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Detection and Extraction of Road Traffic Signs

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ABSTRACT

The real-time road traffic sign recognition focused on the application of computer vision techniques in automatic detection and classification of video images of traffic signs placed on roadways acquired from moving vehicles. In this work, we present results of an attempt to locating traffic signs placed on local roadways based on image processing techniques. The developed algorithm is based on two basic processing stages; localization and extraction of the traffic signs. The algorithm takes a raster image of a background scene with a traffic sign as the input and extracts the sign as the output. The preliminary work shows high performance in the extraction of traffic signs with warning messages on local roads. The algorithm was tested for a variety of images and showed 98% accuracy in locating and extracting traffic signs.

1. INTRODUCTION

Driving is a task based fully on visual information processing. The road signs and traffic signals define a *visual rules* interpreted by drivers. Road signs carry vital information for safe and orderly driving. For example, they describe the current traffic situation, define right-of-way, prohibit or permit certain directions, warn about risky factors etc. Road signs also help drivers with navigation. This project is based on traffic signs at local roads which can be categorized into three classes based on their shapes; (1) diamond shaped signs in yellow background (warning signs) (2) signs in red colour circles (control signs) and (3) rectangular shaped signs in blue background (other signs useful to drivers). Many accidents are reported in Sri Lanka near schools and railway gates as people tend to pay little or less attention to warning signs. Warning signs indicate turns ahead, junctions ahead, slopes and risks ahead. This study explores the initial problems that one encounter in the development of an automatic road traffic sign detection system [1, 2].

The work presented in this paper focuses mainly on the recognition of warning signs; diamond shaped board with black colour sign in a yellow background. The developed algorithm takes the following steps in order to extract the sign.

1. Input of the original (RGB) image
2. Identification of the yellow regions
3. Edge detection
4. Morphological operation
5. Finding the road sign region
6. Extraction and noise reduction

The accuracy of extraction depends on the lighting conditions, angle of image taken, weather conditions, image resolution etc. The techniques followed to minimize some of these effects are also discussed in this paper.

2. DETECTION SYSTEM

The inputs to the system are the images of road signs captured by a digital camera. The captured images were taken from approximately 10 meters distance from the sign plate. Although the images taken from moving vehicles may have different viewing angles to sign plates, it was not considered in this preliminary work. Further, if the road is curved, sign plates may appear tilted to the driver. It was assumed that the sign plates are placed to provide the best viewing angles to drivers in the moving vehicles. In this study, RGB colour space was converted to CIExyz colour space and the yellow regions of images were extracted. The CIE system characterizes colours by a luminescence parameter *Z* and two colour coordinates *X* and *Y* which specify the point on the chromaticity diagram (Figure 1).

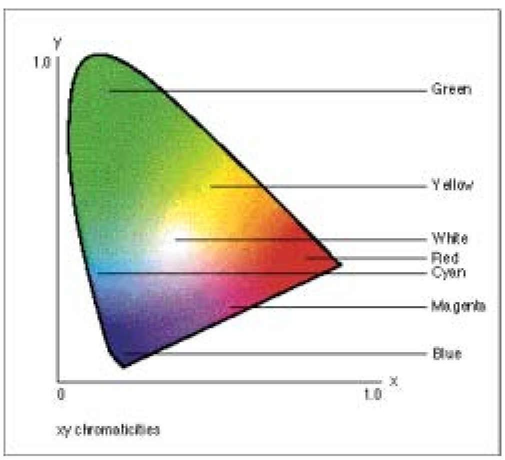

Figure 1: (a) CIExyz colour space (b) A typical input image of a traffic sign

The RGB image can be converted to the CIE space by following transformation [3].

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} 0.412453 & 0.357580 & 0.180423 \\ 0.212671 & 0.715160 & 0.072169 \\ 0.019334 & 0.119193 & 0.950227 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

Using the above transformation, each element in the RGB space was converted to the CIE space. Since there are pattern recognition problems arising due to poor image quality caused by varying ambient lighting conditions in real situations, traffic signs are often difficult to detect accurately and efficiently. Based on the pilot tests carried out with several test runs, it was found that the range of yellow colour in RGB colour space can appear between images taken under different light conditions as shown in table 1.

Table 1: Road sign colour range in RGB space due to varying light conditions.

Colour name	Red	Green	Blue
Yellowish orange	231	224	0
Yellow	234	231	94
Greenish yellow	235	233	0
Yellow green	185	214	4
Yellowish green	170	209	60

Figure 2(a) shows the input image in RGB space, and the identified yellow regions according to the range of possible colour combinations given in the table 1. After converting to CIE space, the yellow regions can still be identified through the transformation equations given earlier.

