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TRAFFIC SIGN DETECTION AND RECOGNITION IN DRIVER SUPPORT SYSTEM FOR SAFETY PRECAUTION

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ABSTRACT

In this paper, an efficient algorithm for the detection and recognition of traffic signs is presented. The proposed system identifies candidate regions as interest region extraction, which offers strength to variations in lighting conditions and wave equation (WaDe) algorithm. A HOG based Support Vector Machine (SVM) is used to classify the traffic signs. The methodology is established on videos under changing weather conditions and poor illumination. The image preprocessing based on the red color channel enhancement improves the detection rate. The SVM classifier also achieve high classification rate.

Keywords: traffic sign recognition, histogram of oriented gradient (HOG) features, maximally stable extremal regions (MSERs), support vector machine (SVMs).

1. INTRODUCTION

Traffic sign recognition is an important part of a Driver Assistance System (DAS) as it provides security information to drivers. Traffic signs develop traffic safety by advising the driver of speed limits and threatening him against possible dangers such as slippery roads, pending road works or pedestrian crossings.

Traffic sign recognition systems undergoes challenging conditions are: i) the quality of the im2age is poor, due to a low resolution of the camera, varying weather conditions or weak illumination, ii) the revolution, corrosion and size of the traffic signs and iii) the requirement for processing and memory efficiency in real time applications such as DAS.

The recognition process consists of a detection and classification of traffic signs. In the detection step, the region of interest is extracted using interest region extraction based on maximally stable extremal regions (MSERs) and wave equation (WaDe). Before extracting the region of interest, Preprocessing is necessary to enhance the sign of interest from background. In classification, the extracted sign of interests are given to the classifier to classify either sign of interest or background. The candidate region is distinguished using a context aware filter by excluding the false alarms and classifying the traffic signs.

This paper is structured as follows: Section II gives a summary of previous works on traffic sign detection. The block diagram of the proposed system is presented in Section III. Experimental results and further analysis are demonstrated in Section IV. Finally, conclusions will be presented in Section V.

2. RELATED WORK

Traffic sign recognition algorithms are sectioning in to two parts: 1) the detection and 2) classification.

The detection is often established on the color based segmentation to retrieve the candidate regions. Since the RGB channel thresholding is sensitive to changes in illumination, the relation between the RGB colors is used. In [8], the color enhancement is used to segment the candidate blobs according to the color. Blobs are obtained from segmentation using SVMs. The recognition process is based on SVMs are used in [2]. In [12] the traffic signs are detected using linear SVMs based on HOG. The RGB color space are less suitable for detection. It is variant to color. In [11], the traffic signs are detect by using Haar wavelet features obtained from Adaboost training.

Other detection algorithms are established on edge detection, assemble the system more robust to changes in illumination. These are shape based techniques exploit the invariance and symmetry of the traffic signs. In [13], detection uses features to detect the road signs using candidate edge orientation histogram. In [18], the traffic signs are detected using symmetric nature of the shapes together with the pattern of edge orientation. In [1], the RSLD algorithm transforms triangle detection in to simple segment detection. The corner candidates are detected using coding gradient method. It provide low computation and cannot detect the traffic signs except triangular shape. In [3], an SVM is trained to classify the shape of a detected traffic signs. It is invariant to translation, rotation, scale and in many circumstances. In [4], detection and classification of traffic signs is carried out by fast radial symmetry detector and normalized cross correlation. It is an efficient method for traffic sign detection. It cause problem under changing lighting conditions. The radial symmetry detector is limited to triangular traffic signs.

Many approaches use gradient orientation information in the classification stage. B. Alefs et al. [13] classify the candidate traffic sign by extracting the edge of the traffic signs. The Histogram of Oriented gradients (HOG) [2] primarily used for pedestrian detection, has been modified to traffic sign detection in several works. In [2], [5], [12], the area of interest achieved from segmentation are classified using a HOG-based classifier. To exploit color features in HOG descriptor calculated on each of the color channels. The advantage of this feature are its scale invariance, invariant to partial occlusions with high accuracy.

3. SYSTEM OVERVIEW

The proposed approach consists of the following two steps: detection and classification. In the detection, preprocessing is necessary to enhance the regions of interest. The regions of interest are extracted by using Maximal Stable Extremal Region (MSERs) and wave equation (WaDe) algorithm based on symmetry and contrast regions. In the classification step, an SVM is accomplished with HOG features of all the types of traffic signs. The extracted regions of interest are classified from the background and eliminate the possibility of false positives. A filter is used to discard the occurrence of false positives. Our proposed method, as described in detail in the following section, is broadly shown in Figure-1.

