International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 05 | May 2020 www.irjet.net p-ISSN: 2395-0072

A REVIEW ON TRAFFIC SIGN DETECTION AND RECOGNITION SYSTEM

Glory Reuben Maxwell[1], Dr. Dinesh D. Patil[2]

[1]PG Scholar, Dept. of Computer Science and Engineering, SSGBCOET, Bhusawal, India
[2] Associate Professor & HOD, Dept. of Computer Science and Engineering, SSGBCOET, Bhusawal, India

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Abstract - *Nowadays, Vehicles with ability to self-drive is given more attention as compared to the ones in previous decades. One of the most important functionalities which need to be taken into consideration is the ability of a self-drive car to recognize and detect the traffic signs from a certain distance in order to take necessary actions and provide security and safety for the people inside the car as well as to the surroundings. Traffic sign detection and recognition system is an exigent technology in developing world to robustly identify, detect, recognize and monitor the road traffic signs to help the driver to provide robust and reliable drive based on image data retrieved. TSDR system detects and recognizes the traffic signs on the basis of features such as color, shape & texture etc. In this paper a comprehensive study on TSDR system along with several traffic signs and various detection and recognition methods on the basis of color, shape, texture is highlighted along with the various hybrid methods involved in object detection. The main objective of this paper is to study and provide information related to various methods used in TSDR over recent years.*

Key Words: Traffic sign, detection, recognition, color, shape, texture, object, color space.

1. INTRODUCTION

Traffic Sign Detection and Recognition (TSDR) System is an intelligent computer vision system that makes the use of artificial intelligence to identify, detect, extract and recognize the road traffic signs from a certain distance to generate vital information to the driver about what actions to be taken. TSDR system captures the image from the vehicle in motion to uniquely identify the traffic sign by just discarding the unnecessary data in the image and focuses on retrieving traffic sign. The problems and challenges that are mainly results in avoidable accidents are not being able to identify the traffic sign from a certain distance to act accordingly. The challenges faced by the driver is to identify the faded, occluded, multiple signs at the same time. This gets even worse in bad weather conditions and in wild darkness of night because the signs are either damaged or invisible to the driving force. To overcome the challenges of identification of traffic sign TSDR system plays a major role which detects and recognizes the traffic sign and generates a voice alert to the driver by providing to the point information about the traffic sign. In this paper, a review on various methods for traffic sign detection and recognition system for identifying the road traffic sign based on its color, shape and texture is described. This study also gives a brief overview on architectures of TDR system and different traffic signs available.

1.1 Basic Architecture of TSDR System

The basic simple architecture of TSDR system consists of two main stages. The First stage is the detection stage which takes the input image or video to identify and rectify the traffic sign from the captured image. The captured image is passed as an input in the detection phase where the noise or unwanted background from the captured image is removed. In the second stage i.e Recognition phase the image generated from the last phase is compared and identified from the existing database to uniquely recognize the traffic sign. This recognition phase uses various features of the traffic sign such as color, shape, size , texture etc. to extract the sign information.Once the sign is identified the sstem genrates a voice alert to the vehicle driver by guiding the driver about the sign and provides the information about what action to be performed.

Fig-1: Simple Block Diagram

1.2 Detailed Architecture of TSDR System

TSDR system is divided into two modules: detection and classification. Primarily in system an image is captured from certain distance and image undergoes procurement to eliminate the unnecessary data and background of the image. In Detection module, the image sustains color segmentation along with shape analysis of the traffic sign available in the image.

Once the detection module is implemented and complete, the generated output from the previous module forwards to the classification module in which the sign gets classified and compared to the existing database on the system. The second module generates the output of uniquely identified and recognized traffic sign in the form of voice alert describing about the vital information of the traffic sign to the driver to perform the action accordingly.

