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Traffic sign recognition application based on image processing techniques

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Abstract: This paper describes a software application for traffic sign recognition (TSR). The application works in four stages. First, an image preprocessing step and the detection of regions of interest (ROIs), which involves a series of steps that include transforming the image to grayscale and applying edge detection by the Laplacian of Gaussian (LOG) filter. Secondly, the potential traffic signs detection, where the ROIs are compared with each shape pattern. Thirdly, a recognition stage using a cross-correlation algorithm, where each potential traffic sign, if validated, is classified according to the data-base of traffic signs. Finally, the previous stages can be managed and controlled by a graphical user interface, which has been specially designed for this purpose. The results obtained show a good performance of the developed application, taking into account acceptable conditions of size and contrast of the input image.

Keywords: Traffic sign recognition; image processing; image segmentation; visual pattern recognition; boundary detection; cross correlation functions.

1. INTRODUCTION

Digital image processing uses algorithms to process digital images. Although it may seem recent technology, many of the techniques were developed in the 1960s at the Massachusetts Institute of Technology, University of Maryland and other research facilities (Chen *et al*., 1993). However, due to the high costs of computers at this time, the digital imaging process was too expensive for many to even consider. That changed in the 1970s, when digital image processing proliferated as cheaper computers and dedicated hardware became available. With the fast computers and signal processors available in the 2000s, images could be processed in real time and digital image processing has become the most common form of image processing (González and Woods, 2007). Computer vision is increasingly used in the field of intelligent transport (Mapanga and Ragavan, 2012), and traffic sign recognition is a very important part of this. These systems are typically based on detecting a region of interest (ROI), in which the traffic sign is located, using characteristics such as color and geometric form. In computer vision, the ROI defines the borders of an object under consideration and is commonly used in many application areas, such as medical imaging (Dougherty, 2009).

Video processing techniques for traffic applications have been an attractive field of research during the last two decades (Piccioli *et al*., 1996; Kastrinaki *et al*., 2003). Several techniques have been proposed to develop traffic sign recognition (TSR) systems (Ruta *et. al*., 2010). The main goal of these systems is the detection and recognition of every traffic sign present in the scene (Ritter *et. al*., 1995). In the last few years, the TSR systems have become important components of advanced driver assistance systems (ADAS) (Gil *et al*., 2008). The main difficulty that TSR systems face is the poor image quality due to low resolution, bad weather conditions or inadequate illumination.

The application developed in this paper determines the area of the original image where the potential traffic sign is located, and compares it with a database which contains normalized traffic signs. The process starts with a preprocessing stage for the input image, where the parameters of the image, such as resolution or contrast, are modified to guarantee that the filters and algorithms used later behave properly. When the parameters of the image have been adjusted, an edge detection algorithm is used in order to determine the potential areas of the image where a possible traffic sign may be located. The next step is to separate the regions of interest (ROIs) found in the image and obtain the potential traffic signs. Every potential traffic sign is submitted to a recognition process, using a cross-correlation algorithm that compares each one with a database, which contains patterns of traffic signs. This software includes a graphical user interface, which allows the user to control each stage of the application. The results obtained show a high success rate, dependent on the environmental conditions of the input image and its resolution.

This paper is organized as follows. In section 2, the preprocessing process and the ROI detection are described. Section 3 shows the potential traffic sign detection stage. Section 4 details the traffic sign recognition process. Section 5 describes the graphical user interface. In section 6 the experiments carried out are described and the results obtained are presented. Section 7 contains the conclusions of the work and finally some references are given.

2. IMAGE PREPROCESSING AND REGIONS OF INTEREST DETECTION

The first step of the preprocessing is to adjust the image size, reducing the space occupied when the resolution of the input image is too high. If the image size were too high, it would slow down the execution of the algorithms to the point that it would restrict the program execution. Next, a contrast limited adaptive histogram equalization (Sepasian *et al*., 2008; Reza, 2004) is performed to enhance the contrast of the image by transforming the values obtained in the intensity image. This method is chosen to prevent the over amplification of noise that adaptive histogram equalization can give rise to (Pizer *et al*., 1987). The contrast amplification in the vicinity of a pixel is proportional to the slope of the neighborhood cumulative distribution function and to the value of the histogram at that pixel value. The next step is to transform the input image into a gray scale image, so the edge detection algorithm can be applied (Pei and Horng, 2000; Wan *et al*., 2007). In Fig. 1, a typical traffic image taken as example and its corresponding gray-scale image, are shown.

