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Mental Stress Assessment of ECG Signal Using Statistical Analysis of Bio-orthogonal Wavelet Coefficients: Part-2

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Abstract: ***In recent scenario, mental stress analysis is important task. There are different methods used in the literature survey to extract the mental stress. Wavelet transform as transformation, Power, Energy, entropy, Co-variance, Standard deviation and Mean, as features and K nearest neighbor (KNN) or Back Propagation are commonly used to build mental stress system. In this paper, a modified approach to mental stress level detection in a person has been proposed. In this method two lead ECG data extraction and bior 3.9 (bio-orthogonal) wavelet transform has been used for decomposition of ECG signal data up to level three. Features Such as Power, Energy, Entropy, Co-variance, Standard deviation and Mean are used for stress detection and analysis. Finally the Back Propagation classification algorithm is used for classification of mental stress level and normal level. The result from this approach is more favorable and acceptable.***

Keywords: ECG, bior 3.9, Wavelet decomposition

1. Introduction

It has been observed that automatic mental stress level detection is an important task in today's world. Brain operates the parts of the body so it reflects partial change in functioning of the part of the body like heart. Heart activity generates ECG; therefore ECG can be used to analyze the mental stress level.

It is observed that stress level is function of various statistical parameters of normal and stressed state of mind. To observe the mental stress level, the features like Power, Energy, Co-variance, Entropy, Standard deviation and Mean are important parameters. These parameters can be extracted directly from ECG signal and transformation like Fourier transformation or wavelet transformation can be extracted. In literature different methods have been proposed to detect mental stress level in a person based on ECG of that person. To detect or estimate stress, features are extracted from wavelet transform of the ECG. The db4 mother transform function of the wavelet is generally used in stress detection but it produces some error due to its shape.

So wavelet mother function should not be changing its shape (QRS wave) because it contains the information about the person's stress level. Bior wavelet family may be useful due to its property that it retains approximate similar shape as original ECG signal.

ECG collection from 12 lead method is too complex and person may go on unnecessarily stress level so ECG collection method should be simple and easy so person can remain in his original state (either stressed or normal state).For this 2-lead or single lead ECG may be useful in stress detection method. Another complexity in mental stress detection is classification. Once features are extracted from test ECG transform data, it is compared with transformed training signal and the result of that training signal to generate the output of test ECG data signal with the help of neural network. In literature different classification techniques are used to classify stress level. KNN and Back Propagation neural networks are commonly used. The problem with KNN classifier neural network is that it is a slow learner i.e. for training it takes more time and it require large database. Back Propagation is fast and more suitable than the KNN neural network. Therefore to find stress, algorithm should be simple and hybrid of most favorable algorithm used in different steps i.e. transformation, features extraction and classification.

2. Algorithm

As discussed above, mental stress level is important task in bio-medical signal analysis .For stress detection, features are extracted from transformed ECG signal (wavelet transform).Wavelet transform decomposed the ECG signal in detailed and approximate coefficients using different mother function. In this, bior3.9 wavelet transformed can be used to overcome distortion occurs in db4 wavelet transform. Features like Power, Energy, Entropy, Co-variance, Standard deviation and Mean can be used for classification. Back propagation classification technique may helpful for the classification of the stress level. Most important task to built mental stress detection system is database collection of different stress level as well as normal level. Two lead data collection is easy to collect from a person so it can be used to take ECG form person at the training and test session. For this less electronic circuitry is required to database collection. The main objectives are;

- To design hardware to collect two lead ECG from a person.
- To collect ECG database from 10 subjects in relaxed and stressed condition.
- To find and analysis the features like Power, Energy, Entropy ,Co-variance, Standard deviation and Mean from decomposed ECG using bior3.9 wavelet transform.
- To build a mental stress detection system using Back Propagation classifier network

- To evaluate the performance of mental stress detection system

3. Training of the classifier Network

The Back Propagation Neural Network has been used to classification the stressed or relaxed state of the subject. For this purpose, training of the Back Propagation Network has been done using real time ECG data of both states (stressed and relaxed). The training is done till the mean square error reached up to the value of MSE = 0.00099995with output is in the range of 0.5 to 1 for stressed and 0 to 0.5 for relaxed state

4. Stress detection

After training the stress can be calculated from any subject i.e. person is in stress or not. The following block diagram shows the process to detect the stress in real time of any subject.

