

# A New Area based Algorithm for Traffic Sign Board Detection and Classification by SVM Approach

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## ABSTRACT

This paper proposes a new approach for traffic sign board detection and also describes the SVM approach for the shape recognition into different classes of traffic sign boards. First, the object is detected using area-based analysis. The area-based analysis is performed on the video frames based on the circularity parameter. The test input for the project is video obtained from a camera mounted on a vehicle. Before that, the image pre-processing techniques are applied to improve the quality of the image and to convert it into a binary image. Then the properties of the image frame have been obtained for further analysis. The feature generation is done to get the principal component for the classification of objects. Then the machine learning algorithm is applied to the dataset classification purpose. The classification into different classes (unsupervised shape recognition) is done with the SVM approach.

## General Terms

Detection Algorithm, Feature Generation, Classification

## Keywords

SVM – Support Vector Machine, Circularity, Unsupervised Shape Recognition

## 1. INTRODUCTION

Traffic sign board detection and recognition system is an exciting topic for the advanced driver assistance and automatic vehicles. The system collects signification information on real time for the drivers to reduce their efforts in safe driving in the driving environment. The system is also essential for the automated road maintenance perspective. Now a day's each road should be checked periodically for any missing or damaged signs, as such signs pose safety threats. The task of manually checking the state of every traffic sign is long and tedious, and it may lead to human error. By using techniques of computer vision, the task could be automated and therefore carried out more frequently, resulting in greater road safety. There are many features of the object like color, symmetry, aspect ratio, shape and others. Shape recognition is a prominent computer vision domain for recognizing image objects from their shape information in real time scenarios. Thus a hybrid system is needed that will help the drivers with the safety information while driving and also for driverless vehicles. There are many potential difficulties in detecting because of the complex environment and scenes around them. Complications are occlusions, climatic conditions and local light variations and not proper lighting in the night time. Recent increases in computing power have brought computer vision to consumer-grade applications. As computers offer more and more processing power, the goal of real-time traffic sign detection and recognition is becoming feasible. Some new models of high-class vehicles already come equipped with driver assistance systems which offer automated

detection and identification of certain classes of traffic signs. The detected regions in the first phase are recognized in the recognition phase. Object recognition algorithms generally involve two essential steps; feature extraction and classification. Feature extraction methods focus on calculating the crucial features of the objects that are invariant under different conditions. And classification methods aim at distinguishing different feature patterns and classifying the objects accurately.

## 2. LITERATURE SURVEY

Dongdong [1] uses a detector that includes classifiers to classify the traffic sign board. The operation is performed in various stages for the system evaluation and the tracking purpose. ElMargae Samira [2] used a Discrete Cosine Transform (DCT) to extract a global feature of a traffic sign, and similarly, Local Binary Pattern (LBP) is to obtain local descriptors. Classification of the features is done by the support vector machine (SVM). Ce Li [6] applied automatic segmentation into the homogenous region for merging based on similarities and then used morphological operators and boundary detection algorithm to extract the traffic sign board. They have used markers for the object and the background to obtain the traffic sign board.

Truong [7] had designed traffic sign board detection and recognition system on the ARM in three steps that are pre-processing, detection and recognition. Pre-processing includes chromatic color segmentation and refinement. They have the shape matching based on moment invariant and recognition by training the support vector machine and classify them. Artificial neural network (e.g., [15]) is another popular method used for optical character recognition in many applications. Road and traffic signs have been designed to be principally distinguishable from the natural or human-made backgrounds. They are characterized by many features make them recognizable concerning the environment.

Harini S [16] used background subtraction, object labeling and morphological operation for the detection of the red object for pre-processing and component extraction. Template matching using correlating coefficients is applied to recognize the detected object. Loy and Barnes [17] presented an algorithm that identifies polygon shaped signs (e.g., square, triangle, octagon) using radial symmetry detector. The accuracy of these shape based methods depends a lot on the edge operators being used by them, and these edges are vulnerable to noisy pixels.

## 3. PRE-PROCESSING

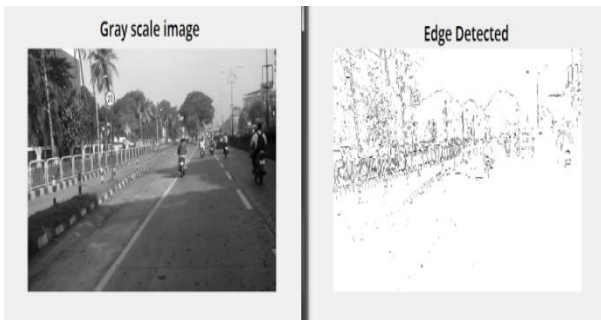
Gray scale conversion is performed to get the 8-bit image from the 24-bit RGB image for the further processing. Figure 1 shows the transformation of the image to a gray scale, gray

scaled image is used for edge detection in the next step of pre-processing.



