TECHNIQUES FOR TRAFFIC SIGN CLASSIFICATION USING MACHINE LEARNING-A SURVEY

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ABSTRACT

The Road Sign Recognition is a field of applied computer vision research concerned with the automatic detection and classification of traffic signs in traffic scene images. The aim of this research paper is to study the various classification techniques that can be used to construct a system that recognizes road signs in images. The primary objective is to develop an algorithm which will identify various types of road signs from static digital images in a reasonable time frame. In this research paper, we will study the various learning systems that are based on prior knowledge for classification. A road sign recognition system faces a classical problem of pattern recognition, classifying between different road signs. On top of that, the location of the road sign in the picture is unknown. Once these obstacles are overcome, such system could be integrated in a Smart Driver system. A variety of MATLAB Image processing toolbox commands can be used to determine if a road sign is present in the image. Neural network or other classification techniques can be applied in order to classify the road signs.

Key words: Computer Vision System, Traffic Sign Detection, Traffic Sign Classification, Neural Network, Image Classification Technique, Support Vector Machine (SVM), Kernel-Based Neural Network (K-NN).


1. INTRODUCTION

In traffic environments, Traffic Sign Recognition (TSR) is used to regulate the traffic signs, warn drivers and command or prohibit certain actions. Fast Real Time and robust traffic sign detection and recognition can support and disburden the driver and thus significantly increase driving safety and comfort. An automated road sign recognition system may play an important role in alerting the drivers of road
conditions making driving safer. Generally, the traffic signs provide the driver with a variety of information for safe and efficient navigation. Automatic recognition of traffic signs is therefore important for automated intelligent driving vehicle or for driver assistance system [1]. However, identification of traffic signs with respect to various natural background viewing conditions still remains a challenging task. An automatic road sign recognition system should be able to first detect and then identify a set of road signs within images. Such a system should be able to analyze the road scene image captured by the camera, extract the road sign region and make intelligent decisions. In addition, it must appropriately alert the driver of the road sign ahead. Automated road sign recognition is a very difficult task. There are a number of important issues that need to be taken into consideration. These include illumination conditions, direction of sign’s face, status of paint on signs, placement of multiple signs near each other, torn and tilted signs, variation in sign’s scale, obstacles such as tree, image sensor’s properties, car vibrations etc. The systems usually have been developed into two specific phases:

1. First Phase: It is normally related to the detection of traffic signs in an image by using image processing.
2. Second Phase: It is related to the recognition of those detected signs, which deals with the interest of performance in an artificial neural network.

The efficiency and speed of the detection play an important role in the system. To recognize traffic signs, various methods for automatic traffic sign detection have been developed and shown promising results. The Neural networks precisely represent a technology which is used in traffic sign recognition.

1.1. Detection Phase
In the detection phase, the acquisition image is preprocessed, enhanced and segmented according to the sign properties of color and shape. The traffic sign images are investigated to detect potential pixel regions which could be recognized as possible road signs from the complex background. The potential objects are then normalized to a specific size, and input to the recognition phase. The detection algorithms are normally based on shape or color segmentation. Therefore, we can say that road sign detection and identification methods can be classified into two main groups: Color-Based Detection and Shape-Based Detection.

1.1.1. Color-Based Detection
Most existing road sign recognition systems include color segmentation process that extracts the color road sign objects from the background for recognition. The colors used in road signs are often simple primary colors. Several techniques on color-based recognition such as HIS/HSV transformation, Region Growing, Color based Thresholding Segmentation, Dynamic Pixel Aggregation etc. have been developed.

1.1.1.1. Color Neural Networks
Neural Networks can be trained to group and recognize patterns of colors. The Neural Network technique is discussed in detail in Section 3.