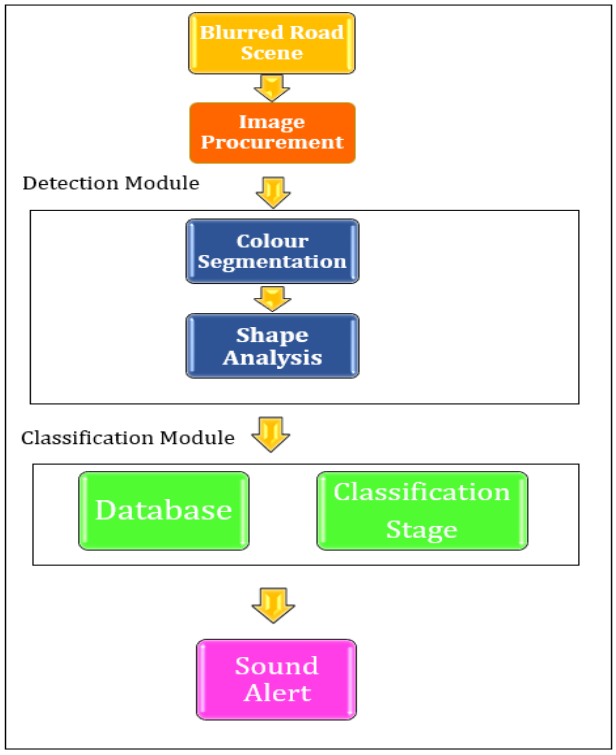

Fig-2: Advanced Block Diagram

2. TRAFFIC SIGNS AND CHARACTERISTICS

Traffic signs can be mainly divided into three categories which are informatory signs, Warning signs, and Mandatory signs. The various traffic signs provides vital information based on destination, direction, roadside facilities, etc. Informatory signs displays the information related to the genrally facilities available on the location such as public phone, petrol pump, hospital , eating place etc. These informatory signs are mainly of blue color. Fig-3 depicts examples of some informatory signs.

Fig-3: Informatory signs

Warning signs are also called cautionary signs warns the driver about the upcoming hazards/ situation on the road. There are total of 40 cautionary traffic signs that are made available by the Roadways and transport department. The most important and main function of these warning traffic signs is to warn the driver about the ahead potential existing danger on the road. These signs are generally of red color with triangle shape and different symbol on it.

Fig-4: Warning or Cautionary Signs

Mandatory signs are those signs that are necessary to be known by the driver. These signs are obligatory on the traffic road which makes use of a specific area of the road. These signs provide the information about the indication of what should be done. These signs are usually red in color and few are in blue color but varies in different shapes such as octagon shape for 'Stop' sign and triangle for 'Give Way' sign and other round shape signs for other directions. Violations of these mandatory signs leads to high penalty and fines. Also, one of the major cause of accidents if these signs are not followed.

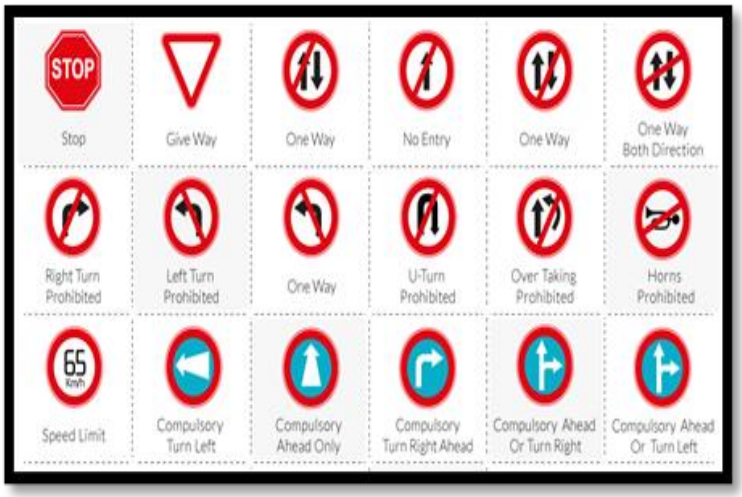

Fig-5: Mandatory Signs

Table - 1: Color and Shape Description

Traffic Sign	Color	Shape
Warning	White or Yellow Background / Red border	Equilateral Triangle pointing Up
Yield	White or Yellow Background / Red border	Equilateral Triangle pointing Up
Prohibitory or Regulatory	White or Yellow Background / Red border	Circle
No Parking, No standing	Blue Background / Red border	Circle
Stop	Red Background / White border	Octagon
Information	Black	Rectangle
Directive/ Information	Blue	Rectangle
Guidance and mileage	Green/ Blue	Rectangle

3. CHALLENGES IN TSRD SYSTEM

There are various challenges faced in TSDR system these factors that majorly affects the traffic signs and are listed below:

- Weather Conditions
- Color Standards
- Obstacles
- Disorientation
- Motion blur and interlacing effects
- Variable Lighting condition
- Fading and blurring effect
- Affected Visibility
- Multiple appearance of sign
- Motion artifacts
- Damaged or partially obscured sign
- Unavailability of public database
- Real-time application

4. TRAFFIC SIGN DETECTION METHODS

Traffic sign detection and recognition system majorly uses 3 types of methods based on these feature vectors identification of traffic sign is computed uniquely, the methods are namely as follows:

- Color-based method
- Shape-based method
- Other methods

4.1 Color-Based Method

Color based segmentation is one of the most commonly used method for the detection or identification of signs or to eliminate the regions that are unlikely to have signs. Color is the leading visual feature that portraits the vital information of the traffic sign to the driver. The color-based information could be extracted from the digital image or video by using various techniques such as color thresholding, dynamic pixel aggregation, Color indexing region growing, histogram, etc. The extricate feature of traffic signs that are based on color simplifies the process of identification and detection.

The main demerit of RGB color-based detection method is the illumination because that varies in intensity and color. Colo space conversion is the mostly used method of detection. Unravelling the color details from the brightness information by adapting the RGB color space into other color space, provides great detection capabilities depending on color cue. There exist various color spaces such as HIS, CIE, RGB, CMYK, HSV, YIQ, YUV etc.

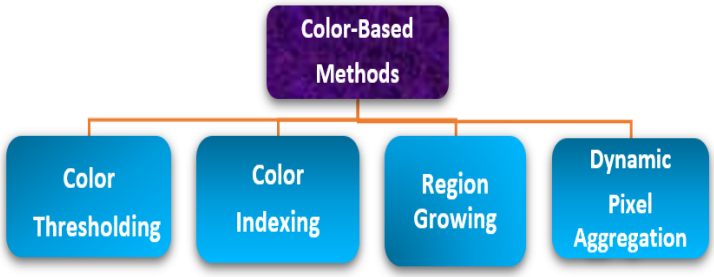

Fig-4: Color-Based Methods

4.2 Shape-Based Method

Shape is the second main parameter in detection of traffic signs. Mainly there are different kinds of shapes of different traffic signs indicating some information with collaboration with color and symbol in it. The traffic signs can be of different shapes such as triangle, circle, Octagon, rectangle. The shape-based features that are used in identification and detection of traffic signs are canny edge detection, Radial symmetry, corner detection, similarity detection, Hough transform, Haar-like feature detection etc.

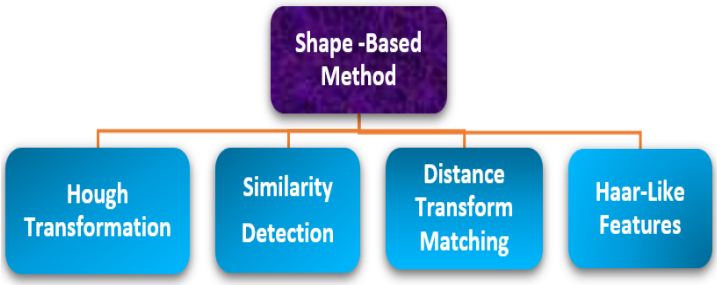

Fig-5: Shape-Based Method

4.3 Other Method

Other than colors and shape-based methods there exists various hybrid methods based on texture also. There are various methods that uses Neural Network, Fuzzy logics, genetic algorithm, Adaboost technologies for detection. Neural Networks uses to locate regions by identifying the centre of signs. Whereas AdaBoost technologies focuses on identifying strong classifiers by generating models by using multiple stages rectification of samples.

Object detection methods are the methods that are either singleton or hybrid that focuses on various techniques of identification of objects. On the basis of color, Segmentation of RGB color space includes template matching and RBF Neural Networks for recognition of an object, whereas in Color space transformation method, there are multiple recognition methods such as Hidden Markov Model (HMM), Behavioral Model of Vision (BMV), MLP Neural Networks and Radial Basis Function (RBF) Neural Network also.