**Fig 1: Color and Gray Scale Image**

The edges of the images are extracted to get the boundaries of the objects on that video frame. Once boundaries are obtained, and then find the different properties of the object. This step improves the quality of the image; also conversion is done into one plane gray scale so that it will take less time in processing when the detection algorithm is applied.



**Fig 2: Gray Scale Image with edges**

#### 4. DETECTION METHODOLOGY

Under-detection stage pre-processed image frame is used. Firstly, Contours of the image frame has been found then the area based algorithm has been applied to get the desired object. For the object detection, the circularity is calculated based on the derived formulae given in equation (2). If the circularity in the defined range then objects is detected and passed it to the next stage for the recognition.

##### 4.1 Finding ROI/Contours

Once the Canny edge operator detects the edges, and then the boundaries of the object have found in that frame. Then region properties of the processed image frame are obtained. Once the borders are detected, the area and perimeter of the objects on that contours have been found out.

##### 4.2 Proposed Area Based Algorithm

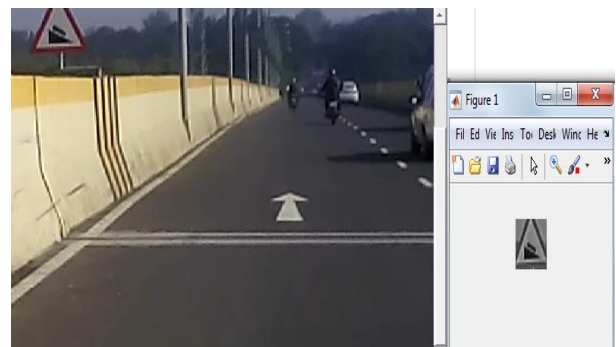
The circularity of the object is how close the object to a circle. The below mathematical equation is used to find the value of circularity. A circle is the most circular object. It is also the most compact in the sense that it encloses the most area for a given perimeter. There are many applications in which you want to say just how compact or circular an object is. One standard measure referred to in different places as circularity, compactness and shape factor compares the perimeter of a shape to the area it contains

$$C = 4\pi A/P^2 \quad (1)$$

The inverse of circularity is used for the area based analysis of the shape detection. In the area-based analysis, the below formulae inverse of equation one has been utilized.

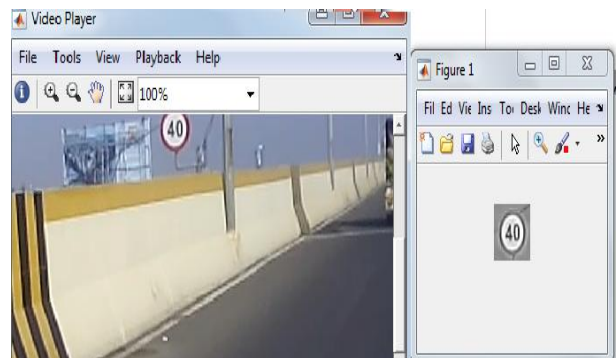
$$\text{Inverse Of Circularity} = P^2/4 \pi A \quad (2)$$

The area-based analysis is selected for our analysis as other approached consumes much time in processing compare to this in real time. Circular, rectangular and triangular traffic sign boards are tried for detection with this analysis and experimental results are obtained successfully. This approach is used for the detection of traffic sign boards because the output of the detection step is passed to next part for the feature classification in different classes with a faster rate. This approach improves the recognition with reasonable accuracy because area based algorithm takes less time in processing compare to Hough transform. Experimental results obtained are shown in fig 3, fig 4 and fig 5 with area-based approach using Matlab software on I3 processor laptop with 4 GB RAM.



