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Research paper

Electrocardiogram Signals Recognition using Neural Network

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Abstract

This paper displays a neural network developed to verify human individuals utilizing electrocardiogram (ECG) signals collected from the database on the network website [1][2][3]. In this paper, noises were first removed from the signals by wavelet filters. ECG cycles were then extracted from the filtered signals and biometric feature extraction by two methods non-fiducial detection at first Autocorrelation, Principle Component Analysis (AC/PCA) and second Autocorrelation, Discrete Cosine Transform (AC/DCT). These coefficient structures were utilized as input vectors to a 2-layer feed forward neural network that generates the verification results. In the present study, 400 sample collected from 20 individuals were applied to train the neural network, which then was tested with 20 new datasets from 20 different subjects. All the 20 individuals in the research were successfully verified. The testing results show that the neural network is effective 97.5 %.
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Keywords: *ElectroCardioGram (ECG); biometric recognition; non-fiducial feature extraction; AutoCorrelation (AC); Principal Component Analysis (PCA); Discrete Cosine Transform (DCT); Neural Network (NN).*

1. Introduction

Recognition Technology and Security devices have to be rapidly changing and advancing all the time since new ways of falsification are coming up. The utmost importance in this field is Innovation to stay ahead of the game. One the possibilities of supplying such protection are biometrics. Biometrics refers to a certain biological, physical and behavioral feature of a human being.
Biometrics properties can be divided into two main classes [4].
1- Physical traits include a face, fingerprint, iris, and DNA.
2 - Behavioral include gait, voice, rhythm, and keystroke

The process of using these unique features of every individual is done through signal processing and computing.

These features previously mentioned remains with her a problem that it is falsified. In the past few years, many researchers have suggested using Electrocardiogram (ECG) to identify biometrics. The electrical activity of the heart is represented by an ECG signal. It has been found to be unique to every person. It is believed to be a promising application in the biometrics domain.

Lots of researches have been done in this domain now. Most researches attempt to study ECG signals by looking at their different aspects. In a biometric system, this is done to find out the best way of using ECG. In this exact project, several sets of aspects of the ECG signal will be taken into account. Using these features or aspects, the recognition process will be done.

Electrocardiogram (ECG) had lately been used to recognize an individual. The application of ECG mostly utilized in biomedical detection [5]. The ECG of an individual can show disease or health condition. An individual must have unique-ness ECG when he is quite alive. That would be a benefit compared to another biometrics signal so as a pattern of a retina or fingerprint. Therefore, ECG can be one of the biometrics' key. This is a unique idea to utilize ECG in the biometrics' system.

There is a great request on the security system, which can detect an individual in the database. Some locations such as a restricted area or the airport were actually just allowing a little number of the individuals to arrival. ECG might be the key to them. Other than allowing a little number of individuals to arrival, we can have a blacklist of terrorist or criminal to recognize them without their face or fingerprint. The face or the fingerprint can face lifting and removed.

Thus, ECG has the benefits like:
1- Uniqueness
2- Universality
3- Circumvention
4- Acceptability

2. New Path and Methodology

I. Pre-processing ECG signal [6].
II. Non-fiducial feature Extractions by two ways (AC/PCA) and (AC/DCT):

A) Extraction of the normalized autocorrelation coefficient measured from the pre-processing signal and then The PCA contrast matrix is creating for the classification phase.

B) Extraction of the normalized autocorrelation coefficient measured from the pre-processing signal and then The DCT contrast matrix is creating for the classification phase.

III. Classification by neural network.
The same steps are recurrent on 20 individuals. The process current illustration of the complete procedure is shown in figure 1.