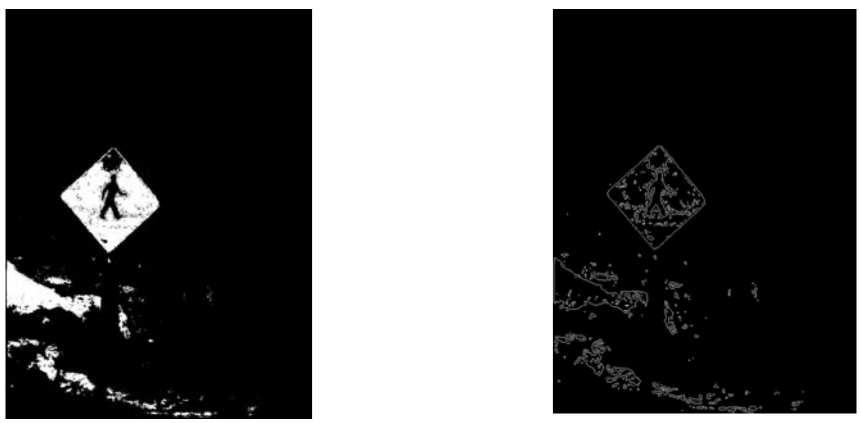

Figure 2: (a) Extracted yellow regions (b) Edge detected binarized image

After the initial pre-processing to identify the yellow regions, the next step was to find the edges of the identified regions. Edge detection is a process for detecting discontinuities in intensity values. Such discontinuities can be detected by using standard first or second order edge detection operator [4, 5]. In this work, “Canny” edge detection operator was used to detect the edges in the captured images. This operator finds edges by searching for local maxima in the gradient of the image. The gradient is calculated using the derivative of a Gaussian filter. First, the image was smoothed using a Gaussian filter with a specified standard deviation to reduce the noise. Then the local gradient and edge detection was computed at each point. An edge point is defined to be a point whose strength is a local maximum. Thereafter the edge points give rise to ridges in the magnitude image. The algorithm then tracks along the top of these ridges and sets all pixels that are not on the ridge top’s to zero to produce a thin line as the output - a process known as non-maximal suppression. Finally, the algorithm performs edge linking by incorporating the weak pixels that are 8-connected to the strong pixels [4, 5]. Therefore, this method is more likely to detect true weak edges. Figure 2(b) shows the binarized extracted yellow regions of the image after processing through the edge detection operator.

After extracting edges, morphological operation “dilation” was applied to the images for locating the plate location. Dilation is an operation that “grows” or “thickens” objects in a binary image. The specific manner and the extent of this thickening is controlled by a shape parameter referred to as a structuring element. Mathematical morphology is a tool for extracting image components that are useful in the representation and description of shape regions such as boundaries. In this work, a diamond shaped structure element (see Figure 3) was chosen to dilate the binary image. Mathematically, dilation is defined in terms of set operations. The dilation of *A* by *B*, denoted as

$$A \oplus B = \left\{ z \,|\, \left(\hat{B} \right)_z \cap A \neq \phi \right\}$$

where Φ is the empty set and *B* is the structuring element [4, 5]. In words, the dilation of *A* by *B* is the set consisting of all structuring element origin locations where the reflected and translated *B* overlaps at least some portion of *A*.

$$\begin{matrix} 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \end{matrix}$$

Figure 3: Diamond-shaped structuring element

Generally, this operation permits identification of yellow regions better than the pure edge detection operation, ignoring for example, the holes (empty regions) inside the sign plate (see Figure 4(a)). The grouping of yellow regions as separate filled components and accentuating the separation between them is very useful for the proceeding steps.

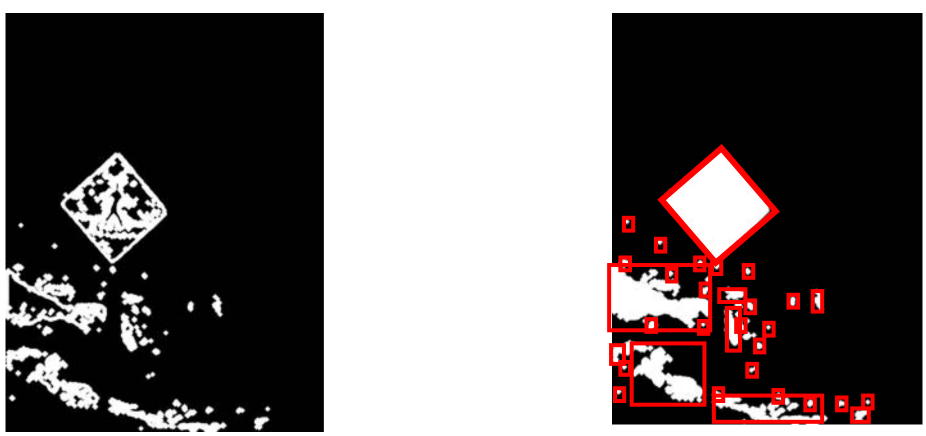

Figure 4: (a) Image after applying the dilation (b) Flood-filled image

Next, morphological reconstruction was applied to the dilated images by using a flood-fill algorithm. Figure 4(b) shows an image after applying the flood-fill algorithm. It is very important to consider accurate bounding boxes along the specified areas by selecting the correct dimension. As shown in Figure 4(b), some yellow components well outside the sign plate region still remain in the processed image and one must use a cropping process to separate other yellow regions from the region of the sign plate.

