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# Person Identification using SOM

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**ABSTRACT**
Security systems are basically based on authentication process. It is being more secure using different approaches. Verity of security systems is available in market but, they uses conventional scheme for identification of a person for an authentication process. Authentication is based on identification process. Recently signals like EEG and ECG called physiological signal of a human is a famous subject for the researcher. Many systems are being developed using this unique human characteristic. It is very hard to copy and universal for every human kind. In experiment for person identification method uses EEG signal, Wavelet Packet Decomposition (WPD) for feature extraction and Self-organizing map (SOM) as a classifier.



## Introduction

Electroencephalograph (EEG) was first recorded by Berger in 1929 by externally attaching several electrodes on the human skull in the past ten years; several studies have been proposed using brain waves, e.g. EEG as a biometric modality. It can be used in biometric security system for maintain privacy of precious data or transaction. Because of uniqueness of the EEG signature system becomes more secure and easily accessible for handicap person also which is main disadvantage of conventional biometric security systems.

In conventional biometric security system basic human characteristics like voice, face, iris, figure print, signature etc are used [8]. Demerits of them are they are not trustable and easy to copy. Because, accidently or handicap person may not have figure print or voice. System is useless for physically challenged person or who accidently loose that characteristics that is called physical damage. Best example is figure print. Handicap person may not have hand or in accident may lose fingers in that case he or she cannot access that system [1]. Solution for this problem is we must have to concentrate on unique characteristics of human traits like physiological signals of a human like EEG or ECG. This is a unique pattern of any human during his life. EEG can be best replacement of the conventional biometric traits of human for the identification process of a human or person, because it has high inter-subject variability (very large difference in two individual EEG signature), low intra-subject variation (EEG signal of a same person have very small difference which can be neglected), universal (every person have this characteristic except brain dead), calculative (It can be recorded and processed like other signal) but complex in calculation.

There are many application are possible for EEG signal. Some of EEG based systems can be used in various domain as well as personal device like login in your computer or mobile, for personal information in bank transaction, building and gate control, voice mail etc. This is the beginning of the era of EEG and ECG based system. Researcher are now capable of driving a wheel chair using EEG signals and find more application which can be useful for human kind one of them is security systems.

In [8] Anil K. Jain, Arun Ross and Salil Prabhakar define the characteristic of ideal biometric identifier, description of different biometric identifier with comparison of them. New types of biometrics are explained, that is based on physiological signals, such as EEG and ECG signals, rather than more traditional biological traits. Typical biometric traits, such as fingerprint, voice, and retina, are not universal, and it can be subject to physical damage. It is the main disadvantage of the traditional biometric traits. In [1] Howida AbdelFattah Shedeed is basically focus on recently treads of researches in a biometric security tend to use new types of biometric that based on physiological signals. Preliminary test used Discrete Fourier Transform (DFT) and Wavelet packet decomposition (WPD) for features extraction with two different measures with each of them. Total of 4 different methods, which produced 4 different features sets. Classification rates were 93%, 87% & 93% using the 3 recommended features sets. After executing the proposed voting scheme, classification rate increased to 100%

The experiment in this paper shows the possibilities of EEG signal in such security system with neural network. For that a method for identification of a person is proposed which uses EEG signal as an identifier for the system and neural network for decision making operation. Raw EEG signal is very noisy so, artifacts and line noise are being removed by the software at the time of data acquisition process. And for further process it should be filter first for selection of a proper band of the frequency according to application requirement. After filtering process, feature extraction process is applied for collect desired feature is extracted from EEG signal. For that many different methods can be applied. Here, in this method Wavelet packet decomposition is used. For classification self-organizing map (SOM) is used for artificial neural network. SOM use an unsupervised type learning rule.

## Methodology

Researchers find the way to use physiological signal like brain activity as a new modality for person identification process. In this paper improved security system concept is represented which uses EEG signal with artificial neural network for human identification. Due to characteristic of the EEG mention above explanation makes it impossible to mimic

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(as the brain activity is sensitive to the stress and the mood of the person, an aggressor cannot force the person to reproduce his/her mental pass-phrase). So, it is called unique EEG signature of a person. Here, some steps are describe for achieve desired identification of a person.

