Indian Traffic Sign Detection and Classification Using Neural Networks

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***Abstract*—This paper presents an automatic Indian Road Traffic Sign Detection and Classification system based on Multiple Neural Networks. Road safety being an indispensable factor for driving and smooth traffic movement has been studied since long time and traffic signs provide the driver with necessary information and warnings. Being very different in color and shape when compared to natural environment these signs can be detected easily by humans.**

The system proposed in this paper uses four stages.1)Image procurement and preprocessing images captured by the camera which might be blurred or corrupted due to environmental disturbances, we try to remove these by deblurring and enhancing quality of the image.2)Color segmentation based on RGB ,YCbCr and NTSC color space to detect green blue and red color respectively then morphological operations to remove any unwanted noises that might be detected.3) Blob Detection using Binarization and Otsu Thresholding to obtain the region of interest and shape classification.4) Classification using Multiple Neural Networks to decide the type of sign. From the results we can conclude that when the neural network is trained over a standard database, the recognition of region of interest has high accuracy and the proposed methodology works with real time images invariant to rotation, illumination and in many situations even with partially distorted and occluded images.

The proposed method is validated on a standard data set of Indian Traffic Signs. As far as our knowledge is concerned no work has been done on the total data set considered by us although few works have been done on restricted data set of the one we considered and the data sets for other countries were also considered.

***Index Terms*—Neural Networks, segmentation, morphological, blob detection, thresholding**

I. Introduction

Road safety and traffic maintenance is a very censorious modern day issue and a topic delve for research by experts across the globe. Everyday occurrence of fatal accidents resulting in the loss of lives and other resources. There can be multiple stimulations leading to these misfortunes like poor road maintenance, reckless driving, psychological state of driver, casual attitude of pedestrians. Another major reason leading to this might be the poor law enforcement and impromptu maintenance of road traffic signs. Occluded or deteriorated signs may mislead the driver. Here we propose a system which can detect and classify road signs. This has following advantages firstly it helps in providing the driver with driving guidelines and warnings. alternatively it also helps is maintenance of smooth running traffic. Indian traffic signs according to standard database of Delhi police [9] and Chandigarh police [10] can be classified as 1) Compulsory 2) Regulatory 3) Warning and 4) Informative in addition to STOP sign and GIVE WAY sign, Figure1. Being distinctive in color and shape from natural environment these can be easily isolated different type based on Table1. To detect these signs we must have information about the color and shape as mentioned in Table1.

Computer Vision based road sign detection and classification proposed here is a two step process

1) sign detection 2) sign classification.

Initiation of detection is based on color segmentation . Various techniques have been applied for color segmentation [1] uses RGB(Red Green Blue) color space and using color thresholding with one color as a reference whereas [12] uses threshold value in YUV(U and V are blueluminance and redluminance) space .Also in [8] uses HSI(Hue Saturation Intensity) threshold system because color information, which is encoded with hue and saturation components, presents low variations for objects of interest with a similar color .But resolving a threshold value is not very accurate as it may depend on brightness, atmospheric condition , night vision , varying lighting may produce shadow or bright spots over the image. Depending on varying environmental constraints the proposed algorithms may fail and in case the background matches with the color being segmented noise might be extracted within the region of interest. For shape matching some mechanisms employed are [1] Optimal Corner Detector , [8] Neural Network and linear Support Vector Machine(SVM). Other possible techniques are [3] FFT (Fast Fourier Transform) and [1] circular and triangular contours matching.

The organization of this paper is as follows: Section II focuses on exhaustive description of algorithm proposed here, Figure2. After initial image preprocessing the color segmentation is done to extract candidate blobs . Using RGB , YCBCR and NTSC color space green, blue and red color blobs are extracted respectively. By establishing the color first, only some geometric shapes are then liable to be considered in the shape classification stage Figure3. Therefore, those objects with similar colors as traffic signs, which hence represent noise are discarded from the consideration. Candidate blobs classified as traffic signs at this stage are converted in form of input vector and inured to the first level of Neural Network which concludes the category of the sign and appropriately