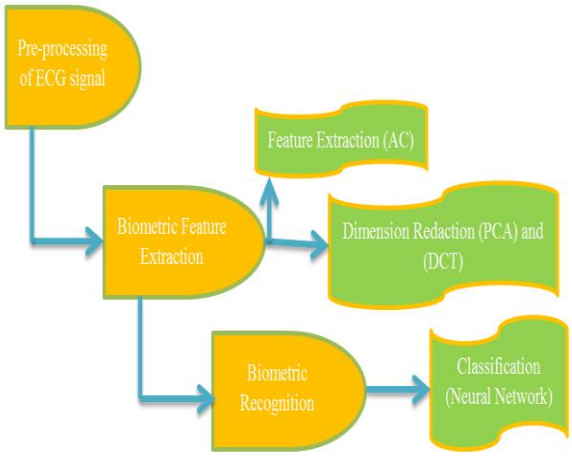

Fig. 1: Process current drawing of the steps complicated in Biometric system

3. Principle Component Analysis (PCA)

Principal Component Analysis is applied to the auto correlated data to reduce the dimension [7]. It rejects the unimportant factors and so reduces the dimension. It does of this by applying the linear transformation. The PCA generates the Hoteling's T2 statistic, which provides the multivariate space of each note from the center of the dataset. It can be seen clearly that everyone is various from another through the figure 2 which illustrations the plot of the T2 statistic of 2 personal.

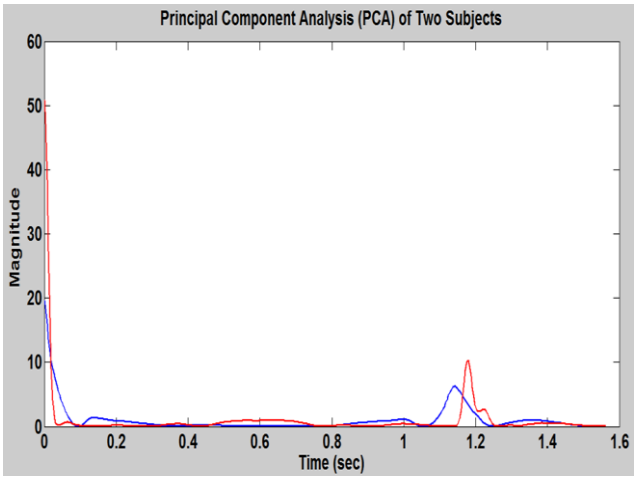

Fig. 2: PCA Hoteling's T2 statistic data for two individuals

The similar stages are repeated for all the 20 personals in building a biometric recognition system.

4. Discrete Cosine Transform (DCT)

The discrete cosine transform (DCT) is an approximation to the Karhunen-Loeve Transformation and is utilized to adjustment a given vector and minimization its dimensionality. Usually, the first few DCT coefficients contain most of the energy of the data sequence. The DCT forms a data sequence x(n) in a period of its cosine series extending with coefficients Ck, calculated as follows:

$$C_k = \sum_{n=1}^{K} 2x(n) \cos\left[\frac{\pi}{2K} k(2n+1)\right]$$

Where
C_k: DCT coefficients
K is the length of the input sequence. k = 0, … , K-1.
n: is the sequence sample index.
x(n): input sequence.

The DCT is utilized for the AC coefficients for dimensionality reduction. After DCT is complete, the number of significant coefficients is reduced even further because a lot of the DCT coefficients will become close to zero values. This is a result of the energy compression feature of the DCT transform. Thus, assuming we take an M point DCT, only C << M DCT coefficients will be important as can be easily visible from figure 3. The C first coefficients of the DCT form the characteristic vector of the suggested AC/DCT biometric verification method.

