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A Review on Road Sign Recognition

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Abstract: In the present, the condition of roads has improved as compared to the past decade. So obviously the speed of the vehicles has increased and there might be chances of driver neglecting the road signs while driving which may result in road accidents. So there is a need for a system that automatically detects the road signs and helps the driver and makes the driving safer and easier. This review paper discusses the various techniques used recently for the detection and recognition of road signs. It also describes the classification of the road signs and the difficulties that arise during recognition.

Keywords: *Advanced driver assistance system, road sign detection, recognition,multi-layer perceptron.*

1. INTRODUCTION

Today car is an essential part of our life and purchasing a car for a person is not a big deal. As the car ownership increases, the road accidents also increase. Many people lose their lives due to the road accidents. So we need a system which helps the driver for driving as well as for the safety of road users. Advance driver assistance system is one of such a system. Examples of such a system are adaptive cruise control, lane departure warning system, collision avoidance system, night vision, traffic sign recognition, and so on [1].

Road sign recognition is a field which is concerned with the detection and recognition of road and traffic signs. It is a technique in which we use computer vision and artificial intelligence to extract road signs from outdoor images. The identification of road signs is done mainly in two stages: Detection and Recognition. In the detection phase, we enhance and segment the image according to their sign properties like color, shape or both. The output of this phase is a segmented image which contains potential regions that could be recognized as possible road signs. In the recognition phase, we test each of the candidates against a certain set of patterns and then decide whether it is in the group of road signs or not and after that according to these features they are classified into different groups.

This paper basically considers the traffic sign detection and recognition system. In this paper, Section 2 describes various road signs and difficulties in recognizing the road signs. Section 3 describes the architectural overview of traffic sign detection and recognition system. Section 4 describes the review of various sign detection methods. Finally, we conclude in section 5.

2. SIGN DESCRIPTION

Different traffic signs are available in different countries. These signs contain a lot of important information about traffic and road environment [2]. It helps the drivers in navigation. It regulates the flow of vehicles and also indicates the danger and difficulties around the drivers and makes the driving safer and easier. There are various signs but normally we classified these signs into three signs: i) Mandatory signs ii) Cautionary signs iii) Informatory signs [2].Mandatory signs are those signs which are designed for the safety of road users and these signs require the driver to obey the signs. There are normally 38 mandatory signs are available for the safety of road users [2]. Cautionary signs are those signs which are designed for the safety of drivers and drivers are advised to obey these signs. Generally, it uses a red triangle with white background and black pictoground[1][2].Total 40 cautionary signs are available [2].

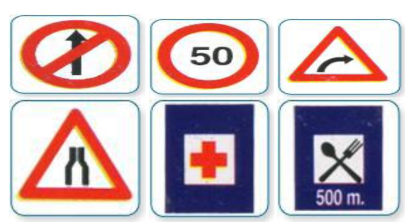

Fig. 1: Examples of traffic signs

Informatory signs are those signs which provide the information to the driver about the facilities that are

available on the road ahead. These signs use the rectangular shape of the blue border with white background and black pictogram. 18 informatory signs are available for the drivers as well as the road users [2]. In the Fig. 1 first two signs are mandatory signs. The first sign is no entry and the second one is the speed limit signs. The next two comes under the cautionary signs which are for right-hand curve and the narrow road ahead respectively. The other two are an informatory sign which gives information about the hospital and eating place that is available on the road ahead.
However, automatic detection of a traffic sign may involve some difficulties to recognize the signs. Some of are:

- Lighting conditions - Lighting condition cannot be same every time, it is changeable and not controllable. Lighting is different according to the time of the day, season, cloudiness and other weather conditions etc. Visibility is also affected by fog, cloudiness and by bad weather condition [7].
- Presence of other objects – Sometimes other objects like trees, buildings, pedestrians often surrounds the traffic signs which produces partial occlusions, shadows etc [2].
- Faded signs – The color of signs fades with the time as a result of long exposure to sunlight and reaction of paint with air [2].
- If the image (sign) is captured from the moving vehicles then signs may look small, noisy, blurry etc.
- Other difficulties – Signs may be found in different conditions such as aged, damaged, disoriented, similar objects in the scene or similar background color [7][3].

Hence for the above reasons, detection and recognition of traffic signs is a challenging task.

3. OVERVIEW OF THE SYSTEM

Fig. 2 shows the overview of the whole system. Our system consists mainly four stages: preprocessing, detection, filtering, and recognition. In preprocessing stage we just preprocessed the image like enhanced or segment the image. In the second stage detection, it detects the traffic signs. We consider the signs like speed limit signs or other informative signs. By this stage, we get the region of interest which is applied to the second stage i.e. filtering stage. This stage provides the better or clearer input to the final stage i.e. recognition stage which recognizes the signs.

