# The Recognition Of Semaphore Letter Code Using Haar Wavelet And Euclidean Function

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***Abstract*— Semaphore are one way of communicating over long distances using the semaphore flags. In Indonesia semaphore is used in scout activities as a method to send information in the form of a sentence containing the message. Sending the semaphore letter code tends to be difficult. Based on the need to semaphore learning, this research proposes an algorithm with image processing as a way to correct the movement of the semaphore letter code based on the image obtained by using the webcam. Digital image processing, Wavelet feature extraction, and Euclidean distance function are applied in this study to determine the best recognition rate of variation decimation and distance variation to sending semaphore letter code using the webcam. This study resulted in the best recognition rate of 95.4% in the 1st decimation, recognition rate reached 94.6% in decimation 2, and recognition rate reached 94.2% in decimation 3. The result of the introduction of the semaphore letter code is on the introduction of movement as far as 3 to 5 meters.***

***Keywords*— Semaphore Flag, Image Processing, Haar Wavelet, Euclidean Function, and Decimation.**

## I. INTRODUCTION

Semaphore is one of many ways to communicate over long distances using semaphore flags measuring 45 cm x 45 cm tied to a 60 cm stick [1]. In Indonesia has been applied as one of the skills that every individual must have in scout activities. To communicate with the semaphore, the flag is held in each hand then adjusted in a certain position as in Figure 1, to represent the letter that will be transmitted as a sentence of information. The semaphore flags used in Indonesia are generally red and yellow [2]. Sending information by using semaphore flags is commonly used in the maritime world as the delivery of information between ships, and also used in the scout world as sending the semaphore letter code [1] [3].

In practice to learn the semaphore movement a semaphore sender requires someone who can see whether the position of the sender is proper or not in delivering semaphore codes. This is very necessary because in each semaphore code delivery has a different position for each letter. Thus, this makes less effective learning of semaphore code if done by a single self.

Semaphore movement has been developed in the form of computer programs to be able to support learning the semaphore letter code in the scout world [5].

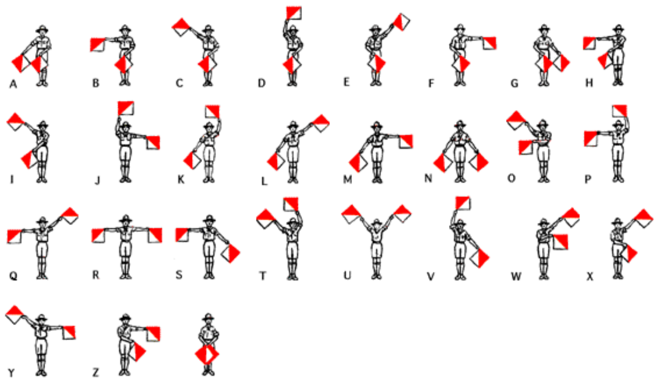


Fig 1. Movement of Semaphore Letter Code [4].

In a previous research [1], the introduction of letters using the Kinect tool with a maximum distance of 2.5 meters and yields a reading rate of 88% and has a weakness that is the length of time used to complete the introduction of letters. Research conducted by [6], semaphore readings obtained a recognition rate of 90% and had constrains in terms of angular readings due to different physical shapes of the sender. Research [5] has succeeded in making computer applications that can help the introduction of the semaphore letters, a weakness in this system is the absence of an instructor role to guide users on using semaphores.

The application of elements of practical and appropriate technology is needed as a supporter as well as an effective solution in solving the problems above, and one of them is by using image processing. Image processing is a generic term for various techniques whose existence is to manipulate and modify images in different ways [7]. The processing of two-dimensional images via a digital computer [8]. Image processing, among others, plays a role in separating the object from the background [9]. The system which will be created can mimic the ability of the human eye to recognize objects in the form of a movement of code delivery that will help humans in learning the delivery as well as receive the semaphore letter code. It can help the user know whether the movement is done right or less precise.

Tests in this study will use variations of distance: 3 meters, 3.5 meters, 4 meters, 4.5 meters and 5 meters and variations of decimation: (1) 32 x 32, (2) 16 x 16, and (3) 8 x 8. This research requires some supporting tools such as webcam [10] [11] which serves to capture motion picture of semaphore letter code, a laptop is then needed to serve as a place to process images to be recognizable so that the information can be delivered to users and software Matlab as a semaphore letter programming code [12] [13].