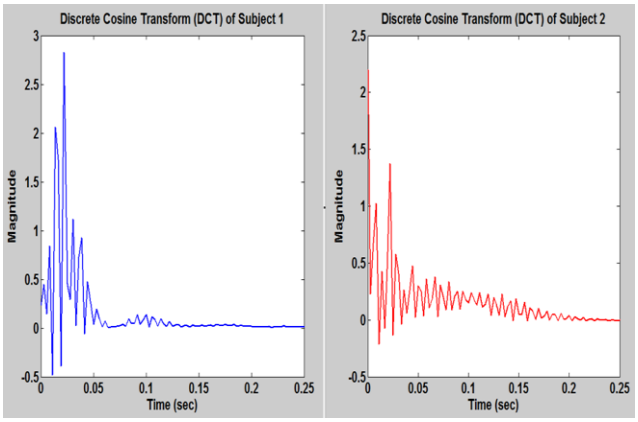

Fig. 3: DCT of the 400 AC coefficients for two individuals

5. Neural Network

The way utilized for classification in this research in the neural network (NN). The name given to this network depends on the biological network in which the biological neurons are functionally joined in a nervous system [8]. In an alike, the NN that is going to be utilized in the classification phase has artificial neurons in interconnected collections. These collections use the joints for computational purposes. It will use in inputs and adjust its structure (weights) to produce a pattern that joins the input to the output. The process is displayed in the flow diagram.

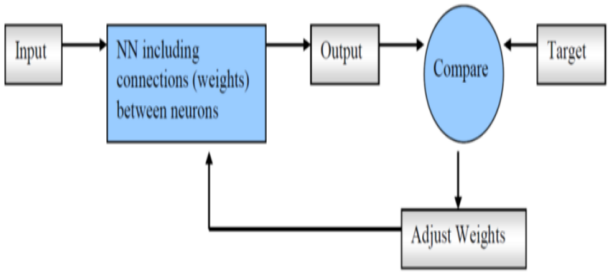

Fig. 4: Process flow diagram of a Neural Network [9]

In figure 4 in the flow diagram, the network is given an input. Its mission is to attempt and equal the output to the target by setting its weight until the output is a near equal to the target.
This method can be compared with the method the neurons in a human brain function. It will work in its own method and discover a solution on its own. It does not depend on anything to discover the solution. There are things that a human might not see but the neural network will not avoid it [10]. It processes data utilizing the high order of interconnection in between its huge simple processing units which work together to perform huge parallel distributed processing. The neural network is exceptional especially for:

1) Adaptive learning: Ability to learn to do a mission depends on the input given to it.
2) Self-organization: Through learning, it regulates the data given to it.
3) Real-time operation: Calculations are done in parallel.
4) Fault permission: Performance is decayed by the partial decay of a network.

5.1. Pattern Recognition Network

The neural network can implement several functions. The classification needs a pattern-identifying tool. Therefore, the pattern identification function was chosen. A matrix where every one of its columns includes the feature vectors received from a person. A target matrix is too supplied along with it, which will have the equal number of columns as the input matrix. The idea of the target matrix is to display in every one of its columns the class to which the similar column in the input refers.

There are groups of 20 individuals that have been collecting signals from them. For every individual, the feature vectors are produced. A group of 20 trials is collected per individual. One trial among the 20 for every individual is kept to be utilized as test input. The other 19 trials from the 20 individuals are utilized to form the training collection (input) matrix which has 400 columns of feature vectors. A target matrix of the size 20 by 400 is formed. Because the target matrix and the training collection matrix have the equal number of columns, thus every column in the target matrix conforms to a column in the training collection matrix. Thus, every column in the target matrix can be designation to an individual by placing a row in every column of the target matrix to 1. If the first 19 feature vectors column in the training set input refers to person 1 then the class 1 in the target matrix will have every of the first 19 columns will have their first row as 1. A part of the target matrix is displayed in the schedule in figure 5 for knowledge.

