizes possible characters in the image by using geometric properties. Secondly, nearby characters are grouped and a "signature" search is performed in each group. The signature is a sequence of intensity minima and maxima computed over a row of pixels that cross the different groups of possible characters in the image. This signature is distinctive for license plates. Finally, a simple neural network and a syntax analysis are used to recognize license plate characters correctly.

A different method was proposed by D. Premnath in [5]. This is a heuristic procedure based on connected components analysis. For the preprocessing stages it is implemented a vertical edge detector and a novel morphological technique called Accumulative Intensity Morphing (AIM). This technique was developed by the author especially for this publication. As in other approaches, connected components are extracted and their geometric features are evaluated in the search for plate-like candidates. Then a number of heuristic rules are applied for the candidate discarding procedure.

III. LICENSE PLATE SEGMENTATION APPROACH

The approach presented in this paper is meant to be used to locate license plates through moving traffic. The proposed method described in flowchart of Fig.1 can be summarized as follows. Three different sequences are applied to segment the license plate candidates, two of them based on different local adaptive binarization onto grayscale version of color images and the third directly applied onto color images. The segmentation result of each sequence is pos-processed by four component reduction steps to reduce the false positives.

The selection of the true license plate is performed by a qualification process applied to all remaining license plate candidates obtained after the component reduction of the three sequences.

A. *First sequence*

A grayscale version of color image is previously performed.

1) *Image enhancement*

A modified Mexican Hat filter is applied to the images to reduce inter-image and intra-image brightness, lighting variations and highlight grayscale license plates. The Gaussian component of Mexican Hat reduces and normalizes the brightness of each pixel to compensate for differences in illumination. The border enhancement produced by the Laplacian component of the Mexican Hat filter preserves the license plate contour. Fig. 6-(b) illustrates the result of modified Mexican Hat filtering.

2) *Binarization*

A local adaptive binarization is performed pixel by pixel inside a 33x33 moving window. The automatic process for calculation the threshold is the same as proposed by Gonzalez & Woods [6]. Fig. 6-(c) depicts the binarization.

3) *Binary component extraction*

A region growing process is applied to the previous binarization. Fig. 6-(d) depicts the region growing result.

B. *Second sequence*

In this sequence, the Mexican Hat filter and the region growing process are applied in the same way than in the first sequence.

The difference between the two sequences comes from the binarization process which consists in thresholding the image by region by means of a non-overlapped 32x32 window. The threshold value is calculated as described in Gonzalez & Woods [6]. Fig. 6-(f) depicts this second binarization.

Fig. 6-(g) depicts the result of the region growing process onto the second binarization.

C. *Third sequence: Color component extraction*

A similar region growing process is applied to color image. Fig. 6-(i) shows the grayscale result of color region growing applied on Fig. 6-(a).

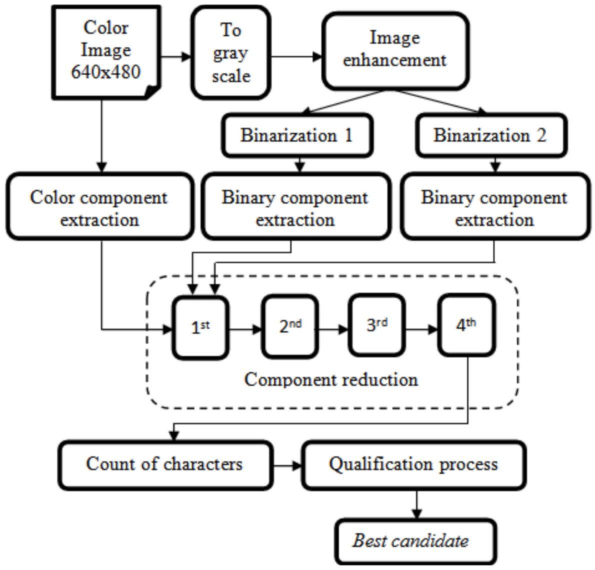

Figure 1. Flowchart of the proposed method.

D. *First component reduction*

For each image in which the region growing algorithm is applied, first component reduction based on a size criterion is performed. For instance, Fig. 6-(j) illustrates the component reduction applied to color region growing (related to third sequence).

E. *Second component reduction*

Each component is bounded by a box. Let be *m*, *n* and θ, the horizontal size, vertical size and skew, respectively. The component reduction is based on the ratio *m/n* where its skew dependency is described by (1), where *a* and *b* are shown in Fig. 2. By using a heuristic knowledge that the ratio *a/b* of license plates used in our country approximately is around 2 and that skew does not exceed 45 degrees, the values of *m/n* are limited in [1,2]. By using this heuristic value, one can reduce the number of components.

$$\frac{m}{n} = \frac{\tan\theta + \frac{a}{b}}{1 + \frac{a}{b}\tan\theta} \qquad (1)$$

F. *Third component reduction*

The reduction is based on eccentricity parameter of each bounding box. The four extreme pixels *A*, *B*, *C*, *D* of the bounding box are used to compute the eccentricity parameter (Fig. 3). The value of $\overline{AB}/\overline{BC}$ has to be 2 or 1/2 approximately. Similarly, opposite sides have to be almost equal, $\overline{AB}/\overline{DC} \approx 1$ and $\overline{AD}/\overline{BC} \approx 1$, as is true for the license plate rectangle.

