

Traffic Sign Detection, Recognition and Notification System using Faster R-CNN

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Abstract - Driving assistance systems need to solve the problem of traffic sign recognition. Here we have designed and implemented a detector fast R-convolution neural network (CNN) framework. Here, color and shape information has been used to refine the localization of small traffic signs, not easy to regress accurately. Finally, an efficient CNN with an asymmetric kernel is used as a traffic sign classifier. Both the detector and the classifier have been trained in challenging public benchmarks. The system gets traffic sign recognition from video which contain traffic and system will send notification to driver by audio message. The results show that the proposed detector can detect all categories of traffic signs and send notification to driver by audio message.

Key Words: R-convolution neural network (CNN), Traffic Sign Recognition (TSR)

1. INTRODUCTION

The development of the technology level of the latest mobile processors enabled many vehicle producers to install computer vision systems for their customer's cars. These systems will significantly improve safety and realize an important step towards driving. Among other tasks solved in computer vision, the problem of traffic sign recognition (TSR) is the most well-known and widely discussed by many researchers, however, as the main problem is the low detection accuracy of the system high demand hardware computing. They do not have a system of classification of traffic signs. Recognition of traffic signs is usually solved in two steps: localization and subsequent classification. The different type of localization methods is available. Effective implementation of image pre-processing and localization algorithm of traffic signs performed in real time. In the classification stage, a simple template matching algorithm is used. The Fig 1 shows the images of GTSDB and GTSRB. The datasets from GTSDB and GTSRB is used for train and test the developed algorithm.



Fig 1: Example images from GTSDB and GTSRB database

End such reduction occurred due to illumination, contrast, and too strong variation in the image of the local traffic signs, while testing the development techniques for detecting and classifying traffic signs in real conditions, using video from cameras installed in the windshield. In this way, the template could not be matched like a simple classification algorithm, so it is a predefined template with a limited set for high-quality recognition. In order to improve the performance of the system, a convolutional neural network which is widely used in recent years can be used to combine the recognition with the localization algorithm which shows good results.

In this paper we present a fast traffic sign recognition (TSR) system. It accurately recognizes traffic signs of different sizes of images. The system consists of two well-designed convolutional neural networks (CNN) for regional proposal of traffic signs and classification of each region. The system gets traffic sign recognition from video which contain traffic. After that system will send notification to driver by audio message. Hence if driver ignore the traffic sign then also by listening audio message he will follow traffic sign.

In this paper study about the related work is done, in section II, the proposed approach modules description, algorithm and experimental setup in section III is discussed and results and discussion is discussed in section IV and at final we provide a conclusion in section V.

2. REVIEW OF LITERATURE

Paper I: Real-Time Traffic Sign Recognition Based on Efficient CNNs in the wild [1]

Description: In this paper they designed and implemented a detector by adopting the framework of faster R-convolutional neural networks (CNN) and the structure of MobileNet. Here, color and shape information have been used to refine the localizations of small traffic signs, which are not easy to regress precisely. Finally, an efficient CNN with asymmetric kernels is used to be the classifier of traffic signs. Both the detector and the classifier have been trained on challenging public benchmarks. The results show that the proposed detector can detect all categories of traffic signs. The detector and the classifier proposed here are proved to be superior to the state-of-the-art method.

Paper II: An In-Car Camera System for Traffic Sign Detection and Recognition. [2]

Description:

This paper presents a driving assistance system for traffic sign detection and recognition. The proposed technique consists of two sub system for detection and recognition. First, the road sign detection subsystem adopts the colour information to filter out most of irrelevant image regions. The image segmentation and hierarchical grouping are then used to select the candidate road sign region. For the road sign recognition subsystem, Convolution Neural Network (CNN) is adopted to classify the traffic signs for the candidate regions. In the experiments, the proposed technique is carried out using real scene images. The performance evaluation and analysis are provided.

Paper III: Traffic Sign Detection and Classification using Color Feature and NeuralNetwork. [3]

Description:

Automatic traffic sign detection and recognition is a field of computer vision which is very important aspect for advanced driver support system. This paper proposes a framework that will detect and classify different types of traffic signs from images. The technique consists of two main modules: road sign detection, and classification and recognition. In the first step, colour space conversion, colour based segmentation are applied to find out if a traffic sign is present. If present, the sign will be highlighted, normalized in size and then classified. Neural network is used for classification purposes. For evaluation purpose, four type traffic signs such as Stop Sign, No Entry Sign, Give Way Sign, and Speed Limit Sign are used. Altogether 300 sets images, 75 sets for each type are used for training purposes. 200 images are used testing. The experimental results show the detection rate is above 90% and the accuracy of recognition is more than 88%.

