Traffic Sign Recognition Application Using Speeded-Up Robust Features (SURF) and Support Vector Machine (SVM) Based On Android

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Abstract— **In this paper, design and implementation the feature extraction method of Speeded-Up Robust Features (SURF) and Support Vector Machine (SVM) classification method into the traffic signs recognition application. The output of this application is the meaning of the traffic sign with two languages, indonesia and english. In the SURF method, the smallest large number of keypoints will affect the accuracy level to recognize a image. Based on the results, accuracy of this traffic signs detection has a high accuracy rate of 96%, when taking this image right in the green box displayed on the smartphone screen and taken when the brightness level of the light on 4106 lux up to 10896 lux.**

Keywords--**Traffic Signs, Android, Speeded-Up Robust Features, Support Vector Machine**

I. INTRODUCTION

Traffic signs are one of the road equipment that may be symbols, letters, numbers, sentences or combinations of them that serve as warning, prohibitions, orders or directions for road users [1]. As road users, are supposed to obey any traffic signs on the road for shared security. For dicipline, we must first understand the meaning of traffic signs [1]. Various signs have many kinds such as warning signs, guidance signs, and instructions [1].

Many travellers not understand the meaning of traffic signs installed in the object of tourism, then in this final assignment utilizing an intelligent technology system and mobile applications. Therefore, in order for many tourists to know the meaning of traffic signs that exist, then in this final assignment utilize android mobile applications to translate the meaning of traffic signs images are available in two languages, english and indonesia.

In android mobile application, domestic and foreign tourists can take pictures of traffic signs that exist with the camera or from the gallery smartphone android to be translated in the form of English and Indonesian. To recognize the traffic signs, an image recognition pattern is needed using a feature extraction method called SURF by performing feature extraction on an image taken from a smartphone camera to search for a characteristic feature of an image. After that use SVM method as classification and machine learning in this application to find the match image in data training. With this android mobile application can travelers understand the meaning of traffic signs installed in the field of tourism.

II. DESIGN SYSTEM

This application has step by step to run. The step by step will be made as shown below :

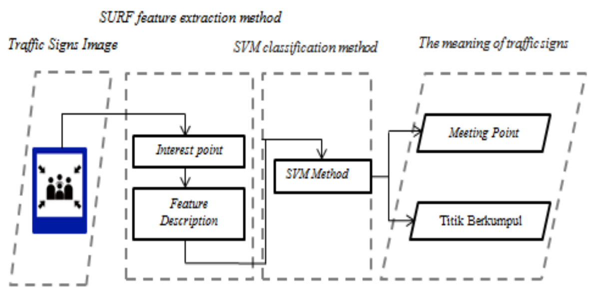

Fig. 1 Design System

For a general of the system, see Fig. 1 above. At the beginning of the system, we input the traffic signs image with the format (.png) or (.jpeg). Then go directly to the extraction process of image characteristics using SURF method which consists of two processes, namely the interest point and feature description to make an introduction to the image and get the descriptor value. Furthermore, the result of characteristic extraction of the value descriptor in the image will be trained and classified by machine learning, namely the Support Vector Machine SVM method. The output generated by this application is an information text from the meaning of this traffic signs image.There are three main parts of the process in the system, namely acquisition, feature extraction, and image classification

In this subsystem, images or images that will be input there in two ways, namely taking pictures directly by using a smartphone camera and by taking pictures that are already available in the smartphone gallery. All processed images have jpeg or .png formats

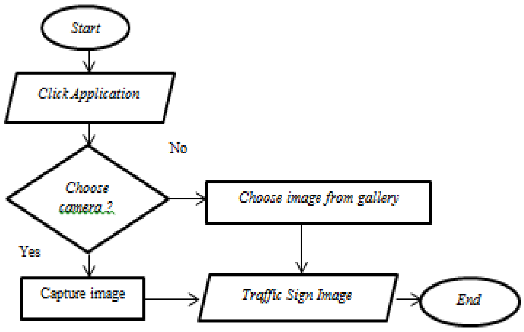

Fig. 3 Image Acquisition

See Fig. 2 above on image acquisition, for input can be done two steps, that first can be done by taking a picture of the image with the available smartphone camera and take picture signs available in the smartphone gallery.

