Traffic sign detection and recognition by improving Region of Interest (ROI) division to support driver assistance system

A Suheryadi*, A Sumarudin, A Puspaningrum and E Prastyo
Informatic Department, Politeknik Negeri Indramayu, Indramayu, Indonesia

*adisuheryadi@polindra.ac.id

Abstract. Traffic signs detection and recognition is a technology that allows automatic identification of traffic signs. In the implementation, it mostly uses a camera to capture video or real-time conditions. The Traffic detection and recognition system can give benefits to improve safety for drivers or passengers. Therefore, traffic signs detection and recognition system are one of the important parts in Driver Assistance Systems (DAS), besides that it is also used in video surveillance to improve traffic safety in the field of Intelligent Transportation System (ITS). In this paper, we propose a method for detecting and recognizing traffic signs by combining color and shape detection and divide the interest object to several regions for object recognition. The first step is image transformation, which aims to determine interest objects in the camera view. Such a process was using hue, saturation, value (HSV) color space, grey level, and black and white (BW) level. The next step is the filter and the segmentation process. The result of the filter and segmentation process then detects area objects by using region determination. The last step is the region of interest (ROI), which is used to recognizing sign traffic by the sum of absolute differences (SAD), and we try to improve area selection of ROI around nine parts. The results of the experiment proved that the proposed method was relatively good with the success rate for detecting objects about 97.38 %, and the true positive of recognition result about 81.67 %.

1. Introduction
The aim of the intelligent transportation system (ITS) development to provide convenience, comfort, and safety of road users, i.e., vehicle drivers. Safety driving is a priority that must be considered by the driver. However, one of the safety driving keys is that the driver should focus on driving a vehicle [1]. About 90% of accidents occur due to negligence in driving. One of the biggest causes of traffic accidents is driver fatigue and unable to focus on driving. In general, accidents occur due to the driver losing vigilance. Furthermore, some factors that cause accidents could be categorized, such as drivers (errors & disturbances), environment, and vehicle damage factors [2]. A driver warning system is needed to help drivers stay alert. The driver assistant system (DAS), a part of ITS, will give a warning to the driver. DAS is a technology applied to vehicles that aim to reduce driver error.

Most of the studies on DAS lead to computer vision. The study consists of object detection and conditions around the traffic lane that the driver passes, such as lane detection [3], pedestrian detection [4-6], distribution of vehicles on the road by detecting vehicles [7,8], traffic signs detection and recognition [9], etc. One of the popular topics in this study is traffic sign detection and recognition (TSDR). The traffic signal detection (TSD) process is the first process that greatly determines the success of the algorithm because the accuracy of TSD to produce the position of traffic signs has a major influence on the tracking or classification (TSR) process.
The TSD process aims to identify the Region of Interest (ROI) and find the location of traffic signs in the observation area. The fewer errors in detecting traffic signs, the better the TSD algorithm used. The challenge faced in detecting traffic signs is finding objects in complex conditions, unclear images, and speed of detection. The results of the detection process are input to the TSR process. TSR aims to classify traffic signs so that traffic signs can be identified. The thing that is often faced in recognizing traffic signs is damage to the image both due to noise, lighting, and environmental disturbances.

TSDR-related studies are using a method by colors [10-12], shape [13,14], and combinations of colors and shapes [15]. Salti et al. [7] referring to a study using color segmentation with red, green, and blue (RGB) color structures. Selcan et al. [9] proposed a TSDR approach using color and loop detection algorithms, while the classification used local and Gabor binary patterns. Huang et al. [12] proposed sign detection using the YCbCr color segmentation and Gaussian color model for segmentation. On the other hand, TSDR research with a focus on the shape of an object has come from Liang et al. [14]. They proposed the TSD method by using ROI and matching template forms, with learning using SVM. The most previous study methods above proposed focus on the possibility of detecting traffic signs without considering the area of space observed.

In this paper, the stages of method that are possible to reduce the space of observation area to detecting and recognizing objects are proposed. The discussion in our paper uses an HSV color structure to segmentation processes and threshold of interest objects to reduce the observation area. Then, the result of the interest object area is processed using the development of ROI distribution and the calculate of SAD to recognizing objects.

2. Methods
The proposed method consists of two main processes that were detection and classification. The traffic signs detection process is done gradually by reducing the ROI. This procedure could reduce the observation area to the detecting process. Whereas the method of recognizing traffic sign uses SAD of traffic sign template. The process stages were image conversion, image filtering, region determination, and traffic sign recognition. The process diagram of this study is shown in Figure 1.

