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Road Sign Detection and Recognition in Adverse Case using Pattern Matching

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ABSTRACT
Application of new technology in building human comforts and automation is growing fast, particularly in automobile industry. Automatic detection and recognition of traffic signs for assisting driver to ensure a safe travel have been givenpractical importance for intelligent traffic system.The proposed method detects the location of the traffic sign in thecaptured image, based on its geometrical characteristics and using color information. Such signs are then recognized using a pattern matching with the normalized cross correlation method and tracked through a sequence of images. The algorithm is tested using image set of different traffic signs and non traffic signs taken under various adverse conditions such as, various backgrounds, lighting conditions, orientation and distances. Experimental result shows the better performance in the detection and recognition of road signs with recognition rate of 90%.Computational time is also quite low which makes it applicable for the real time system.

General Terms
Object Recognition, Image Processing

Keywords
Color segmentation, Shape analysis, Road sign detection

1. INTRODUCTION
Traffic signs are visual languages that represent some special circumstantial information of environment. They provide important information for guiding, warning people to make their movements safer, easier and more convenient. Road signs being among the most important around us, primarily for safety reasons are designed, manufactured and installed according to tight regulations. Road signs have two measurable features, a pictogram of fixed shape and colorwith some information. Traffic sign recognitionis one of the important fields in the Intelligent Transport Systems (ITS). The ITS are critical in intelligent vehicles because,if the driver is drowsy or lethargic, sometimes a slight miss concentration from him may cause of deadly accidents. ThereforeITS plays an important role to prevent road accidents.

Road sign detection and recognition is divided into three stages: detection, classification, and recognition. Detection stage is responsible for identifying region of interest (ROI) from the picture frame. ROI is the most likely part of the image that may contain traffic signs.The second stage of automatic detection and recognition of road sign is the classification stage. In this stage each ROI is classified according to their shape and color. In the third stage individual road sign is recognized from its class.

Traffic Sign Recognition in real-time environment is challenging as visibility is affected by weather conditions such as fog, rain, clouds and snow. The color information is very sensitive to the variations of the light conditions and also the presence of objects similar in colors to the road signs in the scene under consideration, such as buildings, or vehicles pose the challenge. Signs may be found disoriented, damaged or occluded.

In this paper, the location of the traffic signs in the image taken under various backgrounds, lighting conditions, orientations and distances are detected, based on its geometrical characteristics and color information. The HSV(Hue, Saturation, Value), color segmentation algorithm is used to segment the road sign from the image. RGB(Red, Blue, Green) image is converted into the HSV because it decouples the color and intensity information. Red and Blue components are identified by analyzing the H and S components. Then the canny algorithm is used to detect the shape. The output is a segmented image containing potential regions which could be recognized as possible road signs. Individual road sign from its class is recognized using pattern matching method.

This paper is organized as follows: in section 2 the related work about the detection and recognition of traffic sign is presented. Section 3 describes the proposed method. Experimental results are shown in section 4 and finally section 5 presents the conclusion and future studies.

2. RELATED WORK
The color segmentation algorithm to segment the road sign from the image is proposed by Hossain*et al*[1].The RGB color segmentation algorithm is used to segment the road sign from the image. The segmented road sign is then classified according to their color and shape. Hu moment invariants are used as the feature setand neural network classifier is used to classify road signs to their respective classes. Finally, individual road sign from its class is recognized using another neural network classifier.

Pattern matching of the unknown sign’s shape with standard shapes of the traffic signs isproposed by Fleyehand Khan[2] in detecting traffic signs in life images and videos.The pattern matching algorithm works with shape vertices rather than the whole image.

Gabor wavelet for road sign detection and recognition using a hybrid classifier to detect and classify of red road signs is proposed by Fatmehsanet al, [3].The input image is transferred from RGB color space to the YCbCr color space and the red pixels are extracted. Road sign image then convolved with a bank of Gabor wavelets and extract the feature vectors for classification. These feature vectors are classified by a hybrid classifier.