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TABLE I
MEANING OF INDIAN TRAFFIC SIGNS BASED ON COLOR AND SHAPE

Color	Shape	Sign
Red	Triangle	Warning
Red	Circle	Compulsary
Red	Inverted Triangle	Give Way
Red	Octagon	Stop
Blue	Rectangle	Informatory
Blue	Circle	Regulatory
Green	Rectangle	Informatory

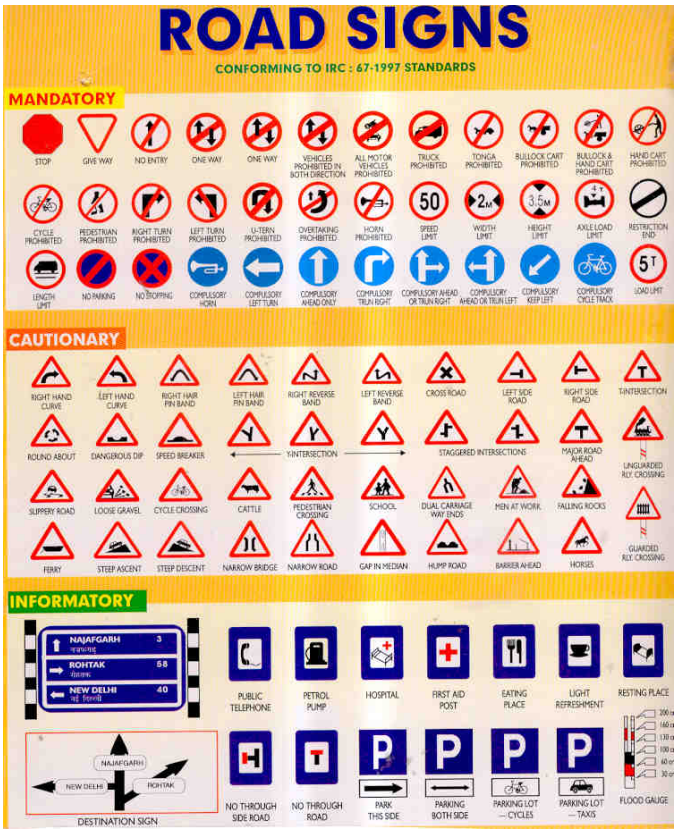

Fig. 1. Indian Traffic Sign Database.

forwards it to the next level for exact classification. Section III includes the result for all the images included in database and many real time images tested on the system and demonstrates the robustness of proposed algorithm including cases of some occluded images. Finally Section IV gives conclusion and scope of future enhancements in the proposed system.

II. INDIAN ROAD TRAFFIC SIGNS

Indian Road Traffic Signs [2] are standardized and pertinent nationwide, these are broadly classified into the following categories.

1) Regulatory signs-These signs inform the road users about the laws and regulations they have to follow. Violation of these signs is legal offence. They are circular in shape with red circumference.

2) Compulsory signs-These signs are an extension to regulatory signs and similar to the violation of regulatory signs, violation of these is a legal offence, which makes them most important signs. They are circular in shape and are filled with blue color and white circumference.

3) Warning signs-These signs warn road users of certain hazardous conditions. They are triangular in shape and possess a red circumference. Violation of these is not a legal offence.

4) Informatory signs - These signs provide information and guidance to road users. They are rectangular and may vary in color, in some cases they might be green with white circumference whereas in others it might be white filled rectangle with blue circumference.

Further classification of each of these categories is based on the information contained by these signs which may be a picture, alphanumeric string or a particular direction indicating arrow.

III. SYSTEM OVERVIEW

Algorithm proposed for Traffic Sign Detection and classification as exemplified by Figure2 consists of three main stages.

1) Image color segmentation using RGB, YCbCr and NTSC color space

2) Blob Detection to attain the Region of Interest

3) Classification using Multiple Neural Networks

The following sections describe these stages. We use examples to demonstrate the actual viability of the proposed algorithm on real time images.

