The combination of Viola-Jones and Eigen faces Algorithm for Account Identification for Diploma

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Abstract. This study aims to identify the account of the diploma/certificate owner in way of face recognition. The process of detecting the face image of diploma/certificate owner is using the Viola-Jones Method. The process is comparing existing face images in database using the Eigen face Algorithm. The trial material in the form of test data is totaling 10 people to identify ownership of data from a diploma/certificate. The test result using the Viola-Jones method and Eigen face algorithm obtained an accuracy value of 70%. The system can identify and recognize facial image data with the provisions of the face position facing to front of the camera, evenly distributed light intensity, and the distance between the face and computer camera ± 35 cm.

1. Introduction

A diploma/certificate is a graduation sign in the form of a state document, the result of the process of someone who has carried out an education. After the person concerned has passed and completed all administrative and academic requirements, the person concerned has the right to obtain a diploma/certificate in accordance with the education carried out. Cases of using fake diploma/certificate are rampant in Indonesia, especially for job searches, continuing education studies to a higher level and political interests. Therefore, an application is needed that facilitates the identification process of the diploma/certificate owner's account. The application can verify whether the data of the diploma/certificate owner is registered in the relevant educational institution or not.

For the face recognition process, using the Eigen faces algorithm. Research conducted by [1], using the Eigen faces algorithm for facial recognition resulted in accuracy of 96% of different lightning variation, 85% accuracy with different face slopes and 64% accuracy with the background size conditions on different face images.

Face detection with Eigen face algorithm uses pre-processing blocks or has no accuracy difference of 9%. The use of pre-processing blocks has an accuracy of 95.45%, while without using pre-processing blocks is 86.36%. This is because of the nature of the Eigen face algorithm which is compares the reference face features with the input image face. This compared feature is actually data or cartesian coordinates that have been transformed by [W] which has the highest variance of a collection of reference images. With the pre-processing block, the position of the features of the eye, nose, mouth is
attempted in the same position as the reference image. This is due to the nature of the pre-processing block which attempts to produce images with only full faces by way of segmenting based on human skin color[2].

This study produced an output in the form of an application with research data in the form of captured images from a laptop webcam. Human face images taken vary with each getting the same variation treatment, namely: slope of the face position angle, facial distance to the webcam and light intensity. The face recognition system application has two main components, namely detection and face recognition process. This study applies the Viola-Jones method for face detection by classifying facial images, the matching them with reference face images. The Viola-Jones method combines the Haar-Like Feature, Integral Image, AdaBoost Machine-Learning, and Cascade Classifier. And the Eigen face algorithm for the face recognition process.

2. Viola-Jones Method and Eigen face Algorithm
2.1. Viola-Jones
The Viola-Jones method is an object detection method that has a fairly high accuracy rate of about 93.7% with a speed 15 times faster than the Rowley Baluja Kanade detector and approximately 600 times faster than the Schneiderman Kanade detector [3]. The Viola-Jones method uses the training data used in the image classification process. Image classification is based on the value of a feature. The Viola-Jones method combines four main keys, namely Haar-Like Feature, Integral Image, Adaptive Boosting or AdaBoost, and Cascade of Classifier [4].

a. Haar-Like Feature
Image classification is based on the value of a feature. The use features is done because feature processing takes place faster than image processing per pixel [5], there are three types of featured based on the number of rectangles contained therein, as can be seen in figure 1.

![Figure 1. Haar-Like Feature][3]

Features (a) and (b) consist of two rectangles, while feature (c) consists of three rectangles and a (d) rectangular feature. How to calculate the value of this feature, is to subtract the pixels in the black area. To simplify the process of calculating feature values, the Viola-Jones method uses an integral form of media.

b. Integral Image
Integral image is an image whose value per pixel is the sum of the pixel values from the top to the bottom right that can be seen in figure 2. To determine the average value of pixels in the rectangular area (shaded area) can be done simply by dividing the values in (x,y) by the rectangular area [5].

![Figure 2. Integral Image Calculation][3]
Using an integral image can determine the pixel value for some other rectangles, for example like quadrilateral D is a combination of the number of pixels in the rectangular area A+B+C+D, minus the number in rectangles A+B and A+C, plus the number of pixels inside A. With A+B+C+D is the value of the integral image at location 4, A+B is the value at location 2, A+C is the value at location 3, and A is at location 1. So the results of D can be computed D = (A+B+C+D)-(A+B)-(A+C)+A. Adaptive Boosting or AdaBoost combines many weak classifiers to make a powerful classifier. Weak here means the filter sequence in the classifier only gets fewer correct answers. If the whole weak classifier is combined it will become a stronger classifier. AdaBoost selects a number of weak classifiers to put together and adds weight to each classifier, so it will be a strong classifier. Viola-Jones combines several AdaBoost classifiers as filter circuits that are efficient enough to classify image regions. Each filter is separate Adaboost classifier that consists of a weak classifier or a feature filter. Adaptive Boosting or AdaBoost selects a number of weak classifiers to put together and adds weight to each classifier, so it will be a strong classifier. Viola-Jones combines several AdaBoost classifiers as filter circuits that are efficient enough to classify image regions. Each filter is separate Adaboost classifier that consists of a weak classifier or a feature filter. Cascade of Classifier is the last stage in the Viola-Jones method. By combining classification in a Cascade of Classifier structure, the speed of the detection process can be increased by focusing on areas in the image that have the opportunity. This is done by using Haar-Like the simplest feature for the initial process and the result is the extraction process with Haar-Like Feature is more complex. So, in the Viola-Jones method a multilevel classification is used.