Paper IV: Traffic Road Sign Detection and Recognition for Automotive Vehicles. [4]

Description:

Traffic road sign detection and recognition is important to transport system with a robotic eyes or camera while driving in the road. This paper presents and overview the traffic road sign detection and recognition, we developed and implemented the procedure to extract the road sign from a natural complex image. The main objective of this paper is to design and construct a computer based system which can automatically detect the direction of the road sign. This paper is based upon a major approach to detect the direction. In this paper, they demonstrate the basic idea of how detect the area and extract it. This system will play an important role for the detection purpose of specific domains like island, schools, traffic sign, universities, hospitals, offices etc.

Paper V: Traffic Sign Detection and Recognition for Intelligent Vehicle. [5]

Description:

In this paper, they propose a computer vision based system for real-time robust traffic sign detection and recognition, especially developed for intelligent vehicle. In detection phase, a color-based segmentation method is used to scan the scene in order to quickly establish regions of interest (ROI). Sign candidates within ROIs are detected by a set of Haar wavelet features obtained from AdaBoost training. Then, the Speeded up Robust Features (SURF) is applied for the sign recognition. SURF finds local invariant features in a candidate sign and matches these features to the features of template images that exist in data set. The recognition is performed by finding out the template image that gives the maximum number of matches. A recognition accuracy of over 90% in real-time has been achieved.

Paper VI: Design of Traffic Sign Detection, Recognition, and Transmission Systems for Smart Vehicles [6]

Description:

Traffic sign detection and recognition (TSDR) is an essential component of advanced driver assistance systems (ADAS). It is mainly designed to enhance driver safety through the fast acquisition and interpretation of traffic signs. However, such systems still suffer from the inability to accurately recognize signs. Moreover, the sharing of wirelessly recognized signs among vehicles is not yet supported by current systems in some safety scenarios; vehicle-to-vehicle communication of traffic sign information is required. In this article, they first address challenges and undesirable factors facing TSDR systems. After that, they show how to design a TSDR system by addressing some useful techniques used in each stage of the system. For each stage, these techniques are regrouped into different categories. Then, for each category, a short

description is given followed by some concluding remarks. Finally, the transmission of the recognized signs is briefly investigated.

2.1 Comparative Analysis of Literature Survey:

In literature review, we studied about different systems and techniques of traffic sign detection and traffic sign recognition in computer vision. Table No.1 shows the comparative analysis of literature survey of different methods with its Datasets.

In first paper using R-CNN techniques traffic sign detection is done, for traffic sign recognition CNN is used and achieves 99.4% accuracy in traffic sign recognition. In GTSBS dataset they used 600 images for training purpose and 300 images for testing purpose.

In second paper colour segmentation method is used for traffic sign detection and in that feature extraction is done using image segmentation and hierarchical grouping. Convolutional neural network is used for traffic sign recognition. The correct rates for the detection and recognition systems are 92.63% and 80.5%, respectively.

In third paper Edge extraction and Template matching technique is used for traffic sign detection and Machine Learning algorithm is used for traffic sign recognition. Wireless transmission system is designed to send notification from one vehicle to another.

In forth paper RGB to HSV Transformation, colour segmentation method is used for traffic sign detection and in that feature extraction is done using colour segmentation. Artificial neural network is used for traffic sign recognition. The detection rate is above 90% and the accuracy of recognition is more than 88%.

In fifth paper Adaboost Algorithm is used for traffic sign detection and in that feature extraction is done using Colour Based and gray scale based technique. Convolutional neural network is used for traffic sign recognition. The recognition rate is 77% for 200 testing images which includes each set of 50 images of morning images, afternoon images, evening images and night images.

In sixth paper Colour - Based Segmentation and set of Haar wavelet features is used for traffic sign detection and in that feature extraction is done using Color based segmentation method. SURF matching algorithm is used for traffic sign recognition. The detection rate and recognition accuracy are 94.3% and 92.7%, respectively. System takes 170ms and 200ms for detection and recognition, respectively.