The next stage is the retrieval of important information in the form of a feature on an image. The purpose at this stage is to retrieve some important information from an image in the form of keypoint and value descriptor. The feature extraction method used is SURF.

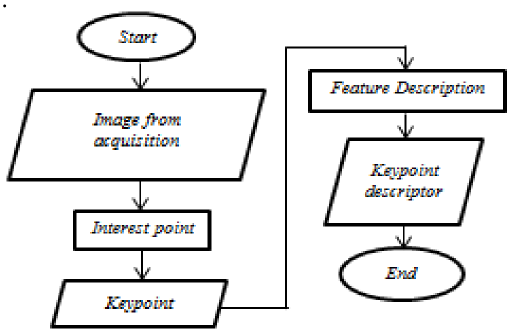

Fig. 2 SURF Extraction

See Fig. 3 above, when the image can be from the camera or smartphone gallery it will go directly to the extraction method SURF feature. The first step in this method, which is looking for value point of interest to get a keypoint of the image. After obtaining a keypoint, then the value of keypoint will go into feature description stage. At this step the value of each keypoint will change to a float value of 64 columns long. So it becomes 1 x 64. Each keypoint has a value with 1 row with 64 matrix columns..

In the next step, the classification step. Here use the SVM calcification. The purpose of SVM here is to data training and get the hypothesis of the best separator (hyperplane)

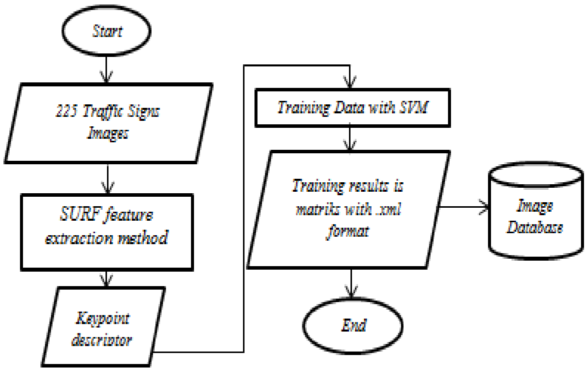

Fig. 4 Training Image

In Fig. 4 above is a flow chart of SVM to data training. When getting the descriptor value of each traffic signs image from the feature extraction step, it will then go into the SVM method. In this SVM a descriptor value will be trained to be classified. The result of this data training is a matrix that has an .xml format. This format can be loaded in android studio.

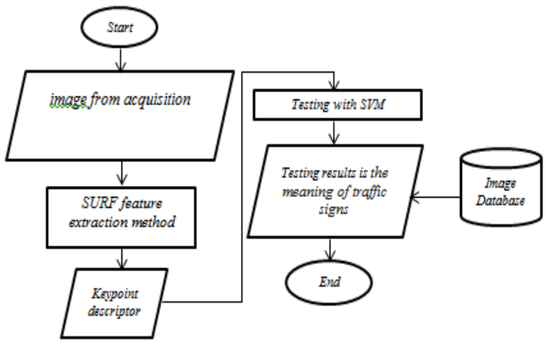

Fig. 5 Testing Image

After getting the result of data training with .xml format. Then the next step, go into the data testing like Fig. 5. At the start of the test phase, capture traffic signs from your camera or smartphone gallery. When the image in can, then go into the feature extraction process with SURF method to get a keypoint and descriptor value of an image. When it has got the descriptor value of an image, then the value of the descriptor will be tested by doing SVM method. Testing is done by testing the value of test data descriptor with value of descriptor already in train in SVM. When the test data gets hyperplane in the data training, then the application will give information about the meaning of a traffic signs image.

III. EXPERIMENT RESULTS AND ANALYSIS

In this testing scenario consists of two components, the parameters of training data used and the successful detection of traffic sign using smartphone camera. This test input is a traffic sign image in the format (.png) or (.jpeg).

