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Haar Cascade Classifier and Adaboost Algorithm for Face Detection with the Viola-Jones Method

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Abstract

Face detection is a significant challenge in image processing and computer vision, with broad security, identity recognition, and human-computer interaction applications. This study explores the effectiveness of the Haar Cascade Classifier method optimized with Adaboost to improve the accuracy and efficiency of face detection in various head covering conditions. In this experiment, two approaches were compared: using the Haar Cascade Classifier independently and in combination with Adaboost, with evaluation based on metrics such as accuracy, precision, sensitivity, and F1-Score. The results showed that the Adaboost combination significantly improved detection accuracy, with the "Hooded" class achieving an accuracy of 99.2% and the average detection time reduced from 14.9 seconds to 1.9 seconds. These findings show that the use of optimization techniques such as Adaboost not only improves detection performance but also overall system efficiency. The conclusion of this study emphasizes the importance of combining methods in developing a more robust and efficient face detection system. The implications of this research can be applied to create more effective security and facial recognition applications and pave the way for further study in optimizing object detection algorithms.

Keywords: Haar Like Feature, integral image, adaptive boosting algorithm, Haar Cascade Classifier

1. Introduction

Technological advances are increasing rapidly, especially in computing, where many technologies are developed that use image processing systems, such as security systems, surveillance systems, and attendance systems. In the increasing improvement of image processing, it is used as an alternative [1].

Globally, for humans, the face is the easiest and simplest measure to determine an individual's identity with one another. Because the human brain has a remarkable ability to remember and distinguish the faces of each individual [2], the human brain can indicate whether the object seen by the eye is human. Therefore, research is needed to make computers capable of functioning like humans. Computers can detect an object and determine a human face [1].

Ramadhani and Musa stated that the Viola-Jones method has a face detection accuracy of 90% and only for one face object [3]. Therefore, in this study, detection will be carried out with several faces more than one in one image or image, and some people use headgear (hat or veil). Face detection uses the Haar Cascade Classifier process and the Adaboost algorithm to detect multiple faces in one image using the Viola-Jones method.

Viola-Jones [4] is an object detection algorithm developed by Paul Viola and Michael Jones in 2001, which is popularly used for face detection. The method uses four main components[5]: a Haar-like feature that detects pixel intensity differences using a black-and-white box pattern, an Integral Image for

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computational efficiency, an AdaBoost algorithm that combines weak classifiers into strong classifiers, and a Cascade Classifier that stacks classifiers in a cascade for quick detection [6]. Despite its limitations, such as face rotation and lighting sensitivity, this method excels in real-time processing speed. It is an essential foundation in the development of modern face detection systems.

Based on the above background, the problem is how the Haar Cascade Classifier process and the Adaboost Algorithm can detect many faces quickly and accurately in one image, and some use a head covering (hat or veil) using the Viola-Jones method. Therefore, this study aims to Detect many faces in one image, and some use a head covering (hat or veil) using the Viola-Jones method with the Haar Cascade Classifier process and the Adaboost Algorithm. To find out the improvement of face image detection and the processing time of face image detection.

2. Related Research

Human face detection is the most important thing for developing digital image processing. A lot of research has been done on various advantages and disadvantages. One of them is a study conducted by Hadi Santoso and Agus Harjoko in 2013 [7] proposed the Haar Cascade Classifier method and the Adaboost Algorithm. With different facial positions tested with ordinary light sharpness, the accuracy is measured by the number of images known directly. Seven images of faces with positions and three distances of face objects can be detected well from 8 images in the classroom.

Aries Suharso [8] conducted another study on facial recognition under various conditions for images on a camera connected to a computer. The Viola-Jones process is applied to face detection, and the Eigenface process is used for face recognition. The test was performed with the usual beam sharpness with different gaps and image locations. The accuracy level of the detected image is 88.89%, with the angle of view of the face facing forward -150, to the left side 300 and exemplary 300, and a threshold value of 75 is obtained, making the highest accuracy with recognition as much as 90.90%.