A. COLOR SEGMENTATION

Any image present in any color space(RGB, YCbCr, HSI, HSV, NTSC) is defined by a triad of pixels. RGB color space being the most intuitive and at hand can be a very conclusive selection for color segmentation but due to its large dependency on illumination any environmental condition that has poor lighting might not give very distinctive colors in the image for segmentation. YCbCr being illumination independent can be selected for color segmentation. It is a way of encoding RGB color space [7] here Y is the luma component representing the illumination intensity of the image and CB and CR are the blue-difference and red-difference chroma components which represent how close the pixel value is to blue and red color component in RGB space. When images taken for detection and classification are extracted from video input, YCbCr color space is distinctively effective as it is used as a part of color image pipeline in videos. HSI or HSV can be used competently to excerpt different color components by adapting to different threshold values associated with each individual color[8] but as mentioned, these threshold values may fail depending on changing environmental conditions like cloudy weather, low brightness, shadow or bright spot generation due to light reflection in night.

Red being the most prominent color with blue to be detected for successful detection of road signs. It can also be mined from NTSC color space, advantage of using NTSC over YCBCR red chroma component is that in some peculiar cases where the sign may have a red background which is not easily distinguishable from the circumference of the sign, which is also red in color may lead to extraction of noise with the sign Figure4. Whereas when the sign is extracted from

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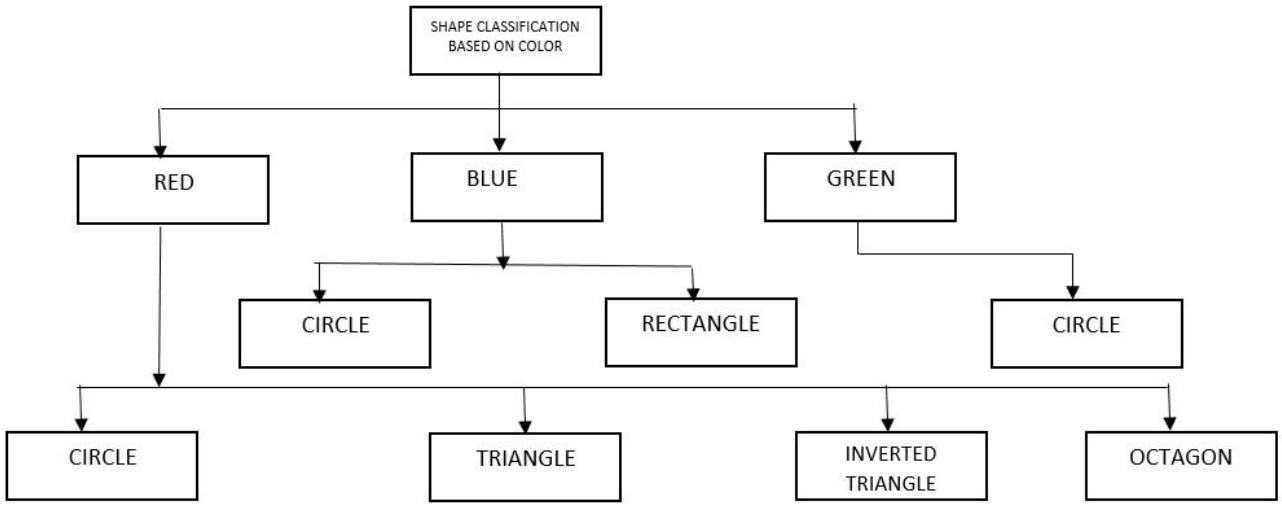

Fig. 2. Color based Shape Classification.

