Investigation on the Performance of Haar Cascade Classifier to Classify Images Using OpenCV

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Keywords: Face Detection, Haar Cascade Classifier and OpenCV.

Abstract: Face is an essential part of human identity that others can recognize directly. As technology develops, face is used as a tool for human interaction with computers in various fields. However, face recognition has many problems such as accuracy, a long process, and recognition errors due to the clothes worn. Therefore, various methods have been developed to overcome facial recognition problems, including the haar cascade classifier method. Therefore, this study aims to investigate the performance of the haar cascade classifier method in classifying images using OpenCV. This study used six datasets with 300 images in each dataset to test the accuracy in classyifing images. The results found that the performance accuracy of the haar cascade classifier method in classifying images increased in each epoch, from 0.2211 in the 1st epoch to 0.7755 in the 10th epoch. In addition, the validation accuracy also had an increase from 0.2492 in the 1st epoch to 0.7803 in the 10th epoch. Thus, this study suggests using the haar cascade classifier method in image classification for detection face.

1 INTRODUCTION

As technology develops, the face is used as a tool for human interaction with computers (Cuimei et al., 2017). Face recognition has been a concern for four decades in various fields and disciplines such as bank card identification, access control, image search, security monitoring, and surveillance systems (Riyantoko et al., 2021). In addition, face recognition can be used to identify human behavior in communicating and interacting with other people (Sharmila et al., 2019) (Yulianto et al., 2021).

The most widely used facial recognition algorithm was Eigenface which was considered one of the basic concepts of face recognition (Choi et al., 2022). This algorithm applies statistical analysis with the concept of Principal Component Analysis (PCA) for face detection, but the Eigenface algorithm is very sensitive to the shape and size of the face, so it is not widely used anymore (Rahmad et al., 2020) (Kainz, 2019).

Paul Viola and Michael Jones introduced an algorithm called Viola-Jones to detect faces in order to process images with large resolutions (Javed Mehedi Shamrat et al., 2022). However, this algorithm produces a lot of errors in the face detection process. Then (Thapliyal et al., 2022) proposed the Histogram of Oriented Gradients (HOG) algorithm for human face detection. This algorithm is more accurate than the Viola-Jones algorithm, but the HOG algorithm has a slow computational process on large-resolution images (Priadana & Habibi, 2019) (Malhotra et al., 2021).

Furthermore, the Local Binary Patterns (LBP) algorithm was introduced (Isnanto et al., 2021) with more accurate face recognition because it can detect differences in face shape and skin color. Although this algorithm achieves the highest success than the previous algorithm, there is an error rate of more than 20% during the face recognition process (Phuc et al., 2019). Previous studies used the Viola-Jones algorithm and Histogram of Oriented Gradients (HOG) for face detection while the Convolutional Neural Network (NN) algorithm was used for face recognition (Kainz, 2019). However, previous studies resulted in errors in the face detection process with slow computational processes on high-resolution images (Ahmad et al., 2021).

Another study conducted an experiment on an Open CV-based face recognition system with the Haar

Bahit, M., Utami, N., Candra, H., Madhani, H. and Noprianto, .
Investigation on the Performance of Haar Cascade Classifier to Classify Images Using OpenCV.
DOI: 10.5220/0011765500003575
In *Proceedings of the 5th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2022)*, pages 313-316
ISBN: 978-989-758-619-4; ISSN: 2975-8246

Cascade Classifier algorithm for face detection and the Local Binary Patterns Histograms (LBPH) algorithm for face recognition. However, this study can only recognize faces with a maximum distance of 15 CM from the camera and with the requirement that no objects cover the face (Mantoro et al., 2018) (Vinh & Anh, 2020). A study by (Ahmad et al., 2021) succeeded in detecting faces with a maximum distance of 20 CM using the Viola-Jones algorithm for face detection and the K-Nearest Neighbor (KNN) algorithm for face recognition. On the other hand, this study has a weakness in the detection process and face recognition must be perpendicular to the camera.