Detection and recognition of mandatory and cautionary road signs using unique identifiable features is proposed by Hemadri and Kulkarni[4]. The image is categorized depending on the color and the form and extracting unique identifiable features of the image. The sign is recognized by comparing these patterns with standard set of road signs.

A method for prohibition traffic signs detection is proposed by Qingsong*et al* [5]. The color information in HSI color space and the symmetry property of circles are used to detect signs, and the histograms of oriented gradients feature and the nearest distance method are used to recognize them.

Eigen-based traffic sign recognition is introduced by Fleyehand Davami[6]. This technique is based on invoking the principal component analysis algorithm to choose the most effective components of traffic sign images to classify an unknown traffic sign. A set of weights are computed from the most effective eigen vectors of the traffic sign. By using the Euclidean distance, unknown traffic sign images are then classified.

Combining detection and classification of circular traffic signs is proposed by Huang*et al*,[7]. The position and scale of sign candidates within the scene are captured by detecting the center of circle using improved fast radial symmetry detector. In the classification stage, pictogram distribution histogram is used to represent the pictogram.

A computer vision based system for real-time robust traffic sign detection and recognition is proposed by Chen et al [8]. Sign candidates within ROIs are detected by a set of Haar wavelet features obtained from AdaBoost training. Then the Speeded Up Robust Features is applied for the sign recognition. The recognition is performed by finding out the template image that gives the maximum number of matches [8].

A two-stage symbolic road sign detection and classification system is developed by Ruta,*et al* [9]. A well-constrained circle/regular polygon detector is used and augmented with the appropriate color pre-filtering. The Kalman filter based tracker is additionally employed in each frame of the input video to predict the position and the scale of a previously detected candidate[9].

The color enhancement with an adaptive threshold is combined to extract red regions in the image is presented by Zaklouta et al [10]. The detection is performed using an efficient linear Support Vector Machine with Histogram of Oriented Gradients (HOG) features [10].

Kiran*et al* [11] proposed detection and recognition of traffic signs from image sequences using the color information. In order to improve the performance of segmentation, product of enhanced hue and saturation components is used. Linear support vector machine with the distance to border features of the segmented blobs is used to obtain better shape classification performance [11].

Most of these algorithms are tested for ideal cases and only a few set of traffic signsare considered. The location of the traffic signs in the image taken under various backgrounds and lighting condition is presented in this paper considering a subset of all three namely cautionary, mandatory and informatory signs.

3. PROPOSED METHOD

The proposed method consists of three phases.

i) Road Sign Detection
ii) Road Sign Classification
iii) Road Sign Recognition

3.1 Detection

Road signs are designed, manufactured and installed according to tight regulations. They are designed in fixed 2-D shapes like triangles, circles, octagons, or rectangles. The colors of the signs are chosen to be far away from the environment like red, blue, black which make them easily recognizable by the drivers. The information on the sign has one color and the rest of the sign has another color.The work in detection is initiated using color information of the road sign. The segmentation of the candidate sign from the scene is carried out by employing a color space. The proposed work uses HSV color space. The RGB image is converted into the HSV as shown below.

$V \leftarrow max(R,G,B)$
$S \leftarrow (V - min(R,G,B))/V$ if V != 0, 0 otherwise

(G - B)*60/S, if V=R
$H \leftarrow$ 180+(B - R)*60/S, if V=G
240+(R - G)*60/S, if V=B

if H<0 then $H \leftarrow H+360$

On output 0<= V<=1, 0<= S<=1, 0<=H<=360.

The values are then converted to the destination data type

$V \leftarrow V*255$, $S \leftarrow S * 255$, $H \leftarrow H / 2$
(to fit to 0…255)

Red and Blue components are identified by analyzing the H and S components. Only the hue and saturation component are used to locate the red and blue colors, as intensity component could be easily influenced by illumination.Figure1(a) shows the real time image and figure 1(b) shows image after color segmentation

(a)Original image

(b) Segmented image

Fig 1: Real time informatory sign

3.2 Classification

After color segmentation, the images are classified with respect to shapes to identify rectangle, circle or triangle. Canny algorithm is used to find edges on the input image using appropriate threshold. The smallest of threshold is used for edge linking, the largest to find initial segment of strong edges.