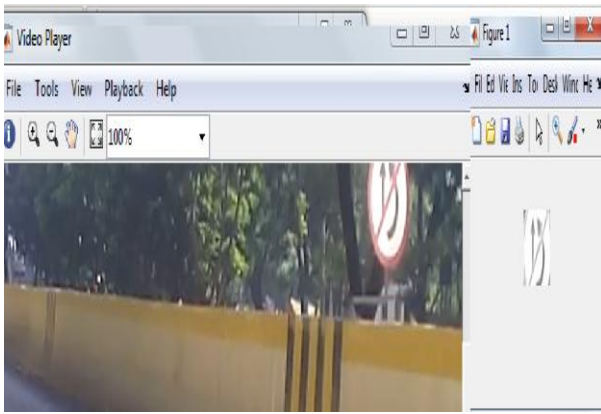
**Fig 3: Triangular Traffic Sign Board Detection using the area-based approach**

The below experimental results are obtained using area-based approach on Matlab software running on the system having I3 processor and 4GB RAM for circular traffic sign board detection with some assumptions that have been mentioned in subsection 4.3.



**Fig 4: Circular Speed Traffic Sign Board Detection using the area-based approach**

The below experimental result is obtained using area-based approach for No Turns traffic sign board detection on Matlab software.



**Fig 5: No Turns Traffic Sign Board Detection using the area-based approach**

### 4.3 Performance Evaluation

The Area-based approach has high detection rate and accuracy for the circular, triangular and rectangular traffic sign boards detection that have been experimented with the real-time video sequences taken by the camera mounted on a vehicle. Statistical analysis has been done to define a circularity range for the objects detection. To get the range, rectangular, triangular and circles are statistically applied to the detection algorithm for the observation.

**Table 1: Statistical analysis of the circularity range for object detection**

Shapes	Range ( $\frac{\text{perimeter}^2}{4 * \pi * \text{area}}$ )
Circle	0.91-1.18
Rectangle	1.38-1.54
Triangle	1.54-1.75

The results obtained in fig 3, fig 4, fig 5 with the assumption of the excellent lightning condition and proper climatic condition. If the different atmospheric condition is considered like the occlusions, severe weather conditions, night time then for that scenario, the system has to be trained more to detect and recognize the traffic sign boards to avoid false detection.

## 5. DATABASE PREPARED WITH TRAINING DATA AND TO GET FEATURE VECTOR

The different traffic sign board is classified into different classes for the training and to create a database. The different classes are informative, No Parking, No Turns, Parking, Turns, Speed. Multiple copies of one traffic sign boards have been put for the training. Once the database has been created successfully for training, then feature generation is done.

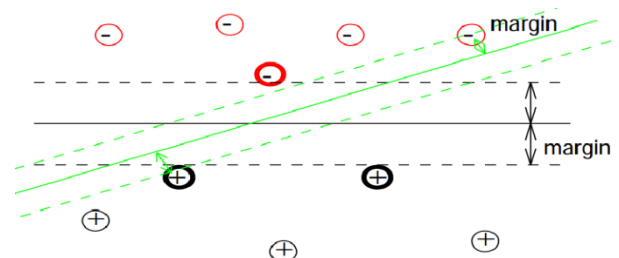
Feature generation can be done with statistical analysis or principal component analysis or Independent component analysis. Principal component analysis (PCA) is selected to get the similar feature into one vector for further steps. Under PCA analysis principal component is obtained, and first principal component has the highest possible variability. The principal components are eigen vectors of the symmetric covariance matrix. The feature of the object is achieved under one class from multidimensional to minor dimension. The

below steps have been performed for the recognition from training for the SVM till classification.

- (i) First, different datasets of traffic sign boards are created, for example, five datasets have been taken for recognition depends on the feature of traffic sign boards. They are mentioned as below from 1 to 5. 1)Informative,2)no\_turns,3)number\_plate,4)speed and 5)turns
- (ii) For each of these training set is created and for creating the training set first read the different datasets.
- (iii) In the path for Dataset give the path location for these different dataset folders.
- (iv) Resize of the images is done and then the cell array will be created for the dataset.
- (v) Now the next step is to create a training set process.
- (vi) Read all the files and then concatenate the image and later extract all its information.
- (vii) Next, images are required to scale so resize operation is required to perform. While performing scaling operation, images need to convert to gray scale, so convert the images to gray scale if they are not already converted and then again resize it.
- (viii) Now creating the training set, calculate the PCA of the images and store in a temporary variable.
- (ix) Take the first row of the matrix where PCA data has been stored as the feature vector for classification purpose.
- (x) Then different training sets has been created which are 1)training\_informative,2)training\_no\_turns,3)training\_number\_plate,4)training\_speed and 5)training\_turns. Then label of the different sets needs to be done for classification purpose.
- (xi) Train the SVM for different training sets using 'svmtrain' function.
- (xii) After this, read the video and segment the different traffic signs from the video.
- (xiii) Calculate their PCA.
- (xiv) SVMclassify function is used to classify the traffic sign boards in different classes.