A. Preprocessing
This is the first stage of the system. In this stage, we preprocessed the image by enhancing the image. We can enhance the image by removing or decreasing the noise from the image. For removing the noise we have various methods like contrast stretching, histogram equalization, different types of filters etc. [2]. We utilize filtering process for decreasing the noise.

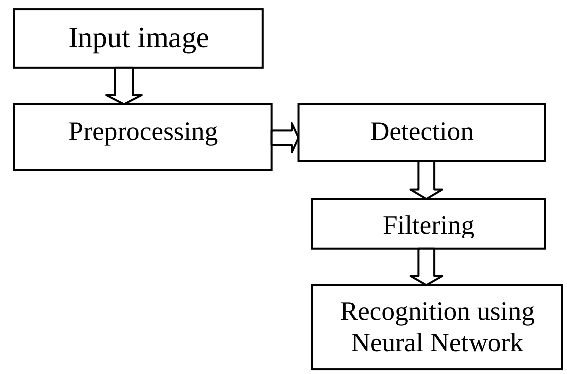

Fig. 2: System overview

B. Detection
We use the HOG-SVM technique for detecting the signs. HOG is a set of feature descriptor that is used for the purpose of detecting objects [9]. In this method, first of all, we divide the image into blocks. These blocks are formed by overlapping cells. Then we calculate the gradient information for each and every pixel. After this, a histogram of orientation is formed for each cell. Then for forming the HOG descriptor, we concatenate the histograms of the cells of each block. After that, we classified the generated features using SVM. It is a binary classifier which classifies an input into one of the two possible classes [23]. Here the two possible classes are a road sign or not a road sign.

C. Filtering
We use several filters like grayscale, bilateral, median, Gaussian to the region of interest that is obtained from the first stage. It provides the better and clearer result to the final stage that is recognition stage. We choose the filters according to the time delay and accuracy [2].

D. Recognition
The main task of recognition module is to recognize or classify whether the extracted region of interest belongs to the road sign category or not. For the recognition, First, we extract the blobs (descriptor of

zones) that are provided by the detection module then we matched it with templates in the database using Multilayer Perceptron (MLP), and take the appropriate decision whether it is a road sign or not.

We choose MLP for recognition because this network is good classifiers and have the capability to successfully solve several object recognition problems [16] [17].

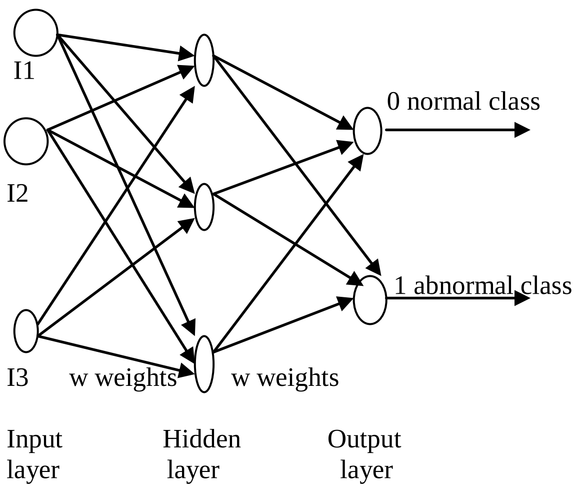

Fig. 3: Simple architecture of multi-layer perceptron

Fig. 3 shows the simple architecture of MLP. As the name suggests the perceptron has multiple inputs that are fully connected to an output layer with multiple outputs. We obtained each output by applying the linear combination of the inputs and an activation function which is generally nonlinear. In Multi-layer perceptron, the perceptron has more than one extra layer of processing elements. These extra layers are not connected to the external world directly and that's why called as hidden layers. Each network composed by around 3600 input neurons corresponding to 60x60 pixel input images. The number of output neurons corresponds to the number of signs which have to be distinguished.

In MLP if the input is given p_i for the m layer, then output q_j of the m+1 layer is computed as:

$$u_j = \sum i\left(w_{ij}^{m+1} * p_i\right) + w_{j,bias}^{m+1} \quad (1)$$

$$q_j = f(u_j) \quad (2)$$

The activation function which we used in this paper is a binary sigmoid function which is defined as:

$$f(p) = \beta * \frac{1-e^{-\alpha p}}{1-e^{-\alpha p}} \quad (3)$$

Here α=1 and β=1. This sigmoid function contains some very useful mathematical properties like monotonicity and continuity. Monotonicity, it means that the function f (p) either always increases or always decreases as p increases. And continuity means there are no breaks in the function; it is smooth [16]. In this paper the road Signs module used is separated to four MLP functions; each one is used for one type of blobs (blue circular blobs, blue rectangular blobs, red circular blobs and red triangular blobs).The database is divided into three sets. First is for training, secondly is for validation and third is for the test. The training set is used to train the MLP; validation set is used at the time of training to increase the generalization property of the network. The test set is used to evaluate the performance of trained MLP [19].