![Figure 1. The stages of image processing.](image-url)

2.1. Image transformation
The image transformation stage aims to convert the original image to detect candidate traffic sign areas easily. This image transformation stage is the conversion of RGB to HSV, HSV to gray, and gray to black and white conversion. The input of image transformation is the original color image (F). The input is processed in the RGB to HSV conversion process. This process will produce a new image on the HSV level (h). The RGB to HSV conversion is processed because, in the HSV color level, the traffic sign is more distinguishable from the surrounding background. The results of the RGB to HSV conversion
process are then converted to a gray level \((g)\). Finally, \(g\) is converted to a black and white level to reduce existing noise. These stages can be seen in Figure 2.

![Figure 2. Proses of image transformation.](image)

2.2. Image filtering

At this stage, there are two processes, i.e., selection of blob limiting the member and morphological filter. Blob selection was operated to get blob candidates, which is part of the traffic sign. The process of selection of blob is explained in equation 1.

\[
{m} = \left\{ {m, \sum_{i=0}^{n} m_i > th} \right\}
\]

(1)

Where \(m\) is the number of blob member candidates, and \(th\) is the threshold used to determine the limit of the number of blob members. Next is the morphological filter; this process is used to reduce noise and improve blob conditions. The result of image filtering is shown in figure 3.

![Figure 3. Image filtering: (a) limited member result; (b) morphological filter result.](image)

2.3. Region determination

After obtaining a candidate blob of a traffic sign, the next process was to determine the region. It aimed to reduce the object's observation area for easing the process of matching traffic signs on the template. The determination of the observation area was done by comparing the area of the candidate of the blob. Then the candidate blob with the largest regional candidate is chosen as the observation area. The reduction of the observation area was made by looking at the corner, i.e., the width and height of the selected blob candidate. The matrix of the region determination process is shown in equations 3 and 4, and the algorithm is shown in Figure 4.

\[
cO = [x, y, w, h]
\]

(2)

\[
f' = \begin{bmatrix}
(x, y) & (x, x + w) \\
(y, y + h) & (x + w, y + h)
\end{bmatrix}
\]

(3)

The \(cO\) is a candidate object, and \((x, y)\) is the position of the corner blob. \((w, h)\) is the width and height of the blob and \(f'\) is a new observation area as a result of region determination, as shown in Figure 5.
The traffic sign recognition process seeks to provide alternative methods that are simple but still reliable to identify traffic signs. The basic concept of traffic sign recognition is to mapping candidate observation areas of the region determination result to the template dataset that has been labeled for each subclass. The stages of the process in this TSR have divided the area into nine parts symmetrically through ROI and then determining the potential area owned to do the matching process. The simple matching method was SAD. The SAD process used equation 5 that have three-level iteration because the process should be evaluating each of the subclass template data.

$$\sum_{i=0}^{n} \sum_{j=0}^{q} \sum_{k=0}^{p} |tM_{i,j,k} - f'_{j,k}|$$

Where $i, j, k$ are the index of iteration and $n, o, p$ are the iteration's maximum limits. $tM$ is a template dataset for each subclass, and $f'$ is the result of the region determination process.

3. Results and discussion
In this section, we will explain the results of experiments that have been carried out. We conduct our experiments by data form German (GTSD) and combine with traffic signs in our country to show the method performances. First, we give a brief introduction to data kinds. Second, we explain the results of our experiment.

We use eight types of traffic signs, which consist of three categories, namely three types of command signs, four types of warnings, and one type of prohibition. These traffic signs are familiar signs used in our country. We provide one template for each type of traffic signs and fifteen pieces for testing so that the total signs we test are around 120 traffic signs. The dimensions of the images used are around 150 x 150 to 300 x 300 pixels. Examples of tested traffic signs are shown in Figure 6.
In measurement testing, we use two-parameter, that are recall and accuracy. The recall is the success rate of methods for detecting objects. The recall is generated from true positive, represented by the number of true positives and false negative [16]. However, the accuracy in this test is the success rate of the method for identifying traffic signs. Our accuracy is to compare the method output with ground truth. The results of the experiment show that the average recall obtained from 120 traffic signs is 97.38%. This shows that the detection rate of this method is good enough, while the average accuracy obtained from this experiment was 81.67%.

4. Conclusion
This paper presented alternative methods for detecting and recognizing traffic signs. There were four main processes in the method, i.e. image transformation, image filtering, region determination, and traffic sign recognition. The main technique to detect traffic signs focuses on reducing the ROI and selecting areas that have potential as traffic signs. The experimental result shows that the proposed method can detecting the traffic signs as shown in 97.38 % for true positive of interest object (recall) and 81.67 % for the accuracy reached to recognize. For future work, the proposed method can be improved by machine learning to optimize traffic sign detection and recognition.

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