Figure 3. Cascade of Classifier [3]

In the first level classification, each sub-windows will be classified using one feature. The results of this first classification are in the form T (true) for images that meet certain Haar-Like features and F (False) if not. This classification will approximately leave 50% of the sub-windows to be classified in the second stage. The results of the second classification are in the form of T(true) for images that fulfill the process of integral image and F(false) if not. As the classification level increases, more specific requirements are needed so that the features used become more numerous. The number of sub-windows who passed the classification will be reduced to reach about 2%. The results of the last classification are T(true) for images that meet AdaBoost and F(false) processes if not.

2.2. Eigen face Algorithm

Eigen face is a face pattern recognition algorithm based on the Principle Component Analysis (PCA) [4]. The basic principle of face recognition is to quote the face's unique information and then encode it and compare it with the decode results previously done [6]. The Eigen face algorithm as a whole is quite simple, for an image matrix (Γ) represented in a matrix set (Γ1, Γ2, ..., ΓM). Look for the average value (Ψ) and use it to extract the eigenvector (v) and eigenvalue (A) from the matrix set. Use the eigenvector value to get the eigen face value from the image. If there is a new image or test face (Γnew) you want to recognize, the same process is also applied to the image (Γnew), to extract the eigenvector (v) and
eigenvalue ($\lambda$), then look for the eigen face value of the image test face ($/\text{new}$). After that, the new image ($/\text{new}$) enters the recognition stage using the Euclidean distance method.

3. Result
The identification process uses a real time (direct) face recognition detection system using the Viola-Jones method and Eigen face algorithm. In the process of detecting facial images the Viola-Jones method is used. The application of the Viola-Jones method is done by taking some functions from the openCV library, namely haarcascade_frontalface which is bridged by emguCV.

The following is an explanation of the process scheme carried out in face detection with the Viola-Jones method (figure 4):

- The first process is reading the image of the face facing the computer camera (webcam)
- Haar-Like Feature
  the face image that has been captured by the camera will be read by the Haar-like Feature by processing the image into boxes to indicate dark areas and bright areas of the face image. The reading with Harr-Like Feature can be seen in figure 5.

![Figure 4. Face Detection Process Scheme with the Viola-Jones Method][3]

![Figure 5. Reading with Haar-Like Feature][4]

At the side of the face, forehead, two eyes, and the whole face image are grouped according to the bright side and the dark side.

- Integral Image
  furthermore, to determine whether or not there is a Haar-Like Feature on a face image and on a different scale efficiently the integral image calculation process is carried out by adding small units simultaneously. In this case the small units are pixel values. The integral value for each pixel is the sum of all pixels from top to bottom. Starting from the top left to the lower right, the entire face image can be summed up with several integer operations per pixel.

- Adaptive Boosting or AdaBoost
after getting the integral image value from the face image enter the next stage is to use Adaptive boosting or AdaBoost which functions to find features with a fairly high level of differentiation. During the process each filter is separate AdaBoost classifier consisting of a weak classifier or a Haar-Like Feature filter, if there is one filter that cannot be classified as a face image area, then that area cannot be recognized as a face image. But when the filter can be classified as a face image area, the area can be recognized as a face image. A face image that is successfully recognized when the face is facing the front of the computer camera (webcam), whereas if the face is too tilted the system will be difficult to recognize as a face image that can be seen in figure 6.

![Image](image_url)

**Figure 6.** Image is not legible as face image because it is too tilted

e. Cascade of Classifier
The order of filters in the cascade is determined by the weight given by AdaBoost. The filter with the largest weight is placed in the first process, aiming to erase the area of the non-face image as quickly as possible displaying objects from face images that have been detected by face or non-face by marking on the detected area of the face with a red box.

Face recognition with the Eigen face Algorithm, to produce eigen face, a set of digital images from a human face are taken in the same lighting conditions and then normalized and processed at the same resolution (e.g. mxn), then the face image is needed as a mxn dimensional vector where the component is taken from the pixel value face image of the diploma/certificate owner. The face recognition process can be seen in figure 7.

4. Conclusion
The application of the Viola-Jones method is able to detect the face image of the diploma/certificate owner in the frontal position in front of a computer camera (webcam) with the detection time affected by the intensity of light, the distance between the face and a computer camera (webcam), a minimum 5.0 Megapixel external computer camera, and the operating system used. The eigen face algorithm is able to recognize and state the identity of the face of the diploma/certificate owner who is detected if there has been input into the database of the diploma/certificate owner.

Based on testing the identification of diplomas as much as 10 times, found 7 face images of diploma owners successfully recognized in accordance with the database of diploma owners, but there is 1 face image of a diploma owner who cannot display the diploma because the password is different from the one in the database of the diploma owner. While 3 faces of diploma owners were not recognized and could not display the diploma, because the detected diploma's face was not found in the database of the diploma owner, the distance of the diploma owner's face with a computer camera (webcam) too far, uneven intensity of lighting, and slope level (distortion), of the face so that it is not detected by a computer camera (webcam). So that the success rate of the application in identifying the diploma owner's account with the correct face recognition is 70%.
Figure 7. The Face Recognition Process

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