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Traffic Sign Recognition

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Abstract: Traffic sign recognition is a technology by whicha vehicle is able to recognize the traffic signs on theroad. In this paper, we propose a novel traffic signrecognition that can operate robustly and accuratelyfor real scenes of Korean roads. The proposedmethod first detects a potential traffic sign and thenrecognizes the content of the potential traffic sign.With this approach, the proposed method canrobustly recognize small traffic signs from longdistances and reduce false alarm significantly. Weemploy Histogram of Oriented Gradient (HOG) andSupport Vector Machine (SVM) in a two-step model.Compared with the original HOG and SVM methodusing three Hyundai data sequences with groundtruth, our proposed method outperforms significantlyand operates robustly in different conditions. Thesource code and datasets are available online at https://github.com/comvisdinh/realtimetrafficsign
recognition.

Keywords: Traffic sign recognition, histogram oforiented gradients, support vector machine.

I. INTRODUCTION

Traffic sign recognition is highly important in driving assistance systems because it can help to understand the environment and prevent vehicle accidents. Thus, this function has a significant potential benefit for supporting drivers. In addition, traffic sign recognition is a part of autonomous driving vehicles, a current hot topic worldwide. Detecting and recognizing distant objects is currentlya challenging problem and a requirement for vehiclesdriving at high speed.

We develop a robust and accurate recognition method for Korean speed limit traffic signs. The method is required to be computed in real-time andto operate robustly and accurately. In addition, the method can recognize other kinds of traffic signs, such as speed-limit-released, minimum speed, construction, and direction signs.

It is a contract fact that when using images with large resolution, detection and recognition can improve their performance because the objects in the images are detailed, but the images require a large computational cost. On the other hand, images with smaller resolution require a lower computational cost;however, the detail of an image is reduced, leading to the detection and recognition method performing more poorly.

In our recognition method, observing that trafficsigns in Korea usually appear in the high positions sothat drivers can see them easily. We remove a lowerpart of an image. Consequently, we can reduce thecomputational cost to achieve real-time computation.In addition, we do not recognize traffic signs directly. However, we design a two-step approach that solves the problem of traffic sign recognition.We observe that traffic signs often have circle,rectangle, and triangle shapes. Therefore, we firstdetect if the shape appears in an image. This can alsoreduce computational cost because the method in thisstage only deal with three patterns instead of manymore. After that, the image regions (that will be processed more) become much smaller.

We divide our recognition method into two steps: detecting traffic signs first and then recognizing the detailed information of the traffic signs. Afterdetermining that an image region (usually small image region) contains a traffic sign, we up-sample the image region before performing recognition.

HOG was originally designed for humandetection. The sizes of humans in images are often large enough to be detected. However, traffic signsin real images are usually small. Using HOG with a small searching patch increases false alarms significantly.

Recently, deep learning methods [1] [2] [3] have been popular in traffic sign detection and recognition.However, deep learning-based methods for traffic sign detection are far from real-time computation and are even supported with GPU.

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II. RELATED WORK

The traditional detection method used color and texture information, shape cues [4], and local features [5] to describe an object. However, Viola- Jones proposed a real time detection method [6] that used Haar feature [7] selection and cascading classifiers [8]. The Histograms of Oriented Gradients (HOG) [9] is a type of feature descriptor. The intent of a feature descriptor is to generalize the object in such a way that the same object (in this case a traffic sign) produces the same feature descriptor as close as possible when viewed under different conditions. This makes the classification task easier.

The HOG traffic sign detector uses a sliding detection window that is moved around the image. At each position of the detector window, a HOGdescriptor is computed for the detection window. This descriptor is then shown to the trained SVM, which classifies it as either a “traffic sign” or “not a traffic sign”.

Support Vector Machine (SVM) [10] is a supervised machine learning method that is commonly used in classification. In this method, each data piece is plotted as a data point in an n- dimensional space. Then, classification is performed by computing the hyper-plane that segregates the twoclasses.