In the training process, the network acquires 63 essential training data parameters. These parameters are extracted and form the Recognition Stage. The weights of 63 node-input layers are modified. Then these parameters are passed to the hidden layer. When network performs, the network recognizes the input patterns and tried to distinguish the associated output patterns. The system dynamically tunes the related outputs with deference to input patterns until moving toward the criteria [16]. Thusly, the best network architecture is proficient chosen by the validation information. After validating, the network conveys the output corresponded to a training input pattern [17].

Fig. 4 (a) shows the input image. And the corresponding detected image is shown in Fig. 4 (b).

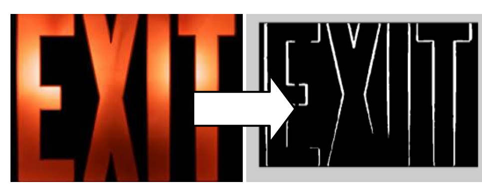

Fig. 4: (a) Input image (b) Detected image

4. Review Of Sign Detection Methods

There are many researchers which give his methods and techniques to deal with road sign detection problem. Some methods are discussed here:

A. Color–based detection approach

The objective of road sign detection is to identify the region of interest (ROI) in which a road sign should be found and check the sign on a vast scale looks for candidate inside an image [1]. Distinctive color based methodologies are utilized by the scientists to distinguish the ROI. These techniques apply a color segmentation utilizing a fixed or versatile threshold, a heuristic, or a statistical technique. When a conceivable region of interest (ROI) are characterized, they are passed to a computer vision stage as hypotheses.

The well-known color-based detection strategies are HSI/HSV Transformation [1], YC_bC_r Color Space Transform [3] [22], and Gaussian color model [4].[8] proposes an entire automatic framework for road sign detection and recognition by preparing the video frames in Lab color space. In that, L signifies the luminance, and a, b signifies the color.

Varun et al. [20] used the formula for color based detection (based on RGB color space) is:

$$1.5R > G + B \tag{4}$$

Fang et al. [15] first calculate the hue h of the candidate pixel denote ($h_1 .... h_m$), a set of hue values for a particular color of traffic sign normally distributed with the varianceσ^2. According to him the output is:

$$z = max_{k=1,........,m(z_k)} \tag{5}$$

Where$z_{k=\frac{1}{\sqrt{2\pi\sigma^2}}} \exp\left(-\frac{1}{2\sigma^2}(h-h_k)^2\right)$ (6)

The main disadvantage of color based strategies is that the color enlisted by the camera changes relying upon accessible light, climate conditions (rain, fog), and shadows. An approach to compensate this impact is to utilize a color model which is more robust than customary Red Green-Blue (RGB) display, e.g. HSI, HSV, CIElab, or YCbCr among others [5]. A few frameworks adapt to the absence of color consistency [6] recording and modeling the variety of a road sign color during a whole day. The subsequent model is at that point used to discover and apply an appropriate threshold [7]. Another approach is to estimate the scene's illumination by examining light conditions in the sky or on the road to modify the threshold automatically.

B. Shape-based detection approach

Techniques utilizing shapes could be a decent option when colors are missing or when it is difficult to recognize colors. Shape-based strategies should have the capacity to avoid troubles related to invoking colors for sign detection and strong to handle in-plane changes, for example, translation, scaling, and rotation. Much effort has been applied to build up these systems and the outcomes are exceptionally encouraging. The prominent shape based methodologies are Hough Transformation [10], Edges with Haar-like features [11] 12], Local Contour Pattern [13], or Local Binary Patterns [14], Histogram of oriented gradient [9] [18], Wavelet transformation[21].

According to [16], Mostly traffic signs are round or circular. To detect the hypothetical signs almost look like traffic signs choose a region with q in the range of 0.7-1.3 are accepted as candidates for traffic signs.

$$q = \frac{Areaoftheregion}{\pi * x^2} \tag{7}$$

Where x= longest width.

Some methods of shape-based approach are discussed below:

I. Histogram of Oriented Gradient

It is an acronym for HOG. HOG is characterized by the features like shape, object appearance distributed by local intensity gradients of the image [21]. Features of HOG are extracted from an image in a dense grid by a chain of normalizing local histograms of image gradient orientations [21]. For the calculation of feature descriptors, an overview of the method is shown in the Fig. 5.