1.1.1.2. HIS/HSV Transformation
The image which is captured by camera is represented by its RGB (Red, Green, Blue) value, and HIS value can be obtained after transformation. In HIS color space, the chromatic information is represented by the Hue coordinate and the Intensity...
coordinate captures varying light conditions. Also, the HIS color space is very much similar to the human perception of colors. This algorithm makes segmentation in adversely illuminated road sign boards possible because the Hue value is invariant for the illumination.

1.1.3. Color Thresholding Segmentation

This is one of the earliest techniques which is used for the purpose of image segmentation [3]. The main purpose of thresholding is to classify pixels of an image into “object pixels” or “background pixels”.

The main disadvantage of color based segmentation is the outdoor illumination which affects the color acquired by the imaging sensor. Most color-based techniques run into problems when the illumination source varies with both intensity and color. This is the main reason why many researchers have tried to come up with algorithms for separating the incident illumination from the color signal which is perceived by the imaging sensors.

1.1.2. Shape-Based Detection

Detection by shape forms the second main group of road sign recognition techniques. As compared to the Color-Based approaches, the Shape-Based techniques would have to deal with imperfect shape problems and the sign appearance. Shape is an important attribute and its detection does not require Color information. However, the selection of an object recognition scheme for the detection of road signs based on their shape will have to address more issues than color because:

1. The sign may appear in cluttered scenes.

Figure 1 Working of the Proposed System
2. Imperfect Shape.
4. Variation in Size.

Shape detection [3] requires robust boundary detection or matching algorithm to detect the relevant shapes. Moreover even if the shape is identified, it can be confused with several other shapes of manmade objects such as commercial signs and building windows. Several techniques on shape-based recognition have been developed. These include the Distance Transform matching, Hierarchical spatial feature matching etc. Shape recognition techniques are more robust to changing illumination because they detect shapes by using boundary detection. Shape detection necessitates robust edge detection and/or matching algorithm to detect the relevant shapes. The common recognition approaches which are based on shape are as follows:

[1] **Shape Neural Network**
Neural networks can be used to match the shape of an input object by using the threshold value. It is usually used in conjunction with Color Neural Networks. There are a lot of good results which are achieved by using this method. One of the important property of this algorithm is that it is more robust.

[2] **Template Matching**
All the signs which are to be recognized are stored in a database. The potential sign is normalized in size and compared to every template of the same shape by using normalized cross-correlations. With the help of this encoding, a template is built for an object, and a correlation computation can be defined, which serves as a measure for computing matches between the templates. The method is fast and can easily be modified to include new classes of signs.

[3] **Similarity Detection**
The sign’s shape detection is done by computing a similarity factor between a segmented region and a set of binary image samples representing each road sign’s shape. The method assumes that both the sampled and segmented image have the same dimensions.

It can be used to search the scene image for the geometrical shapes, which may correspond to the road signs. In HSF, local orientations of the image edges and hierarchical templates are used for shape detection. The input to the algorithm is the traffic scene image and the output is a list of candidate regions. It uses the Sobel’s operator in order to extract the edge information.

### 1.1.3. Recognition Methods
The first research paper on road sign recognition appeared in Japan in the year 1984. A growing number of solutions have been proposed for road sign detection since then. In general, those solutions include detection phase and classification phase.

1. The Detection Subsystem is used to search for the corresponding road signs.
2. The process of Classification is done in order to evaluate the regions which are found by the Detection Subsystem.
The road signs are designed in such a manner that they offer their basic meaning by the combination of color and shape. There are broadly two major methods which are applied for the process of road sign recognition as discussed above i.e. Color-based and Shape-based.