This experiment, we can do to know and understand the parameters that must be improved in order to improve application performance to be good and produce maximum output. The number of image signs used for testing as many as 25 images of traffic signs. The size is 50 cm x 40 cm and the height of the image of the beam is mounted as high as 175 cm from the ground level according to the reference of the Minister of Transportation Republic of Indonesia Regulation 2014 on Traffic Signs.

3.1 Effect of resolution and color for the data training

The first parameter is the smallest image keypoint gained. The purpose of this parameter is to detect and find the keypoint of each image. When the keypoint has been detected then the next search for the smallest signs keypoint of the data training as much as 225 images in the train, to be used as a reference to get into the SVM classification method. Data training used as much as 225 images data because in accordance with the test that is done as much as 225 images data has a high accuracy rate of 96%. The second is to see the size of the data in the data training. Next look for accuracy level of image detection. The accuracy level here is measured by testing different images with the data training. And last, that is calculate the time when the beginning of the detection of the image of the signs to exit the meaning of the traffic signs image. The following tests are done based on the difference of image:

Table 1. Results of Image Resolution Original Image

Parameter	***Keypoint image minimum***	***Size of Data Training* (KB)**	***Accuracy* (%)**	***Computing time of SURF* (s)**
***Resolution* (pixels)**				
60 x 48	1	395	60	0.76
120 x 96	18	6230	92	5.53
240 x 192	71	24422	96	15.28
500 x 400	255	87570	96	52.83

Based on the results of Table 1 above, it can be concluded the data used data training, the resolution of 500 pixels x 400 pixels. This resolution is selected, because it has the smallest large keypoint signs among other resolutions. This largest smallest image keypoint is very important and influential to be used as a reference for entry into the SVM classification method. Although the size of its data is very large and computing a long time, but has a high level of accuracy to be used as data train test data.

In this testing, the same as testing the data with the original image. In this testing, we will test the data with grayscale image. The purpose of grayscale image is the image that has a degree of gray. So that its initial RGB image or original image will be converted into gray image.

Table 2. Results of Image Resolution Grayscale Image

Parameter	***Keypoint image minimuum***	***Size of Data Training* (KB)**	***Accuracy* (%)**	***Computing time of SURF* (s)**
***Resolution* (pixels)**				
60 x 48	1	395	68	0.73
120 x 96	21	7260	92	2.92
240 x 192	67	23049	96	10.75
500 x 400	251	86197	96	43.68

Based on the results of Table 2 above, the best resolution is the resolution of 500 pixels x 400 pixels with the smallest 251 keypoints signs than others, although having a large amount of training data and computing time. Compared with the test results with the original image data, the data with grayscale image is not used, because it has the smallest image keypoint is too small compared to the original image data so it has a low accuracy detection rate compared to the original image.

In this last testing, the same as testing the data with the original image and grayscale image. The difference in its image. In this testing, we will test the data with thresholding image. The purpose of this threshold image is a black and white image that only has black or white. Usually referred to as binary image.

Table 3. Results of Image Resolution Thresholding Image

Parameter	***Keypoint image minimum***	***Size of Data Training* (KB)**	***Accuracy* (%)**	***Computing time of SURF* (s)**
***Resolution* (pixels)**				
60 x 48	1	394	48	0.64
120 x 96	14	4857	84	2.52
240 x 192	30	10347	88	8.77
500 x 400	154	52770	88	39.09

Based on the results of Table 3 above, the best resolution is a resolution of 500 pixels x 400 pixels with the keypoint of the smallest signs and has a high level of accuracy, although it has a large amount of training data and computing time.

See from the 3 image data above, the best data is the data with the original image, although the data has a long computation and has a large data train size, but the data with the original image has a very high accuracy. This very high accuracy is influenced by the SURF feature extraction method which produces the smallest number of keypoint signs, because the larger the image resolution the smallest beam keypoint is also large as well, so the better the data is trained by SVM to be tested.

3.2 The amount of training data used

In this test, which is testing to get the amount of data to be trained to get the high accuracy of traffic mark detection accuracy. The amount of data for each used beam 3, 6, and 9 images. So the training data we tested as much as 75, 150, and 225 images. From the test, it will get the keypoint results of the smallest signs, the size of train data, the accuracy of traffic signs detection, and the computation time of SURF.

