Combining Multiple Feature for Robust Traffic Sign Detection

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***Abstract*—Traffic sign detection and recognition as one of the digital image processing areas has been conducted in many researches for improving the safety of driver and even make driver more comfort. Many driver are inattentive and underestimate the traffic signs on the road that affect their safety. So that this system can serve as a warning in driving on the highway. In this paper, we apply our proposed method for the detection and recognition of traffic sign. In the detection process is performed by using a method based on color, considering signs have differences with the other objects in terms of color. While in phase of recognition, our approach consist of 3 main schema. To strengthen the recognition process, we implement corner detection using Harris method (HCD), we also implement edge detection using Canny method, and comparing pixel ratio for each traffic sign. All of these schema series were used for feature extraction and the feature data matching using K Nearest Neighbor (KNN). From the experiment by using our proposed method improve the accuracy significantly reach to 90.85 % and also speed up the computational times.**

***Index Terms*—traffic sign, Harris corner, edge detection, pixel ratio, KNN**

I. Introduction

Object detection and recognition is one of digital image processing field that can be applied in transportation area such as detecting and recognizing traffic sign. Traffic sign is component of road traffic in form of symbol, number, letter, or the combination of them, as a prohibition, warning, instruction, or guidance for the road users Traffic sign as a tool to support the orderliness in transportation consist of many kinds of traffic sign. But people often don't have appropriate knowledge relate to the traffic sign. In addition, people underestimate the traffic signs while on the highway that can harm driver and other road users. Therefore, the system of traffic sign recognition is indispensable in hopes to facilitate driver and can serve as a warning system.

Some previous research has conducted methods for traffic detection and recognition. Three categories of traffic sign detection were discussed in [1], those are color-based, shape-based and learning-based detection method. An overview of the state of sign detection process which has been split into segmentation, feature extraction, and detection [2]. While [3] used modern variants of HOG features for detection and sparse representations for classification. Road sign detection and recognition using matching pursuit method [4].

Previous research proposed the candidate regions of traffic symbols are detected as MSERs and recognized using HOG features and cascade of linear SVM classifiers [5]. This traffic sign recognition has said that implement in UK. It also considers that method based on cascade classifier need high computational time.

Our proposed method uses a different approach that can implement in Indonesia. In detection process, we determine the traffic sign region based on color. As we can see the traffic sign generally and applicable in Indonesia, it contains red color domain for forbidding sign and blue color domain for command sign. So the approaching method based on color is appropriate, relatively fast, and has been widely used.

In recognition process, our proposed method implements 3 feature all at once for the recognition of traffic sign, during the matching process using K Nearest Neighbor. These feature extraction involve of Harris Corner Detection (HCD), Canny edge detection, and comparing the pixel ratio. HCD will detect corners area on signs that are considered important to differentiate among the other signs. In this case, the threshold determination also affect the number of corners are detected. Canny edge detection method will reinforce the process of recognition where the edge characteristics of each sign must be different and can be easily identified. The last feature is comparing pixel ratio. The colors on the prohibition signs composed of red, white as a background, and black as the icon of the traffic signs. Black color pixels have the variety of shapes and size that can be compared with white background to produce an average feature pixel ratio. As well as, it also applies to the command traffic signs, consisting of blue and white by comparing the number of pixels of the two colors.

In Indonesia, traffic signs are categorized into four types, which are: warning signs, forbidding signs, command signs, and direction sign shows in Fig. 1. In this paper, we only focus on the traffic signs with round shape in forbidding signs and command signs. While, we will explain the traffic sign detection and recognition method in Section II, result and discussion shows in Section III, and the conclusion of our research in Section IV.

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Figure 1. The official traffic signs in Indonesia (Transportation Ministry of Indonesia, 1993)

II. Proposed Method

The proposed system consist of detection phase based on color, and recognition phase based on 3 feature extraction obtained from HCD, Canny Edge detection, and pixel ratio comparing. These feature use for traffic sign matching performed by K-Nearest Neighbor. The block diagram shown in Fig. 2 can explain our system:

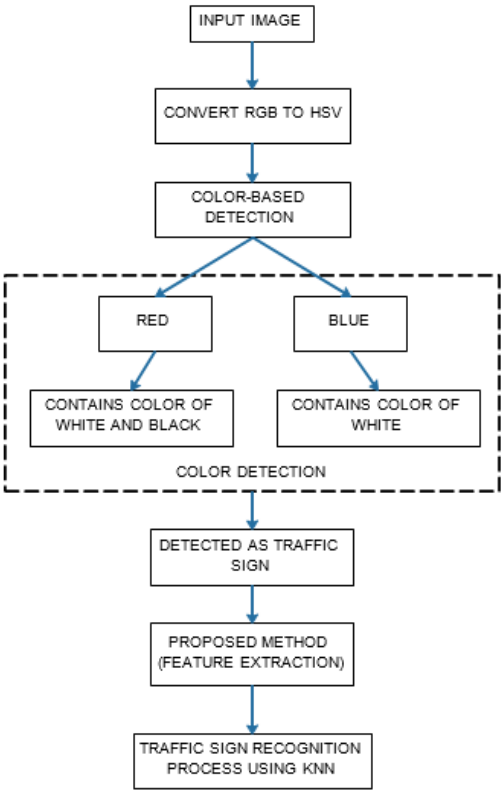


Figure 2. Block diagram for proposed method

A. HSV Color Representation

In real time traffic sign detection based on color, the process of color segmentation easier on HSV model. The R, G, and B components of an object's color in a digital image are all correlated with the amount of light hitting the object. By using HSV model, it separates color information (chroma) from intensity or lighting (luma). Because value is separated, you can construct a histogram or thresholding rules using only saturation and hue. This in theory will work regardless of lighting changes in the value channel. In practice it is just a nice improvement. Even by singling out only the hue you still have a very meaningful representation of the base color that will likely work much better than RGB. The end result is a more robust color thresholding over simpler parameters.

The input image in RGB color space representation has to be converted into HSV color space representation. For detect the region of forbidding sign, Hue, Saturation, and Value for lower red color set into (0, 50, 50) and (180, 255, 255) for upper level of red color. For detect the region of command sign Hue, Saturation, and Value for lower blue color set into (110, 50, 50) and (130, 255, 255) for upper level of blue color.

The R, G, B values are divided by 255 to change the range from 0 until 255 to 0 until 1 and result R', G', B'. RGB to HSV convertion can describe in formula calculation below:

$$H = \begin{cases} 60°x\left(\frac{G'-B'}{\Delta} \bmod 6\right), C_{max} = R' \\ 60°x\left(\frac{B'-R'}{\Delta} + 2\right), C_{max} = G' \\ 60°x\left(\frac{R'-G'}{\Delta} + 4\right), C_{max} = B' \end{cases} \quad (1)$$

Saturation Calculation:

$$S = \begin{cases} 0, C_{max} = 0 \\ \frac{\Delta}{C_{max}}, C_{max} \neq 0 \end{cases} \quad (2)$$

Value calculation:

$$V = C_{max} \quad (3)$$

where $C_{max} = \max(R'G'B')$, $C_{min} = \min(R'G'B')$, $\Delta = C_{max} - C_{min}$

B. Color Detection

Every forbidding traffic sign contains red and white, or black color. So, when detecting a traffic sign, the system will detect the color in input image. When it comes to detect red color, it will switch to one side of detection. And the system will continue to seek whether the image contains white or black color. If the image truly contains those particular color, than the image is detected as a traffic sign.

As well as forbidding sign, the command sign will be detect based on color in input image. When it detects blue color, it will seek whether the image contains the white color or not. If the image also contains the white color, then it is also detected as a traffic sign. In this case, for best red color detection, we set the range of lower red or blue color and the upper red or blue color in HSV.

C. Feature Extraction

After detection process, the next step will be process of traffic sign recognition. To recognize the type of traffic sign, the system needs to ascertain the special features on data training process, so the system may be able to differentiate one traffic sign to the others.

In this research, there are 3 approaches in order to get features used to strengthen the process of traffic sign recognition, those are corner feature, edges feature, and comparing the amount of black pixel to white pixel. The following chapter will describe the details of the features used in this system.

1) Corner detection

One of the main characteristic of traffic sign is the various shape that can be identified by the angular shape of traffic sign image. Physically, the combination and intersection of points may generate the form of an image. So does the form of traffic sign, it is formed from the connection between those points and intersection. So we have the process of corner detection of the image to get the correlation of some images that have same object. There are some corner detection methods have been developed, such as FAST [6].

