Traffic Sign Detection in Static Images using Matlab.

Miguel Ángel García , Miguel Ángel Sotelo, and E. Martín Gorostiza
Department of Electronics
University of Alcalá
Escuela Politécnica. Campus Universitario s/n. 28805 Alcalá de Henares,Madrid
SPAIN

Abstract – In this paper a system for off-line traffic sign detection is shown. Matlab-Image-processing toolbox is used for this purpose. The vision-based traffic sign detection module developed in this work manages 172x352 color images in RGB (Red, Green, Blue) format. The first step in the algorithm is to obtain the gradient image and its vertical edge projection. In a second step, a color and shape analisys is performed.

I. INTRODUCTION

Traffic sign detection and recognition have experimented increasing importance in the last times. This is due to the wide range of applications where this system can be used, as for instance, in intelligent vehicles, driver support systems, etc.

There are four types of traffic signs in the traffic code: prohibition, warning, obligation and informative. Depending on the shape and color, the warning signs are equilateral triangles with one vertex at the top. Prohibition signs are circular having a specific figure in each case over a white or blue background and a red border. To indicate obligation, signs are circular, with a figure over a blue background.

One of the greatest inconveniences of the RGB color space is that it is very sensitive to changes in light [1]. This is the reason why other color spaces are used in computer vision applications, especially the hue, saturation, intensity (HSI) one. This system keeps high immunity to changes in light [2]. The problem with HSI is that its formulas are nonlinear, and the computational cost is prohibitive. Instead, we have used the relation between the RGB components, as this work is proposed for real-time systems and no further processing is needed after digitalization.

To detect a traffic sign in an image, the algorithm follows these steps:

1) Candidate image regions are obtained, by accumulating vertical and horizontal edge projections.
2) Candidate image regions are validated as follows:
   - Red image thresholding, for prohibition sign.
   - Blue image thresholding, for obligation sign.
   - Blob shape analysis.
   - Circular ring template.

II. BORDER IMAGE

The appropriated choice of the color features to use in the process is of crucial importance in order to attain proper and fast detection. Accordingly, only the Red component is considered as it provides a high capacity for color discrimination in the visual analysis of traffic signs and no further processing is needed after digitalization. In an attempt to carry out a preattentive strategy, a coarse analysis of vertical edge is performed in a first stage based on differential characteristics computed on the Red component of the image using a gradient filter [3], as depicted in Fig. 1, where two images containing traffic signs are illustrated together with their associated gradient image applying a vertical edge operator. The gradient image is computed as expressed in (1). Where Gx and Gy denote a Prewitt extended operator, using a 5x5 mask.

$$g(x,y)=\begin{bmatrix} G_x \\ G_y \end{bmatrix}=\begin{bmatrix} \dfrac{\partial}{\partial x}f(x,y) \\ \dfrac{\partial}{\partial y}f(x,y) \end{bmatrix}\approx |G_x|+|G_y| \qquad (1)$$

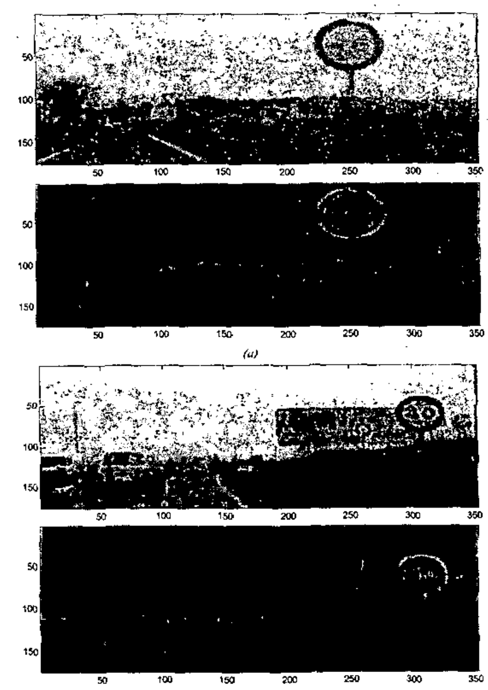

Fig. 1. Original and filtered images using a Prewitt extended operator.

