Face geometry as a biometric-based identification system

C E Widodo, K Adi
Department of Physics, Faculty of Science and Mathematics Diponegoro University, Semarang Indonesia
Corresponding author: catur.ediwidodo@gmail.com

Abstract. In this paper, we present a method for identifying a person with a biometric-based on face geometry. This person identification system design has been done using face biometrics by implementing feature extraction of distances between facial features. Face biometrics were chosen because they have unique characteristics and do not change in each person. In this method, a system analysis that separates the face image into face components, including the eyes, nose, and mouth on the face image is taken from the front view position. Each component of the feature that has been detected is measured by its distance to form the face semantics. The steps taken in image processing begin with determining the region of interest (ROI). Furthermore, the results of cropping ROI feature extraction are done to get the eye, nose and mouth. After that, a centroid is determined for each feature so that the distance between features can be calculated using the equation of the distance between the two coordinates, so we get 8 distances as matching parameters. The matching process is done using euclidean distance, which is calculating the smallest distance between the test image and the database. Based on research results, this system can be used to identify someone using face biometrics with fixed poses and expressions. The accuracy of this system is 100 percent.

1. Introduction

At present, the need for an identification system is increasing, such as in health services, aviation, banks, immigration and security systems. Identification techniques that are often used so far such as recognition based on a password (password), PIN, ID card, or other identification. The system still has weaknesses. The disadvantage of using a password and PIN is that they are easily forgotten and easily accessed by unauthorized users. While the weakness of ID cards is that they are easily lost, damaged, stolen and multiplied by others [1,2,3].

Along with the times, it has been developed a system of identification and verification of someone using biometric features. Biometric technology uses physiological characteristics and habits/behavior of a person to make an introduction. The advantages of using biometrics cannot be lost or forgotten, it is difficult to duplicate or transfer, and authenticity is guaranteed [4]. However, the existing biometric identification system still has shortcomings. Most of these systems require additional tools made specifically to support the success of the system. As a result, it is not practical and tends to be expensive. For example, a fingerprint identification system requires a scanner that requires fingers to come in direct contact with the scanner. Even though the scanner itself cannot detect fingers that are wet, too dry, peeled, dirty and covered in ink [5]. Currently, there is an identification system that does not require special tools, namely face recognition. But the system requires training data that is complicated,
numerous, and varied. As a result, it requires a lot of database storage space [6]. Therefore, it is necessary to develop a system that is more practical and efficient and can be implemented easily and inexpensively. This study developed a personal verification system based on face images with the method of the distance between facial features. The distance between facial features is used as a feature that is stored in a database that will be used in the verification process.

2. Method
The tool used in this study is the Logitech C525 camera with a resolution of 640 x 480 pixels for image acquisition, computer, and the MATLAB programming language for image processing. The material used is facing image format, the image extension JPG. The first stage is the image acquisition using. The camera is attached to the top of the computer screen and arranged so that it does not move and is always in a stable condition as shown in Figure 1.

![Acquisition system](image)

**Figure 1.** Acquisition system

The next stage consists of two processes namely the registration process (enrollment) and the identification process as shown in Figure 2.

![Diagram of the identification process](image)

**Figure 2.** Diagram of the identification process

In the registration process (enrollment), the data from image processing will be stored in a database and used as an identification process parameter. The database will be called back to be compared with the input test data in the identification process. Image processing of the acquisition results begins by determining the region of interest (ROI) using the viola-jones algorithm, then cropped to separate ROI from the regions outside it. After that, feature extraction is performed to obtain facial features namely eyes, nose and mouth using the Viola-Jones algorithm.
After obtaining facial features, the next step is to determine the centroid (center point) of each feature so that four points can be connected to each other and the distance is calculated using Eq. (1). From the calculation of the distance will produce 8 distances between features, then the distance ratio calculation is done by comparing each distance with a certain distance. The final results of these calculations will be used as parameters in the identification process.

The identification process is done using Euclidean distances, namely by calculating the closest distance between the input feature vector and the database feature vector. After all input test images are compared with the images in the database, ranking is then performed to find out the smallest Euclidean distance value as a result of the identification process.

3. Result and discussion
In this research, an identification system has been made using facial biometrics. The design of this system consists of an image acquisition process, a feature extraction process, a database matching process with test data and identification results based on facial biometrics.

