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Research Article

A Survey on Road Traffic Sign Recognition System using Convolution Neural Network

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Abstract

Road Traffic accidents is one of the major reason for deaths taking place in India. These accidents not only result into serious injuries but may also lead to deaths. Image recognition technology is one of the widely used techniques used in various fields in research like agriculture, medicine, automobile etc. At present, majority of the Image recognition techniques use artificial feature extraction technique which is not only time consuming but also is very complex. Hence, various researchers are basically working in order to improve the algorithms, and make them more and more efficient and robust. Initially, traditional principle of convolution neural network was introduced briefly. Its numerous applications in the domain of Image Processing were presented. Finally, the challenges faced by Convolution Neural Network in terms of time complexity and accuracy were analyzed, and then our recent work was introduced in order to overcome the efficiency related issues.

Keywords: *Image Processing, Canny Edge detection algorithm, Frame extraction, Frame normalization, Gray scale image, Convolution Neural Network, Fuzzy Classification.*

1. Introduction

Traffic accidents are a major reason for death and injuries in the country. The condition is improving in many parts of the world, whereas large number of accidents is still taking place in India (S. Singh *et al*, 2016).

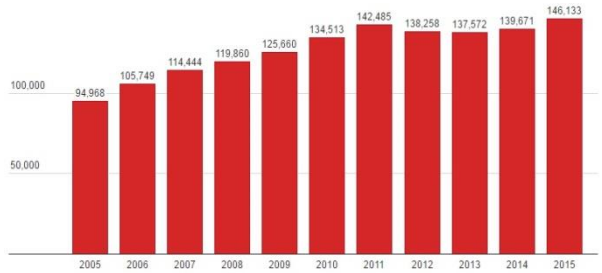

Fig.1 Statistics of annual year and no. of deaths due to road accidents

Fig.2 for percentage of drivers regretted, due to missing of road traffic sign boards. As observed from the graph, it can be concluded that 64% of drivers in India on an average have regretted missing road traffic sign boards (Y. Hatolkar *et al*, 2017). This may also result in road traffic accidents causing into serious injuries or even deaths at times.

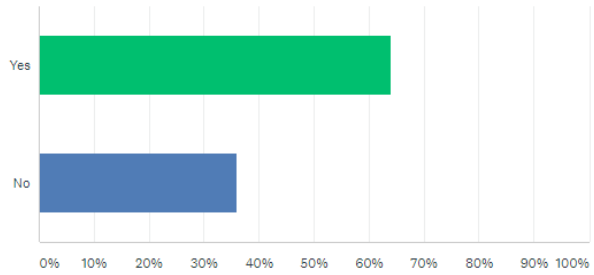

Fig.2 Statistics of regret caused among drivers due to missed road traffic signs

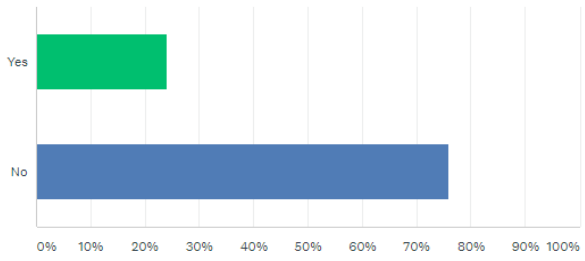

Fig.3 Statistics of drivers checking Google maps application blindly without noticing Road Traffic sign boards

This is the graph of survey for percentage of drivers following Google maps application blindly without

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even noticing on road traffic sign boards displayed. As observed from the statistics, almost 24% of drivers in India follow Google maps application without even paying any attention to the on road traffic sign boards (Y. Hatolkar *et al*, 2017). This could possibly be another reason for on road accidents resulting into serious injuries or deaths.

Traffic Symbol recognition is basically a methodology in which the vehicles are able to determine road traffic signs and avoid the accidents taking place. These signs may include various road symbol alerts like "speed limits", "one-ways", "school ahead", etc. This is one of the hot topics in research Automobile industries. Considering the current Traffic management system, there is high possibility that the driver would miss out the road traffic symbol plate alerts due to overcrowding of the traffic on-road. The condition is even worsening due to over population in urban cities. Some of the road traffic sign information can also be obtained from GPS, but it is not always up-to-date.