## 6. FEATURE SELECTION AND CLASSIFIER DESIGN

SVM classifier is used to classify the data into different classes after the detection and feature generation. SVM classifies the data by finding the best hyperplane that separates all data points of one class from those of other class. The best hyperplane is with the most significant margin between the two classes.



**Fig 6: SVM hyperplane**

The data for training is a set of points (vectors)  $u_i$  along with their categories  $v_i$ . For some dimension  $d$ , the  $u_i \in R^d$ , and the  $v_i = \pm 1$ . The equation of a hyperplane is as below.

$$\langle w, u \rangle + b = 0 \quad (3)$$

Where  $w \in R^d$ ,  $\langle w, u \rangle$  is the inner (dot) product of  $w$  and  $u$ , and  $b$  is real. The following problem defines the best separating hyperplane. Find  $w$  and  $b$  that minimizes  $\|w\|$  such that for all data points  $(u_i, v_i)$ ,

$$v_i(\langle w, u_i \rangle + b) \geq 1 \quad (4)$$

The support vectors are the  $x_i$  on the boundary, those for which  $v_i(\langle w, x_i \rangle + b)$  equals 1. For the convenience to minimise, the problem is usually given as the equivalent problem of minimising  $\langle w, w \rangle / 2$ . This is called a quadratic programming problem. The optimal solution  $(\hat{w}, \hat{b})$  enables the classification of a vector  $z$  as follows:

$$\text{class}(z) = \text{sign}(\hat{w} \cdot z + \hat{b}) \quad (5)$$

Then SVM has been trained using the `svmtrain` function, and it returns a structure, containing information in different fields about the trained support vector machine (SVM) classifier. Training is a matrix of training data where each row corresponds to an observation or replicates and each column corresponds to a feature or variable. Group indicates grouping variable or a cell vector of strings representing a class label. The below MAT file has been obtained after training for No Turns class of traffic sign boards.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	252.4200	252.2900	252.5900	251.7400	246.3000	224.4200	209.2600	199.8000	192.5400	184.5800	178.0700	173.4000	167.4000
2	252.2300	252.0700	252.7900	249.7200	238.4400	216.3600	204.1300	196.5400	188.6700	182.5400	176.7400	172.0600	166.9800
3	253.4500	253.0500	253.1000	250	238.0900	215.9700	203.8400	196.3200	188.3600	181.3100	175.4300	170.6000	164.9800
4	253.6400	253.4400	253.1800	253.0800	253.1800	253.2200	248.0200	227.6400	210.5800	200.6000	192.0400	185.0600	178.0800
5	253.6400	253.4400	253.1800	253.0800	253.1800	253.2200	248.0200	227.6400	210.5800	200.6000	192.0400	185.0600	178.0800
6	253.2300	252.0700	252.7900	249.7200	238.4400	216.3600	204.1300	196.5400	188.6700	182.5400	176.7400	172.0600	166.9800
7	252.4000	252.1400	252.6600	246.8600	224.5600	208.3200	198.9800	191.3300	183.9900	178.0200	172.6200	166.9800	161.9800
8	252.4200	252.2900	252.5900	251.7400	246.3000	224.4200	209.2600	199.8000	192.5400	184.5800	178.0700	173.4000	167.4000
9	253.4500	253.0500	253.1000	250	238.0900	215.9700	203.8400	196.3200	188.3600	181.3100	175.4300	170.6000	164.9800
10	252.4000	252.1400	252.6600	246.8600	224.5600	208.3200	198.9800	191.3300	183.9900	178.0200	172.6200	166.9800	161.9800
11	143.2500	144.8800	147.9600	151.8200	155.4800	158.5700	162.1000	165.3200	166.3300	164.8300	156.2300	153.0500	154.9800
12	147.9900	150.0200	152.2900	154.9700	153.1400	143.4200	141.6500	144.5900	146.7700	146.9300	144.0800	144.8500	147.9800

Fig 6: Mat File for No turns class training

The below result has been obtained after SVM classification on the Matlab platform when the input for the implementation is video captured by a camera mounted on a vehicle.