Then, the research conducted by Prasetyo [2] concluded that Viola Jones' method has an advantage over others with an accuracy of 90%. Its drawback is that it cannot detect images in an oblique or sideways position. The location of the face's viewing angle determines the success of face detection. In general, face detection is only for one face object.

3. Method

The research method functions as a guide for the researcher in conducting the research process, so that the research process can be carried out properly and directed and systematically. Figure 1 shows the stages of the research.

Data collection is part of data collection. This study uses a dataset of human images of more than one face. The images to be processed are 140 images grouped into four images: 35 images of people with veils, 35 images of people with hoods and hats, 35 images of people with hats, and 35 images without head coverings.

Initial data processing is part of the processing and processing of initial data obtained to be processed using the proposed method. Before being processed, the data was grouped into four groups in the images obtained, with 35 images in each group. The four groups can be seen in Figure 2.

Figure 1.
Research and experiment step for face detection.

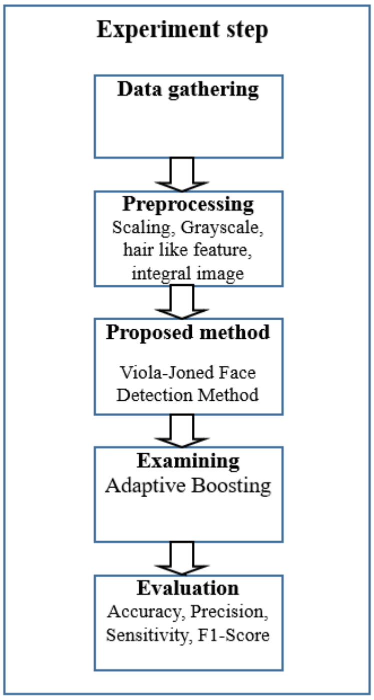
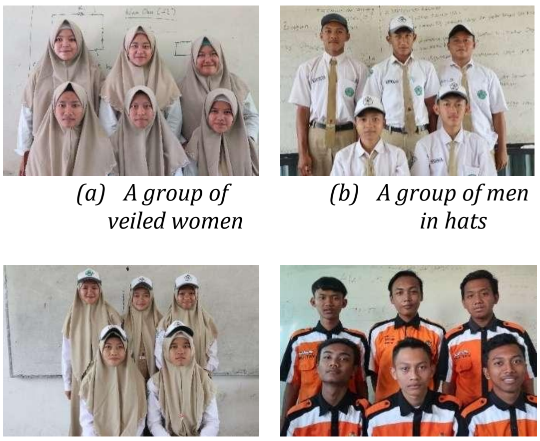


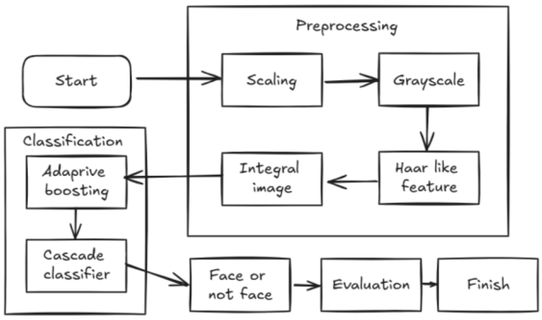
Figure 2.
Experimental image data.



(a) A group of veiled women
(b) A group of men in hats
(c) Group of veiled and hatted women
(d) A group of men without hats

The proposed method is the part used on the data that has been grouped and then analyzed to determine the method's performance. The proposed method in this study uses the Viola-Jones Method by applying the Haar Cascade Classifier and Adaptive Boosting algorithms. The initial stage of this method is preprocessing and continuing with the classification of features resulting from the process of Haar-like features and integral images. Then, the first classification uses adaptive boosting, and the following classification is carried out using cascade classifiers. From the cascade classifier classification, it will be known whether the face is or not.