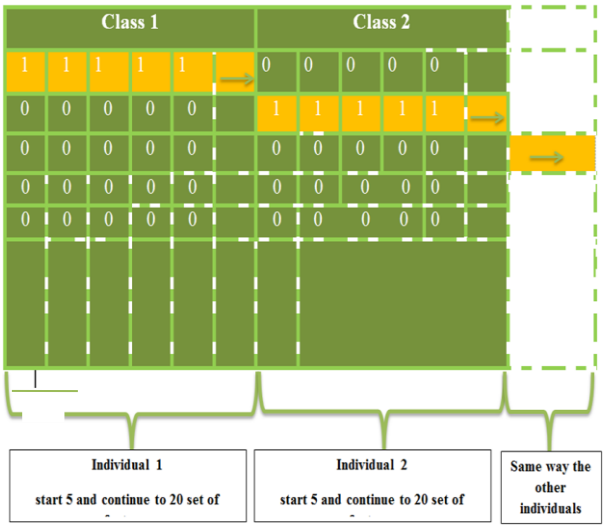

Fig. 5: A portion of the target matrix for training

The one collection of data kept individually from every individual will lead to a collection of 20 data. Therefore, a matrix of 20 columns of feature vectors will be created to be utilized as test input signals in the network that will be created after training the network with the training collection matrix and the target matrix.

The input area is shared by all the neurons. One of the analog neurons is allocated for each pattern being recognized [11]. Many neural nets are operating in parallel for pattern recognition attempting to locate features that are popular among the columns in the matrix. These features are passed into another to find the nearest match. The neural network works in the recognition process this way. All that the network requires is that it is given enough data to training itself for pattern identification and an output with correct structure algorithm**.**

5.2. The Classification and Feature Set

In this phase, every process done by the beginning with training the network and then testing along with the results obtained will be illustrated in details [12].
ECG signals were gathered from 20 individuals. The number of trials gathered per individual was 20. The signals were gathered at a sampling frequency of 256Hz. That means there are a total of 400 separate signals altogether. Now as was illustrated in the previous sections out of the 20 trials per individual were taken for training the system. That means 400 signals were utilized to train the system in total. The 1 signal can be saved aside from each individual will be added to obtain 20 signals to be utilized for testing**.**

The 400 signals would each give a collection of the feature vector. A matrix consists of 20 columns where each column illustrated features extracted from one signal. So the training matrix has 20 columns of features extracted per individual. This will help to make the target matrix where every one of its columns will correspond to a specific individual and the row including a value of one will indicate the individual.

5.3. Training the network

Because we are attempting to recognize individual using certain feature collected from their signals at first the neural network beginning you select the pattern recognition tool. Next, the training matrix and its corresponding target matrix will be loaded. The training matrix will be utilized as a set of input. The training matrix will illustrate the feature vector belongs to which per individual. The system will be simulated based on these matrices created. The network has to be trained many times until the percentage error is tiny. During network training, frequently some of the features such as the number of neurons may be altered to achieve a good performance and a lower error rate than the system. They can be understood from the table 1 that every class is named to one individual.

Table 1: Subjects assigned to classes

class	individuals
1	ECG1
2	ECG2
3	ECG3
4	ECG4
5	ECG5
6	ECG6
7	ECG7
8	ECG8
9	ECG9
10	ECG10
11	ECG11
12	ECG12
13	ECG13
14	ECG14
15	ECG15
16	ECG16
17	ECG17
18	ECG18
19	ECG19
20	ECG20

The network will be trained according to class provided to know the variations in features that one individual might have. This will help for it to know the function of the network. The various abilities of the network during training and testing in terms of performance, time, iterations, success rate, failure rate and other tests will be perfect explained.

The neural network training interface is illustrated in figure 6. we can view the architecture of the network. The layer of the network can be viewed. The 35 are written under the hidden layer illustrations 20. The default option is 10. However, by trial and error, it was found that 35 neurons at the hidden layer gave the greatest result. The aim of the mean squared error is to reach 0 according to the network. The validation checks illustrations 6 maximum failures. Therefore, this means if the maximum failure is 6 then the system will halt its process. The gradient value too has to be accounted for because as soon as its minimum value is met the system will stop too. From the training tool, it can be viewed that the target was met after 282 iterations and at a gradient of 0.0060677.