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III. CANDIDATE IMAGE REGIONS.

Vertical projection of border pixel.

One of the most common techniques for traffic sign segmentation is to use grey-level images, red component in our case, and to project pixels at the edges onto the axes.

Vertical projections of different types of signs are shown in Fig. 2. As can be observed, a maximum occurs in the area of the image where the sign is placed.

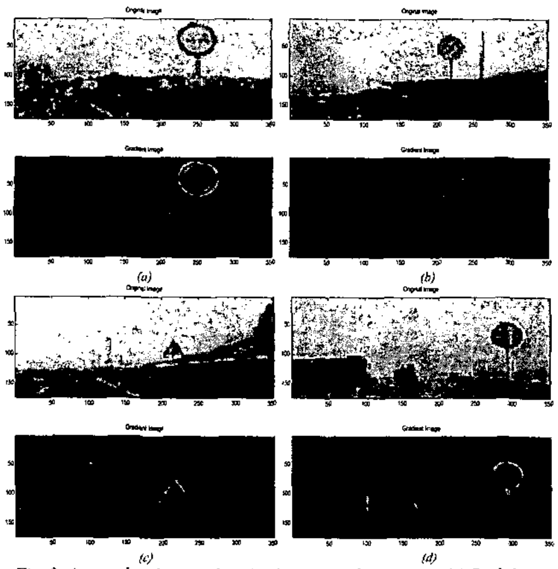

Fig. 2. Accumulated vertical projection on gradient image. (a) Prohibition (b), special case, end of prohibition (c) warning, (d) obligation.

As a first step, an adaptive thresholding is performed aiming at removing the common offset component in the projection profile [4]. For this purpose, a threshold u is computed as expressed in (2)

$$u_v = \mu_v + \mu_v^+ \tag{2}$$

where μ_v stands for the average value of the projection profile, while μ_v^+ represents the average of all points in the projection whose value is greater than μ. The resulting threshold is depicted in Fig. 2. Finally, the coarse detection phase ends by removing narrow peaks from the projection profile. This yields a set of candidate image regions that highly reduces and constraints the portions of the image where traffic signs are likely to appear, as depicted in Fig. 3.

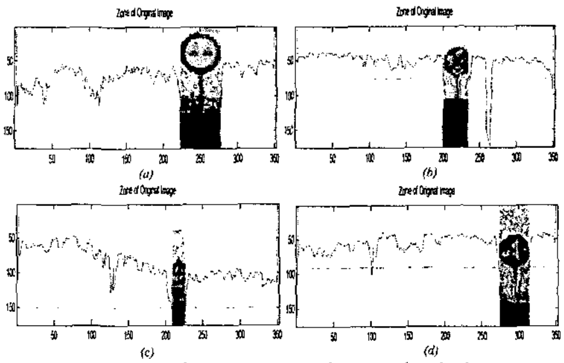

Fig. 3. Candidate image region after vertical projection.

Horizontal projection of border pixel.

In order to restrict the area of interest a bit more, the same method, previously explained, is applied to horizontal projections of edge pixels in the region of interest. In this case the adaptive threshold is obtained as expressed in equation (4)

$$u_h = \mu_h \tag{4}$$

where μ_h denotes the standard average value of the horizontal projection. After applying this segmentation process, regions of interest remain more restricted. Nevertheless, not all the regions include a traffic sign inside. Resultant regions of interest are shown in Fig. 4.