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Canny output is then dilated to remove the potential holes between edge segments. Pixels with too small or too large values are filtered out by applying the threshold of 255. By finding the angle between the vectorssequences squares and triangles are detected. Canny edge detection followed with freeman chain code is used to recognize circle. The figure 2 shows image after classification.

Fig 2: Shape recognition

3.3 Recognition

After segmenting the image based on color and shape, the image not having the required features of traffic signs are dropped and not processed further. Otherwise recognition is achieved by template matching. Template matching algorithm is applied to recognize the candidate sign which is later compared with the one in the database.The function slides through the image, compares overlapped patch with the template to be searched using the normalized cross correlation method, as the brightness of the image and template can vary due to lighting and exposure conditions.

LetI - denotes image, T - template, R - result. The summation is done over template and/or the image patch: x'=0..w-1, y'=0..h-1) where w × h is the size of the template to be searched, which should not be greater than source image of size W × H and same data type as the image. Then the comparison at x, y is given by

$$R(x,y) = \frac{\sum_{x',y'} (T(x',y') \cdot I'(x+x',y+y'))}{\sqrt{\sum_{x',y'} T(x',y')^2 \cdot \sum_{x',y'} I(x+x',y+y')^2}}$$

Figure 3 shows image obtained after template matching.

Fig 3: Template matching

Theblock diagram of the proposed model is as shown in the figure 4.

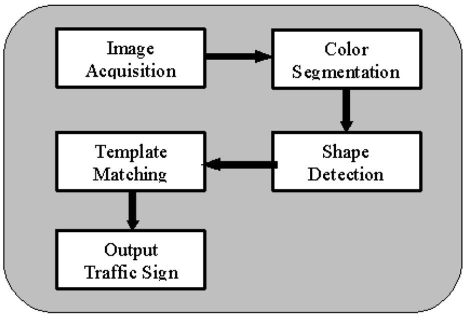

Fig 4: Proposed model

4. EXPERIMENTAL RESULTS

Several experiments have been conductedto verify the efficiency and the accuracyof the proposed method for the detectionand recognition of road signs. Theexperiments are carried out using imageset of different traffic signs and nontraffic signs.Images of traffic signs collected under different conditions are shown in figure 5,6 and 7.

Fig 5: Informatory traffic signs under various conditions

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Proposed method is implemented in Java using Javacvand tested over one hundred images. Some of theexperimental results are shown in Figure 8 and 9. Figure 8(a) shows an input image containing speed limit sign.Figure 8(b) shows the detection of road signs after color segmentation. Figure 8(c)shows the detection image based on the shape. Figure 8(d) showsthe image after template matching.Figure9(a) shows an input image containing informatory food place sign.Figure 9(b) shows the detection of road signs after color segmentation. Figure 9(c)shows the detection image based on the shape. Figure 9(d) showsthe image after template matching and figure 9(e) shows final result displayed as food place informatory sign.

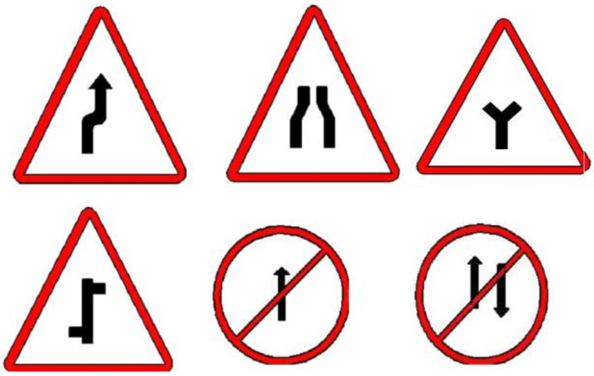


Fig 6: Cautionary sign

Table 1 shows the overall statistics. The experimental results shows that the detection and classification of road signs is quite good as the color and shape of the traffic sign is fixed as compared to sign recognition phase because of variations of interior symbols.Images are categorized based on type of traffic sign such as informatory, speed limit signs and mandatory signs and non traffic signs. The last row of the table gives the statistics of non traffic signs. 10% of the images are falsely selectedas potential road sign.The time complexity of the proposed method is less than onesecond to apply it in a real time system.