2. IMAGE PROCESSING STAGES

Any image classification system goes through numerous phases including data acquisition, preprocessing, feature extraction, classification and post-processing where the most crucial aspect is the preprocessing which is necessary to modify the data either to correct deficiencies in the data acquisition process due to limitations of the capturing device sensor, or to prepare the data for subsequent activities later in the description or classification phase. The data preprocessing [2] describes any type of processing performed on raw data to prepare it for another processing procedure. Hence, the preprocessing is the preliminary step which transforms the data into a format that will be more easily and effectively processed. Therefore, the main task in preprocessing the captured data is to decrease the variation that causes a reduction in the recognition rate and increases the complexities. Therefore, preprocessing is an essential stage prior to feature extraction since it controls the suitability of the results for the successive stages. After the acquisition of image we perform image extraction and Sign Detection. The images that will be taken by a video camera will pass through the image extraction block. The sign detection and extraction stage extracts all the traffic signs contained in each image and generates the small image called as Region of Interest (ROI). Each ROI will be a valuable parameter input to the recognition stage which is the final part. Image Classification cannot be applied without the help of image processing and/or artificial intelligence.

2.1. Image Preprocessing

2.1.1. Smoothing and Filtering

Images are often degraded by noises. The noise can occur during image capture, transmission etc. The noise removal [12] is an important task in image processing. Filters are required for removing noises before processing. They are of many kinds as linear smoothing filter, median filter, wiener filter and fuzzy filter. Any mathematical operation directly on the image matrix is spatial filtering. Any of the two types may be used: Linear Spatial Filters and Nonlinear Spatial Filters. Spatial Filtering is the process of dividing an image into its constituent spatial frequencies to emphasize some image features. This technique increases the analyst’s ability to discriminate the details. Generally the types of spatial filters that may be used in image preprocessing are as follows: High Pass Filters and Low Pass Filters.

2.1.2. Linear Smoothing Filters

One method to remove noise is by convolving the original image with a mask that represents a low pass filter or smoothing operation. A smoothing filter sets each pixel to the average value, or a weighted average, of itself and its nearby neighbors, the Gaussian filter is just one possible set of weights. Smoothing filters tend to blur an image, because pixel intensity values that are significantly higher or lower than the surrounding neighborhood would smear across the area. Because of this blurring, linear filters are seldom used in practice for noise reduction, they are, however often used as the basis for nonlinear noise reduction filters. Linear smoothing filters and
Adaptive filters are examples of linear filters. Median filters and fuzzy filters are the examples of Non-linear filters.

2.1.3. Adaptive Filters
The wiener function applies a wiener filter (a type of adaptive filter) to an image adaptively, tailoring itself to the local image variance. If the wiener is large, wiener performs little smoothing. If it is small, wiener performs more smoothing. This approach often produces better results than linear filtering.

2.1.4. Median Filters
A median filter is an example of a nonlinear filter and if properly designed is very good at preserving image detail. To run a median filter

1. Consider each pixel in the image.
2. Sort the neighboring pixels into order based upon their intensities.
3. Replace the original value of the pixel with the median value from the list.

Median filters are good at removing the salt and pepper noise from an image and also cause relatively little blurring of the edges, and hence are often used in computer vision applications.

2.1.5. Fuzzy Filters
Fuzzy filters provide promising result in image processing tasks that cope with some drawbacks of classical filters. Sometimes, it is required to recover a heavily noise corrupted image where a lot of uncertainties are present and in this case fuzzy set theory is very useful. Each pixel in the image is represented by a membership function and different types of fuzzy rules that consider the neighborhood information or other information to eliminate filter which removes the noise with blurry edges but fuzzy filters perform both the edge preservation and smoothing.

2.2. Feature Extraction
The recognition phase starts with feature extraction [7] representation of images. These features are usually corners and edges. Ideally all edges of objects and changes in color should be represented by a single line. The generalized form of edge detection is gradient approximation changes in intensity will be highlighted, and the areas of constant intensity will be ignored. In order to find the changes in intensity we need to examine the difference between the adjacent points. The standard edge and corner detection algorithms such as Sobel filtering and Canny’s edge detection can be applied to color/gray images in order to generate a binary feature map.

