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Road Sign Detection Using Cascade Classifier

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Abstract— In modern era, road conditions have undergone drastic improvements. So, on driver's point of view there might be chances of neglecting mandatory road signs while driving. The proposed system in this paper, helps the driver in detecting road signs and avoid road accidents which helps driving comfort and increased safety. In the detection module segments, the input image is in YCbCr color space, and then it detects road signs by using the cascade classifier. The road sign recognition system is to be divided into two parts, the first stage includes the detection part which detects the signs from a whole image, and the second part is classification stage that classifies the detected sign into one of the reference signs which are present in the database. The extensive experimentation has shown that the proposed system approach is robust enough to detect and recognize road signs under varying lighting, rotation and translation conditions.

Index Terms— Cascade object detector, HOG (Histogram of Oriented Gradient), Road signs, YCbCr color space, GUI (Graphical User Interface), Positive-Negative Image Database, MATLAB.

1 Introduction

Road sign detection is used to avoid the accidents which occur due to the excessive attention that the driver has to pay to locate road signs. Sometimes even when the road signs are detected the driver may not be able to retrieve the exact meaning of the road sign which will create problems in the proper execution of the rules reflected through the respective road sign. Also, the road signs adopted by different countries are different. Therefore, the road sign detection system will be a helpful guide for people from any place in this world to drive vehicles anywhere without knowing the actual meaning of the signs which are put up.

Various researchers have approached this problem with different algorithms. Algorithms like template matching give accurate response but fail to provide faster response. On the other hand, detectors like SURF (Speeded Up Robust Feature) and SIFT (Scale Invariant Feature Transform) will provide accurate and fast response but are copyright creations which will not allow the system to use the algorithm for any real-time product applications without the author permission [1]. Another proposed system detects candidate regions as maximally stable extremal regions (MSERs), which offers robustness to variations in lighting conditions. Recognition is based on a cascade of support vector machine (SVM) classifiers that were trained using histogram of oriented gradient (HOG) features [2]. Another novel approach presents a study to recognize traffic sign patterns using open CV technique. The images are extracted, detected and recognized by pre-processing with several image processing techniques, such as, threshold techniques, Gaussian filter, canny edge detection, Contour and Fit Ellipse [3]. Another approach of detection, uses color thresholding to segment the image and shape analysis to detect the signs and the classification uses a neural network. [4]. While in the detection module segments, the input image is a YCBCR colour space, and then it detects road signs by using the shape filtering method [5].

In the proposed system, we have used segmentation to extract red color from the frame. The cascade classifier is used for training and detection (using HOG feature). Each red color area is checked to retrieve the largest area which will denote a road sign. Cascade object detector is used to recognize the signs from a previous database created by training. The detailed methodology is explained in the forthcoming paragraphs. Any object detection system includes two main steps. One is the detection and other is the recognition. The detection detects the road signs from each frame based on the color. As we see road signs usually involve red colors. After the detection based on the colors the road signs are classified using the large database obtained by training the video. Therefor training is also an important part of any object detection system. However, traffic sign detection requires a very strong implementation of algorithm because the road signs are lighted by different intensity levels at different times of the day. Also, the road signs are placed at different orientations and are at different heights, and may also be covered by trees, dust or may fade away with time. A powerful algorithm will be needed to extract the road signs accurately in such adverse conditions also. More the trained data in the database more accurate will be the results of recognition. Therefore, this system requires lot of training for best results.

2. Proposed System:

1. Video input and processing video frame by frame:

The GUI (Graphic User Interface) designed provides the provisions to give input through the interfaced camera or through the video saved. The input video is converted into frames for this purpose. For processing on video, it needs to be converted into frames.

