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Security System With 3 Dimensional Face Recognition Using PCA Method and Neural Networks Algorithm

Jonathan
Departement of Informatics
University of Multimedia Nusantara
Tangerang, Indonesia
jonathan2@student.umn.ac.id

Adhi Kusnadi
Departemen of Informatics
University of Mutimedia Nusantara
Tangerang, Indonesia
Adhi.kusnadi@umn.ac.id

Daud Julio
Departement of Informatics
University of Multimedia Nusantara
Tangerang, Indonesia
daudjulio54@gmail.com

Abstract—The increasing use of computers and the internet has resulted in an increasing trend of computer crimes. This is the reason computer security is becoming important. A computer security system should be able to provide some kind of information assurance such as confidentiality, integrity, availability, authenticity and non-repudiation of data. The method used to help meet the authenticity of information assurance is biometric-based authentication, among others, a two-dimensional (2D) face recognition system, but it can make mistakes in recognition. The intruder is also easier to enter the system if has a photo print from the user's face. To overcome these deficiencies can be use a three-dimensional (3D) face recognition system. This research did three-dimensional (3D) face recognition by not doing 3D face reconstruction. But using face data got from camera ToF i.e. distance, amplitude, and intensity from each image pixel as input data. The hypothesis was face recognition execution speed faster and similar accuracy when compared with research conducted by Zhang and Lu. The algorithm used in this research, is back propagation neural networks algorithm and Principal Component Analysis (PCA). Obtained accuracy of 95% and training time of 9728 seconds. Face recognition in this study has a lower accuracy level than previous research but faster face recognition speed

Keywords—face recognition, 3D modeling, 2D, 3D, backpropagation, PCA.

I. INTRODUCTION

The development of computers and the internet does not always produce positive things. The increasing use of computers and the internet has resulted in an increasing trend of computer crimes that could lead to intruders destroying data, copying data, altering data content, and adding fake data. Evident from Kompas daily newspaper that in 2013 in a year, 40 million consumers become victims of hacking [1]. The most obvious example is when the system Sony Pictures Entertainment hacked, some unreleased movies, circulating on the internet and can be downloaded illegally. This is the reason computer security is becoming important. A computer security system should be able to provide some kind of information assurance such as confidentiality, integrity, availability, authenticity and non-repudiation of data that is secured [2]. The method used to help meet the authenticity of information assurance is authentication, to ensures that the identity of the user can be identified and known to be true and not a forgery [3].

The most used authentication system is the use of passwords and user names to login [4]. Based on the analysis of the wpengine site (2015) of the 10 million passwords used, passwords are made often have a low level of difficulty that is easily guessed by intruders. One other way of authentication that can be used is biometric-based authentication. Biometrics is the identification of a human by using the physical and habitual characteristics of a human [5]. Based on research [6], face recognition is the most accepted biometric by users and has been widely used by various authorities for identity. A 2D face recognition system can make mistakes in face recognition when there are different levels of lighting, facial expressions, head poses and shooting quality [7]. The system is also easily compromised if the intruder has a photo print from the user's face for use in the scanning process[8]. These deficiencies can be overcome by the use of a 3D face recognition system [9]. For example, the 3D surface of the face can be recognized by a variety of different lighting conditions [10]. This system is also more difficult to be infiltrated because the user's face photo prints can not be used for authentication.

This research, proposed 3D face recognition by not doing 3D face reconstruction, but directly using face data obtained from Kinect Xbox One as camera ToF then using ANN technique as data learning. The hypothesis was face recognition execution speed more faster and similar degree of accuracy when compared with research conducted by Zhang and Lu.

