Implementation of Artificial Neural Network: Back Propagation Method on Face Recognition System

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***Abstract*—Face recognition is commonly applied to recognize an authorized personal in accessing secured personal information. Each personal owns a specific trait/feature on their face. Many researchers in this field make a pattern of the feature to analyze the characteristic of it. In this paper, author introduce a method called as an artificial neural network (ANN) to analyze and memorize the feature of the face likes how a brain work in remembering anything. Author used a back propagation (BP-ANN) approach of ANN to build a network mapping of the system. BP-ANN would equalize the ability to recognize the input pattern of task with the pattern used along the training process of the ANN. So, the percentage of the recognition process is reliable.**

Keywords—biometric, face recognition, artificial neural network, back propagation

I. INTRODUCTION

Biometrics is methods to recognize human traits based on its physical and behavioural characteristics [1]. Physical is a visible trait of the human body such as fingerprint [2, 3, 4, 5, 6], face [7, 8, 9, 10], palm print [11, 12, 13], iris [14, 15], retina [16], signature [17], hand geometry [18,19], and body scent [20]. Meanwhile, behavioural is about the behaviour of a person such as voice [21] and typing rhythm [22, 23]. The initial idea of biometric is to extract a specific information of someone body as a personal information about him/her [24]. The biometric technologies are usually used by many users as an access for them to recognize an authority personal to be authorized.

One of the main technologies is face recognition. A facial recognition technique is an application of computer for automatically identifying or verifying a person from a digital image or a video frame from a video source. Facial recognition technologies have recently developed into two areas and they are Facial Metric and Eigen Faces.

Facial Metric technology relies on the manufacture of the specific facial features (the system usually look for the positioning of eyes, nose and mouth and distances between these features). The face region is rescaled to a fixed pre-defined size (e.g. 150-100 points). This normalized face image is called the canonical image. Then the facial metrics are computed and stored in a face template. The typical size of such a template is between 3 and 5 KB, but there exist systems with the size of the template as small as 96 bytes. The Eigen Face Method is based on categorizing faces according to the degree of it with a fixed set of 100 to 150 Eigen faces. The Eigen faces that are created will appear as light and dark areas that are arranged in a specific pattern. This pattern shows how different features of a face are singled out. It has to be evaluated and scored. There will be a pattern to evaluate symmetry, if there is any style of facial hair, where the hairline is, or evaluate the size of the nose or mouth. Other Eigen faces have patterns that are less simple to identify, and the image of the Eigen face may look very little like a face. This technique is in fact similar to the police method of creating a portrait, but the image processing is automated and based on a real picture. Every faces are assigned a degree of fit to each of 150 Eigen faces, and only 40 templates Eigen faces with the highest degree of fit are necessary to reconstruct the face with the accuracy of 99 per cent. The whole things are done using face recognition software.

However, a common case happened in implementation of the face recognition technology is that the system could not authorize the face in well because a huge value of the variability when the recognition process is working. For instance, the distance and position are two requirement needed to be similar between an enquiry face and the database. It is necessary to build a system which is able to run a varied procedure when the face verification process is processed. Many application implements a Principal Component Analysis (PCA) to extract the face feature and Euclidean Distance method for the recognition process. However, these approaches could not speculate a varied recognition process.

This problem is answered if the face recognition process implements an intelligent system like artificial neural network (ANN). One of the ANN model is back propagation method (BPM). BPM has three layers i.e. input, hidden, and output layer. The each input has connection with every hidden layer and the all hidden layers have connection with all output layers [25].

II. SYSTEM SPECIFICATIONS

There are nine steps to be considered as the algorithm of the training [25] as follows:

- Weight Initialization
  Specify the training value (α), error value tolerance/threshold value (with the condition that the error value used as a condition to stop), or adjust the maximum iteration/epoch (if the number of epoch used as the condition to stop).
- If the requirement to stop is not fulfilled yet, run to the next step sequentially.
- For the pair of the training scheme, the procedure is called as forward propagation step, each input Xi (from 1 to n of the input layer) would send a signal to each unit of the next layer (the hidden layer)

- Every node of the hidden layer Zj (started from 1 to p; I=1, ..., n; j=1, ..., p), the output signal of the hidden layer is calculated using an activation function of the addition of the input signals with weight Xi:

$$Zj = f(voj + \sum xi.\, vij)_{i=1}^{n} \quad (1)$$

Then it is sent to all units on this layer.

