K-means Clustering 기법과 신경망을 이용한 실시간 교통 표지판의 위치 인식

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Real-Time Traffic Sign Detection Using K-means Clustering and Neural Network

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Abstract

Traffic sign detection is the domain of automatic driver assistant systems. There are literatures for traffic sign detection using color information, however, color-based method contains ill-posed condition and to extract the region of interest is difficult. In our work, we propose a method for traffic sign detection using k-means clustering method, back-propagation neural network, and projection histogram features that yields the robustness for ill-posed condition. Using the color information of traffic signs enables k-means algorithm to cluster the region of interest for the detection efficiently. In each step of clustering, a cluster is verified by the neural network so that the cluster exactly represents the location of a traffic sign. Proposed method is practical, and yields robustness for the unexpected region of interest or for multiple detections

1. Introduction

There are researches for traffic sign detection using the color information [1], [2], [3], [4], [5]. However, the problem using the color occurs in computer vision because of ill-posed condition or an unexpected noise condition. Furthermore, the computation of application should be real-time processing.

Although template matching based methods yields significant performance, since the detection performing entire input scenes requires enormous computation, our work suggests a heuristic method extracting the ROI (region of interesting).

The proposed method yields the multiple traffic sign detections and robustness for unexpected conditions.

2. Proposed Method

Our work assumes that the input image is ROI using the color information. There are methods to extract traffic sign regions such as HSI space or RGB. Proposed method is independent of the method for obtaining ROI of traffic signs.

K-means algorithm clusters the ROI which represents the candidate areas for traffic sign. As a result, similar ROI will be grouped into one single cluster. If the clustering is successful, it can identify all the unique ROI in the scene.

Then, k-means algorithm clusters the extracted ROI. The clustered ROI is normalized to 30 by 30 size, and horizontal and vertical projection histograms are generated from a clustered ROI, and total 60 features are used to verification for traffic signs. The histogram is normalized by vector normalization, and the neural network determines the final detection using it.

In our work, error back-propagation learning is used for training the feed-forward neural network as fallows

$$\mathbf{w}(n+1) = \mathbf{w}(n) - \eta \frac{\partial E(n)}{\partial \mathbf{w}(n)} + \gamma(\mathbf{w}(n) - \mathbf{w}(n-1))$$

where $\mathbf{w}(n)$ denotes the weight at epoch and η and γ represent learning rate and the term of momentum, respectively . $E(n)$ is the sum of squares error $\sum(F(\mathbf{x},\mathbf{w})-d)^2/2$ on whole training data in which $F(\mathbf{x},\mathbf{w})$ denote the actual output from network and d is desired response corresponding the epoch.

The architecture of the network is single hidden layer and all neurons have the sigmoid function $f(x) = 1/(1+\exp(-x))$.

Figure 2 shows the comparison of the projection histograms for traffic sign image. The overview of proposed method is described in Figure 1.
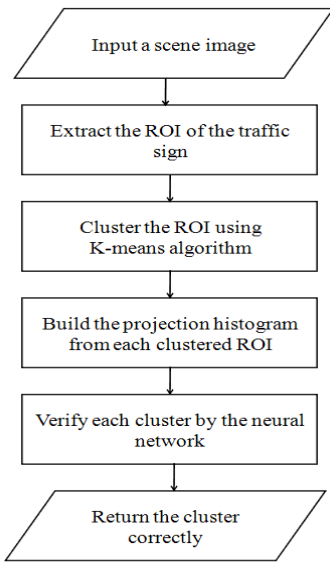
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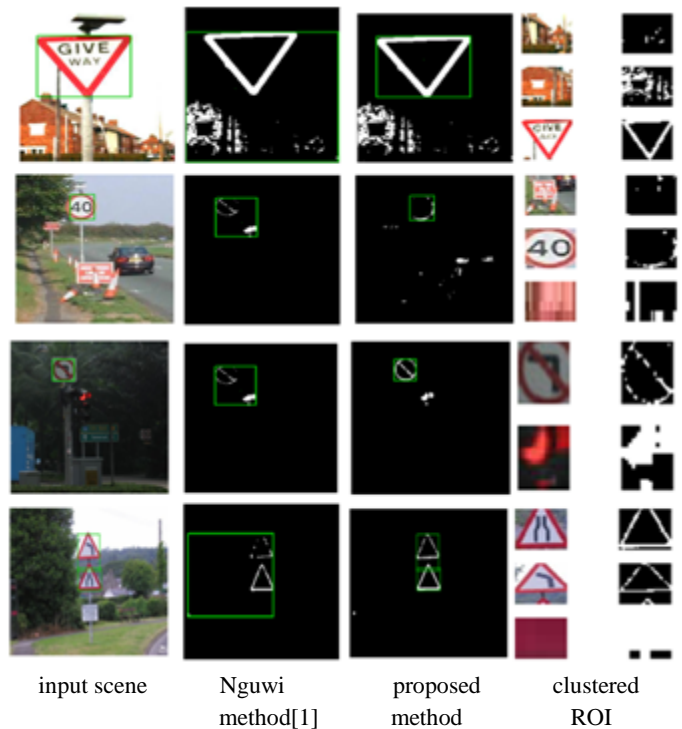Figure 1: The block diagram for the proposed method

