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Traffic Sign Detection and Classification using Colour Feature and Neural Network

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***Abstract*—Automatic traffic sign detection and recognition is a field of computer vision which is very important aspect for advanced driver support system. This paper proposes a framework that will detect and classify different types of traffic signs from images. The technique consists of two main modules: road sign detection, and classification and recognition .In the first step, colour space conversion, colour based segmentation are applied to find out if a traffic sign is present. If present, the sign will be highlighted, normalized in size and then classified. Neural network is used for classification purposes. For evaluation purpose, four type traffic signs such as Stop Sign, No Entry Sign, Give Way Sign, and Speed Limit Sign are used. Altogether 300 sets images, 75 sets for each type are used for training purposes. 200 images are used testing. The experimental results show the detection rate is above 90% and the accuracy of recognition is more than 88%.**

Keywords—Traffic Sign; Colour Feature; Driver Assisted System; Detection and Recognition; Segmentation; Neural Network.

I. INTRODUCTION

Automatic traffic sign detection and recognition is a field of computer vision which is very important aspect for advanced driver support system [1]. The traffic signs define a visual language realized by drivers. Traffic signs carry much information necessary for successful driving - they describe up to date traffic situation, define right-of-way, prohibit or permit certain actions or directions, warn about risky factors etc. Road signs also help drivers with routing the vehicle by identifying the road-sign.

Traffic signs have several unique features that may be used for their detection and identification. Colours and shapes are the most important attributes that assist and get better driving conditions [2]. Moreover the colour used in traffic sign are synchronized by each country and are often nearly simple primary colours (red, green or blue) with the exception a secondary colour of yellow. Therefore colours can be used to classify traffic sign into specific groups. Many methods for traffic-sign recognition have been developed in the literature [1]-[3], [5], [7]-[16]. However, classification of traffic signs invariantly with respect to various natural viewing conditions still remains a challenging task [3] and still is an open research problem in traffic engineering.

In this paper, the detection of the traffic signs is achieved by three main modules: pre-processing, detection, and recognition. In the pre-processing modules, the input are pre-processed to removed noise, enhance the image. In the detection phase, probable road sign are generated from the image. The image is segmented on the basis of colour features. The output of this stage is a segmented image containing Regions of Interests (ROIs) which could be recognized as potential road signs. The segmented potential regions are extracted as input in recognition stage. In the recognition stage, classification and recognition of detected signs is done by an Artificial Neural Network (ANN) [4].

The rest of the paper is organized as follows. Section II describes basic properties of traffic sign. Section III describes the design flow of the proposed approach. Experimental results are reported in section IV. Section V concludes this paper.

II. PROPERTIES OF TRAFFIC SIGNS

Traffic signs are characterized by unique features that make a difference from the other objects.

- They have 2-D shapes such as rectangles, triangles, circles, or octagons.
- The colour used in traffic sign are often nearly simple primary colours (red, green or blue) with the exception of yellow, a secondary colour which are easily identifiable by the drivers [5].
- The colour of the sign has unique colour for a particular traffic sign and the colours of the characters written on the sign has other colour [5] as shown in Fig. 1. Fig. 1(a) is not a compliant sign.
- The signs are fixed in proper location as expected, more or less, by the diver.
- They may hold a figure, characters or both [5].
- The traffic signs, if they have, hold fixed text fonts, and character heights.

(a) (b)

Fig. 1. (a) Non-Compliant Sign (b) Compliant Sign

In this paper we mainly emphasis on the colour of the traffic sign for its recognition because world wide a standard set of colours are used in traffic sign.

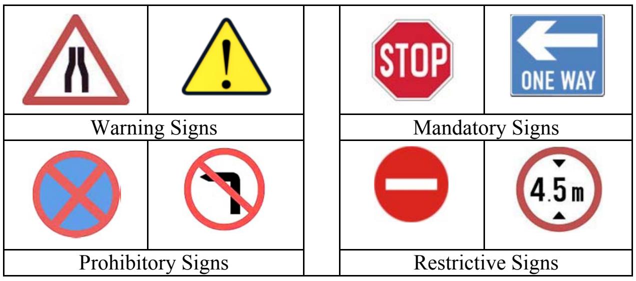


Fig. 2. Examples of Some Popular Traffic Symbols

III. METHODOLOGY

The main steps of the proposed methodology are illustrated in Fig. 3. The algorithm has three main stages: 1) Pre-processing 2) Detection 3) Recognition and Classification. The design flow is shown in Fig. 5 in details. The system takes static colour images as input taken from World Wide Web. The output of the system is the name of the recognized road sign.