After extraction of the road traffic signs from the system, they can be displayed on the panel of the cars, or could be converted to audio signals for providing notification alerts to the driver.

Traffic symbol recognition is one of the solutions proposed for Driver Assistance Systems (DAS) and Automated Driving(AD). However, this task is not that easy for a computer because of changes in environmental conditions such as shadows, lightening, etc. Bright images are captured during sunny days. Recognition of traffic symbols in an image involves two main steps: detection and classification. The main challenge faced by the system is taking into consideration various environmental changes during sunny, rainy days.

Traffic Sign Recognition (TSR) system not only helps in reduction of road accidents but also provides encouragement in maintaining legal speed, obeying traffic rules and instruction, and ensures safe driving as well.

Fig.4 European Speed limit sign recognition system

The initial generation of TSR system was developed by Continental AG and Mobileye (E. Lobo *et al*, 2015). This system is basically used for European speed limit signs. This technology is used in Volkswagen Phaeton and Volvo V40, V60, V70, S6, X80 and XC60 models for speed limit signs (E. Lobo *et al*, 2015).

The remaining contents of the paper are as follows. Section II reviews the related work in road traffic sign recognition system. In Section III, we discuss about techniques used for Traffic signs detection. Section IV describes about methods and algorithms used for Traffic sign recognition. In Section V, comparative analysis of various algorithms used for Traffic Sign Recognition system is discussed. Section VI provides brief idea on the proposed system. In Section VII, conclusions are drawn and finally Section VIII, describes the Future scope and extensions to the existing system.

Related Works

Traffic signs can be categorized into different k-sets based on numerous image classification techniques. In order to simplify driver's task, and avoid various accidents taking place in the country, traffic sign recognition technique is implemented. Image recognition is performed using various techniques by different researchers.

Convolution Neural Network

CNN is used for image recognition technique in various for road traffic sign recognition applications. In (H. Luo *et al*, 2016) system contains three main phases. Traffic sign Region of Interest, ROIs refinement and classification, and finally post processing. Modified Convolution Neural Network is used in the paper for image recognition. Speed of the system also needs to be optimized for this application.

Image Segmentation

In (H. Fleyeh *et al*, 2003) Image segmentation technique is used to determine the shape of the traffic sign by comparing it with the provided data set. Image segmentation technique for road traffic sign recognition results in inaccurate output due to blur images captured during motion of the car. In (V. Andrey *et al*, 2006), RGB color segmentation technique is used along with rule based approach. Image morphological analysis is done to determine the shape of traffic sign. Results obtained contain large amount of false positives.

Support Vector Machines

In (H. Gómez-Moreno *et al*, 2010) basically, the approach is based on Maximally Stable External Regions (MSERs). Support Vector Machine (SVM) is cascaded for training system. This detection technique is significantly insensitive to variations in illumination and lighting condition.

Traffic Sign Detection

Images captured from the camera are usually of poor quality. The system needs to enhance the quality of the images, in order to obtain the correct outcome. There are various pre-processing techniques applied before actual classification of the image. Image is transformed into various color spaces. Different color spaces such as HSI (A. de la Escalera *et al*, 2003), Improved HLS (H. Fleyeh *et al*, 2004), normalized color space (W. Ritter *et al*, 1995) and (J. Greenhalgh *et al*, 2012) are used. Basically, image normalization technique is used for adjusting the brightness of the image, so as to detect the traffic symbols accurately. In (Y. Wu *et al*, 2013) and (M. Liang *et al*, 2013), SVM classifier was used in order to train the system and map each pixel of the frame to gray scale.

Traditionally, threshold based methods (M. Young *et al*, 1989), and (A. de la Escalera *et al*, 2003) were used for object classification using various image segmentation techniques, and compared in order to get the optimal technique. These techniques proved less accurate for environmental changes such as lightening and bright images during sunny days.

In this paper, we have chosen to extend (H. Luo *et al*, 2003) this paper by improving on the efficiency of the existing methodologies used in paper. Frame extraction is primary step from the videos captured from car-mounted camera. RGB is an additive color component model in which red, green and blue colors are combined in order to get various shades of colors. RBG color component is used in order to reduce the time and space complexity of the system. Frame normalization technique is used to adjust the brightness in the images due to environmental factors. This was considered as a drawback in previous papers (W. Ritter *et al*, 1995), (J. Greenhalgh *et al*, 2012). In Binarization technique, the traffic signs are highlight to white pixels, while background remains black.