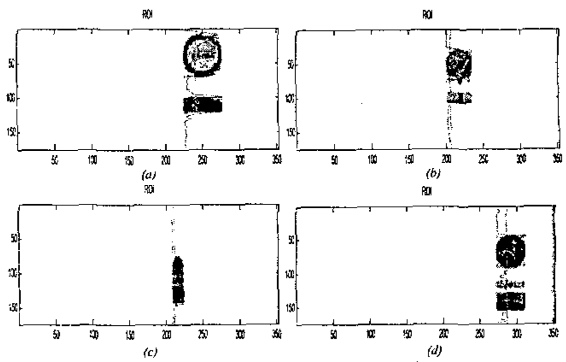

Fig. 4 Candidate image region after horizontal projection.

IV. RED AND BLUE IMAGE.

Color is a very important parameter to be taken into account for road-sign detection and further classification. Some authors choose color-spaces that exhibit high immunity to changes in light, HIS (Hue, saturation Intensity)[5] [6],so that regions are segmented by means of a look-up table (LUT).[7]. In this work, RGB color space has been chosen, so that relations between components are used to highlight red-colored regions in the image. The most important reason why RGB is used is that it allows to speed up the detection process. Computation times needed to obtain the results appearing in Fig. 5, are the following:

Red-component image in HSI space: 180 mseg.
Red-component image in RGB space: 10 mseg.

The way to obtain the red-component image is shown in (5).

$$r(x,y) = 2f_r(x,y) - f_g(x,y) - f_b(x,y) \quad (5)$$

where $f_r(x,y)$, $f_g(x,y)$ and $f_b(x,y)$ are, respectively, the functions that provide the red, green, and blue levels of each pixel of the image.

Blue-component image achievement in RGB space is very similar, as it is shown in (6).

$$b(x,y) = 2f_b(x,y) - f_r(x,y) - f_g(x,y) \quad (6)$$

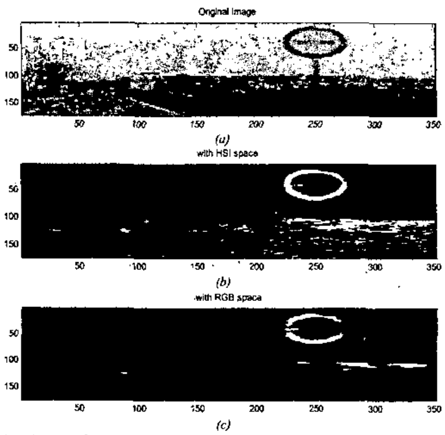

Fig. 5. (a) Original image, (b) red image with HSI space, (c) red image with RGB space.

V. BLOBS

From the regions of interest already obtained red and blue images corresponding to these areas are calculated and thresholded, yielding the blobs that can be seen in Fig. 6.

These blobs, corresponding to road signs must fulfill the size and aspect constraints described by (7) and (8).:

$$A_i \geq A_{\min} \quad (7)$$

$$r_{\min} \geq \frac{|h_i - l_i|}{\max(h_i, l_i)} \geq r_{\max} \quad (8)$$

where A_i is the minimum area that a blob must have and h_i and l_i are the blob's width and height respectively. Resultant blobs are useful to place a road sign-searching template on the image.

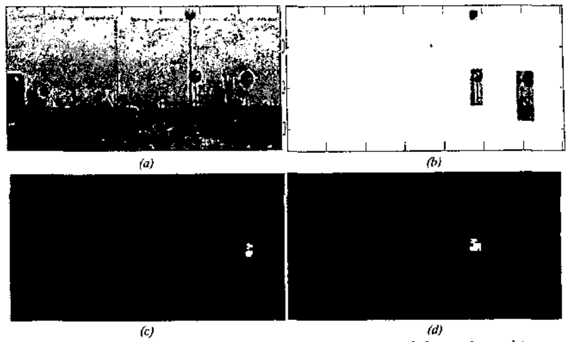

Fig. 6. (a) Original image, (b) Region of interest, (c) Blobs in the red image, (d) blobs in the blue image.