Previous studies used various algorithms for face detection and face recognition but did not pay attention to the effect of light intensity, movement, and computational processes during face recognition on large image resolutions, and the distance between the camera and the face is still too close. This study aimed to investigate the performance of Haar Cascade Classifier to classify images using OpenCV with a distance of 1 meter.

2 METHOD

2.1 Subject

This study was conducted on 6 respondents consisting of 3 men and 3 women with an average age of 21 years. All respondents are from the Computerized Accounting Study Program, Accounting Department, Politeknik Negeri Banjarmasin.

2.2 Tools and Materials

This study used several tools, both in the form of hardware and software in order to run properly;

2.2.1 HP Pavillion Computer

The computer device used was HP Pavilion Gaming 15-dk1041TX with a Intel® Core™ i7-10750H (2.6 - 5 GHz, 12 MB L3 cache, 6 cores) processor and 8 GB DDR4-2933 SDRAM (1 x 8 GB). The operating system used is Windows 11 Home Single Language 64-bit. Video game graphic uses NVIDIA® GeForce® GTX 1650 with memory capacity of 4 GB GDDR6 dedicated. The camera used is Logitech HD WEBCAM C310 with HD 720pixels with max resolution at 30fps.

2.2.2 Logitech Camera

The camera used was Logitech Webcam C310 HD with image and video capture resolution up to 1280 x 720 pixels.

2.2.3 OpenCV

OpenCV is a library used to translate an image in the detection and face recognition process with the haar cascade classifier algorithm.

2.2.4 Python

Python is used to display respondent data on the face recognition system. python is a high-level programming language so it has several advantages, such as simple syntax, object-oriented (OOP), and many libraries that will simplify the program created. Python also has one multifunctional array variable namely 'NumPy' to make programming easier.

2.2.5 Tensorflow

Tensorflow is used as a deep learning library algorithm in the face detection and recognition process with the haar cascade classifier algorithm.

2.2.6 Keras

Keras is a deep learning interface library in the face detection and recognition process with the haar cascade classifier algorithm.

2.3 Procedures

Respondents were asked to face the camera at a distance of 1 meter and freely move. On average, 300 pictures of each respondent were taken with a duration of 60-90 seconds. Before the experiment, each participant was given a letter of consent to become a respondent in the study.

2.4 Datasets

This study used 6 datasets containing 250 160x160 pixel images of each respondent. The data were used to investigate the performance of Haar Cascade Classifier in classifying images.

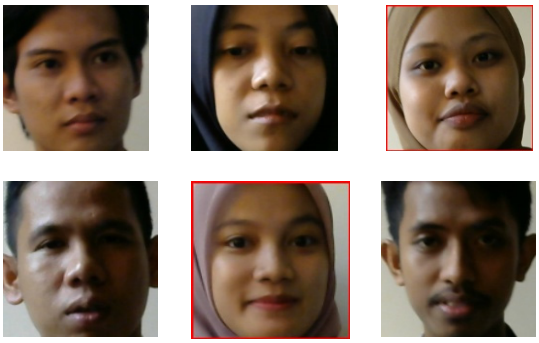

Figure 1: Respondents' faces.

3 RESULTS AND DISCUSSIONS

3.1 Training Loss and Accuracy

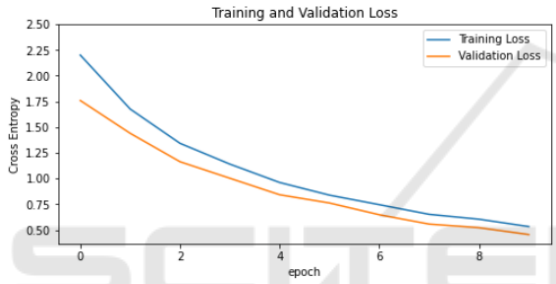

Figure 2: Training and validation loss.