A very first step is data acquisition EEG data from a person. It is very tedious job because brain signal is in terms of μV (around 100μV) [18]. Now a day's nano-sensors are available for recording of EEG signal. Conductive gel is used for place sensor for better recording. Although raw EEG signal is too noisy line noise and other artifacts is removed by software right after the recording. In this paper signal is taken which artifacts and noise is already being removed. Then find out the suitable feature for the application. Selection of a classifier is the key factor (process) for the experiments because classifier output decides the output of the system. All the steep discussed above will be explained in detail and represented in the form of figure 1.

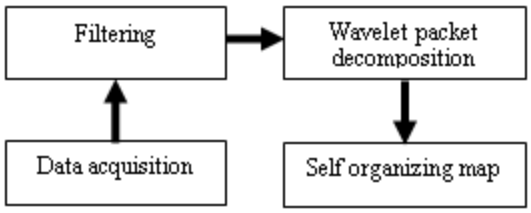


**Figure 1: Block Diagram of Proposed System**

***Data Acquisition***

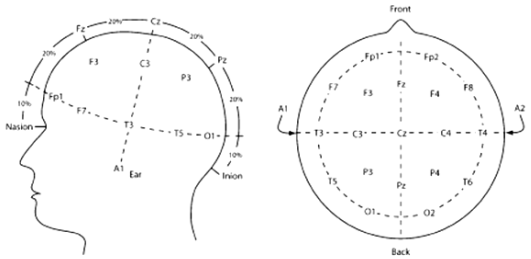


**Figure 2: Standard 10-20 international system for sensor placement.**

Data acquisition of EEG signal from a subject r person is very time consuming process. EEG signal is the electrical responses of the neural cells for various activities. Recorded data is the sum of all potential generated by the neurons. We are record relative potential of the scalp through sensor. Data is collect from the scalp using sensors. The signal from that particular place where the node placed is the average of the total relative potential of the scalp. Raw data is too noisy so it needs to be filtered and amplified for further processing.

In 10-20 international system sensor is place such that distance between two sensors is either 10% or 20% of total area of the scalp [18]. For that measurement of scalp is taken before node placement as shown in figure 2.

**Filtration**

Recorded EEG data can't be used directly. It contains lots of noise and other artifacts which is removed by applying filters with the help of software. It removes noise like line noise etc and other unnecessary artifacts. Then also filtration process is done with the signal for selecting desired EEG band. Digital band pass filter is applied at this stage. EEG signal band is about 0.5 to around 90 Hz. For this experiment we require basic four signal band. To get that band Butterworth band pass filter is designed to extract signal which frequency is 0.5 to 64Hz. At the time of identification person should in fully awake state. EEG signal dived in four basic EEG patterns which define the different mental state of a person such as drowsiness mood or he/she is fully awake state or in deep sleep, it is defined as Delta (δ), Theta (θ), Alpha (α), and Beta (β) [8]. Here, to get alpha rhythm filter cut off frequency is 8 Hz and 12 Hz which would be get in Next task, it is features extraction.

**Wavelet packet decomposition**

Extraction of a feature is defined as it is the process to get desired feature from the EEG. Reason behind the feature extraction is classification process is easy with the feature because of feature we can easily differentiate the person. There are various methods are available for feature extraction but here, Wavelet packet decomposition (WPD) is used for feature extraction. It gives output in both time domain and frequency domain as well. On that basis of that we can take both feature time series as well as frequency.

**Wavelet Packet decomposition (WPD)**

Disadvantage of other time domain methods method is they give feature in either in time domain or in frequency domain. Unlike those methods WPD can analyzing signal in both domain. So, it is used in this experiment for feature extraction of the non-stationary signal as well. In the discreet wavelet transform, each level is calculated by performing the series of operation by passing only last approximation coefficients through both low and high pass quadrature that gives one high pass component and low pass component. High pass component is usually denoted as D and low pass denoted as A. WPD is the wavelet transform where the signal is passed through more filter than the discrete wavelet transform (DWT). Studies using wavelet packet decomposition to analyze EEG signals were able to obtain the four brain rhythms: alpha, beta, theta and delta.

In this research four level of wavelet packet decomposition with 'db5' wavelet filter is use for the EEG signal feature extraction. By using 8 to 12Hz band which is alpha rhythm features are extracted from node (4, 2) of a wavelet packet tree for further processing. In these experiments features such as mean of the signal, Standard deviation, Minimum value of the signal, Maximum value of the signal is used for the training of artificial neural network.