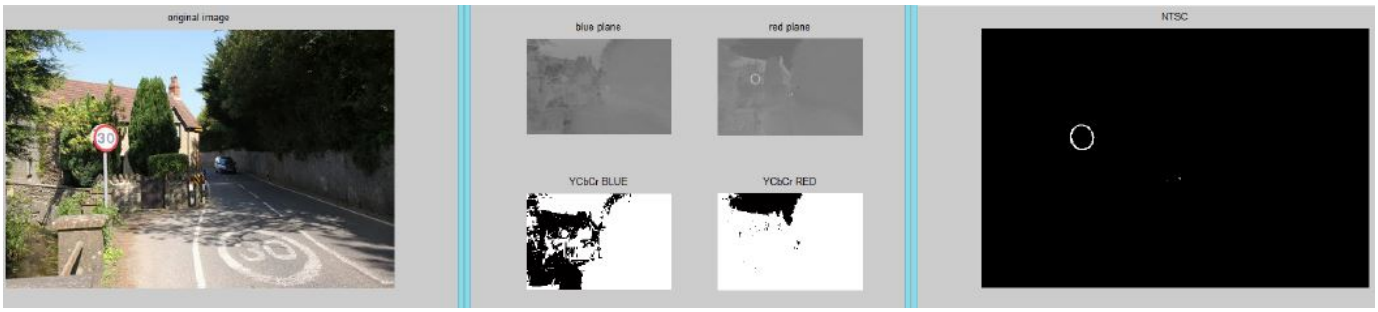

Fig. 3. Comparison of YCbCr and NTSC colorspace used for Red Color Segmentation.

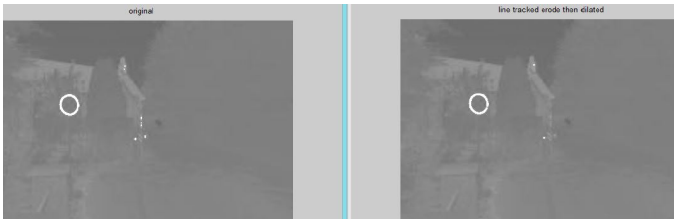

Fig. 4. Noise removal by Morphological operations.

NTSC space the red component is prospected with greater detail as in NTSC The first component, luminance, represents grayscale information, while the last two components make up chrominance (color information).Using the latter the pixels which actually appear red but have difference in their values can be distinguished and only the sign can be attained without noise Figure4. So in the system proposed here we need to segment three possible colors red green and blue to incorporate the entire database of Indian Traffic Signs. After examination the culminating segmentation used is Green color signs from RGB, Blue color signs from YCbCr and Red color signs from NTSC color space Figure5.This segmentation is done based on Otsu Thresholding which automatically perform clustering-based image thresholding [13].This gives output as an image with segmented color components. It is possible that some noise may also be included with the sign being extracted which might be due to the constitution of pixels of same color or within threshold range in the background. To remove any such small noises induced in image fundamental morphological operations of Erosion and Dilation are performed.Figure5 Erosion and Dilation thus performed with a line structuring element also give finer and halcyon edges which increases efficiency of shape classification.

B. BLOB DETECTION

With the input image as the output of color segmentation followed by morphological operations to remove any form of noise that may be comprehended as region of interest. Proceeding towards the acquisition of region of interest. [11] The gray scale image obtained is converted to a binary image using standard Otsu Thresholding for binarization. Then inhibiting the intensity value of pixels and constraining the allowed regions to only connected components which is obtained by reconnoitering the adjacent pixels if the value in binary image for the neighbor is 1 it is considered to be connected and when 0 disconnected. Thus all the connected components in binary image are obtained and are labelled with different colors and numbers serving in distinguishing of all regions thus obtained. Using the MATLAB [5] functions which measure the area, location of centroid and intensity of connected components

