Feature Points for Traffic Sign Detection and Recognition System Using ANFIS

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Abstract

The reliable traffic sign detection provides to achieve performance in traffic sign recognition. Features representation is an important factor for TSDR system. The purpose of this research is to propose an adaptive threshold method based on RGB color for detection and extracting new feature points for traffic sign recognition. In this system, the RGB color based adaptive threshold method is used to detect red, blue and yellow traffic signs. Output traffic signs perform shape verification. Second, new feature points are extracted from the verified image, such as centroid point, end point, and branch point. Finally, ANFIS is used to identify the process. This system uses Myanmar Traffic Sign dataset.

1. Introduction

The real-time traffic sign detection and recognition (TSDR) system becomes an interested research area for an intelligent system. There are many challenges for developing real-time TSDR system due to motion artifacts, variable lighting and weather conditions, and situations of traffic signs. But color detection is challenges for computer vision system. There are many challenges for detecting color traffic signs due to non-uniform illuminations and brightness. The aim of the proposed research is to develop an efficient and effective traffic sign detection and recognition (TSDR) system for real time.

Representation of features is an important factor for TSDR. To be easy to read and recognize drivers, road signs are always designed in certain shapes and colors so that the characters and text in the characters are different background.

In addition, there are actually different road signs datasets in the world, for example, 43 categories are included in the German TSR Benchmark (GTSRB) data set. The other two sets of data should be highlighted: STS datasets and KUL datasets. They are large, although not GTSRB as large and they contain a full image. All of them can be used for testing purposes. STS datasets do not have all comments on images, but include all frames from the video used to extract the data.

In Myanmar there are three types of road signs: red, blue and yellow, and figures are round and rhombuses. First of all, the prohibition sign is a circular logo with a white background, and the inner pictogram is black, surrounded by red. In addition, warning signs are yellow diamonds, black borders, an internal pictogram is black, then a blue circular logo, a white internal logo.

This article mainly presents the steps to detect red, blue and yellow traffic signs. The second section presents the last working TSD system. Section III discusses the details of the proposed methodology. The fourth part shows the experimental results. Section V includes a conclusion.

2. Related Work

Traffic Sign Detection and Recognition System (TSDR) composed of two steps: detection and recognition. In traffic sign, detection stage consists of color-based detection and shape classification. The latest papers of the real-time TSDR system are presented in this section. Some of the researchers focused on red color traffic signs. There have still been challenging for real-time TSDR system. Researchers cannot detect all types of traffic signs from video but also developed for only day-time.

Until now, the research in Traffic Sign Recognition systems has been centered on European traffic signs, but signs can look very different across different parts of the world. Win proposed RGB color model is converted to the HSL color model and color filter is used to extract the traffic signs from candidate image. For shape analysis, Harris corner detector is used on Myanmar traffic signs [1]. Billah, et al. [2] presented grayscale image is converted to binary image. They used circle finding algorithm to detect only circular object. Møgelmose [3] proposed detection methods on US traffic sign (focused on speed-limit sign) detection: Integral Channel Features and Aggregate Channel Features. Romdhane [4] applied their proposed algorithm for lane limit detection to consider as new region of interest and used a thresholding on each of HSV component. Then, used a closed morphology operation and bounding box characteristic (height, width, area) for all potential regions. This paper proposed only for red border traffic sign images in GTSDB. Berkaya et al. [5] proposed an RGB-based color thresholding technique with fixed threshold and developed circle detection algorithm. Daraghmi [6] enhanced through Weiner filter and histogram equalizer. The region of interests is detected using the improved Connected Components Labeling algorithm combined with Vectorization to reduce computational time. Tu [9] presented red color enhancement and thresholding in preprossing step. In detection step, filter and detect MSER regions in traffic signs images. Aparna et al. [10] used global threshold based on RGB color. Connected Component algorithm is used to form ROI and compared between original and new ROI for shape analysis. Islam [13] developed RGB histogram equalization, RGB color segmentation, modified grey scale segmentation, binary image segmentation and shape matching for Malaysia standard and non-standard road signs detection. Wali et al. [11] proposed detection method for red color background traffic signs. They used particular threshold values for each of red, blue and green color. A Median filter is applied and longest width, centre and area the particular ROI is selected and marked.