Figure 3.
Proposed algorithms and methods for the detection of hijab and hated faces.



Scaling

Images taken directly from the camera will be changed and reduced in resolution by calculating the average pixels from the original data. The calculation is done by adding up 4-pixel values and then dividing by 4. Calculating an average of 4-pixel values will result in fewer pixel values. And will speed up the process of testing the image.

Grayscale

A grayscale image changes the RGB image to a grayish image. From the RGB image, the value of each color (red, green, blue) will be searched, and when the value of each color is found, a calculation will be carried out using Equation 1.

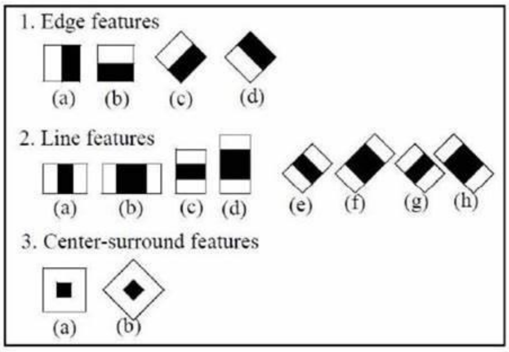
$$Grayscale = 0{,}299.R + 0{,}587.G + 0{,}144.B \qquad (1)$$

where R=Red value, G=Green value, and B=Blue value.

Haar-like feature

Haar-like feature is an algorithm that uses statistical methods to perform detection [9] [10]. Each feature in Haar-like features is defined as a feature between the coordinates and the feature's shape. The features of the haar are seen in Figure 4, which has two parts, namely the light area and the dark area.

Figure 4.
Haar Like Features for extracting three feature type.

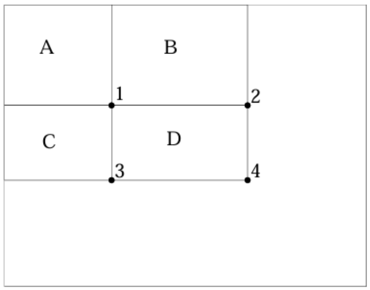


Integral Image

The image integration process was carried out to make dancing the Haar image feature more straightforward in this study. An integral value is the sum of pixel values. Integral images with the value of the Haar-like feature can be calculated more quickly and efficiently with equation 2.

$$\boldsymbol{ii(x,y) = \sum_{x' \le x, y' \le y} i(x',y')} \qquad (2)$$

Figure 5.
Integral image



The value of 1 = represents area A; The value of 2 = represents area A + represents area B; Value 3 = represents area A + represents area C. Furthermore, the value of 4 = represents area A + represents area B + represents area C + represents area D; and Value D = Value 1 + Value 4 - Value 2 - Value 3. The value *of ii*(x,y) is an integral image, and *i*(x,y) is an original image, calculated using formulas 3 and 4.

$$\boldsymbol{s(x,y) = s(x,y-1) + i(x,y)} \qquad (3)$$

$$ii(x,y) = ii(x-1,y) + s(x,y) \qquad (4)$$

Where s(x,y) is the cumulative number of rows, s(x,-1)=0, ii(-1,y)=0. An integral image can be counted in a single pass on top of the original image.

AdaBoost Algorithm

AdaBoost is used to select more specific Haar features. This stage will be performed by evaluating the features against the feature data. The Adaptive Boosting algorithm aims to create a strong classifier with weak classifier considerations [11] [12] [13]. The classification stage created in AdaBoost has an object feature classification stage that is also used to improve feature classification performance by estimating the performance of many weak clusters to produce strong clustering[14]. To determine the search for a strong classifier, use equation 5 and update the weights using equation 6.

