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Feature Detection of Curve Traffic Sign Image on The Bandung - Jakarta Highway

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Abstract. Unsealed roadside and problems with the road surface are common causes of road crashes, particularly when those are combined with curves. Curve traffic sign is an important component for giving early warning to driver on traffic, especially on high-speed traffic like on the highway. Traffic sign detection has became a very interesting research now, and in this paper will be discussed about the detection of curve traffic sign. There are two types of curve signs are discussed, namely the curve turn to the left and the curve turn to the right and the all data sample used are the curves taken / recorded from some signs on the Bandung - Jakarta Highway. Feature detection of the curve signs use Speed Up Robust Feature (SURF) method, where the detected scene image is 800x450. From 45 curve turn to the right images, the system can detect the feature well to 35 images, where the success rate is 77.78%, while from the 45 curve turn to the left images, the system can detect the feature well to 34 images and the success rate is 75.56%, so the average accuracy in the detection process is 76.67%. While the average time for the detection process is 0.411 seconds.

1. Introduction
The ability to recognize or understand an object is one of the major components in the field of computer vision and machine learning that are widely implemented in many things, such as object matching, monitoring systems, video analysis, and information description existing in an image or video that produces a smart system. Another breakthrough done in the last decade is detector and identificator of various traffic symbols or signs that exist in the field of Transportation / Intelligent Transportation System (ITS), and also an interesting focus on development of autonomous driving [1] or Smart vehicle.

Traffic Signs are part of the Road fixtures in the form of symbols, letters, numbers, sentences, and / or combinations that serve as warnings, prohibitions, orders or directions for the Road User [2]. Although traffic signs have already owned its standards through/by/from the Transportation Ministry of the Republic of Indonesia in 2014 [2], but traffic signs have very wide characteristics for their visual appearance in real world environments, for example display may different when affected by the changes of global light, weather conditions, light reflection, discoloration and physical form of signs that may be worn out, so in practice it needs to be done with a very high accuracy. Traffic Signs have been designed to be easily read/recognized by humans who are certainly very good at recognizing the existing symbols, but for a computer system, the problem of detecting, recognizing, and classifying traffic signs still has been a challenge until now, where that is included into the focus pattern recognition. In the field of computer vision and learning machine, until now it is continuously conducted an improvement for
solving and refinng the prblems that occur in the process of detection and recognition of traffic signs[3].

The traffic signs discussed in this Paper are road curve traffic signs, where from the conducted searches, found the data that the single accident is often caused from driver negligence, which from conducted research at the Center of Automotive Safety Research, University of Adelaide - Australia, by [4] it was found that problems with the road surface were a common cause of road crashes, particularly when combined with curves. This inspired this research to focus on curve signs as a preparation of Smart Driver Assistance System in Indonesia, as had been done by [5]. The dataset used in this study is traffic signs data in Indonesia which refers to the Minister of Transportation Regulation no. 13 of 2014 on Traffic Signs in the Republic of Indonesia.

2. Related Work
Research about the detection and recognition of traffic signs or known as Traffic Sign Detection (TSD) and Traffic Sign Recognition (TSR) has been widely conducted in some countries, and each of these studies demonstrates different approaches, methods, and outcomes. The differences are certainly influenced by many factors, one of those is a different traffic sign model in each country. As had been conducted by [6][7], the study discusses the probability and measurement of detection rates to traffic signs in the United States, where the research is conducted as a form of development from the German Traffic Sign Detection Benchmark (GTSDB) competition which refers only to signs in Europe.

Research that was conducted on [8] mentions that using a region interest detector or feature detector such as SIFT (Scale Invariant Feature Transform) [9] or SURF[10] is known to be an improvement from SIFT, making the detection process of interest points to be better, this also applies to feature detection. Another study using SURF for traffic sign detection was conducted at [11], from that study, SURF was combined with FPGA hardware for real-time detection process, but it is conveyed that there was a limitation in real-time detection due to the complexity of the SURF algorithm that slowed the process.

By combining the color threshold, polygon approximation algorithm, and SURF, in the study [12] segmentation is conducted on potential of traffic signs by color threshold, and a polygon approximation algorithm is used to detect appropriate polygons. The potential signs are compared with the template signs in the database using SURF feature matching method. In the identification step, it was used SURF for a CPU system only and a CPU with GPGPU System, the result is there are an improvement in accuracy and efficiency towards some data. A recent study using SURF for traffic sign detection was conducted on [13], where a combination of SURF and Artificial Neural Network Classifier was conducted and the result of accuracy was 97%.

3. Method
Method used in The Study consisted of several steps as follows: Image Input using Mobile Phone Camera Placed on Car Dashboard, Pre Stage Image Processing Consist of Scaling and Gray Scaling, Interest Point Detection, Feature Detection by SURF detector[10] by using dataset of Curve Traffic Sign. As The result, the image input will contain suitable feature with the dataset. All images were captured along on the Bandung – Jakarta Highway. The general architecture of the research methodology can be seen in Figure 1.

![Figure 1. General Architecture](image-url)
3.1. Image Input
All input images used in this research were recorded by using camera of mobile phone that was placed into the car dashboard. Recorded image data were taken per frame that contains curve traffic sign, either that directed to the rights or directed do the left. The set of data can be seen from Figure 2 below:

Figure 2. Set of Image Scene

3.2. Pre-Processing
Pre-processing image step was done to produce a better image to be processed to the next steps of detection phase. In this study, pre-processing the image taken was image scaling 800x450 and the conversion of gray level image (gray scaling).