- For every node in the output layer Yk (started from node 1 to m; I=1, ..., n; k=1, ..., m), the output signal is determined by using the addition of the input signal weight Zj of this output layer as:

$$Yk = f(wok + \sum zj\ wjk)_{i=1}^{p} \quad (2)$$

- Meanwhile, for the back propagation procedure, each output node Yk (from node 1 to m; j=1, ..., p; k=1, ..., m) receives a target pattern *tk*. Afterwards, the false information of the output layer (δ_k) is counted. δ_k is used to calculate the number of correction in the output layer:

$$\delta_k = (tk - yk)\ f'(wok + \sum zj\ wjk)_{j=1}^{p} \quad (3)$$

$$\Delta w_{jk} = \alpha\ \delta_k\ z_j \quad (4)$$

$$\Delta w_{0k} = \alpha\ \delta_k \quad (5)$$

- Every node on the hidden layer (from 1 to p; I=1, ..., n; k=1, ..., m) is counted to obtain the information about how many error happened on the hidden layer (δj). Then, δj is used to find out the correction value of the weight and bias (Δv_{ij} dan Δv_{oj}) between the input and the hidden layer.

$$\delta j = (\sum \delta k\ wjk)_{k=1}^{m}\ f'(voj + \sum xi\ vij)_{i=1}^{n} \quad (6)$$

$$\Delta v_{ij} = \alpha\ \delta_j\ x_i \quad (7)$$

$$\Delta v_{0j} = \alpha\ \delta_j \quad (3)$$

- For every node on the output layer Yk (1 to m node), the bias value and its weight would be renewed (j=0, ..., p; k=1, ..., m). So that, the new bias and weight become as follow:

$$W_{jk}(baru) = w_{jk}(lama) + \Delta w_{jk} \quad (6)$$

Meanwhile, the bias and weight of the hidden layer would be renewed as well, started from 1 to p node (I=0, ..., n; j=1, ..., p) as follow:

$$V_{ij}(baru) = v_{ij}\ (lama) + \Delta v_{ij} \quad (6)$$

Finally, check the condition as it is already stopped

III. Methodology

This research is conducted by implementing several procedures as mentioned as the following diagram:

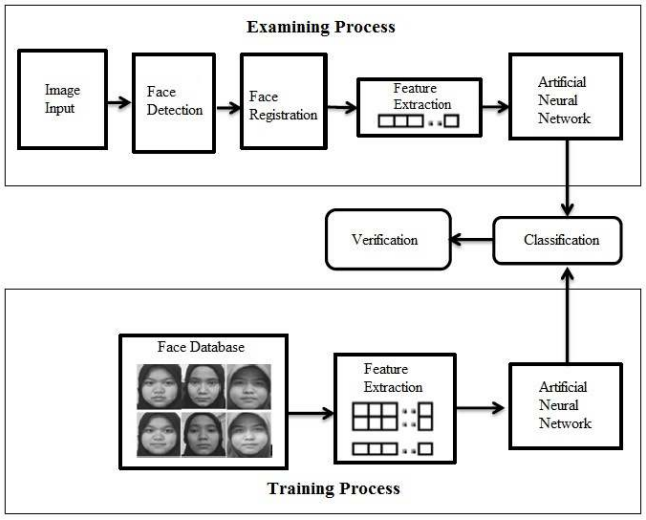

Fig. 1. System Process

The explanation of the above figure is as follow:

A. Training Process

- Database of face: there are 100 images of face from 5 different people. It means that each person has 30 images.
- Feature extraction: this process aims to obtain a dominant feature of face by implementing the *Principal Component Analysis* (PCA).
- Artificial Neural Network (ANN): the network is designed with several variations i.e. 20, 50, 100, 200 of neurons and 1, 3, 5, 7, 9 of hidden layers.
- Classification: in this step, a classified output is attained as weight values which appropriate with the desired target.

B. Examination Process

- The Input Image: images used as an input are required from a person who is registered before and stored it in the database. So, the new data would be verified with the data in the database.
- Face detection: this process would select face as a foreground and the remained as a background.
- Face registration: in this process, the selected face would be cropped and registered as an input of an inquired face.
- Feature extraction: by using PCA, a registered image would be extracted to acquire a specific feature of the face.
- Classification: this process would classify the feature according to the weight value adjusted with the desired target.
- Verification: this is the step of judgement to verify that the inquired face is legitimate or not.

IV. Results and Discussion

A. BPM-ANN Training

The following figure illustrates the performance of the ANN system. It shows that the training line is almost coincided with the validation line on the sixth epochs which means that the best performance is in the sixth iteration.

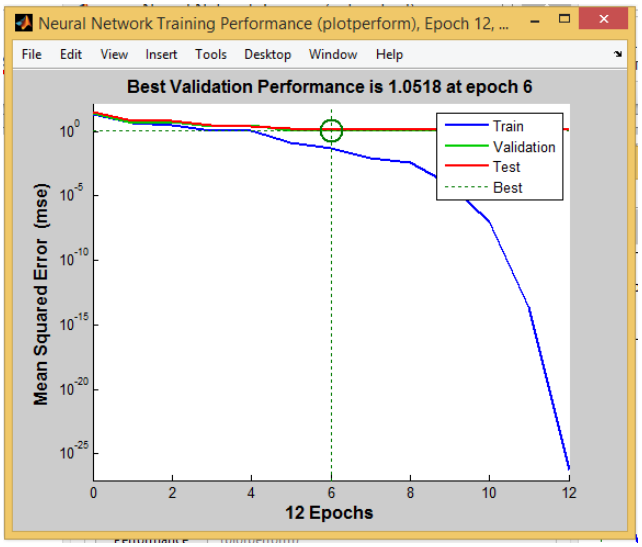

Fig. 2. Performance of the System

Meanwhile, the figure 3 shows a regression plot of the training process. There are four parts of the regression which are training, validation, test, and overall. It is clear that each subplot has a value that verge to 1. It means that the training of the network is well and the training output is corresponding with the desired target. As information, one represents a 100% successful training of the network.