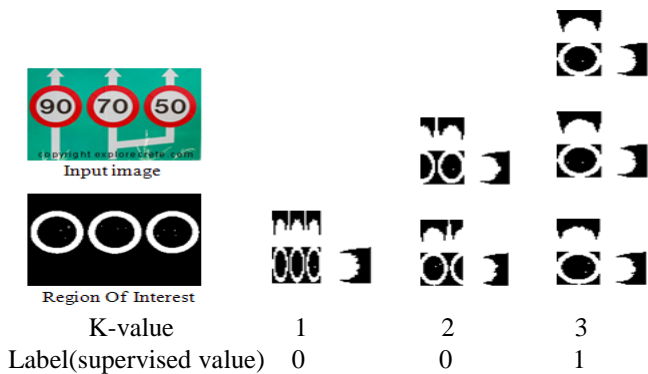| K-value | 1 | 2 | 3 |
| Label(supervised value) | 0 | 0 | 1 |

Figure 2: An example of projection histogram features on the two axes and the label according to each cluster to train the neural network
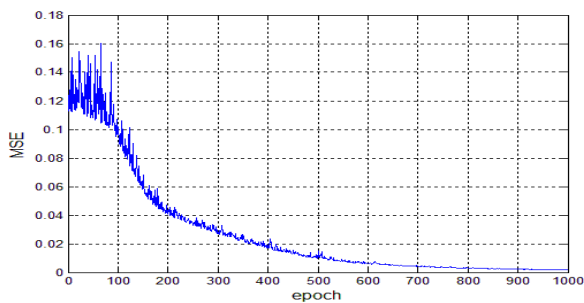

Figure 3: The convergence of BP neural network error over training epochs

Table 1: The BP neural network error for proposed projection histogram features with 10 fold-cross validation (a total of 114 data is used)

Data	MSE	Accuracy
Training data	4.3 ± 0.74 ($\times 10^{-3}$)	$99.14\pm0.12\%$
Test data	4.3 ± 0.82 ($\times 10^{-3}$)	$99.09\pm2.72\%$

| input scene | Nguwi method[1] | proposed method | clustered ROI |

Figure 4: The experimental results of the proposed method (the left column shows the input scenes, the two middle depict extracted ROI in the rectangle, and the right column illustrates clustered ROI by proposed method)

3. Experimental Results

In our work, to extract the ROI, we adapt common sense knowledge that traffic signs are usually colored as red (i.e. other colors are enable). Based on the simple criterion, it is possible to identify ROI with small amount of computational load. Because of ill-condition in the real world scenes, we give small tolerance to the identification of ROI. Our work defines three parameters θ_1, θ_2 and θ_3 to extract the ROI as fallows

$$\theta_1 = R, \theta_2 = \frac{R}{G}, \theta_3 = \frac{R}{B}$$

where, R denotes red intensity of a pixel, G and B represent green and blue intensity, respectively. If the parameters satisfy the threshold, then a pixel of the input scene is extracted for the ROI.

The neural network size is the same to 60 inputs and 60 hidden neurons, and 1 output. The initial weights of the neural network is randomly selected chosen between -0.1~0.1. Learning rate is 0.1 and momentum is 0.01. The network error over training epoch is presented in Figure 3. Table 1 shows training results of the neural network by using 10-fold cross validation method.

The maximum number of clusters is 3. The thresholds $\theta_1, \theta_2, \theta_3$ to extract the ROI are 50, 2 and 2, respectively. Figure 4 shows the results of the proposed method with real-world scenes.

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4. Conclusions and Further Works

This work proposes the traffic sign detection algorithm using k-means clustering and the neural network for real-time processing. To reduce computation time, the color information is used to extract the ROI from the input scene.

K-means algorithm clusters the extracted ROI so that it is possible to find the exact location for traffic sign under unexpected noise or the backlight of the others car. The clustered ROI is verified by trained the neural network to determine the final detection.

The proposed projection histogram features are well suited to train neural network and result in 99.09% for test accuracy with 10-fold cross validation. In our experiments, the proposed method significantly can reduce the processing time than the fully finding work for traffic sign in the given input scene. For further works, it is considered that the problem arises from k-means clustering which starts with initialization randomly which degrades the performance, and there is no way to find appropriately the number of clusters, it would expect to be exploited. Furthermore, to extract ROI with retaining generality is considerable.

감사의 글

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