3.3. SURF Detector
Interest Point Detection was used to select points that contain a lot of information and at the same time is stable towards the local or global distortion changes in digital images. With the SURF of algorithm, in the scene image that contains a curve traffic sign was selected interest point detector that has the invariant character towards the scale, that was the blob detection. A blob is an area of a digital image that has properties that are constant or vary within a certain range. To compute this blob detection, the determinant of the Hessian (DoH) matrix from the image was used. In the SURF algorithm, the determinant of the Hessian matrix was calculated from the Haar wavelet using integral image optimally. The determinant of the Hessian matrix was used as the basis of the SURF algorithm because of its invariant characteristic and "to able to face" the difference in scale, stability and viewing the angle well.

3.4. Detection Process
The detection results in the first step were scene image that had got an interest point or feature interest, as seen from Figure 3 as follows.

Figure 3. Detected Features on Image Scene
Figure 4. Matching Line on Image Scene
In Figure 3 can be seen small blue circles, these points were interest points or features detected by the system through the SURF Detector mechanism. These points were much existing in the Right Curve Traffic Sign, so it shaped a yellow line indicating that the area was match with the image in the dataset. In addition to the detected keypoints, there was also a matching line shown in Figure 4. Matching line in Figure 4 connects the keypoints detected in the scene image to the keypoints on the dataset located at the top of the road scene.

4. Result
The final result in this research is image detection based on match feature between the image contained in the road scene image and match it with the dataset image. Detected circuit images can be seen in Figure 5.

![Figure 5. Detected image for Right Curve (top) and Left Curve (bottom)](image)

Table 1 and Table 2 below are the test results when testing the image scene was conducted. Table 1 is the result of Right Curve Detection and Table 2 is the result of Left Curve Detection. Both tables also contain the duration of time required in the detection process, and time is presented in Second.

| No. | Image              | Features Det. | Time |
|-----|--------------------|---------------|------|
| 1.  | curveRight (1).jpg | Detected      | 0.482|
| 2.  | curveRight (2).jpg | Detected      | 0.361|
| 3.  | curveRight (3).jpg | Detected      | 0.382|
| 4.  | curveRight (4).jpg | Detected      | 0.445|
| 5.  | curveRight (5).jpg | Detected      | 0.422|
| 6.  | curveRight (6).jpg | Detected      | 0.335|
| 7.  | curveRight (7).jpg | Detected      | 0.418|
| 8.  | curveRight (8).jpg | False Feature | 0.522|
| 9.  | curveRight (9).jpg | Detected      | 0.424|
| 10. | curveRight (10).jpg| Detected      | 0.367|
| 11. | curveRight (11).jpg| Detected      | 0.399|
| 12. | curveRight (12).jpg| False Feature | 0.490|
| 13. | curveRight (13).jpg| False Feature | 0.426|
| 14. | curveRight (14).jpg| Detected      | 0.307|
| 15. | curveRight (15).jpg| Detected      | 0.376|
| 16. | curveRight (16).jpg| Detected      | 0.526|
| 17. | curveRight (17).jpg| Detected      | 0.497|
| 18. | curveRight (18).jpg| Detected      | 0.402|
| 19. | curveRight (19).jpg| Detected      | 0.384|

| No. | Image              | Features Det. | Time |
|-----|--------------------|---------------|------|
| 1.  | curveLeft (1).jpg  | Detected      | 0.477|
| 2.  | curveLeft (2).jpg  | Detected      | 0.392|
| 3.  | curveLeft (3).jpg  | Detected      | 0.375|
| 4.  | curveLeft (4).jpg  | Detected      | 0.363|
| 5.  | curveLeft (5).jpg  | False Feature | 0.422|
| 6.  | curveLeft (6).jpg  | False Feature | 0.466|
| 7.  | curveLeft (7).jpg  | Detected      | 0.353|
| 8.  | curveLeft (8).jpg  | Detected      | 0.435|
| 9.  | curveLeft (9).jpg  | Detected      | 0.367|
| 10. | curveLeft (10).jpg | Detected      | 0.385|
| 11. | curveLeft (11).jpg | Detected      | 0.402|
| 12. | curveLeft (12).jpg | Detected      | 0.462|
| 13. | curveLeft (13).jpg | Detected      | 0.442|
| 14. | curveLeft (14).jpg | False Feature | 0.484|
| 15. | curveLeft (15).jpg | Detected      | 0.317|
| 16. | curveLeft (16).jpg | Detected      | 0.364|
| 17. | curveLeft (17).jpg | False Feature | 0.539|
| 18. | curveLeft (18).jpg | Detected      | 0.329|
| 19. | curveLeft (19).jpg | Detected      | 0.522|
To calculate the accuracy of the test, we use the following equation:

\[
\text{Accuracy} = \frac{\text{Detected Features}}{\text{All Tested Data}} \times 100\%
\]

The accuracy of the test results in Table 1 & Table 2 can be seen in Table 3.

| No. | Curve Sign Type   | Number of Data | Number of Correct Detected | Accuracy | Detection Time (Second) |
|-----|-------------------|----------------|---------------------------|----------|------------------------|
| 1   | Curve to Right    | 45             | 35                        | 77.78%   | 0.392                  |
| 2   | Curve to Left     | 45             | 34                        | 75.56%   | 0.431                  |

Average Accuracy = \[
\frac{(35 + 34)}{90} \times 100\% = 76.67\%
\]
5. Conclusion and Future Work
Regarding to some related conducted researches, for case of traffic sign detection, SURF algorithm can not independently role in the detection process, it needs to be accompanied by other methods / algorithms as the initial process such as shape detection or region interest detection. By using only feature detection, detection towards the curve traffic sign produces a fairly low accuracy with an average of 76.67%, in order that, the next work is to add a shape detection method where the curve traffic signs have a distinctive and special shape, so that is expected to increase the accuracy of detection. In addition, will be conducted a Development of Mobile Apps that will detect the Curve Traffic Sign image to give an alert to the drivers.

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