3. SYSTEM OVERVIEW

3.1 Problem Statement

The main problem is the low detection accuracy of the system high demand hardware computing. They do not

| P a p e r N o. | Paper Title | Method Used for Detection | Method Used for Recognition | Data Sets |
|----------------|---|--|---------------------------------|---|
| 1 | Real-Time Traffic Sign Recognition Based on Efficient CNNs in the Wild | Using R-CNN | Using CNN | GTSBS (300 images are used for testing and 600 images for training) |
| 2 | An In-Car Camera System for Traffic Sign Detection and Recognition | Image segmentation and hierarchical grouping | Using CNN | GTSDB (300 images for testing and 39209 for training) |
| 3 | Traffic Sign Detection and Classification using Colour Feature and Neural Network | color segmentation method | Using ANN | GTSDB (300 images for testing and 39209 for training) |
| 4 | Traffic Road Sign Detection and Recognition for Automotive Vehicles | Colour Based and gray scale based technique | Using CNN | 200 images were taken as test images |
| 5 | Traffic Sign Detection and Recognition for Intelligent Vehicle | Color based segmentation method | SURF matching algorithm is used | 200 images were taken as test images |
| 6 | Design of Traffic Sign Detection, Recognition and Transmission Systems for Smart Vehicles | Shape Extraction through Gradient Features | Machine Learning Technique | NA |

Table1. Literature Review

have a system of classification of traffic signs and cannot send the notification alert by audio message.

3.2 Proposed System Overview

Figure 2 show that, proposed system architecture.

1) The system takes input video from webcam or any high resolution camera which contain traffic sign. Then using video interpreting and processing convert video in to frames and then display that frame which contain traffic sign. Traffic sign detection is done using Faster R-CNN, Region Proposal Network (RPN), Region of Interest (ROI) pooling layer and last using classifier i.e. Dense layer, Box Regression Layer.

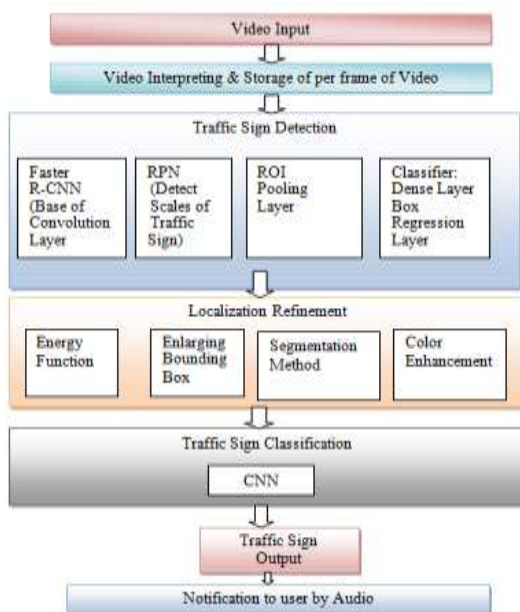


Fig. 2: System Architecture

2) In localization refinement Energy function is used for pixel intensity, Enlarging bounding box are used for object selection, Segmentation is used for dividing image in to number of segments and after color enhancement technique is used to enhance the colors. The output of localization refinement given to Convolutional Neural Network (CNN) for classification

3) Finally the system gets traffic sign recognition from video which contain traffic. After that system will send notification to driver by audio message. Hence if driver ignore the traffic sign then also by listening audio message he will follow traffic sign.

3.3 Algorithm

- Algorithm 1: CNN Algorithm

1) Input it (32x32x3) will hold the raw pixel values of the image.

2) The CONV layer computes the dot product between each weight and the small area they are connected to the input volume, which is connected to the local area of the input, which could be a volume such as (32x32x12) if you decide to use 12 filters.

3) The RELU layer will apply the activation element-wise function, such as the maximum threshold (0, x) at zero. The volume size remains unchanged (32x32x12).

4) A down sampling performed by the pool layers operation along the spatial dimension (width, height) and the volume is (16x16x12).

5) Fully connected (FC) layer, it computes the class scores, resulting in a volume of size (1x1x10).

4. RESULTS AND DISCUSSION

4.1 Experimental Setup

Software required for the system is:

- JDK 1.8
- Net beans Tool
- High Resolution Camera or webcam

The system is not requiring any type of hardware to run system. You can run the application on any standard machine.

4.2 Dataset

We have to use German Traffic Sign Detection Benchmark (GTSDB) dataset.