G. *Fourth component reduction*

Each candidate has a valid area if the sum of the candidate area (2) and the candidate background (3) is approximately equal the bounding box area (4). To verify this condition, consider Fig. 4 and the following expressions.

$$Candidate_{area} = White\ Pixels \quad (2)$$

$$Candidate_{background} = \frac{\overline{BY}.\overline{YC}}{2} + \frac{\overline{CZ}.\overline{ZD}}{2} + \frac{\overline{AW}.\overline{WD}}{2} + \frac{\overline{AX}.\overline{XB}}{2} \quad (3)$$

$$Candidate_{area} + Candidate_{background} \approx m.n \quad (4)$$

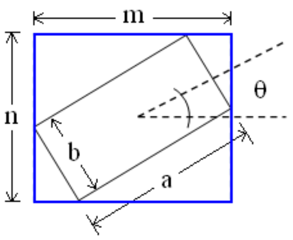

Figure 2. Geometric features of bounding box.

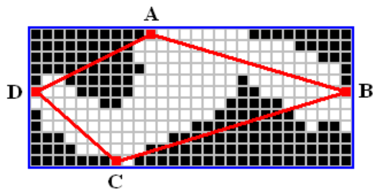

Figure 3. Bounding box extreme pixels A, B, C, D.

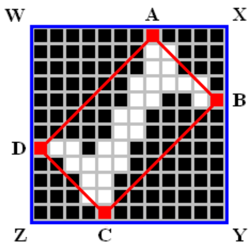

Figure 4. A candidate with invalid area.

Fig. 6-(e) and (h) and (k) show the results of complete component reduction.

H. License plate candidate selection

From a theoretical point of view, after the finishing of all component reductions, each sequence would provide only one license plate candidate. But in practice, due to complexity of urban images, each sequence presents more than one candidate.

The selection of the best candidate is performed by a qualification process applied to all remaining license plate candidates. In example of Fig. 6, the three sequences totalize 8 candidates (Fig. 6-(e) and (h) and (k)). The qualification is based on punctuation of 4 features that are: skew, eccentricity, position and number of characters.

- Skew: it does not exceed 45 degrees. The lower is the candidate skew, the higher is its punctuation;
- Eccentricity: it is based on $\overline{AB}/\overline{BC}$, $\overline{AB}/\overline{DC}$ and $\overline{AD}/\overline{BC}$ values as explained before;
- Position: candidates in front of the camera have higher punctuations than those at the periphery.
- Number of characters: A character is a connected set with determined area, aspect ratio and position inside a candidate (Fig. 5). Similar geometric properties are used in [4] to detect characters, but in the entire image. Based on a heuristic knowledge about the number of characters of license plates in our country, a license plate candidate with six characters has more chance to be the genuine license plate.

When the punctuation of features is finished, a global score for each plate candidate is then obtained by summing the feature punctuations. Only one license plate is selected in this last step corresponding to the highest score. Fig. 6-(o) depicts the successful result.

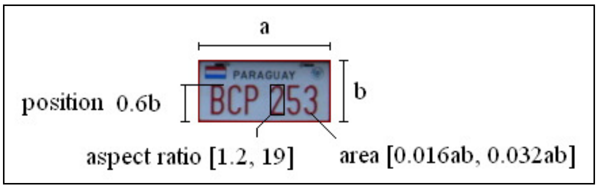

Figure 5. Geometric features of characters

IV. Evaluation Criteria and Experimental Results

The proposed method was tested and evaluated on a database composed of 500 vehicle images. The images were obtained by mounting a camera in front of a car and capturing from that position while the car was in movement during the day. The distance between the camera and the vehicle in front of the driver was in the range of 1 to 10 meters approximately.

The result of the segmentation was manually verified. 41 images were not well segmented. Some of them showed partial license plate segmentation, so they were computed as false results. Fig. 7-(c) depicts an example of partial segmentation.

From 500 vehicle images, 459 license plates were correctly segmented. Fig. 7-(a) and (b) depict two successful segmentations with different lighting conditions. By obtaining a segmentation rate of 91.8%, the experimental results show the efficiency of the methodology in locating and segmenting the vehicle's license plates. The heuristic knowledge used in this work can be applied or adapted for different license plates in different countries. Therefore, the heuristic knowledge does not represent a limitation in our approach.

A comparison between our method and those proposed in Section II is inadequate. The difficulties are: non-specific range for camera-plate distances, no vehicles in movement, and different image resolutions.

V. Conclusions

A methodology to locate and segment moving vehicle's license plate during the day was proposed. The segmentation rate onto a database of 500 traffic images was 91.8%. This numerical result shows the efficiency of the presented methodology in locating and segmenting vehicle license plates from running camera. Main contributions of this work are: the pipeline of modified techniques, which reduces the number of analyzed elements in a fast manner, and the qualification process that selects the license plate.

References

[1] X. He, H. Zhang, W. Jia, Q. Wu, and T. Hintz, "Combining global and local features for detection of license plates in a video," Proceedings of Image and Vision Computing New Zealand 2007, pp. 288–293, December 2007.

[2] B. Remus, "License plate recognition system," Proceedings of the 3rd International Conference on Information, Communications and Signal Processing, Singapore, pp. 2D3.6, October 2001.

[3] T. D. Duan, D. A. Duc, and T. L. H. Du, "Combining Hough transform and contour algorithm for detecting vehicles' license-plates," Proceedings of International Symposium on Intelligent Multimedia, Video and Speech Processing, pp. 747–750, October 2004.

[4] K. Halina, and W. Bartosz, "License plate localization and recognition in camera pictures," Proceedings of Symposium on Methods of Artificial Intelligence - AI-METH 2002.

[5] D. Premnath, "Heuristic approach for license plate detection," NECTEC Technical Journal, vol. 5, No. 16, pp. 653–657, 2005.

[6] G. Rafael, and W. Richard, "Digital image processing," 2nd ed. New Jersey: Prentice Hall Inc, 2002, pp. 599–600.

Figure 6. Different steps of the proposed method.

Figure 7. Three different results.