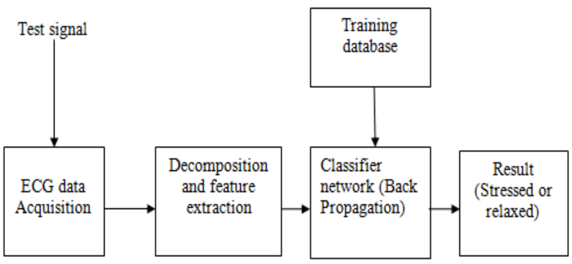
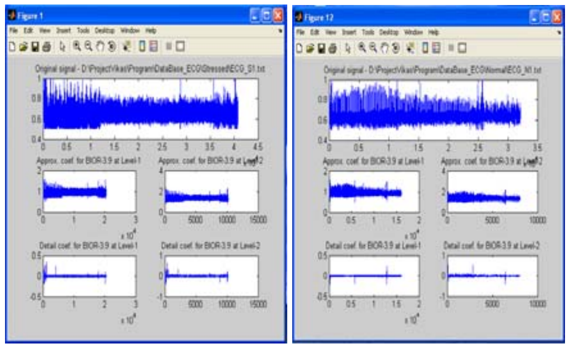


Figure 1: Block diagram of stress test process in real time

The real time test ECG data has been collected from the subject. Then this data decomposed by the MATLAB software up to the three level decomposition and features (i.e. power, energy, mean, entropy, co-variance ,standard deviation) were collected and with the help of classifier Back propagation network the result has been collected.

5. Results

In the presented work, ECG is acquired using AD Instruments. To remove noise we have used band pass and notch filter. As stimuli we have used mental arithmetic task (MAT).Discrete wavelet Transform (DWT) is used to extract the features. These features are then normalized and then classified in two states namely normal and stressed, using Back propagation (BP) algorithm. The following table shows the percentage of error of tested normal and stressed ECG. The approximation coefficients and detailed coefficients of the subject after decomposition up to three levels of normal and stressed ECG data as shown below:



Stressed ECG Normal ECG

Figure 2: Approx. and detailed coefficients waveforms of Decomposed Stressed and Normal ECG data

The below graph shows Power, Energy, Mean, standard variance, co-variance and entropy by taking difference of the decomposed ECG data of normal and stressed states.

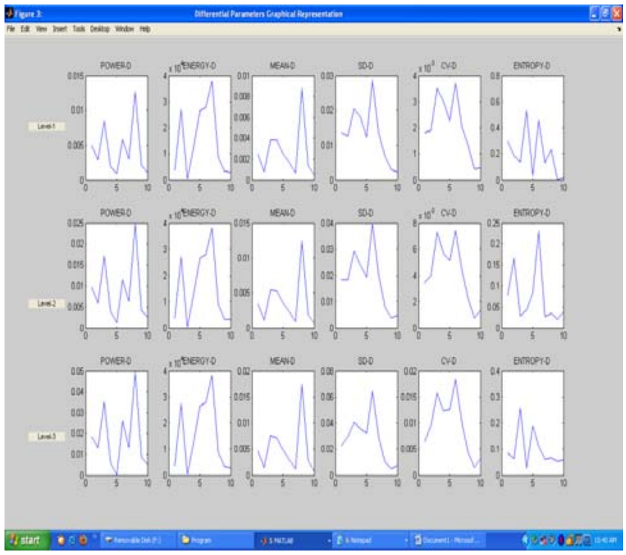


Figure 3: Graph of parameters difference of the decomposed ECG data of normal and stressed states.

Table 1: Testing Phase with Normal ECG data

S. No.	*Normal ECG*	*Result*		*% Error*
		Normal	*Stressed*	
1	10 database using 2-lead method	10	0	0

Table 2: Testing Phase with Stressed ECG data

S. No.	*Normal ECG*	*Result*		*% Error*
		Normal	*Stressed*	
1	10 database using 2-lead method	1	9	10

6. Conclusion

The presented work investigates the stress level of the patient under scanner based on statistical parameters extracted from ECG. The system may be optimized for monitoring the patient online based on the ECG waveform. Further, the presented work investigates the presence of stress level and not the resolution in between the different stress levels. However, the energy factor in ECG waveform as discussed in previous sections is the primary factor that shows a fair amount of change from normal to stressed person under test. The same may be used for creating different stress levels of the stressed person with further if minute changes could be observed and in combination of other parameters. Once the existing or other new additional parameters contribute some changes with respect to different stressed patients, then the proposed neural network may be trained for creating different stress levels using the same algorithm, of course tuning with new parameters is must.

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