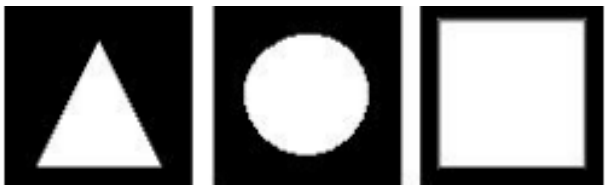


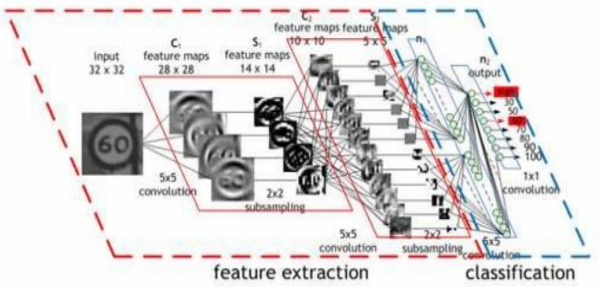
Fig.5 Binarization example for triangular, circular and square shaped road traffic signs

Traffic Sign Recognition

Initially, techniques used for classification involved feature extraction and classifier training. In previous work, SVM classifier was used along with HOG features (I. M. Creusen *et al*, 2010), MLP (Multi-Layer Perceptron) having radial features (Y. Jiang *et al*, 2011), ANN (artificial Neural Network) along with RIBP (Rotation Invariant Binary Pattern) (S. Yin *et al*, 2015). In short, an optimal feature extraction, and accurate classifier is a challenging job.

Convolution Neural Network (CNN), on the other hand can be considered as one of the popular techniques, for training and classification. In (G. Wang *et al*, 2013) modified version of cross entropy loss was used for CNN training. In spite of the fact that CNN has shown excellent performance in image classification, the task of designing a good architecture and train a workable model is still one of the challenging tasks.

In order to handle different geometry variations of road traffic signs, data augmentation technique was used to enlarge the training data set (P. Sermanet *et al*, 2011) and (J. Jin *et al*, 2014).



Convolution Neural Network Architecture

In this paper, we have chosen to extend (H. Luo *et al*, 2016) this paper by improving on the efficiency of the existing methodologies used in paper.

Canny edge detection algorithm (Y. Dong *et al*, 2016) is used in order to highlight the edges so as to compare the shape of traffic sign with the provided data set for image recognition. Canny basically involves four modules for edge detection technique. As discussed in (Y. Dong *et al*, 2016), Gaussian filter is applied in order to smooth the image for suppressing noise. After applying Gaussian filter, intensity gradients of the image are calculated using Sobel filter. Later, a particular threshold is chosen so as to suppress the noise and determine the exact edges. Further, it is necessary to suppress the non-maximal pixels for accurate edges detection. After this, double threshold is applied in order to determine the potential edges. Later, after determination of strong and weak edges, which weak edges are actual edges. In order to implement this, edges are tracked by using hysteresis. This process is carried out in an iterative fashion in order to determine the final strong edges. Finally, the system iterates through the weak edges are set the value to zero, resulting in final image.

Fig.6

According to (H. Luo *et al*, 2016), this output is passed on to CNN to get the probability score of match between the frames extracted and data set used for training.

Canny Edge detection stages

Noise suppression

Application of Gaussian Blur algorithm for noise reduction

Finding intensity Gradient of the image:

Calculation of intensity gradients

$G = (G_x^2 + G_y^2)^{1/2}$
$\theta = \tan^{-1}(G_y/G_x)$

Non-maximal suppression

Threshold is chosen so as to suppress the noise and determine the exact edges. Further, it is necessary to suppress the non-maximal pixels for accurate edges detection.