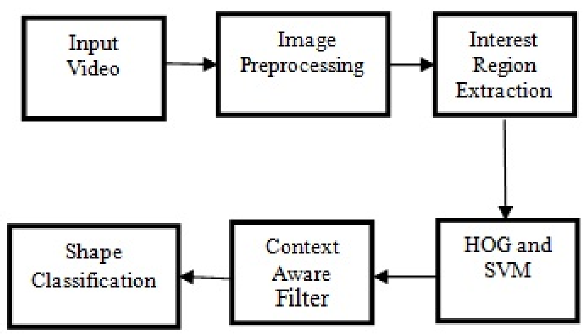

Figure-1. Block diagram of the proposed system.

a) Image preprocessing

For the detection of traffic signs, the image preprocessing is necessary before extracting the region of interest [6]. It is used to enhance the color in each sign of interest and fade background. It consists of three steps: contrast stretching, RGB normalizationand image enhancement.

Contrast stretching is a simple technique to expand the dissimilarity in an image by 'stretching' the range of intensity values. It is necessary to identify the upper and lower pixel value limits over which the image is to be normalized before stretching the image. The value limits are determined by examine the histogram of the original image. It allows to take the ends of the intensity range found in the image and stretch them out so that the lowest intensity value maps closer to 0 and the highest intensity value maps closer to 255.

After contrast stretching, to enhance the color of an image RGB normalization is performed. It is the process of changing the range of pixel intensity values. RGB normalization enhance the three channel of an image. It removes highlighted regions, shadows and make that object easier to detect. RGB normalization is applied to enhance an image by using (1), where C` represents the normalized channel.

$$C` = \frac{C}{R+G+B} \quad (1)$$

Image enhancement is used to improve the perceived image quality by enhancing specific features of an image after normalizing the image. The enhancement of an image can be done in two channels, red channel is enhanced using (2) and blue channel is enhanced according to the (3).

$$C` = \max\left(0, \frac{\min(R-B, R-G)}{R+G+B}\right) \quad (2)$$

$$C` = \max\left(0, \frac{B-R}{R+G+B}\right) \quad (3)$$

The color in each region of interest and background is enhanced by preprocessing. The enhanced image is given to the interest region extractor to detect the traffic signs.

b) Interest region extraction

It is used to extract the candidate region by using two algorithms: Maximal Stable Extremal Region (MSERs) and wave equation (WaDe) [6]. MSERS detect highly contrast regions by using thresholding at different level and extract the connected components that exhibit a stable region across a range of threshold. It is used to extract the MSER+ and MSER- region by finding the difference between dark connected components on a brighter background (MSER+) and brighter connected component on a darker background (MSER-). WaDe algorithm is used to detect highly symmetric regions at various scale and boundary value can be detected. As like MSER, minima highlight bright symmetries on a dark background (WaDe-) and maxima highlight dark symmetry on a bright background are detected to extract the sign of interest. The presences of number of false positives are feed to the next step.

c) HOG and SVM

Histogram of Oriented Gradients (HOG) is feature descriptors used for the purpose of object detection [6]. HOG is used to capture color and shape as one feature. The gradient at each pixel is the gradient with the greatest magnitude among the gradients computed on each of the channels. The bin is increased from 9 to 16 and the binning of the unsigned gradient orientation from 0-180. Then rescaling each region in to 64*64 pixels and describe it by 16x16 blocks of 8x8 cells with 8 pixels. Extracted output from HOG is given to SVM classifier to analyze and recognize patterns, used for classification and regression analysis. SVM classified as either sign of interest or background.

d) Context aware filter

The sign of region obtained from SVM may contain false positives [6]. In order to remove the false positives, a generative filter is used. The features exploit the typical position of traffic signs in urban environments.

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The features used to identify the traffic sign are: size and height of the traffic signs. Based on the size and height of the traffic sign we can discards the false positives and detect the traffic signs. The sign size r and height h can be estimated by normalization range [0, 1]. The probability distribution of the normalized height value h is obtained by (4).

$$p(y|r) \sim N(\mu(r), \sigma(r)) \quad (4)$$

The standard deviations of the estimated distributions follows parametric law depending on the independent variable r is expressed as follows:

$$\mu(r) = a_{\mu}.r + b_{\mu} \quad (5)$$

$$\sigma(r) = a_{\sigma}.r^2 + b_{\sigma}.r + c_{\sigma} \quad (6)$$

The traffic sign can be calculated as:

$$p(y|r) = \frac{1}{\sqrt{2\pi}\sigma(r)} \exp\left(-\frac{(y-\mu(r))^2}{2\sigma^2(r)}\right) \quad (7)$$