On the Other hand, Shape based object detection methods uses Hough transformation, Corner Detection, Edge detection and Fit ellipse methods. Adaboost in which detection is based on the cascade object detector which makes the use of large feature space and also uses Forest ECOC (Error-Correcting Output Code) method for recognition. The Other methods such as GAB or features makes use of Gabor wavelength for detection and Self-Organizing Maps (SOM) for the recognition is used. Linear Support Vector Machine is also majorly used method for detection and recognition of objects. The various object detection methods are depicted in Table 3 along with their description and rate or computational cost. There are various object detection methods based on different features such as color, shapes and texture features. Table 3 describes the various features involved in object detection methods. Texture is a visually graphical and repeated pattern which has properties as fine, coarseness, contrast, entropy energy, regularity etc. sgldm, glcm, lbp, and glrlm are some of the methods that are used for texture information extraction. Texture detection methods are mainly divided into four types on the basis of structure, statistical methods, models involved in detection and transform based methods. Some of the mostly used texture-based methods are given below. And also, Fig-3 and Table 2 depicts the various methods of texture-based detection.

- GLCM: *Gray-Level Co-Occurrence Matrix*
- LBP: *Local Binary Pattern*
- SGLDM: *Spatial Gray Level Dependence Matrix*
- GLRLM: *Gray Level Run Length Matrix*

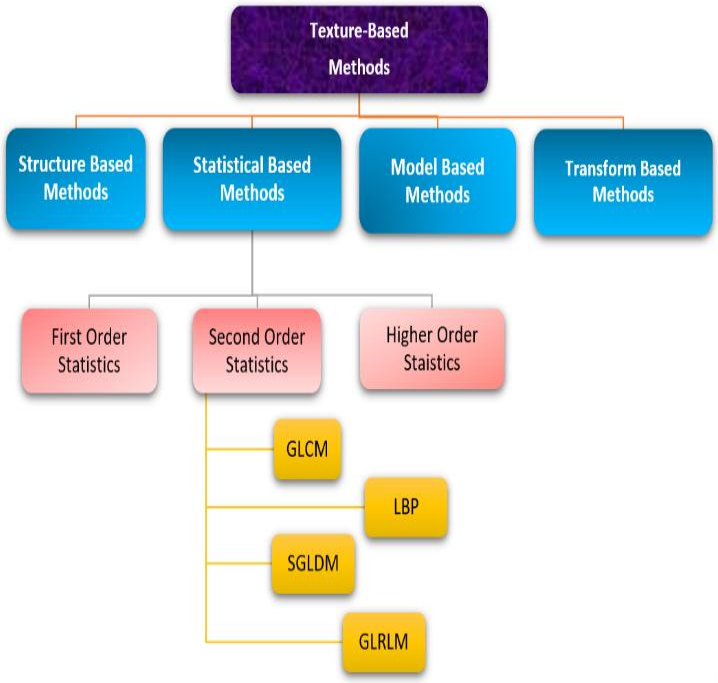

Fig-6: Texture Based Method

Table - 2: Texture Based Methods

Categories	Sub-categories	Method
Statistical	Histogram Properties	• Binary Gabor pattern • GLCM and Gabor filters
	Co-occurrence Matrix	• Gabor and LBP
	Local Binary Descriptors	• wavelet transform and GLCM • local binary patterns and significant point's selection
	Registration- based	• Energy variation • Combination of primitive pattern units and statistical features
	Laws Texture Energy	• Hybrid color local binary patterns
Structural	Primitive Measurement	• Energy variation • Edge-based texture granularity detection • Morphological filter • Skeleton primitive and wavelets
	Edge Features	
	Skeleton Representation	
	Morphological Operations	
	SIFT	
Model-based	Autoregressive (AR) model	• Multifractal Analysis in Multi-orientation Wavelet Pyramid • Markov Random Field Texture Models • simultaneous autoregressive models
	Fractal models	
	Random Field Model	
	Texem Model	
Transform-based	Spectral	• Binary Gabor Pattern • wavelet channel combining and LL channel filter bank • GLCM and Gabor Filters • Gabor and LBP • wavelet transform and GLCM • SVD and DWT domains • Skeleton primitive and wavelets
	Gabor	
	wavelet	
	Curvelet Transform	