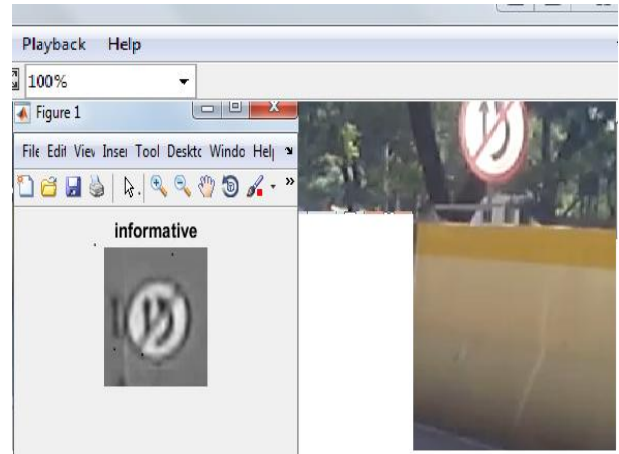


Fig 7: Recognized traffic sign board with the class name

## 7. IMPLEMENTATION ON OPEN CV

The proposed algorithm is implemented on an OPEN CV platform for the faster processing in recognition on the Ubuntu operating system with C++ in real time. It has an excellent response time in classification using support vector machines, and it can process frames up to 35 frames per second. This proposed methodology can be implemented on Raspberry Pi with a camera mounted on vehicles to capture the road scenes. The below experimental results have been obtained on a Ubuntu 17.10 operating system using Open CV software.

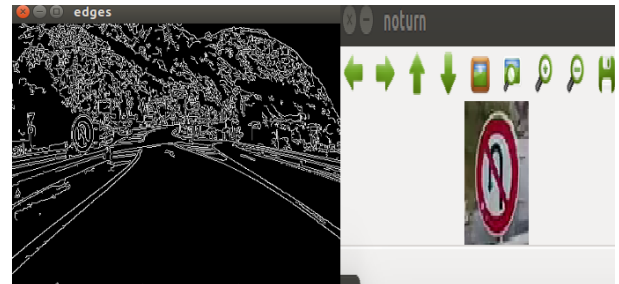
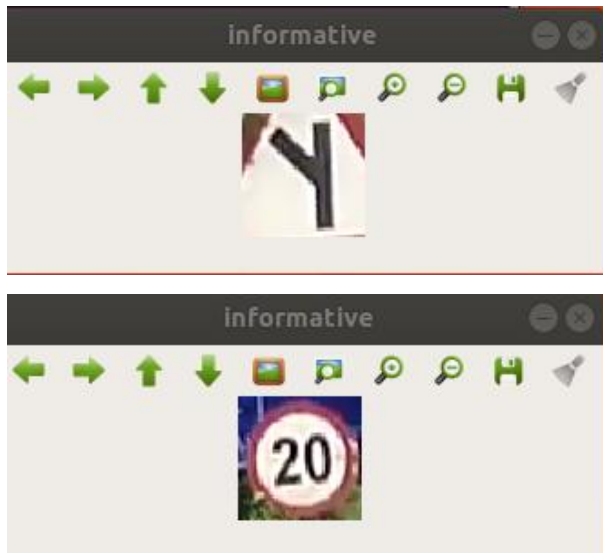


Fig 8: Recognized No Turns Traffic Sign board with the class name of the traffic sign board



Fig 9: Recognized Traffic Sign Board in the output window

The results in figure 8 and 9 are obtained when the traffic sign board detection and recognition steps have been implemented on open CV platform with better response time for classification in real-time processing. The below experimental results are obtained on the system having Ubuntu 17.10 operating system, OPEN CV software with an I3 processor and 4GB RAM.



**Fig 10: Recognized Traffic Sign Boards of informative class**

## 8. CONCLUSION AND FUTURE SCOPE

The proposed system can be used to provide the safety information for the driving assistance also it can be used for driverless vehicles. The inverse of circularity is utilized as derived formulae for the shape detection of different shapes traffic sign boards. The area-based analysis based on circularity provides faster detection rate with high accuracy that helped in the recognition stage with less computation time. The area-based approach is efficient for the unsupervised shape recognition when the detected shape is passed to the classifier. Firstly, the database has been trained with the traffic sign board's images in different classes. SVM classifier is designed to classify the object in different classes based on the feature. The experimental results obtained by the area based algorithm, have excellent detection rate up to 98% with the assumption that there should be appropriate climatic and lightening condition. False detection was also observed that kind of detection is shown under an unknown class. SVM can classify the detected object in the respective six output classes but the response time is slow for the classification in Matlab software. The experimental results have proven that system has fast response and less computation time with the proposed area based algorithms when it is applied on Open CV software for the detection and recognition in real time.

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