Fig 7: Speed limit signs

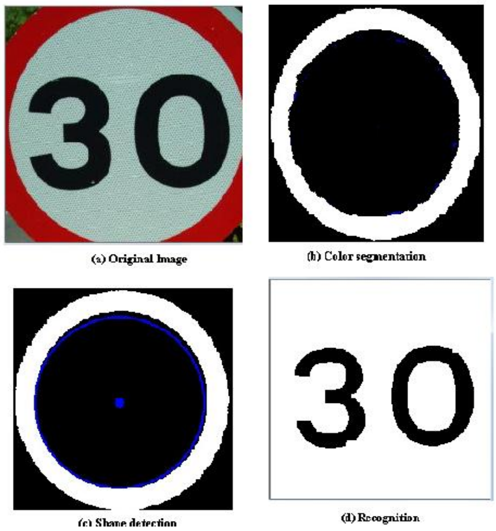
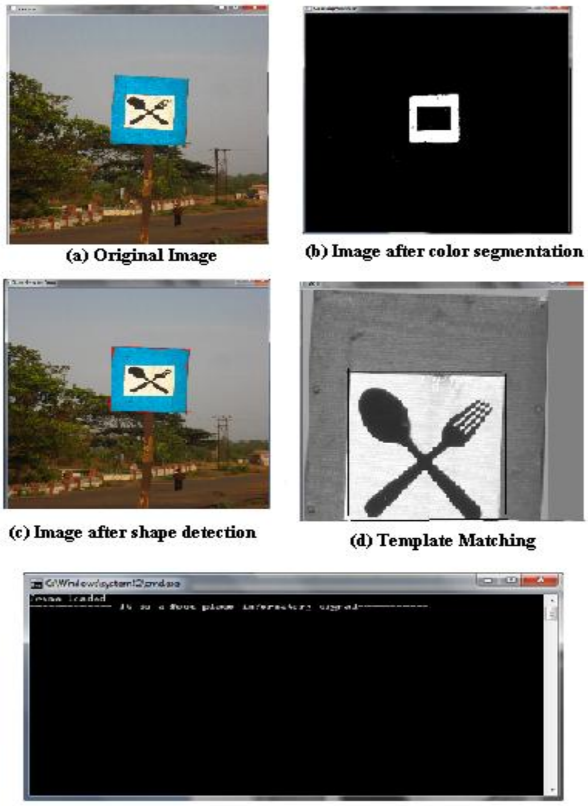


Fig 8: Recognition of speed limit sign

Table 1. Statistics of road sign recognition

Statistics of Road Sign Recognition							
S.No	**Type Traffic Sign**	**Input images**	**Sign Detection**	**Sign Classification**	**Sign Recognition**	**Success rate**	**Recognition Time (T)**
1	Informatory Sign	50	48	49	47	94%	≈ 0.90 s
2	Speed limit Signs	20	18	18	18	90%	≈ 0.92s
3	Mandatory Signs	20	18	18	17	85%	≈ 0.94 s
4	Non Traffic Signs	10	8	5	1	90%	≈ 0.96 s



(a) Original Image (b) Image after color segmentation (c) Image after shape detection (d) Template Matching (e) Final Result Display

Fig 9: Recognition of informatory food place sign

5. CONCLUSSION

In this paper, an algorithm to detect and recognize traffic signs based on pattern matching is proposed. The traffic sign images are captured by a camera from different orientations. The HSV color space is used to segment the traffic sign from the image as it decouples the color and intensity information. The different shapes of the sign are classified using canny algorithm and freeman chain code and finally recognized using pattern matching. The experimental analysis showed the better performance under various conditions such as,different backgrounds, lighting conditions, orientations and distances. The algorithm can be improved to perform better in all kinds of atmospheric and luminance conditions and can be made dynamic to work in real time.

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