In the detection module, the region of interest from the image is extracted based on colour segmentation and make them ready for the recognition stage. The second module, artificial neural network is used to carry out the recognition and classification job.

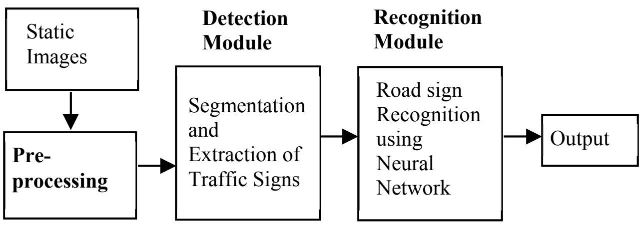
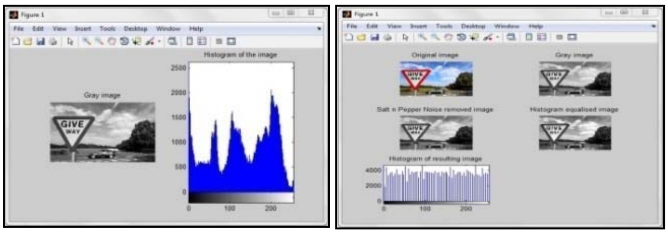


Fig. 3. Stages of the Proposed Method

A. *Pre-processing*

This step is used to increase the accuracy of the classification step [6]. The fundamental function of the pre-processing stage here is to remove noise, enhance the input image.



(a) (b)

Fig. 4. Pre-processing Result (a) Original Input Image and its Histogram (b) Salt and Pepper Noise Removed Image, Histogram Equalized Image, Histogram of the Equalized Image.

B. *Traffic Sign Detection Module*

The main task in this module is to extract the Region of Interests (ROI) from the images and to make them ready for the recognition stage. For better accuracy in the recognition stage, all possible ROIs are considered as because each ROI could be a sign.The detection of the location of the traffic sign is carried out based on its colour. Colour based segmentation is used and ROI has been extracted. After getting the traffic sign image, it further normalized to 50 × 50 pixels. Different steps of this module are shown in Fig. 5 and discussed in brief.

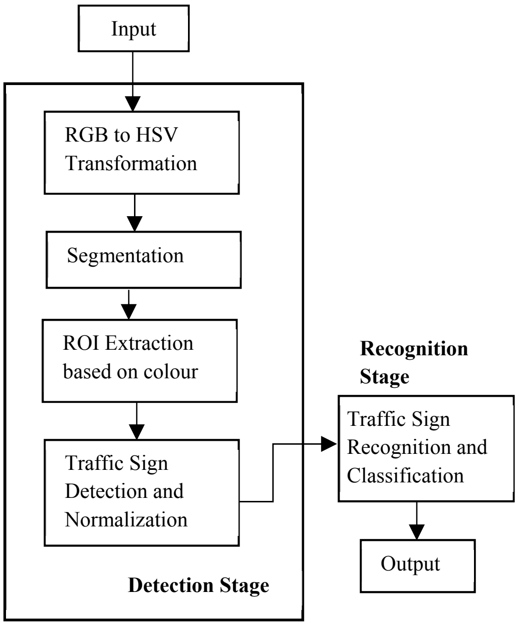


Fig. 5. Design Flow of the Proposed Method

1) *Conversion from RGB to HSV*: RGB (Red, Green and Blue) is the primary color space commonly used for representing an image [4]. But RGB is seldom used directly for colour segmentation. HSV is quite similar as humans perceive color and much more suitable for color segmentation because the hue value is invariant for illumination which makes HSV color space one of the best choices for color segmentation [7]. A transformation from RGB to HSV colour space is done using the following formulas (1)-(3) [2]:

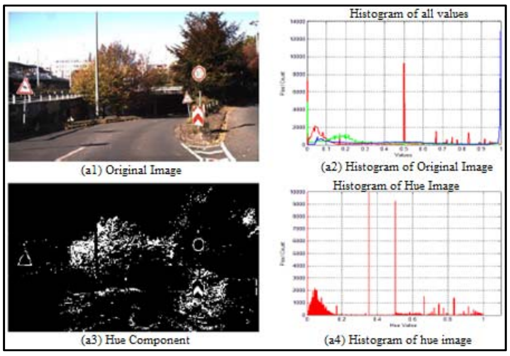
$$H = \cos^{-1}\left(\frac{0.5*(R-G)+(R-B)}{[(R-G)^2+(R-G)(G-B)]^{0.5}}\right) \quad (1)$$

$$S = 1 - \left(\frac{3}{R+G+B}\right)[\min(R,G,B)] \quad (2)$$

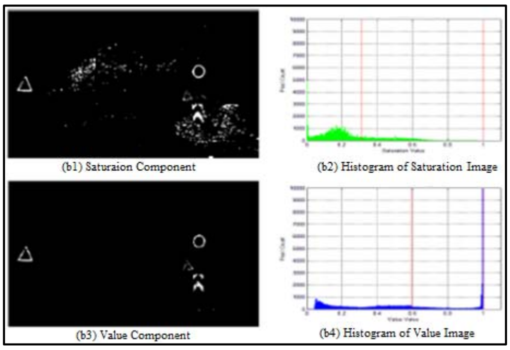
$$I = \frac{1}{3}(R+G+B) \quad (3)$$

Fig. 6 shows the same image in RGB and HSV colour space, respectively. In Fig. 7, original image, HSV components with their histograms are shown.

Fig. 6. RGB Image and HSV Image



(a)



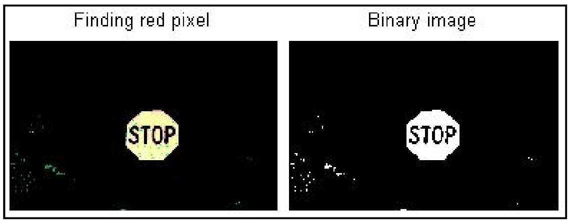
(b)

Fig. 7. (a) Original Image, The Hue of the Image with its Corresponding Histograms (b) Saturation and Value Component of the Image with its Histograms respectively.

2) Region of Interest Extraction Based on Colour Segmentation: Firstly, the RGB images need to be changed into HSV space images. And then, H and S components need to be extracted. If the gray values of components have a certain colour (red, yellow, or blue) in the gray scale, the gray value will be retained; if this is not the case, it will be set to 0; and, in this way, the position of Region of Interest (ROIs) are determined. In the segmentation process, the component of hue played the central role; this is because it shows more invariance in the context of shadows and highlights, to variations in light conditions, and to changes in the colour saturation.

In this section, the color threshold technique is used to detect the red color traffic sign. The reason of thresholding is to segment pixels of an image into 'object pixels' or 'background pixels' [8]. By putting definite threshold, a pixel is categorized in 'object pixel' and 'background pixel'. It falls on 'object pixel' if its colour is close enough to a reference level, if not it will be a 'background pixel'. For example, the following ranges of values are used as the thresholds to find the red pixel in the image after the HSV conversation [5]. Fig. 8 shows the red pixel which has been found.

- Hue < 0.05 or Hue > 0.95
- Saturation > 0.5
- Value > 0.01



(a) (b)

Fig. 8. (a) Red Pixel (b) Red Pixel are converted to Binary Image

3) Region of Interest Extraction Labeling and Selection: The image is converted to binary image consisting of only black and white colors, which shown in Fig. 8(b). A red color pixel will be translated to white color, the rest of the colors are black color. The binary image is then labelled according to each pixel's 8-connectivity [4].

Next, the criteria selection has been applied. It will examine the labeled cluster size output from the previous stage. If the cluster is between 100 and 3000 pixels, it will be regarded as consisting of a road sign. This stage will get rid of objects like red flower, red building or even the road sign when it is too small and unrecognizable. Below figure is shown the road sign which have been detected and labeled successfully.

Fig. 9. Labelled Road Sign

4) Extract and Resize: Finally, the labelled traffic sign region is extracted and resize to 50 ×50 pixels and proceed to classification sub-module.

Fig. 10. Labelled Traffic Sign used for the Recognition Module

C. Classification Module

The classification stage takes the output from previous detection stage as its input. It then performs classification and gives the output with the sign type. Neural networks are applied in this stage, which had been experimented for result comparisons. A road sign image which contains 50 × 50 pixels is proceed to classification sub-module, and Multi-Layer Perceptron (MLP) network [4] has been created and trained to classify the type of road signs in this sub-module.