Table - 3: Object Detection Methods

S. NO.	DETECTION TECHNIQUE	CATOGORY	METHOD	RECOGNITION TECHNIQUE	METHOD	RATE OR COMP. COST
1.	Color Segmentation in RGB	Color	RGB Color is directly segmented.	Template Matching	The result of detection stage is scaled to a size of 48 X 48 and is compared with stored sign template of same size	63-86%
			To Overcome the problem of illumination the RGB colors are normalized by intensity	RBF Neural Network	Principal Component analysis is used to reduce dimension and Fishere's Linear Discriminant is used to get discriminating features and RBF NN is used to recognize.	95%
2.	Color Space Transformation	Color	In HSV color space color are quantized to specific 8 colors then horizontal and vertical projection of specific color are used for detection	Hidden Markov Model	The candidate detected are sorted using HMM and the first ranked is regarded as recognized result	P4,1.6 Ghz, 512 MB, Image size 88X88 required 1.5s
			Color model CIExyz is used for segmentation	Behavioral Model of Vision (BMV)	BMV model is used to recognize complex gray level image with respect to shift, plain rotation and in certain extend to scale.	88-90%
			HSL color space is used on detection is performed on the basis of marginal distribution of color regions	Template Matching	Phase only correlation and partial template matching is used to recognize	90.1%
			Dynamic threshold in pixel aggregation process on HSV color space is used for segmentation.	MLP Neural Network	MLP topology has been fixed by the input data number, by the output classes and making an RGB values compression (3:1) between the input layer and the hidden layer.	84-100%
			A statistical linear model of color change space that makes road signs colors be more compact and thus sufficiently concentrated on a smaller area	RBF Neural Network	A radial basis function (RBF) network is used to train a classifier to find all possible road sign candidates from road scenes	95.6%

3.	Hough Transformation, Corner detection	Shape	HSI color space is used. Hough transform is used to detect the triangular and circle sign. The corner detection method is used to divide connected triangular sign and circle shape sign	RBF Neural Network	RBF-NN is used to identify the traffic sign and k-d tree is used to recognize the sign.	95.5%
4.	Edge Detection and Fit ellipse	Shape	Gaussian filter and canny edge detection are used to enhance image. Thresholding is used to convert a B/W image into binary and then contour and fit ellipse is used to detect the sign	MLP Neural Network	MLP is trained with supervised back-propagation learning technique	37.27 msec
5.	Adaboost +	Others	Detection is based on a boosted detectors cascade, which allows the use of large feature spaces	Forest ECOC	A battery of classifiers is trained to split classes in an Error-Correcting Output Code (ECOC) Framework	6% Error Rate
6.	Gab or Features		Gabor wavelets are used to encode visual information and extract features	SOM	Self Organizing Maps are used to cluster and classify the traffic signs	96%
7.	Linear Support Vector Machine		HIS color space to extract candidate blobs using color thresholding then the sign is detected using linear SVM.	SVM	The recognition of traffic sign is based on SVMs with Gaussian kernels. Different SVMs are used for each color and shape classification.	44.90% To 93.24%

5. CONCLUSION

In this paper, a discussion was made on basic and detailed architecture of TSDR system along with various categories and characteristics of traffic signs. There are several major challenges that affects the detection and recognition process of traffic signs and makes it difficult for the driver to identify the signs in adverse weather conditions and darkness, these challenges and problems are highlighted in this study. Traffic signs are detected and recognized based on various features such as color, shape, and texture etc. Based on these features numerous methods exists for detection of traffic signs. The study is made on these methods in detail. Object detection methods are also brought into focus that how objects are detected and recognized by using various features and hybrid methods along with their computational rate or cost. With the modern evolution in the field of Automatic TSDR system, Multiple machine learning methods on various features can be implied. In future various methods can be combined to generate multiple techniques and methods to minimize the complications in TSDR especially to emphasis on robust, efficient, fast, reliable and real-time environments. Different Hybrid technologies can be composed to develop a highly reliable system that is accurate and fast in computation of detection and recognition of the road traffic sign.

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BIOGRAPHIES

Glory Reuben Maxwell completed her Bachelor of Engineering in Computer Science & Engineering from St. Peter's Institute of Higher Education and Research, Chennai in 2018. She is pursuing her Masters in Technology in Computer Science and Engineering from Shri Sant Gadge Baba College of Engineering and Technology, Bhusawal affiliated to Dr. Baba Saheb Ambedkar Technological University, Lonere.

Dr. Dinesh D. Patil is working as Associate Professor and Head of Department in Computer Science and Engineering with 13 years of Experience at Shri Sant Gadge Baba College of Engineering and Technology, Bhusawal. He completed his PhD in the Feburary 2020.