Table 4. Results of Accuracy Training Image

Parameter	*Keypoint image minimum*	*Size of Data Training (KB)*	*Acuracy (%)*	*Computing time of SURF (s)*
Amount of Data Training				
75	255	10503	4	15.16
150	255	39695	4	27.38
225	255	87570	96	52.83

In the results of Table 4 above, we can conclude that the smallest keypoint signs are obtained equal 255. Which becomes different, the size of the data training, the accuracy of traffic signs detection, and the computation time of SURF. Based on the results above, then the amount of data that is to be used to train data that is as much as 225 data. The number of 225 data is chosen because it is very high level of accuracy compared to the number of other data, although the size of data training will be greater and the longer SURF computation time. But to be data training required a high level of accuracy so that later when tested will be successful and can detect the image of expected traffic sign. So based on the above test can be concluded the amount of data training used is 225 data traffic signs image.

3.3 Accuracy of image detection against angle of capture

In this test is implemented in android smartphone. In this test, the position when take the image of a beacon by using a smartphone is very concerned for testing. This test to determine the level of accuracy of test data taken through camera smartphone with various positions and angles are determined when taking the image of traffic signs.

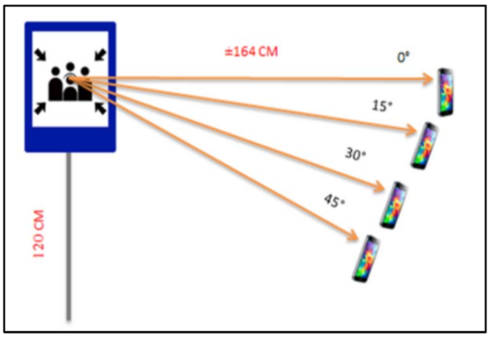

Fig. 6 Image Taking Position from the Bottom

In accordance with Fig. 6 above, the parameters used are the position when taking from the bottom by measuring the angle when taking the image of traffic signs. So in this test we will test the image taken from under the object with the angle of 15, 30, and 45 degrees.

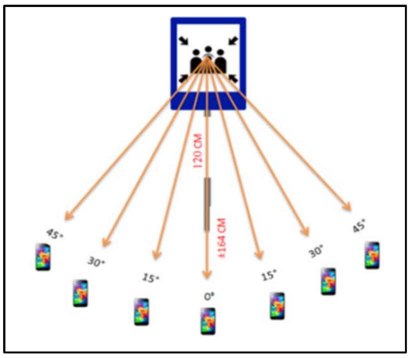

Fig. 7 Image Taking Position from the Right and Left

According to Fig. 7 above, the parameters used are the position when taking from the right or from the left object by measuring the angle while taking the image of traffic signs with the angle of 0.15, 30, and 45 degrees. This image retrieval is taken with an ideal distance of ± 164 cm, which takes the right image in the green box available on the smartphone screen. The number of true image detection is here for the correct image accuracy of 25 different traffic signs image. For accuracy level, that is measure the accuracy level of detection success of images with various angle of taking taken.

Table 5. Results of Accuracy Detection Against The Position of The Angle

	Angle of Traffic Signs Taking(°)									
	Bottom			*C*	*Right*			*Left*		
	15	**30**	**45**	**0**	**15**	**30**	**45**	**15**	**30**	**45**
True Data Image	24	22	17	24	23	20	14	23	20	13
Accuracy (%)	96	88	68	96	92	80	56	92	80	52

Information :
Bottom = Taking image from the bottom.
C = Taking image from the center.
Right = Taking image from the right.
Left = Taking image from the left.
0° = Taking image from the 0 degrees.
15° = Taking image from the 15 degrees.
30° = Taking image from the 30 degrees.
45° = Taking image from the 45 degrees.