In this paper, MLP network has been built to classify the type of road sign as shown in Fig. 11. The input signal transmits through the network in a forward path, on a layer-by-layer basis. The network has been trained on 300 sets of training patterns taking 75 for each type of road sign and 200 test patterns taking 50 images of each road sign. The network has 7500 input neurons and 4 output neurons. The hidden layer is 5.

TABLE I. NUMBER OF TRAINING AND TEST SET SAMPLES PER CLASS

	Data set	
Traffic Sign Type	**Training**	**Testing**
Stop Sign	75	50
No Entry Sign	75	50
Give Way Sign	75	50
Speed Limit Sign	75	50
Total	**300**	**200**

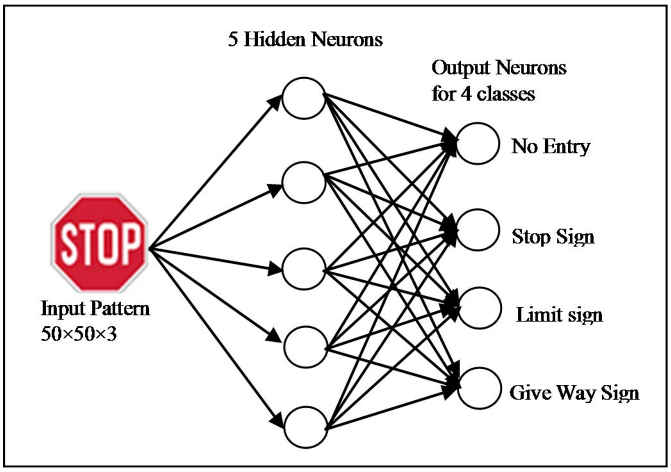


Fig. 11. Architecture of Feed-Forward Back-propagation Network

The created MLP network is trained by the training set images. The resized road sign image which contains 50 × 50 pixels is proceed to classification sub-module, and is compared to the data which stored in the training dataset; finally the system will produce an output message based on the class type.

IV. EXPRIMENTAL RESULTS

A PC was used to perform the training and the testing of the proposed system. The configuration includes a single CPU Intel (R) Core(TM) i5-4590 at 3.30 GHz and 4GB RAM. The system is realized in the MATLAB environment. Altogether 300 sets images, 75 sets for each type road sign are used for training purposes. 200 images are used for testing. Four type traffic signs, Stop Sign, No Entry Sign, Give Way Sign, and Speed Limit Sign, shown in Fig. 12, have been successfully trained by the network. Below shows the trained traffic signs, training plots for stop sign and No entry sign.

(a) (b) (c) (d)

Fig. 12. Training Images: Four type traffic sign used in India (a) Give Way Sign (b) No Entry Sign (c) Stop Sign and (d) Speed Limit Sign are used

From Fig. 13-15, it is visualized that the detection stage successfully detects and labels all images which contained road signs. Stop Signs, No Entry Signs, Give Way Signs and Speed Limit Signs have been used for our purpose. Some traffic signs are unable to detect due to multiple sign as shown in Fig. 16. The experimental results are shown in Table II with detection rate. Simulated plots of training are given in Fig. 17-18. Here goal and training are shown in black and blue.

TABLE II. THE PERFORMANCE OF DETECTION SUB-MODULE

Traffic Sign	**Total tested**	**Successfully detected**	**% Correctly Detected**
Stop Signs	100	93	93
No Entry Signs	50	44	88
Give Way Signs	70	65	92.6
Speed Limit	30	27	90
	Overall		**90.9**