Thus total four feature of the one channel such three channels are used in this project so total number of feature for each data is 5*4=20 feature for each person data. All the feature of all data use in the experiment is stored in one metrics which is used for training for the neural network.

**Classification**

Artificial neural network is the best technique for the classification purposes in many areas. There are many advantage of neural network one of those is it is complex but once it is trained from data it is too fast in calculation. Classification of any signal or input is to verify or categorize in the pre-define classes and cluster. In classification two different learning rules is use one is supervised rule and other is unsupervised rule. Unlike supervised rule in unsupervised learning method there are no such pre-defining classes.

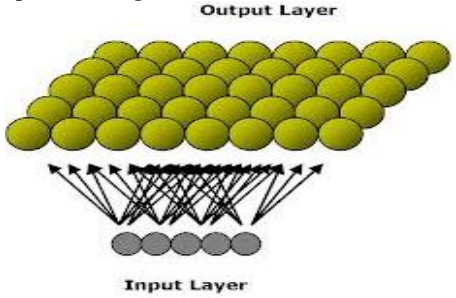


**Figure 3: Architecture of SOM neural network**

First architecture of the network is done. Then weights are allocated and initialized to the networks neurons. After that distance is calculate according to the algorithm or type of the classifier. That decides the winner and according to the winner weights are adjusted. In unsupervised learning there are more than one winning neurons that creates different clusters. Series of operation (iteration) is done until stopping criteria is matched. Now a day it is very popular because of its speed of calculation and data handling capacity is very high.

In this paper self organizing map (SOM) neural network is used. SOM is a standard statistical clustering technique for classifies the input to the specified output classes after training SOM assign weight vector to the input pattern. Here data is given to the network for training thus, it is unsupervised learning technique we do not know the output of the system. Basically, network output is the signal is lying in which cluster.

Architecture of the SOM neural network is shown below in figure 4. In this network there are basically two layer, first is input layer in that number of neuron is depends upon the number of inputs then second layers it can be one or more according the necessity of the application then lastly, output layer.

The Self-Organizing Map algorithm can be broken up into 6 steps [16]:

Step 1: Each node's weights are initialized.

Step 2: A vector is chosen at random from the set of training data and presented to the network.

Step 3: Every node in the network is examined to calculate which ones' weights are most like the input vector. The winning node is commonly known as the *Best Matching Unit* (BMU). (2).

$$DistfromInput^2 = \sum_{i=0}^{i=n} (I_i - W_i)^2 \dots\dots\dots (2)$$

Where, I = current input vector, W = node's weight vector, n = number of weights.

Step 4: The radius of the neighborhood of the BMU is calculated. This value starts large. Typically it is set to be the radius of the network, diminishing each time-step. (3a, 3b).

$$\sigma(t) = \sigma_0 e^{\left(-\frac{t}{\lambda}\right)} \dots\dots\dots\dots\dots\dots\dots\dots (3a)$$

Where, t = current iteration, λ = time constant, σ0 = radius of the map

$$\lambda = \frac{numIteration}{mapRadius} \dots\dots\dots\dots\dots\dots\dots\dots (3b)$$

Step 5: Any nodes found within the radius of the BMU, calculated in step 4, are adjusted to make them more like the input vector (4a, 4b). The closer a node is to the BMU, the more its' weights are altered (4c).

$$W(t+1) = W(t) + \Theta(t)L(t)\big(I(t) - W(t)\big) \dots (4a)$$

$$L(t) = L_0 e^{\left(-\frac{t}{\lambda}\right)} \dots\dots\dots\dots\dots\dots\dots\dots (4b)$$

$$\Theta(t) = e^{\left(-\frac{distFromBMU^2}{2\sigma^2(t)}\right)} \dots\dots\dots (4c)$$

Step 6: Repeat step 2 to 5 for N iterations.

The classifier performs a series of operation with each pattern of the training set until N iterations are met. Classification is done using SOM in different cluster. Many tests are performing for optimum solution for the neural network configuration that will be explained in the experimental results.