## II. Research Methods

This study uses variation of distance and decimation to know the effect on the introduction of semaphore letter code. The stages of the introduction phase of the semaphore letter code can be seen in Figure 2. The first process is semaphore letter code capturing using a laptop as a digital data processor machine. The captured image will then enter the preprocessing process and the output of this process will enter the self-extraction process using the Haar Wavelet. The result of the feature extraction will be compared with the data on the database by using the Euclidean. The output of the distance function will display the semaphore letter code on the monitor screen.

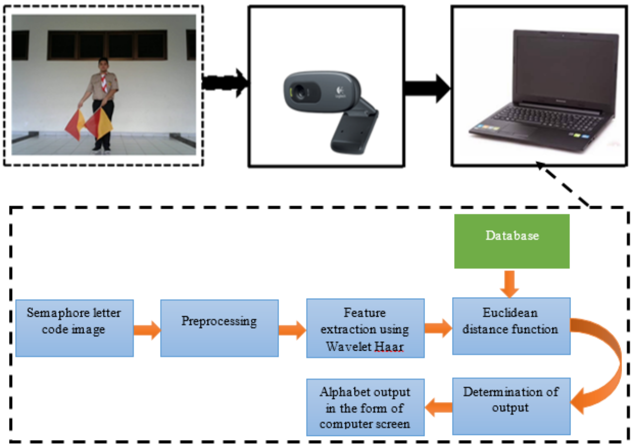



Fig 2. The Flow Diagram of The Semaphore Letter Recognition Process.

### A. Data Collecting

The total of used images for semaphore letters codes is 650 images. The images is obtained from 5 visuals, each of which displays the semaphore letter code from A to Z with variations of distance 3 meters, 3.5 meters, 4 meters, 4.5 meters and 5 meters. Each casted distance produces 26 images, so the images obtained from 1 view is 130 images. As many as 390 image data is used as a database and as many as 260 image data as test data.

### B. Preprocessing

Preprocessing an image is a process aimed to obtain objects contained within the image or to divide the image into several regions of each objects or region (that has) similarities [9]. The preprocessing step is started by converting the RGB image into a HSV image, continued by a process of colour segmentation on the image. The colour segmentation is done to achieve the yellow part of the image as it is on the semaphore flag. The next step is to "crop" and "resize" the image according to the image's size. The image processing step can be seen on Figure 3.

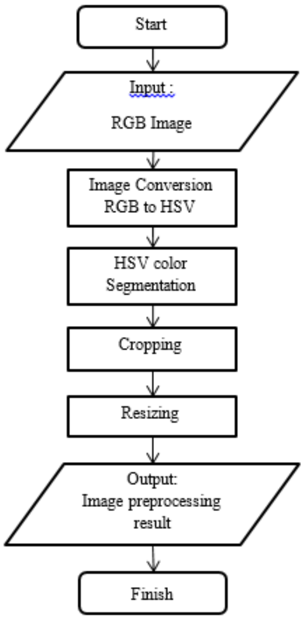
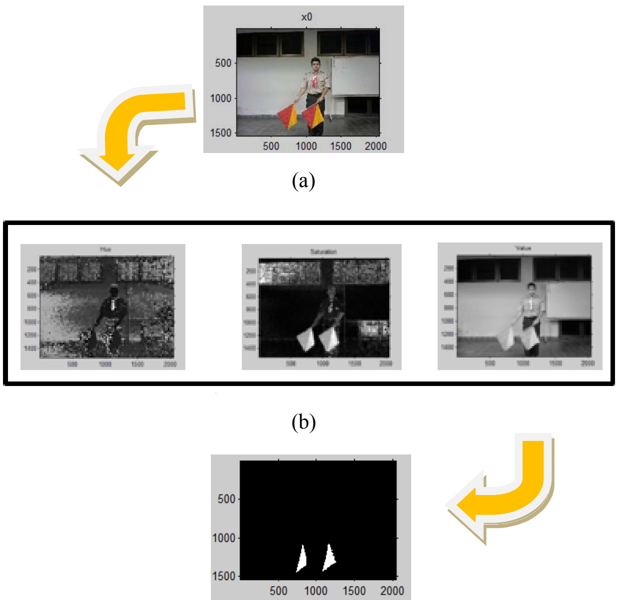



Fig 3. Flow Chart of Image Preprocessing.