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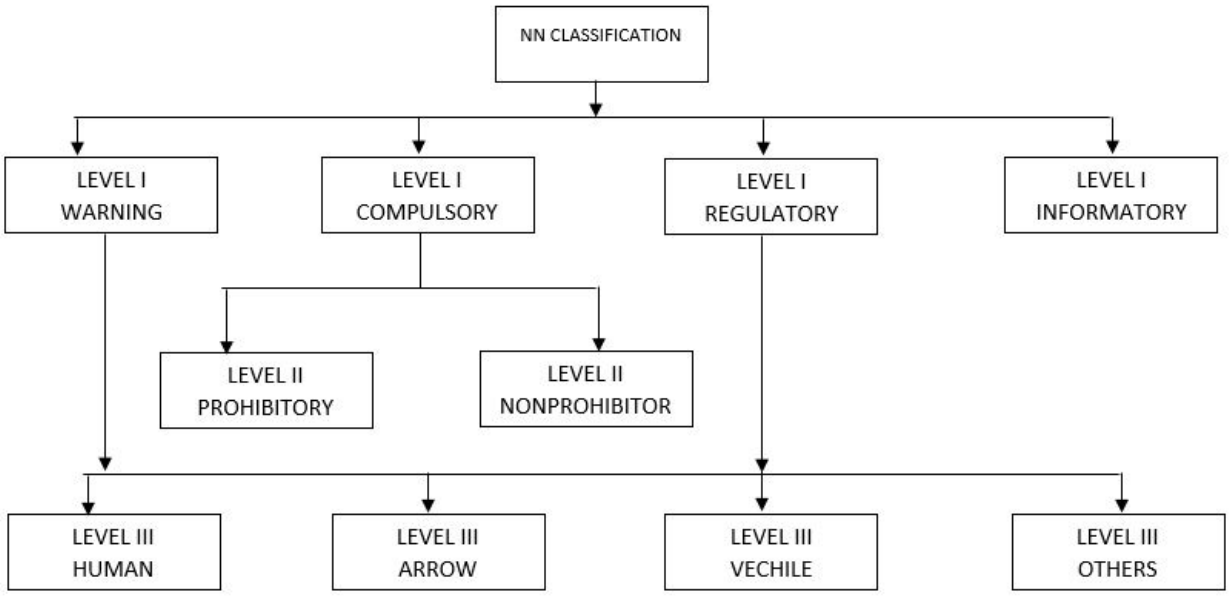

Fig. 5. Neural Network Classification for each Level.

Fig. 6. Multiple Sign detection simultaneously.

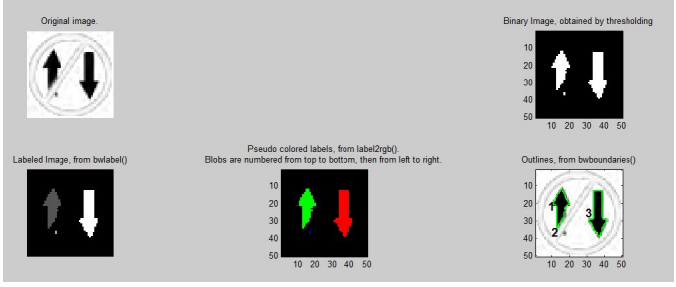

Fig. 7. Disjoint components extracted in case of Prohibitory Signs.

in a binary image. The individual blobs can be excerpted and considered for shape classification. But all the candidate blobs are not to be tested for shape classification, the efficiency of system can be increased in the two following ways such that any unnecessary blobs which might be noise are not taken into consideration.

1) Confine the area, length and breadth of Blob

2) Avoid overlapping blobs

As mentioned due to presence of background which might be same in color as that being segmented some noise may be incurred within the image which is input to the Blob Detection and as a result might also be present in the binary form of image and hence the extracted region of interest.Figure6 such noises which are reported as a candidate blob may be removed by constraining the area of blobs which are to be considered. As the traffic signs being considered at any time can only occupy a fixed ratio of image the parameters for area of the blob can be established also the candidate blobs with the traffic sign are mostly squares or have the length to breadth ratio within well defined limits. So using these as secondary conditions only those blobs which actually contain the traffic signs remain as candidate blobs and rest are removed being considered as noise. Also as discussed earlier it might occur that the background is similar in color to the segmented color and overlaps with the sign being detected. In such case either the sign may be detected as a candidate blob with or without noise so if a conditional statement to check that no overlapping region is included as a candidate blob then the candidate blob being considered are only the once which are needed.

After the candidate blobs are determined they are used as input for shape classification. Initial shape classification is basic template matching used by [2] using a standard database

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Fig. 8. Blob extraction with measurement constraints.

Fig. 9. Different types of Informatory Signs.

which has the following shapes. Triangle, octagon, circle, inverted triangle and rectangle these are grouped into five classes and each class has various similar shapes. To abrogate the effect of size and rotation which might be present due to environmental conditions which may displace the sign or in the image captured the size of sign may be small or large as compared to the template in database, each class has various possible sizes of each shape and each shape is also saved in database after being rotated by a 10 degree measurement from 0 to 180 degree so that rotation of the sign doesnt cause the system to give inaccurate results. Formerly the blob has been identified and needs to be shape classified but only some shapes are credible and must be contested as portrayed by Figure3. Those candidate blobs which are correctly classified according to color segmentation and shape classification and abide by the rules established in Figure3 are region of interest for Neutral Network classification.