In traffic sign recognition stage, authors of Win converted color image to grayscale. And then, Sobel edge detector is used to segment road sign. Lastly, the segmented road signs are matching with images stored in the database by using template matching method. Billah, et al. [2] proposed six features which will be given as input to the ANFIS for recognition. They obtained a satisfactory result which leads to the use of ANFIS system for traffic sign recognition. Romdhane [4] calculated HOG features and used SVM classifier for recognition traffic signs. They applied the Lucas-Kanade tracker to find the traffic sign in the next frame. Berkaya et al [5] combined Gabor features, local binary patterns, and histogram of oriented gradients within a support vector machine classification framework. Daraghmi used the histogram to match the detected image with other images stored in the database [6]. Tu [9] used HOG features and SVM for recognition. Aparna et al. [10] used correlation, mean value, histogram values are given as input for SVM classification. Islam [13] proposed 278 features points for each road signs and ANN is used for recognition.

Billah, et al. [2] only detected red circular traffic signs and Romdhane et al. detected also 25 red traffic signs from GTSDB dataset. Berkaya et al. [5] proposed for circular traffic signs images from GTSDB dataset, and the researchers of Daraghmi [6], Tu [9] also can detect for red traffic signs and speed limit signs only.

3. Proposed Method

The system flow of the system proposed is shown in Fig 1. The proposed system consists of three main stages: the detection stage, the stage of extraction of features and the classification stage. The testing procedure consists of two parts: the color control process and the shape recognition process. On the first pass, the candidate road signs are identified using the RGB color threshold method from each frame of the video sequence. The output of the color detection process includes a binary image. The second process applies the form validation process to the binary image to determine if the road sign is. Candidate signs are confirmed, which are the input data during the extraction phase of the system function. Finally, the system identifies the selected points of the function and gives the result.

3.1 Frame Extraction

The video input frame is extracted to reduce the search space. All extracted image frames are saved for fast processing time. This system extracts all the first frames in three frames.

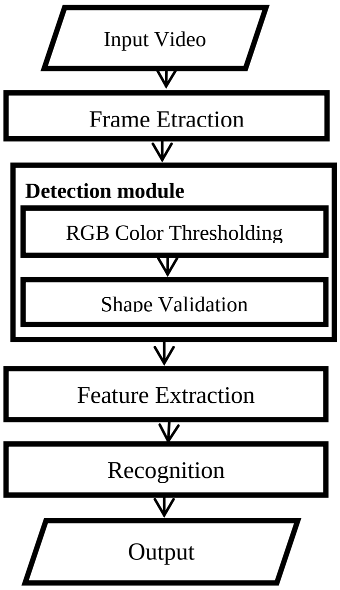

Fig. 1 The system flow of this propose system

3.2. Detection

Traffic signs detection aims to find region of interest in image frames. As described in Fig. 1, the detection stage has two processes. The first one is RGB color thresholding, and the second one is shape validation.

There are various techniques by which adaptive form of thresholding selection can be utilized, but the aim of all the ways is to find the appropriate threshold for different regions in the image [7]. In this process, thresholding based on RGB color method detects yellow color and blue color traffic sign in input frame. In this process, an adaptive threshold method based on RGB color is used to detect the red, yellow and traffic signs in the color frame. First, as an input image frame, a method of increasing the contrast and increasing the color of the road sign is used. The adaptive threshold is implemented using the red, yellow and blue luminance values based on the RGB color calculated from each pixel value of the localized frame of the input image. The maximum value is also marked and can be converted to the respective threshold values of these red, blue and yellow intensity values. The intensity value of the actual traffic sign is smaller than the final maximum threshold. Therefore, the maximum threshold is reduced to 25%. Yellow is detected by subtracting the blue intensity value from the red and green intensity values. The following formula is used to detect various situations of the yellow input signal.

$$TS_{rb} = \max\left(R_{(i,j)} - B_{(i,j)}\right) * 0.75$$
$$TS_{gb} = \max\left(G_{(i,j)} - B_{(i,j)}\right) * 0.75 \qquad (1)$$