$$\boldsymbol{H}(\boldsymbol{x}) = \boldsymbol{sign}\left(\sum_{t=1}^{t} \boldsymbol{\alpha}_t \boldsymbol{h}_t(\boldsymbol{x})\right) \tag{5}$$

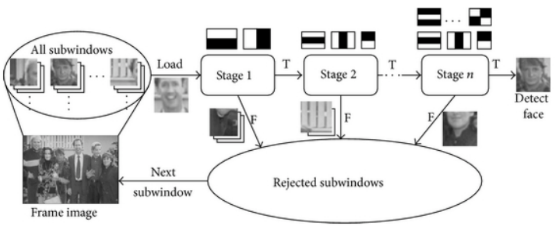
$$D_{t+1}(i) = \frac{D_t(i)\exp\left(-\alpha_t y_t h_t(x_i)\right)}{Z_t} \tag{6}$$

where D_t is the weight at the previous level. Next, we normalize the weight by dividing each weight by the sum of all weight Z_t.

Haar Cascade Classifier

At this stage, Haar Cascade removes features categorized as non-faces and leaves reasonable features for further classification.

Figure 6.
Elimination of non-facial features



In the initial classification process, image features will be classified by reducing and eliminating non-facial features by 50%. The second stage of classification leaves 30% of non-facial features. Until the final classification stage, 2% of non-facial features are left.

Evaluation

The Confusion Matrix is the conclusion of a classifier. The Confusion Matrix generally has two-dimensional spaces; one side shows the value according to reality, and the other dimension represents the prediction results. From the results of the Confusion Matrix obtained, several values will be sought, including True Positive (TP), True Negative (TN), False Positive (FP), and False Negative (FN) from each existing class or label. A value is considered TP if the reality and prediction values are valid. Meanwhile, TN said that if the actual value is wrong and the prediction value is incorrect, A value is said to be FP if the value of reality is faulty and the value of the prediction is correct. In contrast, the value is considered FN if the actual value is accurate, and the prediction value is wrong.

The TP, TN, FP, and FN values obtained are used to find each class's accuracy, precision, and sensitivity values.

$$\boldsymbol{Accuracy} = \frac{\boldsymbol{TP} + \boldsymbol{TN}}{\boldsymbol{TP} + \boldsymbol{TN} + \boldsymbol{FP} + \boldsymbol{FN}} \boldsymbol{x100}\% \tag{7}$$

$$Precision = \frac{TP}{TP + FP} x100\% \tag{8}$$

$$Sensitivity = \frac{TP}{TP + FN} x100\% \tag{9}$$

$$F1 - Score = 2x \frac{Precision * Sensitivity}{Precision + Sensitivity} \tag{10}$$

At this stage of evaluation, the face image will be tested and divided into two classes: a scaling image and a typical image. The two image classes will be detected with two tests; the first test will be only one classification process (Haar Cascade), and the second will use two classification processes (AdaBoost and Haar Cascade).

4. Result and Analysis

The test in this study was carried out by detecting 35 input images, the input images of which were facial images that were photographed at the same time. The images that will be tested will be grouped into several variants that will be tested, and four variants will be detected in this test, namely the veiled image, the veiled and hated image, the helmeted image, and the unveiled and non-capped image.

From the image, it will be tested in two stages: the first stage is tested using the Haar Cascade Classifier, and the second stage is tested with the Adaptive Boosting classification and combined with the Haar Cascade Classifier. From each test, two attempts will be carried out. The first experiment was done by changing the image by scaling it, and the second experiment was done with a normal or the original image that was directly tested.

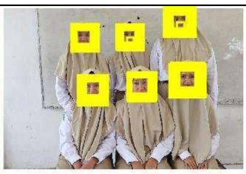
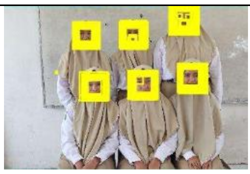
Image Testing with the Haar Cascade Classifier

The image testing carried out only uses the Haar Cascade Classifier process. The tested image is divided into two classes: the scaling image class obtained from changes in the image with a smaller size and the typical image, which is the original image without any changes.