From Table 5 above, we can see the results from various positions in the middle corner 0 degrees to produce a high degree of accuracy, although there are still undetected. Based on the above, the level of accuracy when the image is taken from the bottom, the angle of taking 15 degrees has an accuracy of 96%, the angle of 30 degrees has an accuracy of 88%, and the angle of 45 degrees has a 68% accuracy rate. For the angle of taking from the right side of the object, it can be seen that the 15 degree angle has 92% accuracy, the 30 degree angle has 80% accuracy, and 45 degree angle has 56% accuracy. As for the angle of retrieval from the left side of the object, it can be seen that the 15 degree angle has 92% accuracy, the 30 degree angle has 80% accuracy, and the 45 degree angle has an accuracy of 52%.

So, can conclusion, the angle that has a high accuracy, ie the position of the traffic signs capture image right in the middle 0 degrees with 96%. This is due to the position when taking the image right in the middle of the object, the image of the beacon right in the green box that is on the smartphone screen, so lets can detect correctly. The angle of retrieval that has a low level of accuracy that is from the left side of the image object with 45 degrees of 52%. This is also because the retrieval is too tilted against the object so it is difficult to detect traffic signs. So this application runs well when taking the right image in the position 0 degrees or right in the green box displayed on the smartphone screen.

3.4 Accuracy of image detection againts light effect

The next testing process is testing against the effect of light when detecting traffic signs using a smartphone camera. In this test, the influence of light used into two conditions, namely when the light in the morning to daylight and light during the night.

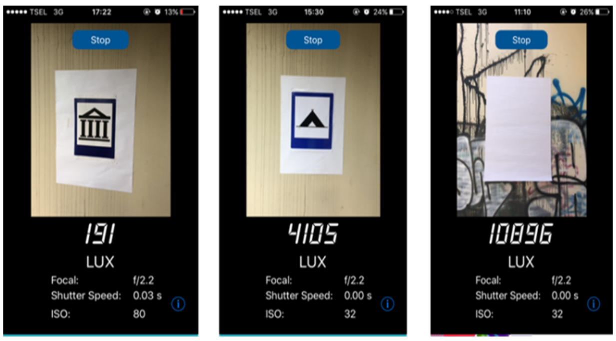

Fig. 8 Size of Brightness Level of Light

According to Fig. 8 above, the intent of light moment in the morning until afternoon, namely the influence of light on the image of signs. The unit to measure the brightness of a light here is to use lux. lux is the metric unit of light measure on a surface. Measure this by using an android app called light meter. This light meter is an application to measure the brightness level of a light somewhere with light sensor on android smartphone. This application has a maximum error rate of 5%. Here the brightness level parameter of a used light there are two conditions that is the first condition when taking traffic signs images starting from 9 am to 12.30 pm with 4106 lux to 10896 lux. For the second condition can be started to take the image of traffic signs from 4 pm to 6 pm with a range of 191 lux up to 4105 lux.

This test position is taken from the position of the middle angle 0 degrees because according to the previous test, the position of the angle of 0 degrees or right on the green box on this screen has a high level of accuracy detection of traffic signs. This test is conducted to determine how the influence of light on the detection of traffic signs. The effect of light is very important to detect the image of the beacon, because the light here determines the detected keypoint.

Table 6. Results of Image Detection Against Light Intensity

	***Brightness Level of Light* (lux)**	
	4106 – 10896	**191 - 4105**
True Data Image	24	22
Accuracy (%)	96	88

From Table 6 above can be seen, the accuracy level of traffic signs detection when the range 4106 lux to 10896 lux has 96% accuracy. As for the success of traffic signs detection when 191 lux up to 4105 lux has an accuracy of 88%.

From the above test results, can be seen that the accuracy of the success of traffic signs detection image has a high level of accuracy when taken when 4106 lux up to 10896 lux. And when in the range 191 to 4105 lux, the keypoint of each image is too few and hard to classify in training image. So it can be concluded that this application runs properly and maximally when the brightness level of light on the traffic beacon image is on 4106 lux up to 10896 lux.