4.3 Result

Table 2 shows the 42 categories of traffic sign and their recognition accuracy. Figure 2 shows, the traffic sign recognition accuracy of 42 traffic sign categories. The Precision, Recall and Accuracy are calculated from following formulas.

$$\text{Precision} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Positive}} \text{ on True Positive/True Positive} + \text{False Positive} \quad (1)$$

$$\text{Recall} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Negative}} \quad (2)$$

$$\text{Accuracy} = \frac{TP+TN}{TP+FP+TN+FN} \text{ yTP+TN/TP+FP+TN+FN} \quad (3)$$

| Sr. No | Class Name | No. Of Images | Recognition Accuracy in % |
|--------|--------------------------------|---------------|---------------------------|
| 1 | 20 Miles/ Hour | 15 | 93% |
| 2 | 30 Miles/ Hour | 15 | 85% |
| 3 | 50 Miles/ Hour | 15 | 98% |
| 4 | 60 Miles/ Hour | 26 | 93% |
| 5 | 70 Miles/ Hour | 30 | 97% |
| 6 | 80 Miles/ Hour | 30 | 98% |
| 7 | 100 Miles/ Hour | 22 | 97% |
| 8 | 120 Miles/ Hour | 30 | 98% |
| 9 | All cars prohibited | 12 | 98% |
| 10 | Crossing high speed limit | 30 | 94% |
| 11 | Cross Roads | 30 | 96% |
| 12 | Distance to stop line | 27 | 93% |
| 13 | Double bend first to the left | 30 | 89% |
| 14 | End of 80 Speed limit | 28 | 89% |
| 15 | End of one way road | 30 | 88% |
| 16 | End of no passing zone | 30 | 90% |
| 17 | Heavy vehicles prohibited | 26 | 93% |
| 18 | Keep right | 30 | 93% |
| 19 | Keep left | 21 | 94% |
| 20 | Traffic circle | 30 | 98% |
| 21 | End of restriction | 17 | 93% |
| 22 | No overtaking | 14 | 100% |
| 23 | No overtaking by heavy vehicle | 17 | 98% |
| 24 | No By cycles | 16 | 97% |
| 25 | Prohibited for all vehicles | 15 | 98% |
| 26 | One way | 17 | 98% |
| 27 | Priority | 12 | 94% |

| | | | |
|-------|-----------------------|-----|-----|
| | road | | |
| 28 | Risk of ice | 16 | 87% |
| 29 | Road narrow on right | 14 | 93% |
| 30 | School | 14 | 89% |
| 31 | Stop | 14 | 94% |
| 32 | Straight or right | 25 | 90% |
| 33 | Straight or left | 23 | 90% |
| 34 | Turn left | 16 | 93% |
| 35 | Traffic signal ahead | 25 | 93% |
| 36 | Single curve to right | 29 | 85% |
| 37 | Turn left | 14 | 93% |
| 38 | Turn right | 15 | 90% |
| 39 | Un even road | 15 | 97% |
| 40 | Wild animal | 17 | 81% |
| 41 | Work in progress | 16 | 89% |
| 42 | Zebra crossing | 17 | 90% |
| Total | 42 | 885 | 93% |

TABLE II: Accuracy Comparison

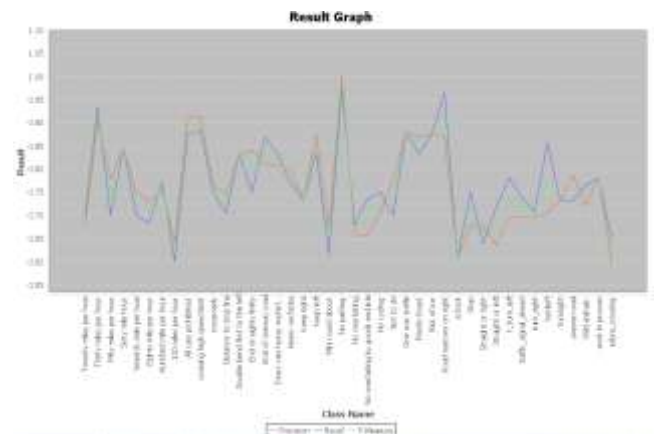


Fig.3. Precision-Recall-F-measure Graph

5. CONCLUSION

We propose a system to recognize all categories of traffic signs in low quality short videos captured by a car mounted camera. Here we have designed and implemented a detector fast R-convolution neural network (CNN) framework. Here, color and shape information has been used to refine the localization of small traffic signs, not easy to regress accurately. Finally, an efficient CNN with an asymmetric kernel is used as a traffic sign classifier. Then system notifies the user with

meaning of sign in the form of audio information for better driving performance. Finally we show that the proposed system decreases the accidental rate.

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