The algorithm used in this research to do face recognition is backpropagation neural networks algorithm and eigenfaces. [11] has conducted a study to compare the accuracy of backpropagation neural networks algorithm and eigenfaces algorithm for 2D face recognition, backpropagation neural networks algorithm has a level of accuracy with rate of 66.7% for eigenfaces algorithm and 93.33% for backpropagation

neural networks algorithm. And [12], conducted research for the recognition of road cracking by using eigenfaces, for 1 type of road crack there reaches 100% accuracy. [7] has shown that 3D face recognition can be done using backpropagation neural networks algorithm and using input values obtained from 3D reconstruction of the face. On the basis of this, then this research used the PCA/eigenfaces algorithm and artificial neural network for face recognition in 3D by not doing face reconstruction process and directly use data from ToF camera.

II. Previous Research And Development

Illustrated in Figure 1 is the flow of system in a study conducted by Zhang and Lu [7].

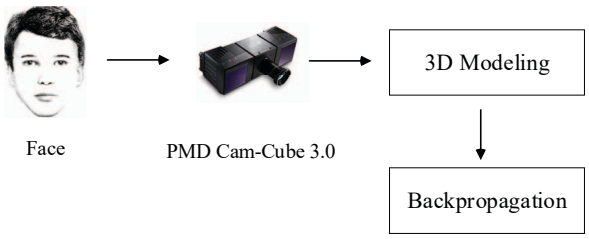

Figure 1. Zhang and Lu Research Flow [7]

Seen in Figure 1 is the data of face taken by Tof PMD Cam-Cube 3.0 camera. Time-of-flight camera (ToF) is the camera that could do a 3D scanning of an object by measuring the time-off-light, or the time light travels from the camera to the object for every image point. This ToF camera can get the result of each image with laser or light [13].

CamCube 3.0 is a depth camera with a high resolution (200 x 200 pixels), high frame rate (up to 40 fps at full resolution, 80 fps at 160 x 120). But, the price of this camera is high. The face data got by this camera became data for build 3D model. After that, back propagation algorithm would recognize the face.

This research proposes a new technique by changing the flow discussed above mentioned as illustrated in Fig. 2.

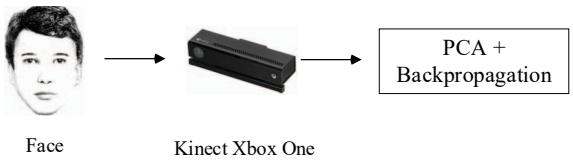

Figure 2. Research Flow

The face image acquisition used cheaper price camera, compared with the PMD Cam-Cube 3.0 camera, i.e. Kinect Xbox One. This device is an interaction peripheral produced by Microsoft as an additional hardware for Xbox One, to add modalities palette of the user interfaces: gestures and speech [12].

Kinect Xbox One is a further development of Kinect Xbox 360. Kinect Xbox One use the time-of-flight (ToF) camera technology to get a more accurate data depth to recognize the body gesture more accurately [14]. Other than price, Meisner [14] also mention that the light used for the distance calculation is infrared, so the distance calculation can be done even with a low or even no light at all. Figure 3 illustrates the connection of Kinect Xbox One and computer.

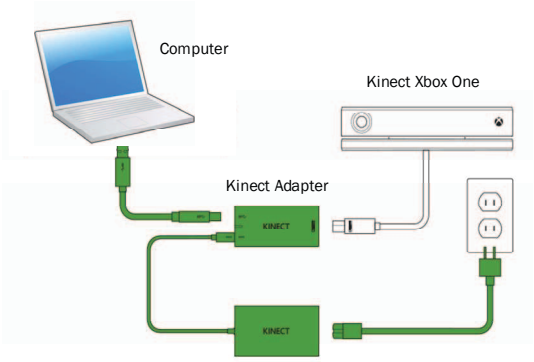

Figure 3. The Connection of Kinect Xbox One And Computer

According to Zhang and Lu [7] a ToF camera will produce three types of data for every pixel which are distance, amplitude, and intensity. Distance is the gap between the camera and the object. Amplitude is the reliability of distance value got. The more reflective an object's surface is, the higher the amount of amplitude. If the object's distance is out of range, the amplitude will be closer to 0. Intensity is the brightness of an object. The more light enter the camera, the higher its intensity will be. These data became data input to the back propagation algorithm without undergoing 3D modelling.