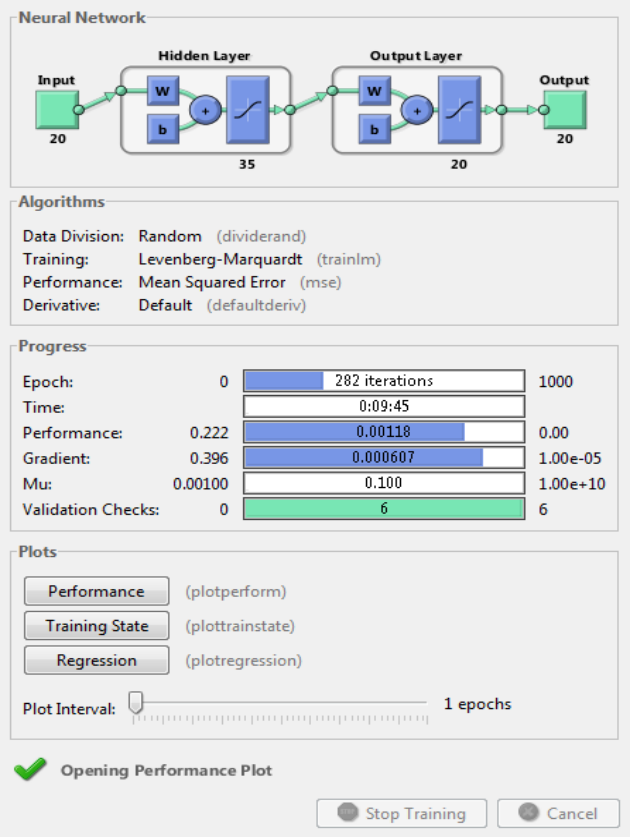

Fig. 6: Neural Network Training tool for (AC/PCA)

The plots part in the training tool illustrates various methods of analyzing the network. The first is the graph of the performance. This is obtained from the training, testing and validation set. Now the system automatically takes a certain ratio of the training matrix data for validation and testing when we provide training and target matrices for training the network. In this case, the ratio is 15%. This is done because the validation will indicate the system to halt if the maximum from the failure equals the number of the validation samples. This means that the generalization of the network no longer displaying any improvements. Test samples are utilized mainly to verify the network performance. That means to view how effective the network is. It will illustrate the performance as shown in figure 7.

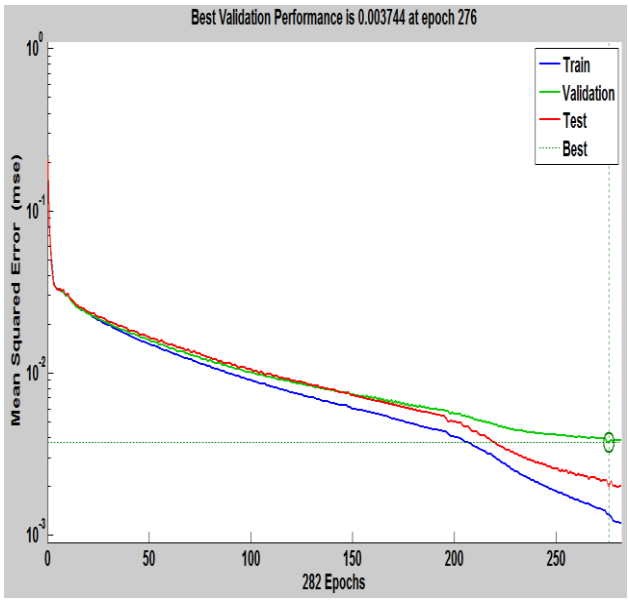

Fig. 7: The best validation performance of neural network using (AC/PCA)

The training data has passed the threshold of the Mean Squared error long before the validation and test data. The test data stays illustrating that the test performance is good which means the network is operating in the correct direction. The validation is right under the test curve. Both the validation and test curve cross the best threshold at the different time. The circle on the graph displays the case where the best iteration is realized which is at 282 iterations. This is the returning case of the network.