Hysteresis Thresholding

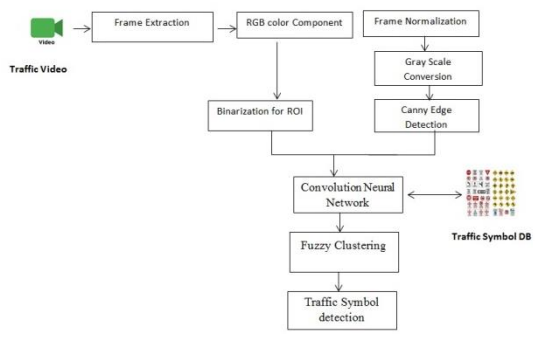
edge > $thresh_{max}$: Included
edge < $thresh_{min}$: Excluded
$thresh_{max}$ > edge > $thresh_{min}$: Included (Only if edge is connected to strongly connected edge).

Comparative Analysis

Sr. No	Ref No.	Year	Algorithms	Advantages	Disadvantages	Tools
1	6	2002	Generic Algorithm	Traffic sign is recognition properly for images with no disturbance in weather conditions.	System Working is based on occlusion and with lack of occlusion system does not perform efficiently	C++
2	3	2003	Color Segmentation	Traffic sign is recognition properly for images with no disturbance in weather conditions.	Blur images due to moving car	C++
3	20	2015	K-d tree and Random forest based Image detection	Histogram of Oriented Gradients (HOG) based approach	Classification results need to be improved. Need to work on varying illumination.	MATLAB
4	21	2015	Integral Channel Features and Aggregate Channel Features detection methodology	Combined decision taken for sign identification from two methods. System tested for LISA-TS traffic sign dataset	Color clue is challenge. Majority of images in US are in white background. system has been tested for direction sign, only of simple shape	Java
5	22	2016	Convolution Neural Network	Works well for German and Chinese Traffic sign recognition.	Two complex algorithmic procedures are implemented requiring higher hardware which is major challenge.	C++
6	4	2006	Image morphological analysis	RGB color segmentation with rule based approach	Large number of false positive cases in results which needs to be reduced.	Java

Proposed System

The block level representation of the proposed application is shown below.



System Architecture of Road Traffic Sign Recognition Application

Traffic sign detection and recognition consists of four main stages.

Pre-processing

In pre-processing phase, image is converted into RGB color component model. Further, frames are normalized in order to optimize the image appearance and control excess brightness due to sunny weather at times.

Gaussian filter is used in order to smooth the image and remove unwanted noise which can lead to inaccurate results. This pre-processed image frames are sent to image detection module for further processing.

Image Detection

In Image detection module, optimized and pre-processed image frames undergo binarization

technique. In binarization, the traffic symbol is represented by white pixels, whereas the background is represented by black pixels. This helps to find approximate location of the road traffic symbol in the image. The result is obtained in the form of (x,y) coordinates.

Shape classification

Further, after locating the approximate coordinates of the road traffic from the image frame, Canny edge detection algorithm is used to highlight the edges of the road traffic symbol, whose location is obtained from the previous phase. This output is sent to Convolution Neural network, where matching of the actual road traffic symbol from the image frame, and provided template of road sign from the data set is done. This output is further provided to Fuzzy classification in order to improve the accuracy of the system.

Fuzzy Classification

With reference to the paper (H. Luo *et al*, 2016), Fuzzy classification technique is applied as extension in order to improve the efficiency of the system and optimize the outcome of the application. According to the proposed system, Fuzzy Classification output will be divided into certain set of probabilities and final result will be extracted from matching probable class and will in turn be converted into audio.

Conclusion

In this paper, we propose a new modified approach for road traffic sign recognition technique. Short and low quality videos are captured from a camera mounted on a car. Pre-processing techniques are applied in order to improve the quality of the image frames. Approximate position of the traffic sign is determined, and sent to convolution neural network for training and classification. Fuzzy classification module acts as an optimizer module for improving the results obtained by CNN. This traffic sign recognition system will help drivers to track the traffic symbols with ease, and avoid the accidents and in turn reduce the number of deaths.

Future Scope

In future research, it is planned to apply Fuzzy Classification technique to the output obtained from Convolution Neural Network and Fuzzy Classification, and minimize the time-complexity of the Traffic Sign Recognition System. This technique as discussed in the proposed system will help to reduce the number of serious injuries caused as well as minimize the number of deaths taking place in India due to overlooked traffic signs.

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