3.1. Image acquisition
The image acquisition process is carried out in a closed room so that the lighting is stable and not affected by the environment. The position of the body and face must be upright and expressionless. The distance between the camera and the face varies between 50 cm to 100 cm, which in this paper the most optimum distance is 70 cm. Image acquisition is done on 25 people with each person taking the best face image as a database and one face image for test data. Examples of the results of image acquisition can be seen in Figure 3.

![Figure 3. Example of image acquisition results](image)

3.2. Determine the ROI of the face on the image
Determination of region of interest (ROI) on the acquisition image is carried out using the Viola-Jones algorithm. This step is done to narrow the scope of the detection of facial features so that the extraction results can be more accurate and minimize the possibility of detecting other facial features. Figure 4 shows an example of the results of the ROI determination process and cropping results from ROI.

![Figure 4. (a) Determination of ROI (b) Cropping results](image)

Viola-Jones algorithm is used to determine ROI because it is able to detect quite quickly and accurately. The computational speed is due to the image classification performed based on the value of features...
whose processing is faster than pixel processing. Basically, this algorithm is an object detection framework, so that it can not only detect faces, but also detect parts of the face such as eyes, nose, and mouth, depending on the classifier trained during training.

3.3. Feature extraction

Feature extraction and calculation of the distance between features is done after the ROI determination process. The cropping image is processed to obtain facial features, namely eyes, nose and mouth using the Viola-Jones algorithm. After obtaining facial features, namely eyes, nose and mouth, the next step is to determine the centroid (midpoint) of each of these features to obtain 4 points, each of which has coordinates (x, y). These points are used to determine the distance between features by connecting one point to another so that the distance can be calculated using Equation (1). The results of these calculations produce 8 distances between features consisting of the distance between the left-right eye (J1), right-mouth eye (J2), left-mouth eye (J3), right eye-nose tip (J4), left-eye edge nose (J5), mouth-tip nose (J6), nose width (J7), and nose height (J8) as represented in Figure 5.

![Figure 5. Representation of 8 distances between features](image)

After obtaining 8 distances between features, the distance ratio calculation is then performed. This process is carried out to adjust the input image data with database image data so that it still has the same comparison even though there is the effect of variations in the distance between the camera and the object. Distance ratio calculation is done by comparing each distance between features with the distance between the right eye and the left eye.

The end result of the distance ratio calculation is used as a parameter in the identification process, as shown in Table 1.

| Name | J1  | J2  | J3  | J4  | J5  | J6  | J7  | J8  |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| Aida | 1.2131 | 1.1629 | 0.7317 | 0.7189 | 0.5532 | 0.7625 | 0.7625 |
| Ana  | 1.3939 | 1.3863 | 0.7986 | 0.8229 | 0.6597 | 0.8271 | 0.8271 |
| Atika| 1.3340 | 1.3461 | 0.8213 | 0.8368 | 0.5820 | 0.7239 | 0.7239 |
| Azis | 1.2573 | 1.2626 | 0.7512 | 0.7162 | 0.6207 | 0.7783 | 0.7783 |
| Dea  | 1.1712 | 1.1243 | 0.7344 | 0.7045 | 0.5159 | 0.6368 | 0.6368 |
| Elin | 1.2687 | 1.2591 | 0.7599 | 0.7757 | 0.5787 | 0.7517 | 0.7517 |
| Elzami| 1.3904 | 1.3948 | 0.8402 | 0.7918 | 0.6572 | 0.8150 | 0.8150 |
| Farid| 1.3027 | 1.2682 | 0.8220 | 0.7411 | 0.5851 | 0.7312 | 0.7312 |
| Hami | 1.1244 | 1.1485 | 0.6873 | 0.6616 | 0.5695 | 0.6401 | 0.6401 |
| Husen| 1.2316 | 1.2854 | 0.7612 | 0.7804 | 0.5692 | 0.7115 | 0.7115 |
| Inayatur| 1.1976 | 1.2044 | 0.7463 | 0.7329 | 0.5473 | 0.7646 | 0.7646 |
| Irham| 1.1855 | 1.1848 | 0.7340 | 0.7292 | 0.5404 | 0.6649 | 0.6649 |
| Khusna| 1.3471 | 1.3292 | 0.7981 | 0.7960 | 0.6208 | 0.7761 | 0.7761 |
| Lely | 1.1763 | 1.1240 | 0.7137 | 0.7246 | 0.5220 | 0.6480 | 0.6480 |
| Mufa| 1.3927 | 1.3632 | 0.8466 | 0.8180 | 0.6186 | 0.7705 | 0.7705 |
| Nazil| 1.3105 | 1.2729 | 0.7870 | 0.7541 | 0.6046 | 0.7605 | 0.7605 |
3.4. Identification System