III. Neural Network Backpropagation Design

This study used one of data obtained from the ToF camera i.e. distance (depth maps) as input data.. Following figure is system flowchat in this research:

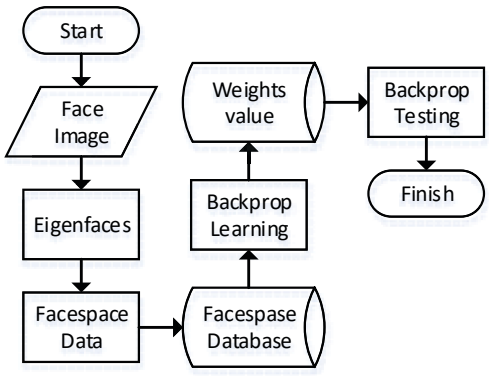

Figure 4. System Flowchart

The data from the camera has resolution of 512 x 424 pixels with each pixel contains the decimal number from

eleven binary number. These numbers can be any between 0 to 211 or 2048. Then reduced to 80 x 80 pixels. After that, made the data extraction by finding the central point of face and used it for depth data extraction, represented as vectors of length 6400.

System begin by reducing dimensionality to a practical value by application of PCA.The mean is calculating using equation (2) by summing the entire database 1D (depth maps) vectors together and then dividing by the amount of faces in the database. Each face is then centered by subtracting the mean image from each image using equation (1) [15].

$$\bar{x}^i = x^i - m \quad (1)$$

where

$$m = \frac{1}{p}\sum_{i=1}^{p} x^i \quad (2)$$

Next, the data matrix is created by combining the centered database image side by side to create a data matrix. The covariance matrix is then be calculated by multiplying the data matrix with is transpose, as in equation (3) [15].

$$\Omega = \bar{X}\bar{X}^T \quad (3)$$

This is followed by the calculation of the eigenvalues and eigenvectors for covariance matrix using equation (4). [15]

$$\Omega V = \lambda V \quad (4)$$

Where V is the eigenvectors set and λ is coresponding eigenvalues. An eigenspace is created by the sorted eigenvectors matrix.

To recognition face, it used neural network backpropagation. Neural network design has two stages: training and testing. During the training phase, back propagation algorithm tries to find the right weight, by changing the weight between neurons with speed according to the learning rate and momentum rate predetermined to achieve an appropriate result: a network that could recognize the expected data input.

The next stage is testing to recognize input data, the network uses the weights derived from the training phase. Both aforementioned stages need the data from camera. Below is the step by step in designing an artificial neural network used by the system:

1. This neural network is formed in three layers, called the input layer, hidden layer, and output layer as illustrated in Figure 5.
2. The number of hidden nodes using 5, 10 and 11. the test will determine which one is best
3. Output node is 1 for the recognized person.
4. Learning rate are 0.05, 0.01, or 0.005.
5. Tolerance number is as 0.01.
6. Threshold number is 0.04.
7. Number hidden layer is one.
8. Nguyen and Widrow [16] optimization will use between input layer and hidden layer.
9. A momentum factor to speed up the learning and makes the new weight
10. The initial weights range between -0.5 to 0.5

The illustrated design of artificial neural network in Figure 4.