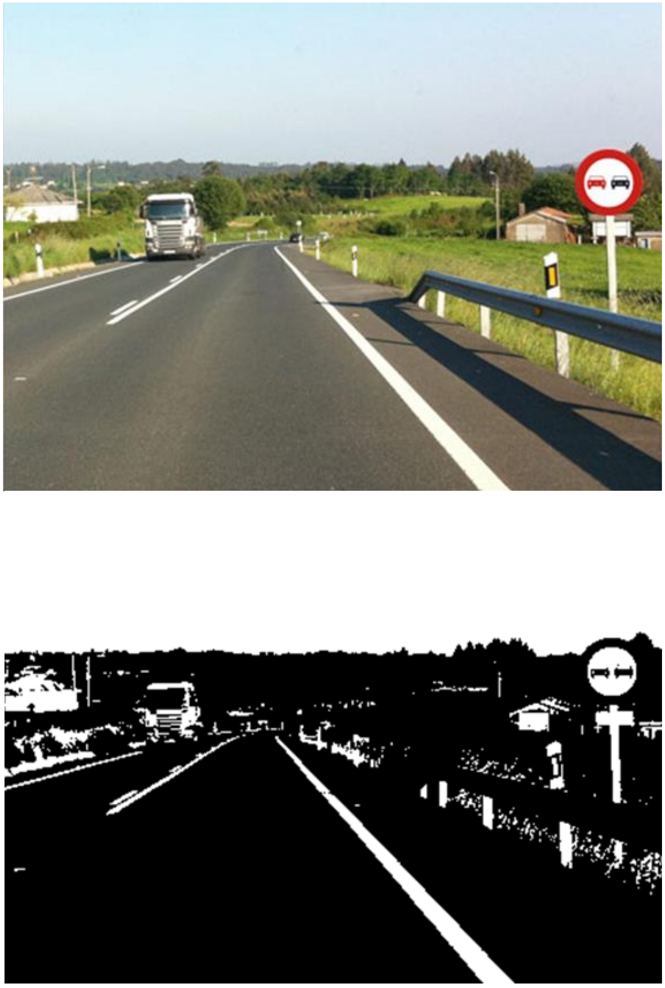

Fig. 1. Traffic image and its corresponding grayscale image.

The algorithm used to detect edges in the image is the Laplacian of Gaussian (*LOG*), which takes a grayscale image as input and produces another grayscale image as output, where only the edges are shown. The *LOG* is a hybrid filter that contains a Gaussian smoothing filter and a Laplacian filter, and then convolves it with the image to achieve the required result (Sharifi *et al*., 2002). The function used, centered on zero and with standard deviation σ, is given by (1) and has the form shown in Fig. 2, where (x,y) are the coordinates of each pixel.

$$LOG(x,y) = -\frac{1}{\pi\sigma^4}\left[1-\frac{x^2+y^2}{2\sigma^2}\right]e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (1)$$

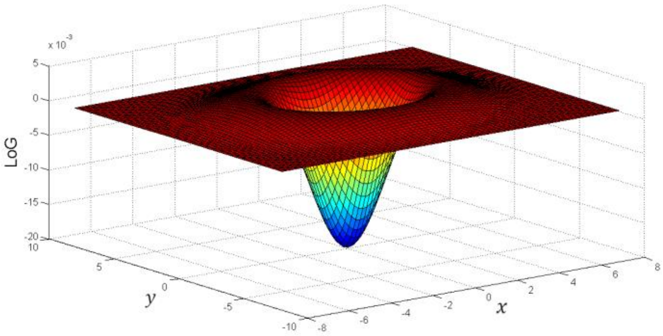

Fig. 2. Laplacian of Gaussian function.

The *LOG* operator calculates the second spatial derivative of an image. In areas where the image has a constant intensity, the gradient is zero and the response will be zero too. In the vicinity of a change in intensity, the response will be positive just to one side of the edge and negative just to the other side of the edge. In the case of the image used as an example, the result obtained is shown in Fig. 3.

Fig. 3. Edge detection.

Once the edge filter has been applied, the areas of the image that do not exceed a certain size are eliminated to avoid possible confusion with the environment. This is done because traffic signs are quite big objects so small edges correspond to objects that cannot be regions of interest. Figure 4 shows the ROIs for the image taken as example. In this figure, every ROI must be evaluated separately.