After getting the maximum thresholding value, the following equations are used to detect different situations of inputs yellow color traffic signs.

$$YI_{(i,j)} = \begin{cases} YI_{(i,j)} = 1 \; if \; (\max(R_{(i,j)} - B_{(i,j)}) \geq TS_{rb}) \wedge \\ \qquad (\max(G_{(i,j)} - B_{(i,j)}) \geq TS_{gb}) \\ YI_{(i,j)} = 0 \qquad else \end{cases} \qquad (2)$$

Blue pixel values are greater than red and green pixel value in blue color traffic sign. So, we calculate blue color traffic signs using the following equations.

$$TSB_{rb} = \max\left(B_{(i,j)} - R_{(i,j)}\right) * 0.75 \qquad (3)$$
$$TSB_{gb} = \max\left(B_{(i,j)} - G_{(i,j)}\right) * 0.75$$

$$BI_{(i,j)} = \begin{cases} BI_{(i,j)} = 1 \; if \; (\max(B_{(i,j)} - R_{(i,j)}) \geq TSB_{rb}) \wedge \\ \qquad (\max(B_{(i,j)} - G_{(i,j)}) \geq TSB_{gb}) \\ BI_{(i,j)} = 0 \end{cases} \qquad (4)$$

where R, G, and B are the red, green, and blue color intensities value with range from 0 to 255. The following figures show the detection results of traffic signs obtained from our proposed RGB color thresholding method. Clearly, the following figure 5 to 7 show the detection results under the different lighting and weather conditions of traffic signs by applying proposed method.

3.3. Shape Validation

In this proposed work, aspect ratio method is used to validate the detected image is traffic sign or not. The following equation is used to calculate the shape of the candidate region.

$$\text{AspRatio} = \frac{\text{BDWidth}}{\text{BDHeight}} \qquad (5)$$
$$\text{AbsRatio} = \begin{cases} 1 & (1 - AspRatio) < 0.25 \\ 0 & else \end{cases}$$

where BDWidth is the width, and BDHeight is the height of the detected traffic sign. AspRatio is the aspect ratio. AbsRatio is the absolute value of aspect ratio.

3.4. Feature Extraction

The main contribution of our proposed work is feature extraction. TSDR system needs to recognize the output image from the detection stage. There are various features of detection steps of traffic signs. The significant features for TSDR system are needed to be extracted. The main point of TSDR system is fast processing time. In the feature extraction process, the outputs of the shape validated traffic sign images used Sobel edge operator to detect the edge points. Secondly, thin operator of the morphological operators is also used for thinning the detected edges. The main three features: termination points, bifurcation points and 90° angles are extracted from thinned images. TSDR system gets the accurate results by using the proposed features. The following equation is used for finding termination points in the candidate region.

3.4.1. Centroid Point

The centroid points are the center point of maximum row and column of detected binary sign image. In this system, the center point of row and column points are extracted. The following figure 2 shows the row and column centroid points of binary traffic sign image.

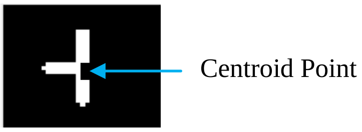

Figure 2: Centroid point

The following equation is used to find termination points in validated traffic sign.

$$\text{Tr} = \begin{cases} 1, & \text{if } ((Cen == 1) \wedge sum(N == 1)) \\ 0, & \text{else} \end{cases} \quad (6)$$

where, Tr =Termination point, Cen= Center point in 3x3 matrix, N=3x3 matrix.

3.4.4 Bifurcation Point

The following equation is used to find the bifurcation points from output sign board.

$$\text{Bf} = \begin{cases} 1, & \text{if } ((Cen == 1) \wedge sum(N == 3)) \\ 0, & \text{else} \end{cases} \quad (7)$$

where, Bif =Bifurcation point, Cen= Center point in 3x3 matrix, N=3x3 matrix. The following figures show the termination points and bifurcation points of output traffic sign from detection step.

(a) (b) (c)

Figure 3: (a) Candidate image (b) thinned image (c) 3 termination point and 1 bifurcation point

Some of the traffic signs produced the same number of termination and bifurcation points (eg. Left turn and Right turn sign). This system calculates the average values of termination and bifurcation points of row and column. So, four features points for termination and bifurcation are extracted. The discussed image for ten features is presented in the following table 1. These features points are given as input to ANFIS for recognition.