In this paper, we apply Harris corner detection that was done by Chris Harris & Mike Stephens in 1988. HCD is on of interest point detection method which is quiet popular because it can detect corner in stable by rotation, scale and exposure [7]. The Harris operator is also very sensitive to the noise in an image [8].

```
read image
set img_hsv = convert image from rgb to hsv

set lower_red = array [hsv of lower red]
set upper red = array [hsv of upper red]

set red = range of img_hsv from lower_red
  to upper_red
set res = bitwise (image, mask=red)
set cont = find countours(red)

for all img_contour in cont do
  area  = contour area of img_contour
  if area >200
then set sign = img_countour
j,k,l,m = bounding (sign)
set FoundWhite = false
set FoundBlack = false
for x = j to l do
   for y = k to m do
      set px = image [x][y]
   end for
      if each blue, green, red of px> 230
         then set FoundWhite = true
      end if
      if each blue, green, red of px< 40
         then set FoundBlack = true
      end if
end for
if FoundWhite = true and
   FoundBlack = true
    then draw rectangle in image from (j,k)
    to (j+l, k+m)
end if
```

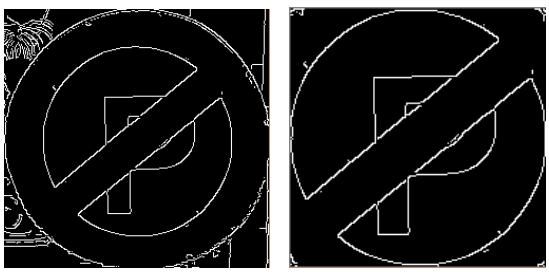
In this case, the corner detection is being held on the shape of the letter on traffic sign, not on the red or white colour part of the traffic sign. The count number of corners from the result of corner detection is used as training data features and compared to the testing data. (Fig. 3)

Figure 3. Corner detection using Harris method in forbidding and command traffic sign

2) Canny edge detection

In addition to corner detection, we also use the edge detection as one of the features. There are some famous edge detection methods, but in this research we use canny edge detection. Canny edge detection is one of the modern edge detection algorithm that has good capability of detection and localization, and also clear response [9].

With this method, we may get result in the form of edge of each traffic sign. As well as the corner features, this feature generates significant image edge differences from each traffic signs. For reduce the noise of background edge, we minimizing the region into white contours, then we calculate the non-zero (white) pixel, the result is shown in Fig. 4.



(a) (b)

Figure 4. Edge detection in red circle region (a) contains background edge and (b) edge detection in white circle region reduce unused edge

D. Comparing Pixel Ratio

Every shape both of forbidding and command traffic sign has significant difference. This difference can be seen from the number of black pixels in the character contained in traffic sign, and from the number of white pixels contained in background in forbidding sign. For commands sign, the number of white pixels in the character contained in traffic sign, compared with the number of blue pixels contained in background.

For example, -in plain view- No-Parking forbidding sign, that has letter P on, has smaller number letter area compared to letter area contained in Stop forbidding sign, that has letter S on. Then, this letter area is represented in black pixel form, and the white pixel area as background generating an average value of those pixels colors. This process is performed only on the positive object that is the detected traffic sign, and it does not involve the other negative object, such as the view around the traffic sign.

$$Forbidding\ Sign = \frac{\sum BlackPixel}{\sum WhitePixel} \tag{4}$$

$$Command\ Sign = \frac{\sum WhitePixel}{\sum BluePixel} \tag{5}$$

E. Traffic Sign Recognition

We use the k-Nearest Neighbor (KNN) classification, which is a method for classifying objects based on closest training examples in the feature space. K-nearest neighbor algorithm is among the simplest of all machine learning algorithms. Training process for this algorithm only consists of storing feature vectors and labels of the training images. In the classification process, the unlabelled query point is simply assign to the label of its k nearest neighbors.

In this research, training process is done on image datasets that have been collected and taken from streets around Malang city. Training process generates three types of features described before. We classify the traffic sign into some classes according to the name and the type of the traffic signs. Fig. 5 shows the block diagram of traffic sign recognition using K Nearest Neighbor of our method.

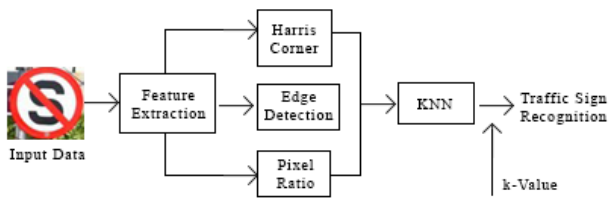


Figure 5. Block diagram of traffic sign recognition using k nearest neighbor

While data testing, the matching process is done by calculating the Euclidean distance of the traffic sign data testing feature value compared to the data training feature value. The distance function calculation for KNN is using the Euclidean distance described in Formula (6).

$$D(a,b) = \sqrt{\sum_{k=1}^{d} \left(a_k - b_k\right)^2} \tag{6}$$

where $D(a, b)$ is the scalar distance of two vectors a and b of the matrix size D dimension.