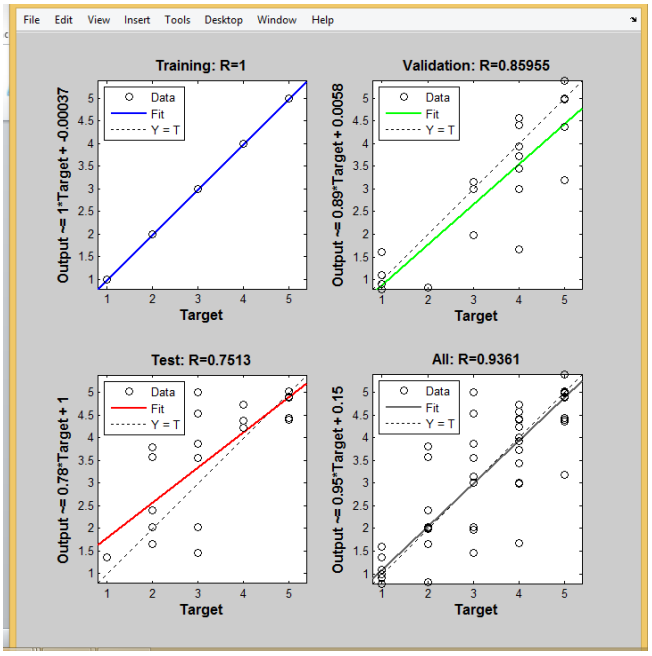

Fig. 3. Regression of the System

B. *Examination of Face Detection System*

In this examination process, five samples of new image of face. These images acquire by assigning the distance and the expression of the source of images should be distinct from the data established in the database. This procedure is aiming to ascertain the system would work appropriately.

1) Neuron Variation of the Hidden Layer. In the beginning, it is appointed several parameters as references, i.e. 100 iteration, sigmoid bipolar as activated function, 0,01 as the training rate, and 5 hidden layers. The following tables illustrate the result of the examination.

TABLE I. EXAMINATION RESULT OF VARIED NEURON

Name of Resource	Number of Neuron	Examination Results		Accuracy
		Valid	*Invalid*	
Reza	20	11	14	44%
Nadia				
Elsi				
Ade				
Susan				
Reza	50	17	8	68%
Nadia				
Elsi				
Ade				
Susan				
Reza	100	19	6	76%
Nadia				
Elsi				
Ade				
Susan				
Reza	200	17	8	68%
Nadia				
Elsi				
Ade				
Susan				

According to the result, it is mentioned that the optimum accuracy happened when the neuron of the hidden layer is 100. Another phenomenon is that the performance is declined when the neuron is increased to 200. The system undergoes saturation at this point because the ability of the network to generalize and draw the conclusion of the training data is subsided. This condition causes the declination of the accuracy level of the training process.

TABLE II. EXAMINATION RESULT OF VARIED HIDDEN LAYER

Name of Resource	Number of Layer	Examination Results		Accuracy
		Valid	*Invalid*	
Reza	1	16	9	64%
Nadia				
Elsi				
Ade				
Susan				
Reza	3	18	7	72%
Nadia				
Elsi				

Name of Resource	Number of Layer	Examination Results		Accuracy
		Valid	*Invalid*	
Ade				
Susan				
Reza				
Nadia				
Elsi	5	19	6	76%
Ade				
Susan				
Reza				
Nadia				
Elsi	7	20	5	80%
Ade				
Susan				
Reza				
Nadia				
Elsi	9	18	7	72%
Ade				
Susan				

2) Variation of the Hidden Layer. In previous experiment, the most optimal accuracy happened when the neuron is 100. Therefore, in this step, it is decided for combination that the number of the neuron for all hidden layer is a hundred. Beside the 100 neuron, there are several parameters used the reference i.e. 100 iteration, sigmoid bipolar as the activated function, and 0.01 as training rate. The result of the examination is showed in the table 2.

In table 2, it is showed that the optimal accuracy is 80%. The invalid verification is happened because the error value between the output value of the test and the output value of the training along the matching process is huge. Another possibility of this error is that the expression of the face is extremely different.

V. Conclusion

Based on the experiment result, it is clear that the system could work with several combination of the input. The system could recognize an acquired face in real time with several variations of distance and expression. The result data shows that the highest accuracy is 80% when the number of iteration is 300, the activation function is sigmoid bipolar, the number of neuron is 100, the training rate is 0.01, and the number of the hidden layer is 7.

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