In the same way for the (AC/DCT), the recognition rate for 20 individuals was found to be at 17%. That means 4 out of 20 individual were correctly recognized. This is the bad result for this way. The results of (AC/DCT) are explained for the neural network and best validation performance in figures 8 and 9 respectively.

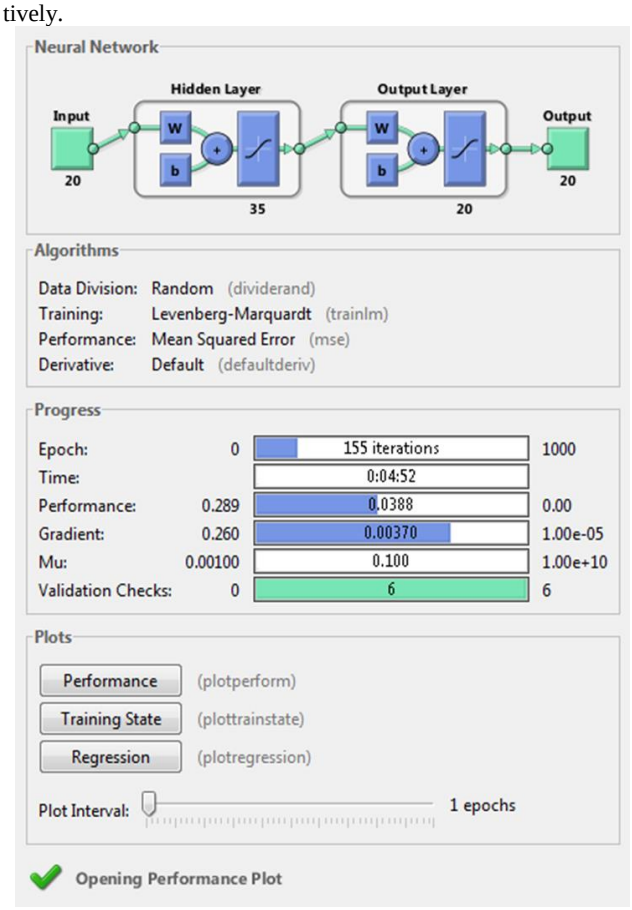

Fig. 8: Neural Network Training tool for (AC/DCT)

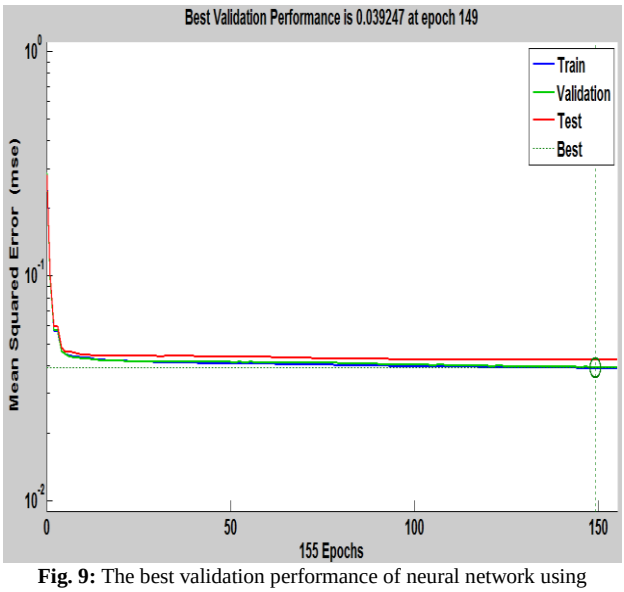

Fig. 9: The best validation performance of neural network using (AC/PCA)

5.4. Testing the network

The test samples taken by the network itself during the training are small. Therefore, it is better to verify with a larger database display as in figure 10.