Table 1. Results of Features Points for ANFIS training

Features	Results
Cen_R	0.5
Cen_C	0.823529
Avg_Tr_R	0.466667
Avg_Tr_C	0.644444
Avg_Bif_R	0.6
Avg_Bif_C	0.866667

Where, Cen_R is centroid point of row , Cen_C is centroid point of column, Avg_Tr_R and Avg_Tr_C are average termination point of row and column, Avg_Bif_R and Avg_Bif_C are average bifurcation point of row and column.

3.5. Adaptive Neuro Fuzzy Inference System (ANFIS)

The ANFIS classifiers are used to recognize road signs. ANFIS is with the training ability of a neural network and the advantage of a rule-based system. This is the main advantage of fast convergence. In this system, the ANFIS system is built with 6 inputs and functions of the trapezium function and two membership functions used for input functions. The output data presented to each input was represented by the output label of each set of input functions. The rule output is combined into one conclusion.

4. EXPERIMENTAL RESULTS

In this system, we collected data by using smart phone on highway and freeway. The speed of the vehicle was approximately 40 km/h. The image resolution in the video sequences is 720x480. The video frame rate is 30frames/second. In this experiment, we tested the video under cloudy, drizzle rain, and normal weather conditions. In our experiments, this proposed method can detect approximately above 80 feet before the traffic signs. So, drivers reduce and control their driving speed on time. The extracted feature points are used to recognize detected traffic signs in real-time. So, this system extracted six feature points.

In figure 5, 6 and 7 show the detection results. In figure 4 shows the recognition results. In figure 6 the traffic sign is captured under drizzle rain and figure 5 the input frame is under cloudy condition. This proposed detection method detected this situation. In figure 4 shows the recognition result using proposed features.

The system tested various threshold ranges. The threshold range decrease start detected frame number is increased and output region not includes traffic signs so it consumes system's performance. The proposed threshold values for yellow and blue are appropriate for all weather conditions such as drizzle rain and cloudy weather. In this system, the various time lengths of 16 videos are used. The recognition and detection rate of accuracy is calculated as the following equations. The following table 2 and 3 shows the result of this proposed method. The following table 4 shows the comparison of overall accuracy of our method and other published method.

$$\text{Accuracy} = \frac{\text{No of correctly detected traffic signs}}{\text{Total number of traffic signs}} * 100 \quad (8)$$

where TP is the number of true positives, FP the number of false positives, and FN the number of false negatives.

(a) (b)

Figure 4. (a) Yellow color, (b) Red color traffic signs recognition

(a) (b) (c)

Figure 5: Blue Color Traffic Sign under cloudy weather

(a) (b) (c)

Figure 6: Yellow Color Traffic Sign under drizzle rain

(a) (b) (c)

Figure 7: Yellow Color Traffic Sign under normal weather

Table2. Detection Results for proposed method

Myanmar Traffic Signs	Test Images	Correctly detected signs	Accuracy
Prohibitive	223	220	98.6%
Mandatory	357	353	98.8%
Informative	159	156	98.1%
Total	739	729	98.6%

Table 3. Recognition Results

Traffic Signs	Test Images	Correctly classified signs	Accuracy
Mandatory	178	162	91%
Informative	191	165	86%
Prohibition	98	98	100%
Total	467	425	91%

Table 4. Accuracy: Our Method and Other Published Method

Method	Win [1]		Our Method	
	Total Signs		Total Signs	
Detection Rate	95%	83	98.6%	739
Recognition Rate	94%		91%	467

5. Conclusion

The TSDR system is an integral part of the driving assistance system. This system warns about the situation with the road to the driver. Such a system must be fast and accurate to detect road signs from the video sequence. In this article, we proposed a new method for determining the color based on RGB for the detection and recognition of a road sign in real time. This system applies to the red, yellow and blue traffic signs of Myanmar. This system recorded actual signs of traffic. This system provides effective results in recognition using the proposed feature points. In future research, we will continue to extract some other feature points and improve system performance.

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