The wrongly detected false positives are discard by using thresholding. There is no need for negative samples in learning stage of a generative approach.

e) Shape classification

The region of interest that are obtained from the previous step detection is classified in this stage depend on their shape using Hough transform and verified using peri2area ratio which is the ratio between square of the perimeter to the area.

f) Line detection

The Hough transform is the one global method for detecting edges, lines and curves. Hough line transform is the simplest method. However, this method is not so stable. As vertical lines get more and more, the magnitudes grow towards infinity. The normal form of a line is given by

$$P = x \cos(\theta) + y \sin(\theta) \quad (8)$$

The above equation (8) states that a line passing through (x, y) is perpendicular to the line drawn from the origin to (p, θ) in polar space. It is more efficient method, as it is stable formatching lines of any angle. The objects besides lines can also be represented by using Hough transform. A circle can be parameterized in general as

$$r^2 = (x-a)^2 + (y-b)^2 \quad (9)$$

Here, (a, b) is the coordinate of the circle that passes through (x, y), and r is its radius.

After finding the Hough transform, peaks are identified in the parameter space. These peaks characterise potential lines in the input image of road signs. After identifying the peaks in the Hough Transform, the number of line segments (*k*) of the shape is produced corresponding to the peaks to determine the shape of the image. Three lines represent triangular shape, four lines represent either diamond, rectangular or square shapes, eight lines represent hexagonal shape, and more than eight lines represent circular shape.

g) Peri2area

The classified shape is verified using peri2area ratio. The total number of pixels in a blob is defined as the area of that blob and the sum of the distances between adjacent pixels is accounted as the perimeter. To determine the shape based on the value of the parameter Peri2Area, if the value is between 9 and 11.75, then the shape is considered an octagon; for values from 11.8 to 14, it is a circle; from 14.1 to 15.77, it is a pentagon; from 15.78 to 19.14, it is a rectangle; and from 19.15 to 23, it is a triangle. Any value less than 9 or greater than 23 is considered as a non-road sign shape. Peri2Area can also be calculated using the formulas listed below:

Table-1. Formulas used in per12 area calculation.

Shape	Formula
Circular	$\frac{(2 \Pi b)^2}{\Pi b^2}$
Triangular	$\frac{(3b)^2}{\frac{1}{2} bh}$
Rectangular	$\frac{(2(b+h))^2}{bh}$
Octagonal	$\frac{(8b)^2}{\left(2b+\frac{2b}{\sqrt{2}}\right)\frac{b}{\sqrt{2}}+b\left(2b+\frac{2b}{\sqrt{2}}\right)}$

4. EXPERIMENTAL RESULTS

The proposed system can operate under a variety of lighting and weather conditions. The input chosen for the process is a real time video obtained from the website. The implementation process is done using MATLAB 13.0. The video format is avi.

The input is a real time video which consists of number of frames. First the video is converted into frames using MATLAB. Figure-2 shows the input frame obtained after converting the video into frames.

In the preprocessing step, initially contrast stretching is applied. Contrast Stretching is applied to improve the contrast in an image by stretching the range of intensity values. Figure-3 shows the contrast stretched image for the input frame shown in Figure-2. The enhancement of an image can be done in two channel red and blue. Figure-4 shows the red channel enhancement and blue channel enhancement is shown in Figure-5.

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Figure-2. Input frame.

Figure-3. Contrast stretched image.

Figure-4. Red channel enhancement.

Figure-5. Blue channel enhancement.

Finally the sign of interest region can be detected by the highly contrast and symmetry regions. Figure-6 shows the extracted image which removes background present in an image. SVM is used to classify either sign of interest or background based on HOG features. It provide 100% classification rate. Figure-7 shows the final detected output.

Figure-6. Interest region extraction.

Figure-7. Detected traffic sign.

5. CONCLUSIONS

We have proposed a real-time system for traffic sign recognition. Candidate regions are detected as MSERs. This detection method is significantly insensitive to variations in illumination and lighting conditions. The traffic signs are classified from the background using SVM based on HOG features. The experimental results shows 100% classification rate of objects. The experimental results suggest that the images obtained with the proposed algorithm have higher detection rate than that produced with other well-known methods.

As future work, this information is combined with recognition to provide the exact traffic symbol for driver support system. Furthermore this method can be improved for real time applications.

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ARPN Journal of Engineering and Applied Sciences

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