Figure 4, shows the RGB image that has been obtained from the webcam will be converted to HSV image, then the image will be preprocessed to obtain the yellow color contained in the semaphore flag. To get the yellow color corresponding to the color on the semaphore flag, researchers used the color-range of the Hue scale of 35-50 on the color scale shown in Figure 5.




(a)

(b)

(c)

Fig 4. Image Segmentation Process to Yellow Color an Semaphore; (a) RGB Imagery; (b) Results of RGB to HSV Image Conversion; (c) The Image is a Yellow part of The Semaphore Flag.

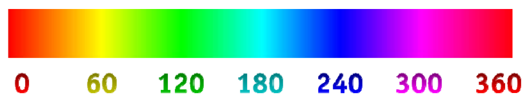



Fig 5. Hue Scale [14].

### C. Haar Wavelet

Wavelet is defined as a small wave or short wave. The Wavelet's transformation will convert a signal into a Wavelet sequence. The shortwave is a basic function that lies at different times [15], seen in Figure 6. *Haar Wavelet* is the simplest wavelet, introduced by Alfred Haar in 1909. The coefficient of transformation low pass filter (Eq. 1) and high pass filter (Eq. 2) are the base functions of Haar Wavelet. In the image, high pass filters and low pass filters can be represented as 2D matrices. The decomposition of flattening and substraction that has been done before is actually the same as doing the decomposition (transform) image with Haar Wavelet. Both filters are orthogonal but not orthonormal. The orthogonal and orthonormal tapis Haar are [16]:

$$h_0 = \left(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right) \tag{1}$$

$$h_1 = \left(\frac{1}{\sqrt{2}}, -\frac{1}{\sqrt{2}}\right) \tag{2}$$

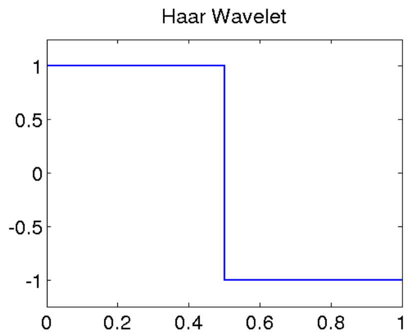



Fig 6. Haar Wavelet [17].

### D. Euclidean Distance

*Euclidean* distance is the most commonly used metric to calculate the similarity of 2 vectors. The smaller the value of Euclidean distance to an object, the higher the level of similarity. The Euclidean distance calculates the roots of squares of differences of 2 vectors [9]. The formula of the Euclidean distance.

$$j(v_1, v_2) = \sqrt{\sum_{k=1}^{N} \left(v_1(k) - v_2(k)\right)^2} \tag{3}$$

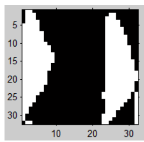
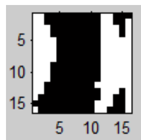
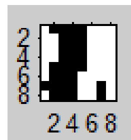
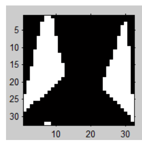
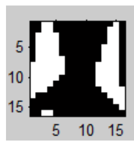
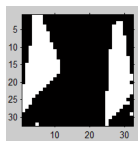
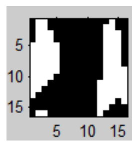
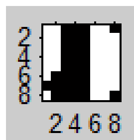
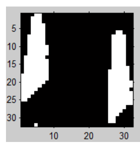
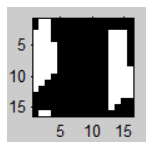
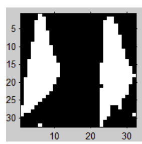
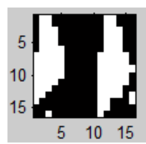
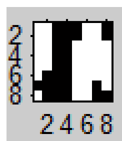
Where v1 and v2 are the two vectors whose distance will be calculated and N denotes the length of the vector. Distance function will find the difference of the minimum value between data from the self-extraction's output with the data on the database as an output from the recognition of the semaphore letter code.

## III. Result and Discussion

### A. Testing Using Haar Wavelet

Tests are conducted to determine the effect of distance variation and variation of the decimation on the success rate of introducing the semaphore letter code and to know the distance and the value of the decimation that has the optimal success rate. The A letter image on semaphore letter code with many variations of the distances and decimations can be seen on Table I.

TABLE I. THE IMAGE OF THE VARIATION OF DISTANCE TO THE VARIATION OF THE DECIMATION.