Hooded Image Testing

The image of the veil is an image taken of female students wearing a scarf, and the detection results and detection time can be seen in Table 1.

Table 1.
Hooded image testing

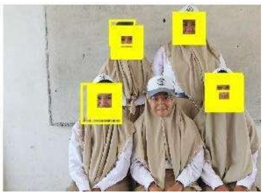
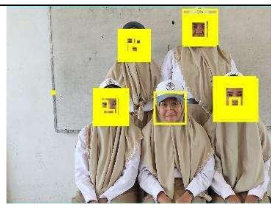
Scaling image	Normal image result
	
Time: 263/15.7 sec	Time: 500/42.3 sec

The testing of 35 hooded images carried out resulted in an accuracy of 99.46% for Scaling Images and an accuracy of for normal images of 98.85%. The average detection time is 14.9 seconds for mutual images and 43.7 seconds for normal photos. With the fastest detection time of 5.4 seconds for scaling imagery and 32.1 seconds for typical imagery.

Hooded Image and Hatted Image Testing

The image of the veil and hat was taken on the students who wore the veil, who were given additional hats and then photographed in groups. The results of the detection and the length of detection time of the veiled and hated images can be seen in Table 2.

Table 2.
Hooded Image Detection and Hatted Image Detection.

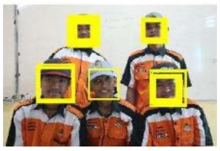
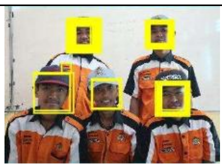
Scaling image	Normal image result
	
Time: 163/10.2 sec	Time: 379/37.4 sec

From the testing of 35 images with hoods and hats, the detection accuracy was 99.56% for scaling images and 98.48% for normal images. The average detection time is 9.8 seconds for mutual images, 38.2 seconds for normal images, and the fastest detection time is 6.1 seconds for scaling images and 31.7 seconds for normal images.

Hat image testing

The image with a hat is taken of students wearing hats and photographed in groups. The hat's detection and duration results can be seen in Table 3.

Table 3.
Hatted image detection.

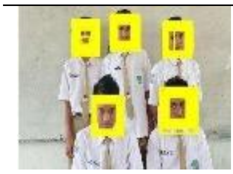
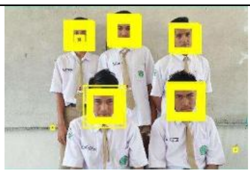
Scaling image	Normal image result
	
Time: 83/6.2 sec	Time: 274/29.2 sec

From testing 35 images with hats, the detection accuracy was 99.38% for scaling images and 98.66% for normal images. The average detection time is 7.2 seconds for mutual images and 32.4 seconds for normal images. The fastest detection time is 4.3 seconds for scaling images and 27.7 seconds for normal images.

Headcapless Image Testing

This image without headgear was only taken on the students because they were not hooded and did not wear hats, and they were then photographed in groups. The results of the detection can be seen in Table 4.

Table 4.
Image detection without a headgear

Scaling image	Normal image result
	
Time: 193/11.7 sec	Time: 441/38.2 sec

From testing 35 images without headgear, the detection accuracy was 99.58% for scaling images and 98.48% for normal images. The average detection time is 15.3 seconds for mutual images and 43.6 seconds for normal images, with the fastest detection time of 4.9 seconds for scaling images and 31.7 seconds for normal images.

Image Testing with AdaBoost and Haar Cascade Classifier

The image testing only uses the AdaBoost process and is combined with the Haar Cascade Classifier. The tested image is also divided into two classes: the scaling image class obtained from changes in the image with a smaller size and the normal image, which is the original image without any changes.

Hooded Image Detection

The image of the veil is taken of female students who use the veil, and the detection results and time can be seen in Table 5.