3.5 Accuracy of image detection againts distance taken

The next test is to test the effect of distance to the detection of traffic signs. In this testing, the distance conditions are divided into three conditions, namely the distance of the close to the image of the beacon, the ideal distance to the image retrieval, and the distance taken away from the image signs. This distance measurement is based on the green box in the smartphone camera. Created a green box in this camera is also very important for the detection of this traffic signs image. So that the background outside the green box will be removed and only remaining images in the green box with the size of 500 pixels x 400 pixels.

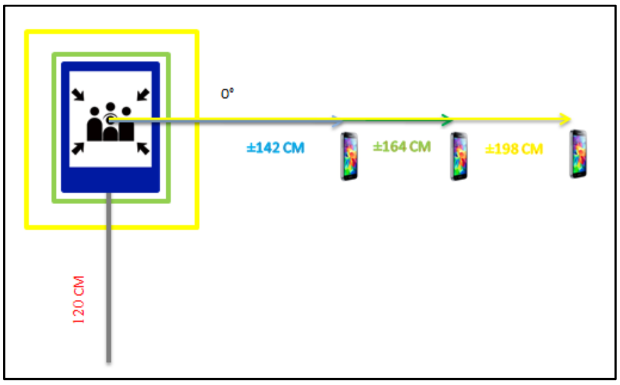

Fig. 9. Distance Takes Image

From Fig. 9 above, the distance of the close proximity of the image of the beacon, the traffic signs image capture is too entered into the green box or the image of the signs can be taken with a distance of approximately 142 cm. Ideal distance to image retrieval, ie the image of this traffic sign is located in the green box or the image of the signscan be taken at a distance of approximately 164 cm. Finally, the distance taken away from the image of the signs, traffic signs image taken with the background behind or image signs can be taken with a distance of approximately 198 cm so that the background of the image signs also took to take. The purpose of this test is to determine the accuracy level of traffic beacon detection when image taking is influenced by different distance.

Table 7. Results of Level of Detection Accuracy Against distance

	***Distance capture image* (cm)**		
	±142	**±164**	**±198**
True Data Image	20	24	18
***Accuracy* (%)**	80	96	72

From Table 7 above, the level of accuracy of success for the detection of traffic signs when the distance of approximately 142 cm has an accuracy of 80%. For taking with a distance of approximately 164 cm, has an accuracy of 96%. And when taking with a distance of approximately 198 cm, has an accuracy of 72%.

Based on Table 7 above, it can be seen that the application is running well when taking traffic sign images with a distance of approximately 164 cm or the ideal distance when the right image is on the green box displayed on the screen because it has a very high accuracy rate of 96%. This is because the more precisely we take the image of traffic signs in the green box, the better and accurate the keypoints in the can so get the traffic signs detection image that has a high degree of accuracy

3.6 Testing Performance

This test is performed to compare application perfomance when in use in different types of smartphones. The parameters used are the android smartphone version, smartphone processor, smartphone RAM, and the current time of computing on the smartphone

Table 8. Results of System Response Time

No	***Smartphone Device***	***Android Version***	***Processor* (GHz)**	**RAM (GB)**	***Computing Time of SURF* (s)**
1	*Smartphone* 1	Kitkat (4.4)	1.2 Quad-Core	2	6.43
2	*Smartphone* 2	Lolipop (5.1)	1.3 Quad-Core	2	5.78
3	*Smartphone* 3	Marsmallow (6.1)	2.5 Quad-Core	2	3.98

Based on Table 8 above, it can be seen the application runs well and fast when using a device that has a Quad-Core 2.5 GHz processor, has a Marsmallow android version (6.1) with image detection time for 3.98 seconds. The larger the processor used and has the latest android version, the faster the time required for the detection of traffic signs.

IV. CONCLUSION

From the results of testing and analysis in the previous chapter, it can be concluded accuracy of this traffic signs detection has a high accuracy rate of 96%, when taking this image right in the green box displayed on the smartphone screen and taken when the brightness level of the light on 4106 lux up to 10896 lux. In the SURF method, the smallest number of large keypoints greatly affects the accuracy to recognize a signs image. The larger the resolution, the higher the number of keypoint detected and the greater the accuracy in the can, although for the size of the data training very large and long computing time.

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