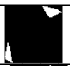
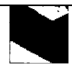
| Distance (m) | Decimation | | |
|---|---|---|---|
| | 32 X 32 | 16 X 16 | 8 X 8 |
| 3 |  |  |  |
| 3.5 |  |  |  |
| 4 |  |  |  |
| 4.5 |  |  |  |
| 5 |  |  |  |

It is seen that the greater the value of the decimation variation, the smaller the pixel level in the image, causing the image to break so that the recognition rate will be lower. The farther the distance is used, the lower the recognition rate. This is because the greater the value of the decimation variation, the decimation experiences repeated convolution and downsampling process as many as the users want, this process resulted in the inserted image to become more blur so that the level of recognition will be lower.

### B. Level of Recognition

At the level of recognition, as many as 260 test data that have been in the process when testing the data will be compared with the data stored in the database. Each value from the Euclidian function on different decimations and letters with the distance of 3.5 meters can be seen on Table II.

TABLE II. THE DISTANCE VALUE OF EACH LETTER IN THE VARIATION OF THE DECIMATION

| Alphabet | Alphabet Image | Decimation | | |
|---|---|---|---|---|
| | | 32 X 32 | 16 X 16 | 8 X 8 |
| A |  | 5.8813 | 3.1922 | 1.7176 |
| B |  | 13.0396 | 7.1204 | 4.01 |
| C |  | 14.0755 | 7.6714 | 4.3012 |
| D |  | 14.2471 | 7.6805 | 4.3417 |
| E |  | 14.308 | 7.9618 | 4.3566 |
| F |  | 14.5674 | 7.9912 | 4.4034 |
| G |  | 14.6888 | 8.0629 | 4.4553 |
| H |  | 14.8482 | 8.0889 | 4.4855 |
| I |  | 15.412 | 8.4178 | 4.7476 |
| J |  | 15.4522 | 8.5358 | 4.8693 |
| K |  | 15.5155 | 8.6081 | 4.8785 |
| L |  | 15.6003 | 8.6833 | 4.899 |
| M |  | 15.6407 | 8.7063 | 4.983 |
| N |  | 15.6761 | 8.7247 | 5.0259 |
| O |  | 15.7143 | 8.8532 | 5.0784 |
| P |  | 15.7575 | 8.9208 | 5.3852 |
| Q |  | 16.5466 | 9.5362 | 5.7367 |
| R |  | 16.9414 | 9.7883 | 5.7376 |
| S |  | 16.9906 | 9.7974 | 5.8421 |
| T |  | 17.057 | 9.8194 | 5.8652 |
| U |  | 17.0936 | 9.9489 | 5.9615 |
| V |  | 17.5923 | 9.979 | 5.9867 |
| W |  | 17.6227 | 10.007 | 6.0893 |
| X |  | 18.1135 | 10.2937 | 6.1237 |
| Y |  | 19.0481 | 10.458 | 6.1709 |
| Z |  | 20.05 | 11.0977 | 6.3561 |

From the tests that have been done, the value of variations of the decimation and distance variations that have the best recognition rate can be obtained. The result of the average variation of the decimation and the distance variation which has the best recognition rate can be shown in Figure 7, there are 3 different colors, the blue color represents the result of the influence of the 1st decimation to the distance variation. The red color represents the result of the effect of decimation 2 on the variation of distance and the green color representing the result of the effect of the decimation 3's to the distance variation. The process on the decimation shows that, on decimation 1, image will be processed once on the self-extraction Haar Wavelet process to an image with the size of 32 x 32. On decimation process 2, image will be feature extracted twice so that the image's size will changed into 16 x 16. On decimation process 3, datas will be self-extracted and processed three times and the process will be repeated three times so that the image's size will be 8 x 8.

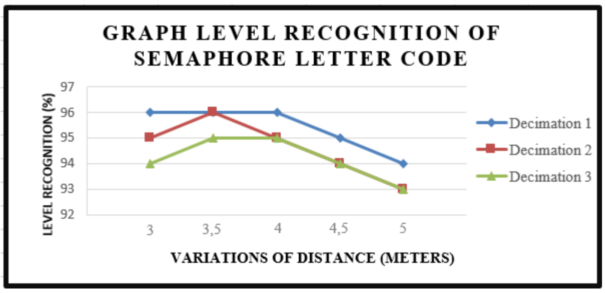



Fig 7. Graph Level Recognition of Semaphore Letter Code.