The results of Euclidean Distance calculation are sorted from the smallest distance value to the largest one.

Typically the testing object is classified based on the labels of its k nearest neighbors by majority vote. Based on the k value, with regard to the value of Euclidean Distance to the nearest distance and number of obtained majority class, the data testing is classified as the class of the object/sign traffic nearest to it. This matching process done by OpenCV in Python. The scheme of traffic sign recognition using KNN shown in Fig. 6.

Figure 6. Some of experimental result from (a) forbidding sign, (b) command sign

III. Result and Discussion

F. Result and Discussion

To test the proposed method that have been created, it was done by testing the system on a highway in Malang city, using a webcam with 100 x 100 resolution in realtime. Collected training dataset consist of 30 until 50 data. As a limitation, this test is performed in the morning or afternoon which means have a good lighting. Each data that will be tested had undergone a process of scaling by 280 pixel height and adjust width of the image. This experiment is implemented on an Intel Core i5-5200U processor 2,7GHz using Python 2.7 with OpenCV.

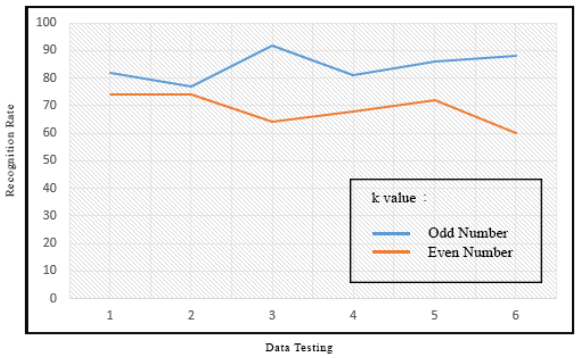


Figure 7. Recognition rate response with difference k value

The following Fig. 6 shows the results of our proposed method and Fig. 7 shows recognition rate response with difference k value.

Before implement the proposed system, we consider that matching process using K-Nearest Neighbor depends of k value. In order to evaluate the algorithm, the following para-meters were tuned: from experiment, we determine k size = 3 for the best result.

Experimental result obtained from means of Recall and Precision [10]-[12], for evaluation the performance of our proposed system in traffic recognition. Recall and Precision define by the number of true positive (TP), false positive (FP), and false negative (FN). True positive means the traffic sign detected and correctly classified. False positive means, another object on background detected as a sign. And false negative means sign detected and wrong classified.

$$\text{Precision} = \frac{TP}{TP + FP} \tag{7}$$

$$\text{Recall} = \frac{TP}{TP + FN} \tag{8}$$

From the Table I, it can describe the difference of precision rate using our proposed method superior than SVM+HOG method. The Mirmehdi method generates more number of false detection and false recognition. Table II shows the accuracy of proposed method compared with SVM+HOG method.

TABLE I. THE COMPARISON RESULT OF PRECISION AND RECALL

SVM+HOG Method	Test 1	Test 2	Test 3	Test 4
Correct Detection	19	24	14	26
False Detection	11	6	16	4
Correct Recognition	12	20	13	15
False Recognition	7	4	1	11
Precision	52,17%	76,92%	44,82%	78,94
Recall	63,15%	83,33%	92,85%	57,69
Proposed System	Test 1	Test 2	Test 3	Test 4
Correct Detection	18	26	17	28
False Detection	12	4	13	2
Correct Recognition	16	23	12	27
False Recognition	2	3	5	1
Precision	57,14%	85,18%	48%	93,1%
Recall	88,88%	88,46%	70,58%	96,42

TABLE II. THE COMPARISON OF ACCURACY

Method	Accuracy
SVM + HOG	88,21 %
Proposed System	90,85 %

IV. CONCLUSION

Increasing accuracy and minimizing error on traffic sign recognition process can be handled using the proposed system in this paper. Some of testing data with different angle also showing better recognition compared with the previous method. By using the scheme of three feature combination, the detection of traffic sign can be improved effectively, as well as the computation time can be improved. The drawback of this proposed method is come up with any different lighting condition of captured image. We also consider that the image of traffic sign sometimes not clearly in a good condition and there is a few noise. Some of traffic sign color was faded, even there is some scratch that can disrupt the recognition process. Thus for further research, it can improve the performance of image in different lighting condition and another approach for handling the noise of traffic sign image, in order to run more quickly and accurately.

CONFLICT OF INTEREST

The authors declare no conflict of interest for this work.

AUTHOR CONTRIBUTIONS

Renaldi P. Prasetya and Rizdania are supporting the data. Fitri Utaminingrum analyzed the data and wrote the paper. All authors had approved the final version.

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