Table 5.
Hooded Image Detection

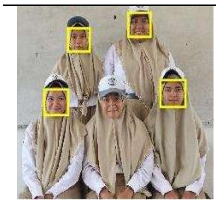
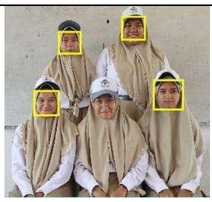
Scaling image	Normal image result
	
Time: 7/2.7 sec	Time: 6/9.4 sec

From testing 35 veiled images, the accuracy for Scaling Images was 98.42%, and the accuracy for normal images was 91.11%. The average detection time is 1.9 seconds for mutual images and 19.2 seconds for normal images. The fastest detection time is 1.7 seconds for scaling images and 18.0 seconds for normal images.

Hooded with Hats Image Detection

The image of the veil and hat was taken on the students who wore the veil, who were given additional hats and then photographed in groups. The results of the detection and the length of detection time from the hooded and capped images can be seen in Table 6.

Table 6.
Hooded and Hatted Image Detection

Scaling image	Normal image result
	
Time: 4/1.8 sec	Time: 5/19.2 sec

From testing 35 images with hoods and hats, the detection accuracy was 92.74% for scaling images and 84.76% for normal images. The average detection time is 1.8 seconds for mutual images and 19.4 seconds for normal images. The fastest detection time is 1.67 seconds for scaling images and 18.2 seconds for normal images.

Hatted Image Detection

The image with a hat is taken of students wearing hats and photographed in groups. The hat's detection and duration results can be seen in Table 7.

Table 7.
Hooded and capped image detection

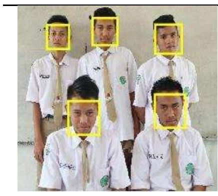
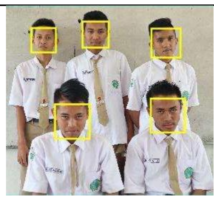
Scaling image	Normal image result
	
Time: 3/1.6 sec	Time: 3/18.2 sec

From testing 35 images with hats, the detection accuracy was 72.68% for scaling images and 67.69% for normal images. The average detection time is 1.8 seconds for mutual images and 19.1 seconds for normal images. The fastest detection time is 1.57 seconds for scaling images and 17.7 seconds for normal images.

Image Detection Without Headgear

This image without a headgear was only taken on the students because they were not wearing a hood and did not wear a hat, and they were then photographed in groups. The results of the detection can be seen in Table 8.

Table 8.
Headcapless Image Detection.

Scaling image	Normal image result
	
Time: 5/1.8 sec	Time: 7/19.3 sec

From testing 35 images without headgear, the detection accuracy was 95.26% for scaling images and 86.97% for normal images. The average detection time is 1.8 seconds for mutual images and 18.7 seconds for normal images. The fastest detection time is 1.62 seconds for scaling images and 17.4 seconds for normal images.

Test Results and Detection Time

The face detection results using the Haar Cascade Classifier process and the Adaboost Algorithm 4 variations of the detected images and as many as 140 photos. There are 2 test results presented, namely the results of image testing with the Haar Cascade Classifier process and the results of testing the AdaBoost and Haar Cascade Classifier processes.

Image Testing Results with the Haar Cascade Classifier Process

The results of image testing with the Haar Cascade Classifier process carried out on two processed image classes, the accuracy, precision, sensitivity, and F1-Score values are seen in Table 9.

Hasil Pengujian Citra dengan Proses AdaBoost dan Haar Cascade Classifier

The results of image testing with the AdaBoost and Haar Cascade Classifier processes carried out on two processed image classes, as well as the accuracy, precision, sensitivity, and F1-Score, can be seen in Table 10.