Depth information [11] and optical flow [12] can be used as a supplementary to improve detection and recognition performance.

III. THE PROPOSED METHOD

Observing the images reveal that the bottom part of an image usually contains roads, vehicles, pedestrians, etc. In other words, traffic signs are often located in a high position so that the driver can see them easily. Therefore, traffic signs usually appear in the upper part of an image.

In addition, we classify the traffic signs into categories in terms of their shapes, including circle, square, and triangle. The proposed method first searches if the shapes exist in an image. This can reduce false alarm and computation cost significantly. Figure 1 shows the idea of the proposed method. The three shapes are first detected as potential traffic signs.

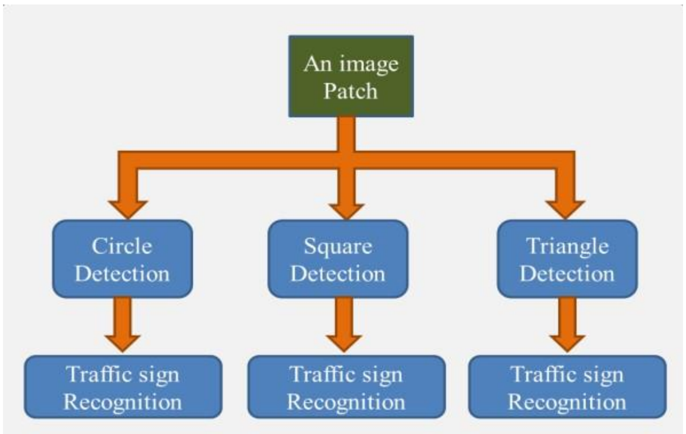

Figure 1: Illustration of the idea of the proposedmethod.

Current, HOG and its variations are often employed for detection and recognition applications because it can achieve real-time computation andaccurate performance. However, HOG was originallydesigned for human detection. If directly using HOG for traffic sign recognition, the false alarm problem can occur frequently.

The reason for this is that the region sizes of traffic signs are often much smaller than those of humans. If trying to recognize a traffic sign in the beginning step, it is easy for HOG to recognize it wrongly; in these situations false alarms are common.

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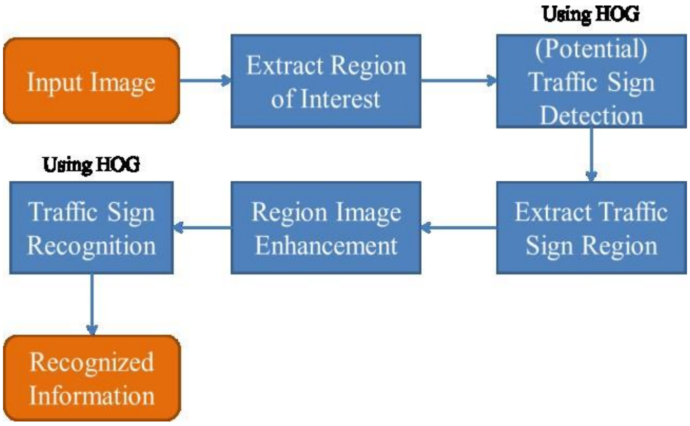

Figure 2: Flowchart of the proposed method.

For the above reasons, we design a recognition method especially for traffic sign recognition. Figure 2 shows a flowchart of the proposed traffic sign recognition method. There are two main steps in our proposed method: potential traffic sign detection and traffic sign recognition. Potential traffic sign detection only locates the potential regions of traffic signs. However, we are not certain of what the detected traffic signs are. The exact information is extracted from the traffic sign recognition.

Figures 3–5 show examples of the training imagesfor circle detection and traffic sign recognition.

Figure 3: Examples of training images for for trafficsign recognition.

Figure 4: Examples of training images circledetection.

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Figure 5: Examples of training images for trafficsign recognition.