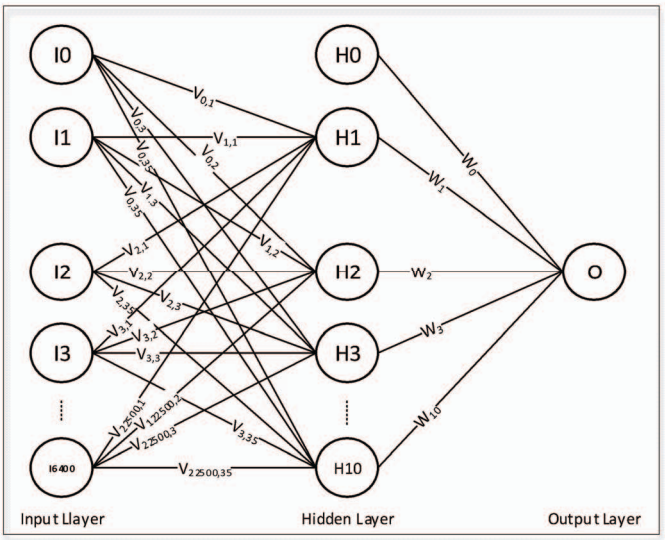

Figure 5. Neural Network Achitecture Design

IV. Implementation and Testing

By using 10 face images as the data, for training data using images one to eight, and testing data using images nine and ten. Every face image is taken 8 times, so there are 80 of training data and 20 of testing data.

Hidden node is the number of nodes in neural network's hidden layer. The greater the numbers are, the better chance to find an optimal weight. However, it will also increase the artificial neural network's training time. This is why a test is needed to find an optimal number of hidden node during the process of neural network training. Learning rate is the rate of learning undertaken by an artificial neural network. The greater the value of learning rate is, the training time will be shorter, but at the same time also lead to the failure of achieving optimal weight value. Tests are necessary to determine optimal learning rate so the training can be done in a shorter time and accurately.

Table 1 shows the results of tests on various combinations of the hidden node number and value of learning rate used. The number of hidden nodes tested were 1, 5, 10, 20, 50, and 100. The Values of learning rate tested were 0.05, 0.01, and 0.005.

Table 1. Architecture Network Test

Hidden Node	Learning Rate	MSE	Epoch	Time (second)	Accuracy	Recognition Speed (millisecond)
1	0,05	4,502	700536	26776	-	-
1	0,01	4,999	28708	1217	-	-
1	0,005	5,000	79166	3204	-	-
5	0,05	4,501	72174	3997	-	-
5	0,01	3,936	85601	4703	-	-
5	0,005	3,405	178129	11047	-	-
10	0,05	0,009	266334	15754	0%	76,6139
10	0,01	0,009	479491	23742	70%	69,908
10	0,005	0,009	14227	22688	70%	70,2573
20	0,05	0,009	47604	3716	70%	89,461
20	0,01	0,009	96251	8491	75%	90,0354
20	0,005	0,009	171771	17657	75%	87,6835
50	0,05	0,009	9963	2182	80%	137,481
50	0,01	0,009	37109	7133	70%	158,2017
50	0,005	0,009	59951	11640	75%	141,5055
100	0,05	0,009	5184	2205	80%	252,9227
100	0,01	0,009	22946	9728	95%	233,2333
100	0,009	0,009	46328	21210	90%	234,5826

Referring to Table 1, the average speed of fastest face recognition is 69.908 milliseconds per face with 10 hidden node and the learning rate value of 0.01. But the accuracy is not maximum. The average speed of the slowest face recognition is 252,9227 milliseconds per face with a hidden node 100 and the learning rate value of 0.05. The best Architecture design network is 100 hidden node, 0,01 learning rate, because it has the greatest accuracy of 95%.

The use of a larger number hidden node with the same learning rate resulted in an increased number of iterations. The use of hidden node number more greater or less than 10 with the same learning rate resulted in an increase in training time. the artificial neural network does not recognize the face when the number of hidden node is under of 10.

V. CONCLUSION

In this research, artificial neural network with back propagation and PCA can be implemented to do a 3D face recognition with at best 95% accuracy and the fastest training time of 9728 seconds. Face recognition on this research has a lower accuracy than research [7] but has a faster speed of recognition per face compared to [7]. The amount of hidden node and learning rate level has an effect to the number of iteration, total training time, and face recognition speed. The most optimal training is done by using 100 hidden nodes and 0.01 learning rate.

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