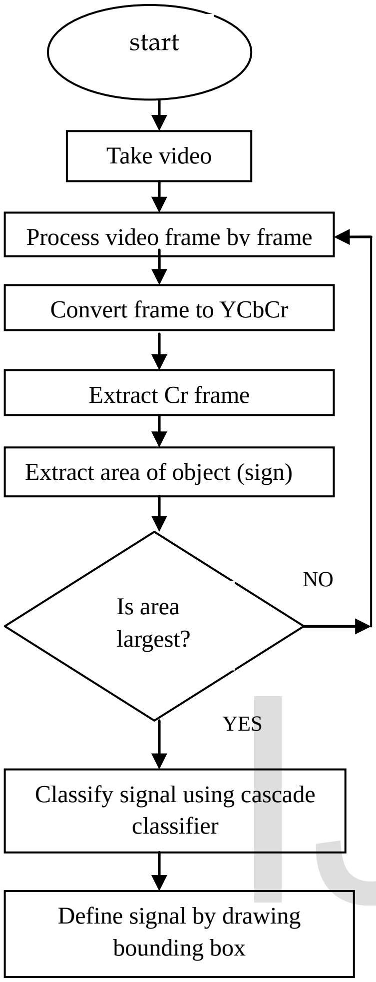

Figure.1. Flow chart of the system

2. Convert frame to YCbCr:

Each frame is in RGB colour format. These frames are converted into YCbCr format. Where Y stands for 'luminance', Cb stands for 'chrominance blue' and Cr stands for 'chrominance red'. The reason for this conversion is because of the more number of rods (receptors for brightness) as compared to cones (receptors to color) in the human eye. Luminance is the grayscale view of image

3. Extract Cr frame:

After the conversion of the frame to YCbCr format, the Cr areas are extracted. The reason for extracting Cr is because most of the road signs have red colour elements present in them. Therefore, when a particular frame is being processed all the Cr (chrominance red) components are extracted for detecting the road sign. Therefore, the system follows color based segmentation.

4. Check for biggest area:

Assumptions are made that the largest area among all the red signs are for the road signs. Assuming this, the largest red area among all the detected red colour objects is computed.

5. Classify signal using cascade classifier:

Working with cascade classifiers uses both detection and training.

Preparing training data:

For training, we need a set of samples. The samples have to be negative and positive samples. Negative samples of a particular road sign include all other frames except for the frames of the required sign. This may include trees, vehicles, and road sign. The negative samples of stop sign will include all other frames apart from the required stop sign. Other road signs apart from the stop sign will also be included in this negative sample data. Positive samples of a particular road sign include the particular road sign in different orientation, different lighting condition that is in all forms. More the training data available, more accurate will be the output.

Detector:

A cascading classifier has multiple stages. Each stage is given a chance to classify the frame as positive or negative. More the stages, more accurate will be the output. More the stages, faster will be the rejection of the negative samples. Each classifier will check each frame for the positive samples, if the sample is not found the sliding window moves to the next frame. The next frame is checked again by that particular classifier. This goes on till the entire frames of the video are covered. After the results of each classifier is cascaded and compared for giving the best detection. Different errors may take place while classifying by using the classifiers:

A true positive takes place when a positive sample is correctly classified.

A false positive takes place when a negative sample is mistakenly classified as positive.

A false negative takes place when a positive sample is mistakenly classified as negative.

For accurate results, each stage in the cascade must have a low false negative. If a stage labels a true positive object as negative, the classification has to stop, and the mistake cannot be corrected. On the other hand, each stage can have its false positive rate high. Even if the detector labels a non-object as positive, the mistake can be corrected in the next stages.

Thus, adding more stages decreases overall false positive but it also decreases overall true positive. The region of interest can be shown by bounding boxes. For detector accuracy, the number of stages, false alarm rate, the feature type and other parameters is set.

Choosing number of stages:

One needs to choose between fewer stages with a lower false positive rate per stage or more stages with a higher false positive rate per stage. Stages with a low false positive rate are more complex because they contain a large number of weak classifiers. Stages with a higher false positive rate contain fewer weak classifiers. It is better to go for high number of stages with low alarm rate as the cascade effect will reduce overall error.

Y = (77/256)R + (150/256)G + (29/256)B
Cb = -(44/256)R - (87/256)G + (131/256)B + 128
Cr = (131/256)R - (110/256)G - (21/256)B + 128

Feature choosing:

Cascade classifiers allows three types of feature to be used which are Harr, local binary patterns (LBP), and histograms of oriented gradients (HOG). Haar and LBP features are used to detect faces because they work for fine-scale. The HOG features are used to detect objects like people and vehicles. They capture overall shape of any object. We have used HOG feature as feature type for our cascade object detector.

HOG (Histogram of oriented gradients):

HOG is used as a feature described image region for object detection. For increased efficiency of the object searching, normalization of color and gamma takes place.

The first step divide the source image in blocks (for example 16×16 pixels). Each block is divided by smaller regions i.e. cells (for example 8×8 pixels). Due to overlapping of blocks the same cell may be indifferent block. The vertical and horizontal gradients are obtained for each pixel within the cell

$G_x(y,x)$ and $G_y(y,x)$ is the horizontal and vertical gradient. The phase and magnitude is given by

$$G(x,y) = \sqrt{G_x(y,x)^2 + G_y(y,x)^2}, \theta(y,x) = \arctan\left(\frac{G_y(y,x)}{G_x(y,x)}\right)$$

After this, HOG is created for each cell. Contrast normalization is used due to different images having different contrasts [5], [6].