Through this research and previous studies shows that found when taking a large number of samples and conduct the process of training by the neural network is found a small error rate with a high probability of the process of classification when taking 20 Sample 20 individuals were obtained 97.5%.

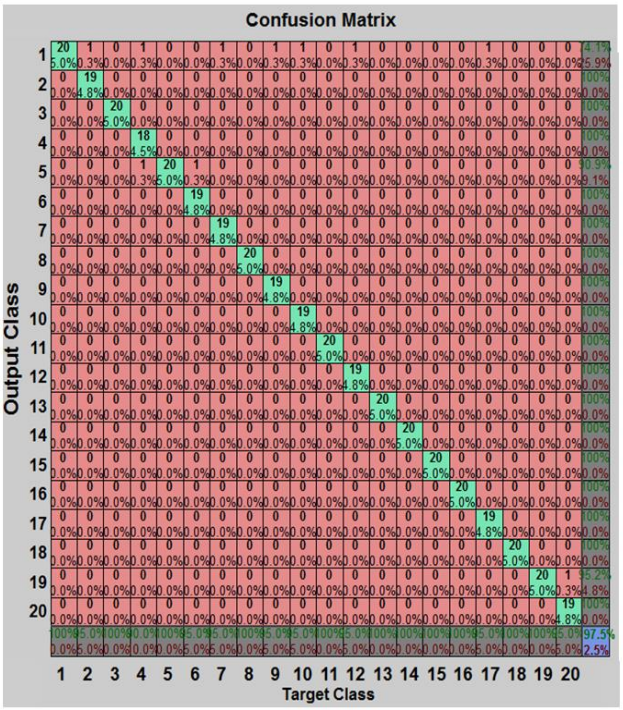

Fig. 10: Confusion matrix with test results of 20 Individuals by (AC/PCA)

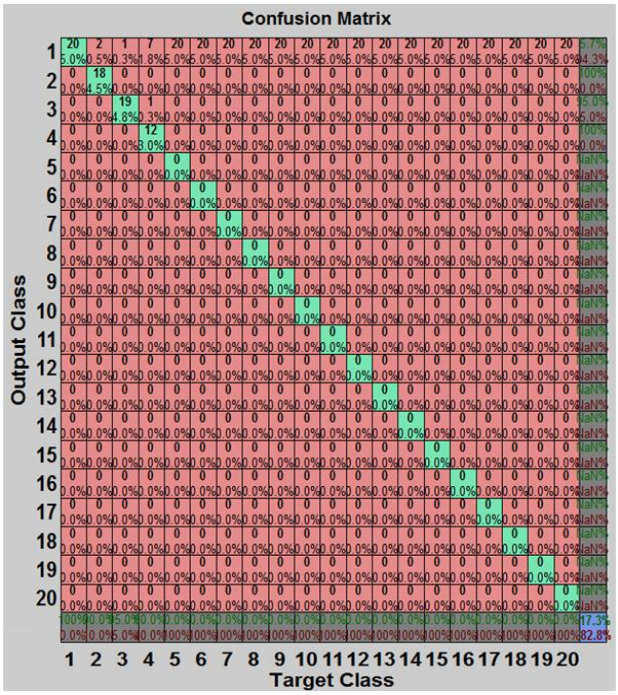

Fig. 11: Confusion matrix with test results of 20 Individuals for 20 samples per individual by (AC/DCT)

6. Conclusion

The system of doing fiducial detection in recognition is not a strong option. Rather than the non-fiducial is showing the best result and strong and permanent performance. It has high computational benefits as opposed to the fiducial detection. This is faster than the fiducial detection algorithm.

In this paper, A biometric identification system was designed by autocorrelation (AC) based feature extraction and dimension reduction using DCT and PCA. The 20 persons are used in ECG biometric recognition in both DCT and PCA. The recognition obtained is equal to 17% in DCT but it is equal to 97.5% in PCA.

Thus, (AC/PCA) is a better system than the (AC/DCT) for ECG biometric recognition.

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