In order to do that, bounding boxes for each region was computed. It was found that the smallest rectangle that can contain the region is 1-by-4 vector. By choosing the maximum area covered by individual bounding boxes, the sign plate location was found (see Figure 5(a)).

To identify traffic signs through techniques such as neural networks or template matching, the traffic sign plate must be free of alignment errors as well as background information. By applying the "Radon transformation theory", the angle required to rotate the images to align with the horizontal direction was found. The radon transform represents an image as a collection of projections along various directions. In the final step, the license plate region was extracted and generated as the output (see Figure 5).

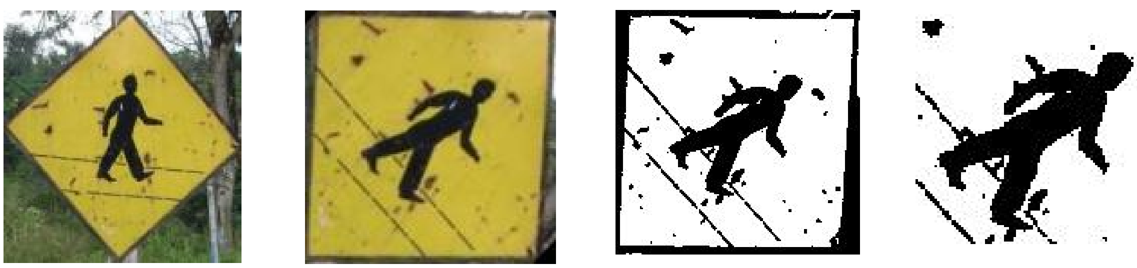

Figure 5: (a) Identified road sign region (b) Extracted region after Radon transformation (c) Binarized image (d) Cropped image (96x96)

As shown in Figure 5(b), the sign is not yet clearly separated from the background. Therefore, additional processing was required to separate the sign from the background. First, located plate regions under various illuminating conditions were converted to grey colour images and a suitable threshold value was chosen by investigating the regions where the yellow colour was present. Using this threshold value, the grey colour images of the traffic sign plates were converted to black and white (binarized) images with the sign appearing in black colour (see Figure 5(c)). Based on the tests carried out with several trials, it was found that 96x96 cropped images sufficient for producing low noise images (see Figure 5(d)).

In the final stage, the images were further enhanced by removing noise from binarized images. In order to recognize the true boundaries of the segmented parts, row sum of pixels and column sum of pixels were considered (see Figure 6(a)).

First, upper and lower boundaries were identified by searching for a signal whose row sum is greater than or equal to a threshold value within the first and last 25 rows. Threshold value was chosen by analyzing the available images. Similarly, by considering the column sum, left and right boundaries were identified. Finally, the noise minimized images taken under variety of illumination and background conditions were resized to a common dimension of 40x40 (see Figure 6(b)). The normalized (40x40) images were suitable for identification and classification of traffic signs by subjected to techniques such as neural networks or template matching.

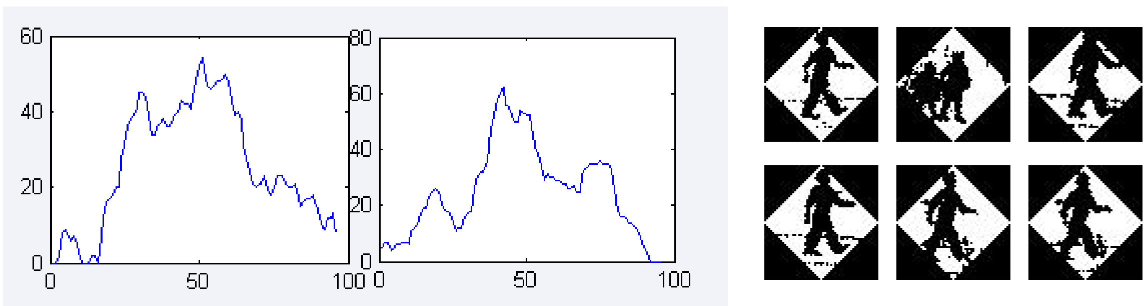

Figure 6: (a) Row sum and column sum (b) A set of normalized binary images (40x40)

3. CONCLUSIONS

In this paper, we presented an image processing technique, designed for the detection and extraction of warning signs in traffic sign plates which correspond to diamond shape plates with black signs painted on a yellow background. First the yellow regions (square region) were extracted, and then through a mathematical morphological operation, the sign region (diamond shape) was extracted. Based on the experimental results, a criterion was developed to reduce noise in the extracted sign plates. Pilot tests showed that the developed algorithm was highly successful (98%) in extracting road signs under various illumination conditions.

Further work is in progress to develop neural network based technique in automatic identification and classification of traffic signs.

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