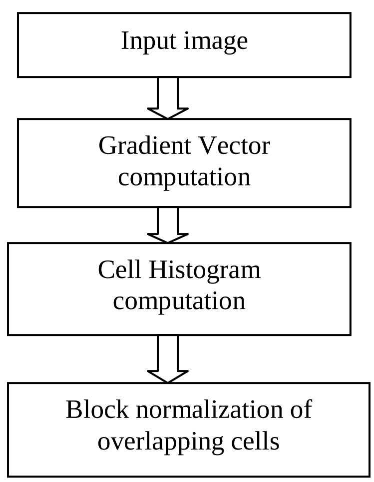

Fig. 5: An overview of HOG descriptor calculation

This method is based on the computation of normalized local histograms of image gradient orientations but in a dense grid. So firstly we divide the image into small regions which are called cells, where each cell collects local gradient information of 1-D histogram. Gradient information means directions or edge. Then we combine each and every cell. It is useful to do contrast-normalization for a better variance, which can be accomplished by collecting a measure of local energy (histogram) over a bit larger spatial regions termed as block [18]. We referred Normalized descriptor blocks as Histogram of Oriented Gradients (HOG).

We use the size of one cell as 16x16 pixels and the block size of 2x2 cells for calculation of HOG vector. Fig 4 describes the construction of the HOG feature vector for an image. In the second step, we compute the gradient magnitudes for every pixel. After this, we compute a histogram for every cell image. At the end of this process, we take 2x2 overlapping normalized blocks are normalized and normalizing the histogram within the block [18]. We do normalization because it provides some invariance which changes in contrast by multiplying every pixel in the block by some coefficient.

II. Wavelet Histogram of Oriented Gradient

It is an acronym for WHOG. It is a descriptor which provides a better classification result for intensity image over the normal HOG [21]. It represents shape information by storing local gradients in the image. In this method, we performed discrete wavelet transformation of an image. This transformation decomposed the grayscale image into different four sub-images in which one sub-images have low-frequency content and others are the high-frequency components of the image at different orientations. After decomposition of the image we extract the HOG feature from all the sub-images in separately then we combine it into a single column vector which gives the size of one feature vector of the grayscale image which is of four times the size of feature descriptors that is produced by one sub-image.

C.Color-shape based detection approach

By invoking a mix of color and shape, it is conceivable to exploit both methods to detect road signs. Every approach has its own positive properties and troubles. This adaptive hybrid approach can invoke one procedure in specific situations and summon the other under various conditions. As both color and shape represent data which ought not to be disregarded, it is possible to avoid numerous issues and drawbacks from the previous detection method. Fang et al. [15] used color-shape based detection approach. He built a road sign recognition framework in which color pictures from a camera are changed over into the HSI framework. Color elements are separated from the hue by utilizing a two-layer neural system. Gradient values in particular color regions are procured by an edge detection technique to build an edge image which is fed to another two-layer neural system to extract shape features. To form an integration map color and shape elements are consolidated by utilizing a fuzzy approach.

5. CONCLUSION

Table 1 shows the recognition rate of different signs by different authors. By the above table we can analyze that although all the techniques used for recognition of road signs give the result beyond its expectation but due to the uncontrolled and changeable lighting conditions, the unpredicted road environment, and the deformations of the road signs make it a very difficult task to design a robust reliable working road sign recognition system. Most of the researchers use single color space model for detection of road signs but for making system more effective and robust we can also be used color combined model (CCM) for detection of road signs. Although CCM gives better color segmentation it is more costly than single color space.In future, we can also reduce the computational efficiency of CCM by reducing the search region of the image sequence and by introducing object tracking. Also in future, it might be possible to find the best possible feature descriptor and classifier pair that gives optimum accuracy.

TABLE I. RECOGNITION RATE OF DIFFERENT SIGNS

Author	Road signs	Method used	No. of times testing	Recognition Rate	Error rate
Mohammad Badrul AlamMiah	Circular road sign	Neural Network	10	90%	10%
Moham-mad Badrul AlamMiah	Stop sign	Neural Network	10	95%	5%
Umaka-nt P. Kulkar-ni	Speed limit sign	Pattern matching	20	90%	10%
Vidyag-ouri B. Hemadr-i	Mandatory sign	Pattern matching	20	85%	15%
S.-H. Hsu, C.-L. Huang	Triangular road sign	Matching by pursuit method	356	93%	7%
S.-H. Hsu, C.-L. Huang	Circular road sign	Matching by pursuit method	125	92%	8%

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