Each detector window is provided a descriptor (which has histograms for each cell in detector window). This information is used for object recognition. This descriptor is used for training and testing. There are many methods to classify objects using these descriptors

Define signal by drawing bounding box:

A rectangular box is drawn around the detected object. A text notification is provided for the detected sign and an audio notification is also provided along with the text notification on GUI.

3. Experimental Results:

The database for training of road signs has been made and the frames that are formed after the sampling of the video are compared with the signs in the database.

The database includes folder for positive and negative images of each road sign. For e.g. the folder Yield Negative includes all the images except for the ones which have yield signs. A .XML file is generated after training.

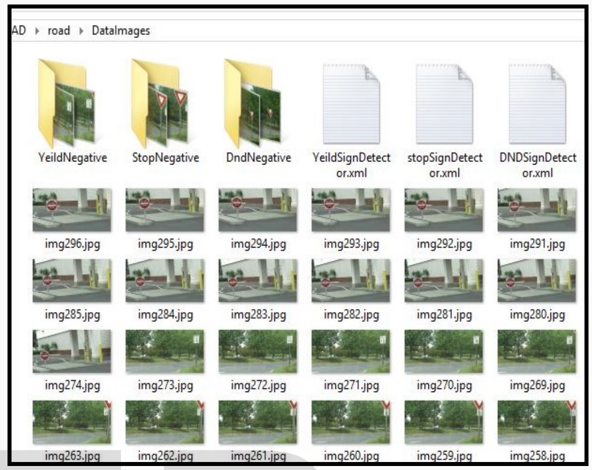

Figure.3. Database

The algorithm has two main parts, the detection and the classification. In the first part, the color and the corners of the shape of the sign were chosen as features to extract the sign from the environment. The image in RGB format is converted to YCbCr and Cr is extracted from each image. The white represents the red elements in the image. All the other part is shown in black. Therefore, image is converted to binary form.

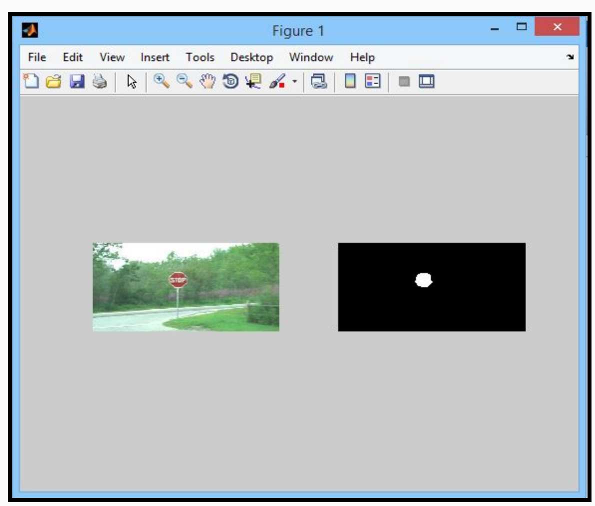

Figure 4. Extracted Cr Frame

For the classification, the detected sign was used as the input pattern for the recognition stage. Later the detected signs are classified using the cascade classifier. The GUI has been made so that the input can be given as live video through camera or the saved video. As soon as the sign is detected, it is extracted and a bounding box is created around the sign. This sign is recognized by cascade classifier as it compares the sign with the signs already stored in the database. Here, more the classifier stages the more accurate is the result. Then the recognized sign is displayed in terms of the text on the GUI itself. The database for the audio that conveys the recognized sign is also made. Hence the recognized sign is conveyed to the driver in visual as well as audio format.

Figure.5. Graphic User Interface

Figure.6. Test Result of Road sign recognition

4. Conclusion:

In this paper, the reliable approach of the recognition and detection of the road sign has been discussed. Image detection has been implemented on real life road sign image. Robust method of color segmentation is employed in the YCbCr color space. The experimental results show that the image detection method is accurate. In the image segmentation, also we have achieved to remove unnecessary background image and then the segmented image is then fed to the classification stage where the input image compared with the road sign database. The tool used for developing this proposed work is image processing toolbox of MATLAB for reading the images and for performing the preprocessing operations on these images. Cascade classifier approach is understood with its applications and advantages. The HOG feature extraction is studied in brief. The implementation of a GUI using a MATLAB toolbox is studied. Hence this paper introduces one of the approaches that can be used for detecting road signs. The speed and accuracy given by this system is comparatively better than other algorithms. Output is obtained in both text and audio.

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