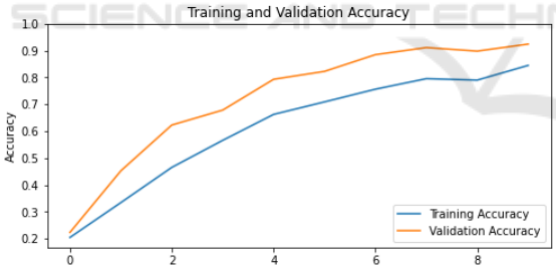

Figure 3: Training and validation Accuracy.

Figures 2 and 3 above show the results of the data train and data test with 10 iterations (epoch). Based on the figure above, it can be seen that iteration produces accuracy values and loss values for train data and test data. The accuracy value is used to determine the model success rate. While the loss value indicates errors made by the network that must be minimized. Figures 2 and 3 show that the haar cascade classifier method does not experience overfitting. Overfitting is a condition in which the model fits too well with the training data and does not have good generalizability, thus providing low accuracy on new data (Yustiawati et al., 2018). Overfitting checks can be performed by conducting a validation process at each iteration of the deep learning model training process (Indraswari et al., 2021). The overfitting model has good performance in classifying training data but has poor performance in classifying new data, such as validation data.

Figure 2 shows the training and validation loss for train data and test data for each iteration (epoch). Based on Figure 3, the blue line shows the training loss, while the orange line shows the validation loss. Figure 3 shows that in the train data, the validity loss value continues to decrease until the 10th epoch. Figure 3 shows the accuracy of the test data generated in each iteration (epoch). Based on the figure above, it can be seen that the accuracy value for the data train is increased up to the 10th epoch. For the train data, at the end of the iteration, the accuracy value was 0.8357. While the validation accuracy in the last epoch was 0.9148. The iteration results for each epoch can be seen in table 1 below.

Table 1: The iteration result of each epoch.

Iteration	Loss	Accuracy	Validation Loss	Validation Accuracy
Epoch 1	1.0629	0.2211	1.7337	0.2492
Epoch 2	1.6364	0.3550	1.3813	0.4492
Epoch 3	1.3275	0.4807	1.1129	0.6426
Epoch 4	1.0889	0.5835	0.9574	0.7049
Epoch 5	0.9231	0.6504	0.8093	0.7803
Epoch 6	0.8026	0.7052	0.7246	0.8164
Epoch 7	0.6961	0.7755	0.6412	0.8492
Epoch 8	0.6051	0.8303	0.5514	0.8852
Epoch 9	0.5774	0.8256	0.5107	0.8951
Epoch 10	0.5240	0.8357	0.4624	0.9148

Table 1 shows that the 1st epoch of 1.0629 decreased to 0.5240 in the 10th epoch. The results showed the decreasing error in face classification. The accuracy for each epoch increased, where the 1st epoch was 0.2211 and the 10th epoch was 0.835. The increase in the accuracy value indicates an increase in the face classification results.

In addition, Table 1 also shows the Validation Loss for each epoch, where the 1st epoch of 1.7337 decreased to 0.4624 in the 10th epoch. Thus, this shows the decreasing Validation Loss in performing face classification. Based on the Validation Accuracy, the value of each epoch increased, where the 1st epoch was 0.2492 to 0.9148 in the 10th epoch. With the increase in the Validation Accuracy, the haar cascade classifier in classifying images has good

accuracy. This can be seen from the increase in Validation Accuracy.

4 CONCLUSION

This study aimed to investigate the performance of Haar Cascade Classifier to classify images using OpenCV. The performance accuracy of haar cascade classifier in classifying increased the accuracy of each epoch where the 1st epoch was 0.2211 and 0.7755 in the 10th epoch. Meanwhile, the validation accuracy increased where the 1st epoch was 0.2492 and 0.7803 in the 10th epoch. Thus, the haar cascade classifier has good accuracy in classifying images. This can be seen from the decreasing training and validation loss from 1st epoch to 10th epoch.

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