C. NEURAL NETWORK CLASSIFICATION

Region of Interest (RoI) procured is the input for Neural Network (NN) classification [6]. The classification is a multiple NN approach and each level is as described below.

1) Level I. This level classifies the RoI as warning or regulatory or compulsory or informative sign.

2) Level II This level classifies the RoI as prohibitory or non-prohibitory sign if the RoI is classified as compulsory sign after Level I.

3) Level III This level classifies the RoI as arrow or vehicle or human or others sign if the RoI is classified as compulsory sign or warning sign or regulatory sign after Level I.

TABLE II
STANDARD DATABASE IMAGES CLASSIFICATION

Type	Total	Color and Shape	Level I	Level II	Level III
Prohibitory	56	56	54	54	51
Non Prohibitory	22	22	21	21	19
Warning	67	66	64	-	60
Informatory	12	11	10	-	-

4) Separate NN has been used for the signs stop and give way.

The overview of NN classification is as shown in Figure7.

NN implementation database is divided into three phases. Learning, validation and testing. This has been carried out using the MATLAB functions which significantly reduce the time for neural network training, validation and testing. The input vector and target vector differ for the different levels of NN. The RoI is resized to image of 25*25 pixels which is then subdivided into 25 equal zones by doing this we get 25 pixels in each zone which can be averaged to get a single value for sample vector which needs to be tested. In training the network, a similar procedure is followed for all the images in the database which constitutes images of all Indian Traffic Signs with a rotation of each image also stored with variation of angle of rotation from 0 to 180 degrees with an incremental factor of 10 degrees.

In such a case the input vector is of size 25*NUMBER OF IMAGES IN DATABASE*18. It is assumed that there are Q input vector/target vector pairs. Each target vector has K elements. One of these elements is 1 and the rest are 0. Thus, each input vector is associated with one of K classes. So the target vector is NUMBER OF CLASSES* NUMBER OF IMAGES*18 [4] . Individually Level I has 4 classes Level II has 2 classes and Level III has 4 classes and independent NN has 2 classes one for give way sign and one for stop sign. Neural systems solves problem by adapting to the nature of the data signals they receive. Here forward feed backpropagation with MLP training is used in proposed system [6].The NN data set is divided as 90

For prohibitory signs the input vector is 50*NUMBER OF IMAGES IN DATABASE*18 as there is loss of information due to overlapping red channel and the extracted information constitutes two different parts Figure8 using which two different vectors are generated and then vertically concatenated. Similar procedure is followed for training the level III NN for prohibitory sign. Eventually after the NN gives output and hence classifying the input sample vector as per Figure7 the inner part of each RoI can be extracted and input to a separate NN for individual classification of its type.

IV. RESULT

The proposed algorithm is experimentally tested on a images incorporated within a standard database, real time images and video frames.

The results thus generated are summarized in Table2 and Table3. The frames excerpted from the video are also used as real time images. The video is recorded with a mobile camera 1920x1080. The real time images used for testing