Table 10 shows that the results of the face detection test provide better performance compared to Normal Imagery. For example, in the Accuracy metric, the "Hooded" image class achieved the highest score of 98.42% with Scaling Imagery, while Normal Imagery only reached 91.11%. It shows that the image scaling technique can improve the detection of faces in various head-covering conditions.

The Precision and Sensitivity metrics also show excellent results for Scaling Imagery. The highest precision was achieved in the "Hooded" class with a value of 100%, which indicates that all face detections in this category are correct. Sensitivity also performed well, scoring 99.41% for the "Hooded" class on Scaling Images. The F1-Score metric, a combination of Precision and Recall, also showed positive results, with the highest score of 99.2% for the "Hooded" class on Scaling Imagery. These results show that using the Haar cascade classifier optimized with Adaboost effectively detects faces with different head coverings.

Results of Face Image Detection Time Test

Based on the testing of the Haar Cascade Classifier with the Haar Cascade Classifier combined with Adaboost, as seen in Table 11, the "Hooded" class has an average detection time of 14.9 seconds with a fast time of 5.4 seconds and a long time of 31.8 seconds. Meanwhile, the average detection time in the "Wearing a Helmet" class was 7.2 seconds, indicating better efficiency than other classes.

Table 9.
Recapitulation Face detection testing.

Metrics	Class	Image with scarf	Image with hat and scarf	Image with hat	Image without hat and scarf
Accuracy	Scaling image	99,46	99,63	99,38	99,58
	Normal image	98,85	98,48	98,66	98,48
Precision	Scaling image	99,46	99,63	99,54	99,61
	Normal image	99,85	99,48	99,67	99,49
Sensitivity	Scaling image	100	99,93	99,84	99,98
	Normal image	100	100	99,98	99,99
F1-score	Scaling image	99,73	97,69	99,69	99,79
	Normal image	99,42	99,42	99,67	99,23

Table 10.
Recapitulation Face detection testing.

Metrics	Class	Image with scarf	Image with hat and scarf	Image with hat	Image without hat and scarf
Accuracy	Scaling image	98,42	92,74	72,68	95,26
	Normal image	91,11	84,76	67,69	86,97
Precision	Scaling image	100	98,81	97,08	97,84
	Normal image	91,48	90,82	85,16	88,09
Sensitivity	Scaling image	99,41	93,79	74,30	97,31
	Normal image	99,51	92,71	76,73	98,57
F1-score	Scaling image	99,2	96.23	84.18	97.57
	Normal image	95,33	91.75	80.73	93.03

Table 11.
Test Results Face Image Detection Time

Class	Scaling image			Normal image		
Haar Classifier	**Average**	**Fast**	**Slow**	**Average**	**Fast**	**Slow**
Image with scarf	14,9	5,4	31,8	43,7	32,1	62,9
Image with scarf and hat	9,8	6,1	15,7	38,2	31,7	46,7
Image with hat	7,2	4,3	12,7	32,4	27,7	37,9
Image without scarf and hat	15,3	4,9	26	43,6	31,7	53,8
AdaBoost dan Haar Cascade Classifier						
Image with scarf	1,9	1,7	2,7	19,2	18	20,4
Image with scarf and hat	1,8	1,7	2	19,4	18,2	20,5
Image with hat	1,8	1,6	2,1	19,1	17,7	20,4
Image without scarf and hat	1,6	1,2	1,9	18,7	17,4	20,1

However, when using Adaboost, the average detection time for all classes decreased significantly, with the "Hooded" class taking only 1.9 seconds and the "Hooded" class also showing a lower average time of 1.8 seconds. It shows that combining Adaboost with the Haar Cascade Classifier improves detection accuracy and drastically reduces the time required for the detection process, making it a more efficient method than using the Haar Cascade Classifier alone.

5. Discussion

Four types of facial images were distinguished based on test data on facial images taken in groups. The test image was changed into two images: the normal face image and the scaling face image. Two testing procedures were carried out, namely the Haar Cascade Classifier process test and the AdaBoost and Haar Cascade Classifier process test, by making the face image into two image classes to be tested so that several analyses could be carried out on the results obtained.