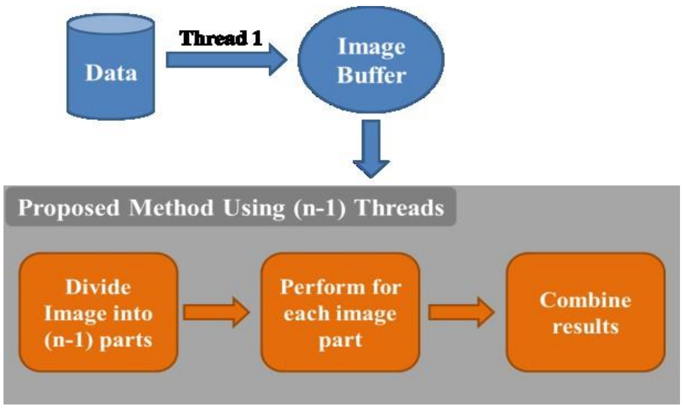

Figure 6: Multi-threading model for real-timecomputation in CPU.

Multi-thread programming is used to accelerate the computation of the proposed method. Suppose there are n threads that can run concurrently. The implementation of the proposed method using a multi-threading model is presented in Fig. 6.

IV.EXPERIMENTAL RESULTS

We used three sequences of the provided Hyundaidataset with the ground truths for traffic signs. Imageresolution is 1280x960. The moved bottom part is 1280x200. After that, we evaluated the results of our method with the ground truths and compared them with those of the HOG+SVM method.

An error was counted when a speed-limit sign was not recognized or a false alarm occurred. A false alarm is a situation where the method recognizes wrongly. The accuracy **A** (%) was computed as where N is the number of the union of ground truth and detected objects. In our implementation, we employ the OpenCV [13] and Dlib [14] libraries.

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Figure 7: Detected result of the proposed method.

Figure 8: Detected result of the proposed method.

Figure 9: Detected result of the proposed metho

Figure 10: Detected result of the proposed method.

Figures 7–10 show the qualitative results of the proposed method for different testing images. The traffic signs in these images are very small comparedwith the image resolution. However, the proposed method first tries to detect the shape of traffic signs that are not required to obtain detailed information. For each potential image patch, the proposed method obtains detailed information to recognize the type of traffic sign. This can reduce the false alarm rate significantly. The proposed method successfullydiscarded the rate of false alarms and recognizedtraffic signs correctly.

Table 1 shows the quantitative results of the proposed method and HOG+SVM for the five testingsequences of images. For all the testing sequences, the proposed method outperformed the HOG+SVM significantly. For sequence 2, for example, the proposed method increased the accuracyapproximately 22%.

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Table 1: Performance comparison ofHOG+SVM and the proposed method.

Dataset	HOG+SVM	Proposed Method
Sequence 1	78.6%	95.7%
Sequence 2	70.8%	92.4%
Sequence 3	74.1%	94.6%

The experimental PC platform had a configuration consisting of an Intel Core i7-7700
3.60 GHz CPU and 32.0 GB of memory. We used 8 threads for the computation, as shown in Fig. 6. The average computation time of the proposed methodfor an image is about 38 milliseconds, and the average frame rate is approximately 26 fames per second.

V.CONCLUSION AND DISCUSSION

Detecting and recognizing distant objects iscurrently a challenging problem and is a requirementfor vehicles driving at high speed. A simple solution is up-sampling images as shown in the followingfigure. When an image patch is up-sampled four times, the features of the traffic sign become clear and recognizable.

However, when the distance is very far away, the feature is unclear and unrecognizable, even if it is up-scaled. Using super-resolution cameras makes thecomputation power high but prevents the achievement of real-time computation. In addition, super-resolution cameras are often with high prices.

We plan to use two normal cameras with differentfocal lengths to detect distant objects while implementing real-time computation. In addition, wecan use these two cameras to obtain depth information [15] that can be useful for improving theperformance of traffic sign recognition.

ACKNOWLEDGEMENT

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