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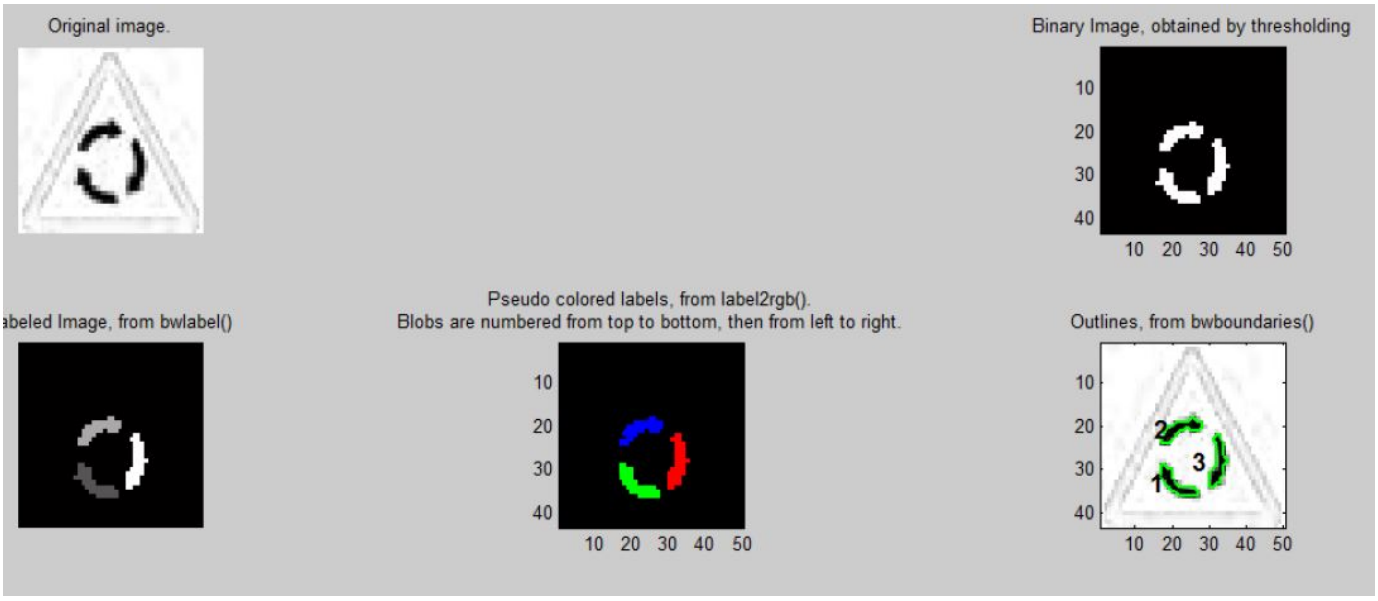

Fig. 10. Multiple Disjoint components extracted in case of extraction of information within a sign.

TABLE III
REAL TIME IMAGES CLASSIFICATION

Type	Total	Color and Shape	Level I	Level II	Level III
Prohibitory	70	59	58	58	51
Non Prohibitory	56	52	51	51	47
Warning	42	40	39	-	36
Informatory	19	13	-	-	

TABLE IV
PERFORMANCE OF PROPOSED SYSTEM WITH OCCULDED IMAGES

Type	Total	Color and Shape	Level I	Level II	Level III
Prohibitory	10	8	6	4	4
Non Prohibitory	3	2	2	1	1
Warning	4	3	2	-	1
Informatory	6	4	2	-	-

Fig. 11. Occluded Images Successfully Classified

vary in size 640x480, 1920x1080, 2592x1944, 3920x2204 and 3920x2940.Figure12 illustrates the working of proposed algorithm with partially occluded images.

The implementation of NN classification for different levels is undergoing research to obtain the average time for classification and misclassification of signs.

V. CONCLUSION

This paper has described a complete method to detect and classify the Indian Road traffic Signs. The algorithm proposed has three main parts, the color segmentation, blob detection and NN classification taking into consideration many outdoor environment difficulties like poor lighting and occlusion of signs.

The improvements are successful study of images with background similar to color being segmented, images with environmental distortions like poor lighting, partially occluded images and introduction of Multiple NN for classification with classification of STOP and GIVE WAY signs also. Multiple signs present at same instant are also detected successfully Figure10.

Experimental results indicate the proposed methodology is efficient and accurate. Working with a standard database multiple real time images and images taken from a video sequence the algorithm gives result with high accuracy. It allows us to detect different signs invariant to the rotation

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and change of orientation. Some future work that can further enhance the robustness of system are as mentioned.

1) Informatory signs contain information which is not correctly classified due to its complexity. They may represent very distinctive information from distance of a particular place to images of a hospital ahead. Figure9

2) When extracting information symbol within a sign blob detection may result in multiple components wherever these are not connected. Figure11

3) Images taken from night vision camera do not have uniform illumination. Any shadow or bright spots generated over the sign lead to misclassification of sign.

4) Real time implementation requires more robust system which has reduced proceeding time. The classified sign must be associated with an audio signal or text information which can be the output to the driver for assistance in safe and automated driving system.

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