**Experimental Results**

Experiment is done with two sets of data and combination of subject is selected randomly. During the process of recording the data, subject should sit at rest with eye close in a silent room and remain calm throughout the whole process. In this experiment data is taken from channel C3, P3 and O1 at sampling frequency 240 Hz for 3 second epoch. Here results are shown below:

1. Data of EEG signal is lying between 0.5 to about 64Hz. Here for the further process EEG signal of 0.5 to 90Hz is passing through butter-worth band pass filter which has pass-band frequency is 0.5Hz and stop-band frequency is 64Hz (alpha rhythm). All three channels follow the same operation. Following figure shows the filtering operation and resulting alpha rhythm of channel F3.
2. Four level of wavelet packet decomposition is applied in a filtered signal. Here detail coefficient of the D1 component is used to extract the feature from every channel. Features that are used in this method are: mean minimum, maximum, standard deviation and entropy of the signal. All features are calculated with equation which is mention in above explanation. These feature are stored in a metrics which will be used for the training of a neural network

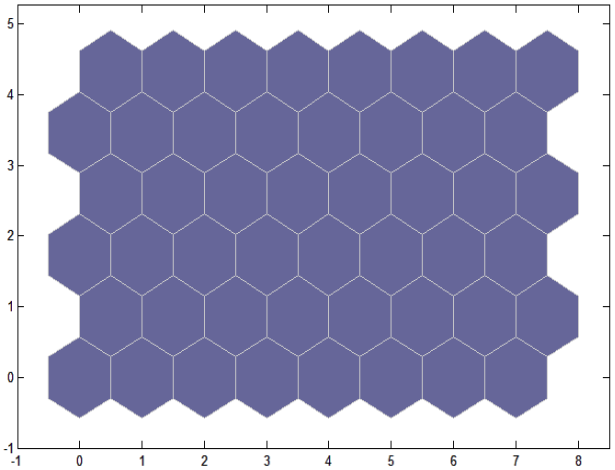

**Figure 5: SOM Topology**

Self organizing map neural network is train by the data is use for the classification in this paper. The number of neuron in the input layer varied accordingly of the number of the feature is used here in this experiment 5 feature of each channel is used for the training here SOM topology is set up of 8X6 neurons as shown in figure 5. Output layer contains neuron according to the number of cluster for each feature extraction method, the configuration that produces weight arte optimized to maximum classification, sensitivity and accuracy. Thus we can say that configuration of the classifier plays important role in the experiments to achieve best classification. This experiment is implemented in Matlab 2011 and using neural network tool box.

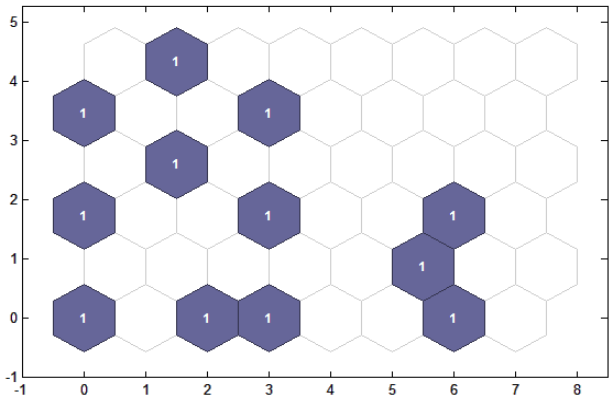

**Figure 6: Hits of the SOM topology while training**

**Table 2: Performance of the SOM Neural network**

| Parameters | Data set 1 | Data set 2 | Data set 3 | Data set 4 |
|---|---|---|---|---|
| TP | 576 | 576 | 576 | 576 |
| TN | 12 | 12 | 12 | 12 |
| FP | 08 | 11 | 11 | 11 |
| FN | 08 | 11 | 11 | 11 |
| Sensitivity (%) | 98.63 | 98.13 | 98.13 | 98.13 |
| Specificity (%) | 60.00 | 52.17 | 52.17 | 52.17 |
| Accuracy (%) | 97.35 | 96.39 | 96.39 | 96.39 |

**Conclusion and Future Work**

In this paper one unsupervised learning type classifier is suggest for person identification in biometric security system. Importance and explanation of feature extraction is explained in this paper. Technique for the feature extraction plays very role in this system, because classification process is based on that feature which is extracted from the signal. Here, Wavelet packed decomposition technique is used for it and self organizing map neural network performs very well and give about 95% to 97% classification in inputs in the right cluster for all data set of the different subject. In future system testing for more data and achieve 100% accuracy for more number of data. Here, three channels are used for identification process; in future research can be done on how we can reduce the number of the channel for this application with 100% accuracy and sensitivity.

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