The identification process is done by the euclidean distance method. The test begins with the input data in the form of a test image, then compared with the data that has been stored in the database. Data from the input test image is compared or matched with all data in the database one by one and the euclidean distance. After the euclidean distance value in each data is obtained, then to be able to find out the image that has the smallest euclidean distance is to use a ranking model. The ranking model is a ranking of values from the largest value to the smallest value. The principle of the matching method using Euclidean distance is the database image that has the smallest euclidean distance value with the test image considered to have a small difference so that it is said to be identical. Therefore, using the ranking model, we can find out the smallest euclidean value as a result of the matching process. Table 2 is a sample of matching results using euclidean distances.

| Input  | Database | Eucl. distance |
|--------|----------|----------------|
| Rosyi  | Aida     | 0.2184         |
|        | Ana      | 0.3744         |
|        | Atika    | 0.2136         |
|        | Azis     | 0.2330         |
|        | Dea      | 0.1742         |
|        | Elin     | 0.1801         |
|        | Elzami   | 0.3642         |
|        | Farid    | 0.1824         |
|        | Hanni    | 0.2122         |
|        | Husen    | 0.1921         |
|        | Inayatur | 0.1952         |
|        | Irham    | 0.1170         |
|        | Khusna   | 0.2665         |
|        | Lely     | 0.1732         |
|        | Mufa     | 0.3061         |
|        | Nazil    | 0.2179         |
|        | Qonaah   | 0.3528         |
|        | Renni    | 0.2010         |
|        | Ria      | 0.0988         |
|        | Rosyi    | 0.0120         |
|        | Subkhan  | 0.1524         |
|        | Suci     | 0.2036         |
|        | Triana   | 0.2469         |
|        | Ulfa     | 0.1133         |
|        | Willy    | 0.3015         |

Based on Table 2, the input test image from Rosyi's face image is matched or compared with all data in the database. It can be seen in Table 2 that the lowest euclidean value is 0.0120 in the database owned by Rosyi. Thus, based on these results the process of matching Rosyi test images was correctly
identified. The testing process was carried out on 25 test images. The accuracy value of the test results can be seen in Table 3.

### Table 3. Accuracy values of test results

| Target | Euclidean distance | Recognize status | Result |
|--------|--------------------|------------------|--------|
| Aida   | 0.0393             | Aida             | True   |
| Ana    | 0.1494             | Ana              | True   |
| Atika  | 0.0266             | Atika            | True   |
| Azis   | 0.0173             | Azis             | True   |
| Dea    | 0.0361             | Dea              | True   |
| Elin   | 0.0479             | Elin             | True   |
| Elzami | 0.0756             | Elzami           | True   |
| Farid  | 0.0596             | Farid            | True   |
| Hanni  | 0.0717             | Hanni            | True   |
| Husen  | 0.0188             | Husen            | True   |
| Inayatur| 0.0377             | Inayatur         | True   |
| Irham  | 0.0376             | Irham            | True   |
| Khusna | 0.0444             | Khusna           | True   |
| Lely   | 0.0579             | Lely             | True   |
| Mufa   | 0.0338             | Mufa             | True   |
| Nazil  | 0.0441             | Nazil            | True   |
| Qonaah | 0.0440             | Qonaah           | True   |
| Renni  | 0.0639             | Renni            | True   |
| Ria    | 0.0271             | Ria              | True   |
| Rosyi  | 0.0177             | Rosyi            | True   |
| Subkhan| 0.0590             | Subkhan          | True   |
| Suci   | 0.0156             | Suci             | True   |
| Triana | 0.0183             | Triana           | True   |
| Ulfå   | 0.0314             | Ulfå             | True   |
| Willy  | 0.0376             | Willy            | True   |

Based on Table 3, the accuracy of the test results is 100%.

### 4. Conclusion

Based on the results of research that has been done, it can be concluded that the system can be used to identify someone using facial biometrics with fixed poses and expressions. In the test process with 25 samples produced 100% accuracy. These results are obtained at a distance of 70 cm from the camera with the face. Thus, the best distance to identify in this study is the distance of 70 cm

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