From four image classes that were differentiated into two types of images and tested by the Haar Cascade Classifier process, the highest accuracy was obtained in the image class without a headgear in the scaling image type of

99.58%, while for the normal image type of 98.85% in the hooded image class. For the image detection process time, the fastest time was obtained in the detection process of the image class with a hat on the scaling image type, which was 4.3 seconds. The longest time was 62.9 seconds for the veiled image class in the normal image type.

From four image classes that were differentiated into two types of images and tested with AdaBoost and Haar Cascade Classifier, the highest accuracy results were obtained in the hooded class image with the scaling image type, which was 98.42%, and for the normal image type of 91.11%. The fastest time was obtained for the detection process time on the image, 1.6 seconds for the hated image class in the scaling image type, while for the longest time, which was 20.5 seconds for the hooded and hated image class in the typical image type.

These findings indicate that image preprocessing through scaling can be a crucial step in improving the accuracy of the face detection system. In addition, the significant difference in processing time between the two methods – where the combination of AdaBoost and Haar Cascade Classifier shows faster processing times (1.6 seconds compared to 4.3 seconds in the most rapid case) – provides essential considerations in developing real-time systems[15]. These results also show the potential for creating a face detection system more adaptive to variations in head accessories (such as headscarves and hats), which is very relevant for implementation in culturally diverse societies. These findings can be the basis for developing more robust algorithms in handling facial appearance variations and optimizing face detection systems' performance for practical applications.

This experiment compared two main approaches: using the Haar Cascade Classifier independently and in combination with Adaboost. The results show that applying Adaboost improves detection performance, especially regarding accuracy and detection time. For example, the "Hooded" class showed an increase in accuracy from 98.42% to 99.2% when using Adaboost, as well as a reduction in detection time from 14.9 seconds to 1.9 seconds. It is in line with previous research that shows that Adaboost can improve efficiency and accuracy in object detection algorithms.

Further analysis shows that the Scaling Image method provides better results than Normal Image in all evaluation metrics. The "Helmet" class shows a striking difference, where the Scaling Image reaches 72.68% in accuracy, while the Normal Image is only 67.69%. The significant reduction in detection time across all classes when using Adaboost also shows that this combination improves accuracy and overall system efficiency. These findings support the argument that combining optimization techniques such as Adaboost with facial detection algorithms can produce a more robust and efficient system.

6. Conclusion

From the results of testing and discussing the face detection process with four image classes, which are divided into two types of images, several conclusions were obtained, namely that the accuracy of the Haar Cascade Classifier process is greater than that of the AdaBoost and Haar Cascade Classifier processes, which is with a difference of 1.16%. Scaled image types produce better accuracy and process time values than normal image types. The detection process time in the AdaBoost and Haar Cascade Classifier processes is faster than in the Haar Cascade Classifier process. The larger the pixel value of the image to be processed, the longer it will take.

Based on the results of a study comparing the Haar Cascade Classifier method and its combination with AdaBoost in face detection, it was found that both methods showed optimal performance when applied to scaling images compared to normal images. The Haar Cascade Classifier achieves the highest accuracy of

99.58% on face detection without a headgear with scaling imagery. The combination with AdaBoost achieves 98.42% accuracy for hooded faces on scaling imagery. Regarding time efficiency, the combination of AdaBoost and Haar Cascade Classifier shows better performance with the fastest processing time of 1.6 seconds, compared to the Haar Cascade Classifier, which requires a minimum of 4.3 seconds. These findings indicate that the use of scaling techniques on imagery and the selection of the proper method is crucial in optimizing face detection systems, where there is a trade-off between accuracy and speed that needs to be considered according to the needs of the application, especially in dealing with variations in the use of head accessories such as veils and hats.

7. References

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