2.2.1. Sobel Filtering
Most edge detection methods work by assuming that the edge occurs where there is a discontinuity in the intensity function or a very steep intensity gradient in the image. By using this assumption, if one takes the derivative of the intensity value across the image and find points where the derivative is maximum, then an edge could be located. The gradient is a vector, whose components measure how rapid the pixel value is changing with the distance in the x and y direction. Out of the many methods of detecting edges, different methods may be grouped into these two categories:

1. Gradient: The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image.
Techniques For Traffic Sign Classification Using Machine Learning-A Survey

2. Laplacian: The Laplacian method searches for the zero crossings in the second derivative of the image to find the edges. The Sobel operator is an example of the gradient method. The Sobel operator performs a 2D Spatial Gradient measurement on an image and so emphasizes the regions of high spatial gradient that corresponds to edges. Typically, it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image.

2.2.2. Canny Edge Detection
The Canny Edge Detector (Canny, in 1986) is currently the most popular technique for image processing. It is used in a wide range of applications with successful results. It should satisfy the following three objectives:

1. Optimal detection with no spurious responses.
2. Good localization with minimal distance between the detected and true edge position.
3. Single response to eliminate multiple responses to a single edge.

Optimal smoothing and Gaussian filtering was used for achieving the first aim. The second aim is for accuracy. The technique of Non-maximum suppression (peak detection) is especially used for this purpose. It retains all the maximum pixels in a ridge of data resulting in a thin line of edge points. The third aim relates to locating single edge points in response to a change in brightness. This requires getting the first derivative normal to the edge, which should be maximum at the peak of the edge data where the gradient of the original image is sharpest. Calculating this normal is usually considered too difficult and the actual implementation of the edge detection is as shown in the figure below:

3. APPLICATIONS AND FUTURE SCOPE
The road sign provides significant information that can help driving in a manner that is safe for the driver and other road users. The information provided by the road signs is characterized into colors and shapes for easy identification. Most of the road accidents are attributed to either reduced attention of drivers or that they simply choose to ignore the road signs. The weather conditions like rain and sometimes heavy fog and dew, especially during the early morning and late evening, also have been reported as some of the causes of many accident cases. Therefore, the recognition of road signs would be of great help in order to reduce the number of traffic accidents and deaths. The development of road sign detection and recognition systems using image processing technology will ensure that each driver is aware of the rules and hazards on the road and will hopefully reduce the number of accidents and deaths. The Road Sign Recognition project (RSR) is a field of applied computer vision research concerned with the automatic detection and classification of the traffic signs in a traffic sign images which are acquired with the help of a moving car. The application of the system will be help in improving the road safety. The RSR can be a subsystem of Driver Support System (DSS). The main aim is to provide DSS with the ability to understand its neighborhood environment and so permit the advanced driver support such as collision prediction and avoidance. This application can also prove to be important to a robotic vehicle that automatically drives on the road. The most important future work for this present topic would be to work on a collection of large number of road sign images, expanding the database, retrain the neuron network. This would also involve studying more robust techniques for detection of images which
will recognize traffic signs during poor lighting conditions also. The system can be enhanced by using cost-effective techniques, which would assist the driver in notifying the distance between the road sign and the current position of the car. Even the system could be expanded to detect and differentiate between inanimate and living objects for example people crossing the roads.

4. CONCLUSION
Traffic Sign Recognition is a primary goal of almost all the road environment understanding systems. A vision system for traffic sign recognition was developed by DAIMLER-BENZ research centre UTM. The two main modules of the system are detection and verification (recognition). Here the regions of possible traffic signs in color image sequence are first detected before each of them is verified and recognized. In this research paper, we have paid our attention to the various verification and recognition methods/techniques. During the detection process, each color image which is taken with the help of a camera is first segmented into some regions according to the color values of each pixel. After the process of color classification, each region in the labeled image is checked whether it satisfies certain constraints are satisfied the region can be marked as a Region of Interest (ROI) for the following recognition process. Now, the task of the recognition process is to verify whether a given ROI is really a traffic sign and to identify the pictographic symbol of the ROI if it was verified.

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Techniques For Traffic Sign Classification Using Machine Learning-A Survey