For example, the effect of decimation variation on the distance can be known in the 1st decimation to get the recognition rate of 96%, for the 2nd decimation gained 95% recognition rate and the 3rd decimation gained a recognition rate of 94%. The greater the value of decimation variation, the pattern recognition rate will be lower, because the greater the chosen decimation value will make the process of repetition of convolution and downsampling more and more in accordance with the variation of the decimation chosen by the user. This will cause the image to be blur and affect the lower recognition rate.

In this study, the percentage of semaphore letters recognition rates on the decimation variation of the overall distance is shown in Table III.

TABLE III. PERCENTAGE OF RECOGNITION RATE

| Decimation | Percentage of recognition rate |
|---|---|
| 1 | 95.4% |
| 2 | 94.6% |
| 3 | 94.2% |

It is known that at the 1st decimation has the best recognition rate with the percentage of recognition rate of 95.4%.

## IV. CONCLUSION

In this study, the percentage of the recognition rate of the semaphore letter code in the 1st decimation is 95.4%, the decimation 2 is 94.6%, and the decimation 3 is 94.2%. So the best recognition rate is in the 1st decimation with the recognition rate at 3 meters distance of 96%, the distance of 3.5 meters by 96%, the distance of 4 meters by 96%, the distance of 4.5 meters by 95%, and the distance of 5 meters by 94 %. The results obtained show that the introduction of the semaphore letter code by using color recognition on the semaphore flag and using Wavelet feature extraction, can result in better recognition rates with longer distances.

## REFERENCES


[1] A. Rachmad and M. Fuad, "Geometry algorithm on skeleton image based semaphore gesture recognition," *J. Theor. Appl. Inf. Technol.*, vol. 81, no. 1, pp. 102–107, 2015.

[2] A. Madore, "Make Semaphore Flags," 2015.

[3] Q. Zhao, Y. Li, N. Yang, Y. Yang, and M. Zhu, "A convolutional neural network approach for semaphore flag signaling recognition," in *2016 IEEE International Conference on Signal and Image Processing, ICSIP 2016*, 2017, pp. 466–470.

[4] Kualo, "Semaphore." [Online]. Available: https://www.omniglot.com/writing/semaphore.htm.

[5] H. Sinaga, "Learning Application on Signal Scout Semaphore Multimedia And Web-Based Using Computer Assisted Instruction Method," *J. Inf. dan Teknol. Ilm.*, vol. V, no. 3, pp. 160–164, 2015.

[6] N. Iwane, "Arm movement recognition for flag signaling with Kinect sensor," in *Proceedings of IEEE International Conference on Virtual Environments, Human-Computer Interfaces, and Measurement Systems,VECIMS*, 2012, pp. 86–90.

[7] R. Gonzalez and R. Woods, *Digital image processing*. 2002.

[8] A. K. Jain, *Fundamentals of Digital Image Processing*, vol. 14, no. 8. 1989.

[9] A. S. Abdul Kadir, "Teori dan Aplikasi Pengolahan Citra," no. May, p. 640, 2013.

[10] D. M. Togasaki *et al.*, "The Webcam system: A simple, automated, computer-based video system for quantitative measurement of movement in nonhuman primates," *J. Neurosci. Methods*, vol. 145, no. 1–2, pp. 159–166, 2005.

[11] T. L. W. Ce, "HD video desktop collaboration."

[12] The Mathworks Inc., "MATLAB - MathWorks," *www.mathworks.com/products/matlab*, 2016. .

[13] S. E. Lyshevski, "MATLAB Basics," *Eng. Sci. Comput. Using MATLAB®*, pp. 1–26, 2003.

[14] C. Wikimedia, "File_HueScale," 2018. [Online]. Available: https://commons.wikimedia.org/wiki/File:HueScale.svg.

[15] L. Sumarno, "Evaluasi Unjukkerja Ekstraksi Ciri Wavelet dalam Pengenalan Huruf Tulisan Tangan Berderau dan Terskala menggunakan Jaringan Syaraf Probabilistis," pp. 1–15.

[16] D. Putra, *Pengolahan Citra Digital*. Yogyakarta: C.V ANDI, 2010.

[17] Mathematik, "Wavelet and multiscale library - Download," 2017. [Online]. Available: https://www.mathematik.uni-marburg.de/~waveletsoft/demo.php.