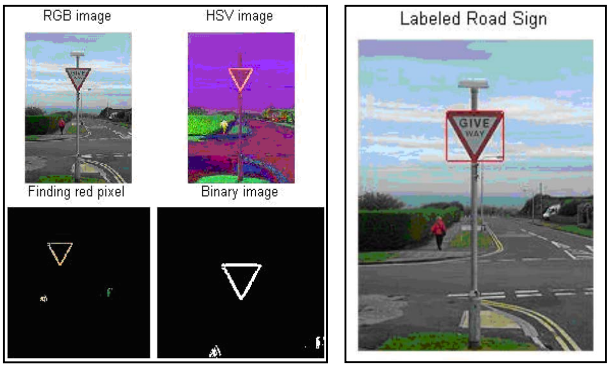


Fig. 13. Detected and Labelled Give Way Sign

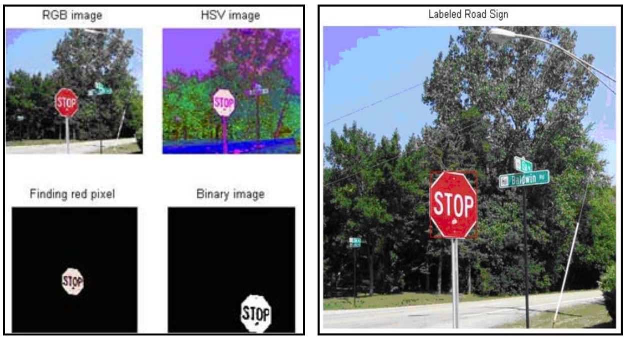


Fig. 14. Detected and Labelled Stop Sign

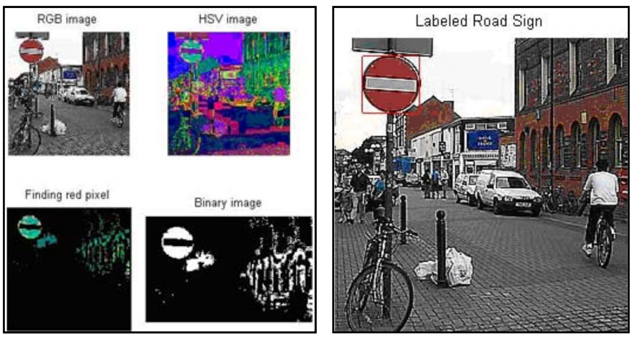


Fig. 15. Detected and Labelled No Entry Sign

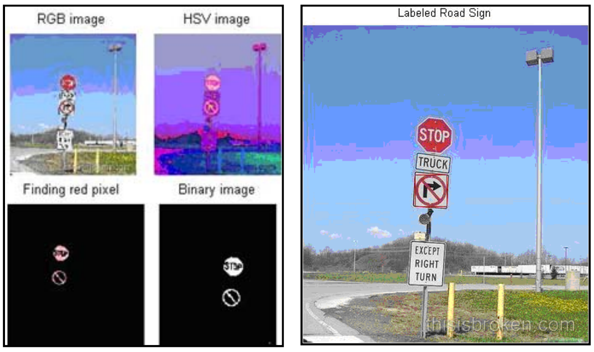
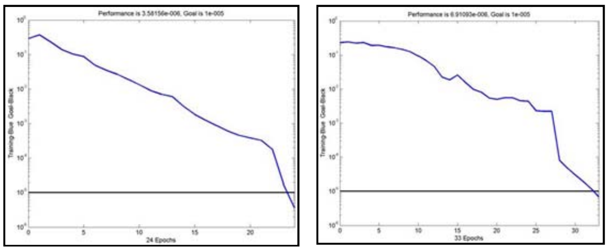
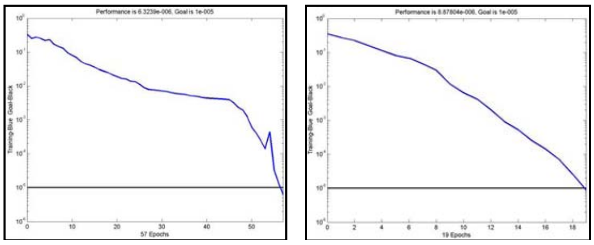


Fig. 16. Failed to Detect Stop Sign due to Multiple Signs



(a) (b)

Fig. 17. Training Plot (a) Stop Sign (b) No Entry Sign



(a) (b)

Fig. 18. Training plot (a) Speed Limit Sign (b) Give Way Sign

V. CONCLUSION

This paper proposes Colour-based detection framework that will identify and recognize road signs from static digital images in a reasonable time frame. The algorithm consists of two main stages: road sign detection, and classification. For evaluation purpose four type road signs, Stop Sign, No Entry Sign, Give Way Sign, and Speed Limit Sign are used. Altogether 300 sets images, 75 sets for each type road sign are used for training purposes. 200 images have been tested and the performance of the system is evaluated. The experimental results show the detection rate is above 90% and the accuracy of recognition is more than 88%. The visual and quantitative results validated the usefulness of the proposed framework.

Apart from the promising results presented in this paper, there are different aspects for future research. As a future work, we would like to extend this approach for recognizing two or more sign and titled sign in the same region of interest with increasing the robustness of the system in lighting conditions.However, identification of traffic signs still remains a challenging task becausecolor information is affected by varying illumination like weather conditions and faded colour on road sign. To overcome this problem, the both of shape-based recognition and colour-based recognition can be used to give more superior performances.

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