VI. TEMPLATE

A ring-shaped template will be placed in the centre of the blob, as shown in Fig. 7 (a), for prohibition and - signs, which are circular. The sequence to adjust the template is:

1. The template is moved over the edge-image $g(x,y)$, along the eight directions indicated in Fig. 7 (b), while the sum of all the points remaining inside the ring at the shifted position is bigger than the sum of all the points inside then ring in the previous position.
2. Radius R and r of the ring are set following the same criteria as in the ring-centre adjustment.
3. The first two steps are repeated at each shift step.
4. For a candidate object (region) to be considered as a road sign the sum of the points in the ring must be bigger than a certain threshold value (9).

$$\sum t(x,y) \geq U \quad (9)$$

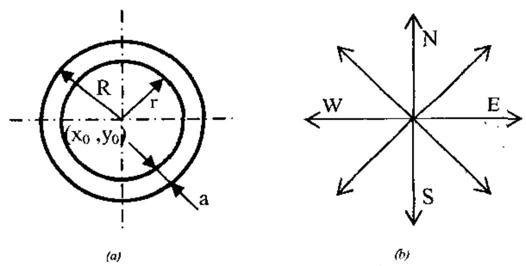

Fig. 7. (a) Circular ring template, (b) directions.

The result of applying this method is shown in Fig. 8. In Fig. 8 (a) two signs have been detected, an obligatory-direction blue one and a Stop-one which is not circular but can be adjusted with this method. A smaller obligatory -direction road sign has not been detected, because it is still too far from the ego-vehicle. In Fig. 8 (b) an overtaking prohibition sign has been detected, and a triangular give-way sign as well, but the template has been only adjusted to the first one. Finally, in Fig. 8 (c) only the closest obligatory-direction sign is detected and the template adjusted to it.

VII. CONCLUSIONS

An algorithm for static images detection has been presented in this work. It is nevertheless the beginning of a work devoted to road signs detection and recognition in real time, for the near future. Detection is carried out by projecting pixels at the edge onto the axis. The algorithm is valid for every type of road sign and there is a classification stage done, using a template.

Future work continuing this research line: detection improvement, road sign detection under adverse conditions, use of templates for both circular road-signs and for triangular ones as well, in a first classification stage, and finally, sending the results obtained in previous stages to a neural network that will be in charge of performing a finer classification. The system is thought to be working in real time conditions.

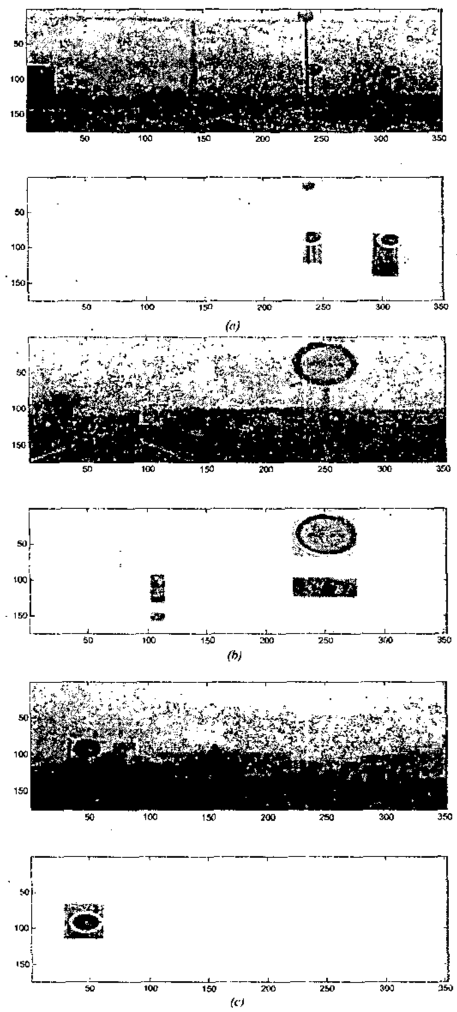

Fig. 8. Traffic sign detection.

VIII. ACKNOWLEDGMENTS

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