CHARACTERISTIC OF MOTION ARTEFACTS IN ELECTROGASTROGRAM THE CUTANEOUS RECORDING OF GASTRIC MYOELECTRICAL ACTIVITY OF STOMACH

B.T. Mika*, E.J. Tkacz*,**

* Institute of Electronics, Silesian University of Technology, Gliwice, Poland
** Medical University of Silesia, Faculty of Pharmacy and Laboratory Medicine, Department of Bionics, Sosnowiec, Poland

b_mika@wp.pl

Abstract: The paper presents two approaches for solving the problem of detection and elimination of motion artefacts in the electrogastrogram recording. The first one is the characteristics of various motion artefacts and comparison of different combinations of extracted features from EGG signal used as the input of the neural network in order to obtain the optimal set of parameters for the best detection of motion artefacts by artificial neural network. The second one based on Continuous Wavelet Transform as the effective tool for detection motion artefacts in EGG signal and using Wavelet- Neural Network for eliminating the artefacts from the EGG date.

Introduction

Electrogastrogram (EGG) is a surface measurement of stomach wall nerve activity. It is a non-invasive test, relatively inexpensive and easy to perform. Electrodes are placed cutaneously on the abdominal skin over the stomach and the signal is recording during about one hour. EGG is an appropriate diagnostic tool when there is a suspicion that the nerves controlling stomach muscles or the stomach muscles themselves are not working properly. As EGG test is very vulnerable to motion artefacts, which devastate the signal recording, they have to be eliminated before using EGG as a tool in gastroenterology.

Materials and Methods

Motion artefacts in EGG recordings depend on both subject and kind of motions. The group of 20 volunteers have been examined in order to study the motion artefacts generated by such motions as: reading loudly, coughing, sitting up, lying down, turning the body, raising legs and tapping the electrodes. Each exercises were conducted in the lying position with the motions lasting 2 minutes and with 3 minutes break during above one hour.

As a result it was obtained that reading generated motion artefacts in 4 cases, while turning body cause strong artefacts in 18 cases. For reading there were observed three types of artefacts for three person: one was pulse type in the time domain one was with strong components of low frequency in the frequency domain and one was with high amplitude in the time domain.

In case of turning body and raising legs artefacts do not vary each other, all of them showed high amplitude in the time domain and stronger components of high frequency in the frequency domain. Coughing, sitting up and tapping electrodes, generated two types of artefacts one with strong components of high frequency in the frequency domain (additionally some of them showed pulse character) and one with high amplitude in the time domain.

The artificial neural network was used for detection motion artefacts in the EGG date. Because of the time shift effect in the raw EGG recording some special features based on the characteristic of motion artefacts were derived from EGG date to improve detection. Such features as: amplitude spectra, maximum derivative, standard deviation and relative amplitude were taken into consideration in order to fix the optimal set of parameters for the best accuracy in the detection of motion artefacts.

Amplitude spectra gives opportunity to avoid the time shift effect simultaneously preserving all characteristic features which has a signal in the time domain. As far as motion artefacts are concerned the difference in the amplitude spectra for the date with and without motion artefacts were observed mainly in the high frequency above 0,1 Hz. Maximum derivative is very effective tool for detection pulse type artefacts which sharply vary in a short time period and it can be calculated as follows:

$$\Delta_{\max} = \max\{|x_i - x_{i-1}|\} \quad (1)$$

for i = 1, 2 , ... ,N-1 where x_i is the i-th sample of the segment , and N is the number of samples in the one segment. Standard deviation (σ) is a good tool for detection of motion artefacts as they show large variation in the amplitude in the time domain. Relative amplitude is defined as:

$$RA = \frac{\max(x_i - \min(x_i))}{\sigma} \quad (2)$$

Different combinations of the four features were studied using a perceptron type neural network with backpropagation learning algorithm as well as with 3 neurones in the hidden layer and one neuron in the

ISSN: 1727-1983

output layer, which returned adequately 1 for the date with motion artefacts and 0 for the date without motion artefacts. The number of neurons in the hidden layer was obtained experimentally.

The underneath table shows the comparison of accuracy (in percent) of detection motion artefacts using combination of different feature (MD-maximum derivative, AS- amplitude spectra, SD- standard deviation, AR- relative amplitude)

Table 1: Comparison of accuracy detection for various combinations of feature

Parameter	Accuracy (%)
SD	94,9
AS	96,2
MD	97,4
AS & SD	96,2
AS & MD	98,7
MD & SD	98,7
AS, MD & RA	98,7
AS, MD & SD	**100**
AS, MD, SD & RA	100

Testing results of detection motion artefacts present that using two features for detection result in the same or better then using one feature. The effect of three parameters detection was equal or better than two-features detection and simultaneously as accurate as four parameters detection thus amplitude spectrum, maximum derivative, and standard deviation were fixed as an optimal set of features for detection of motion artefacts by artificial neural network.

Wavelet-Neural System as an alternative way for detection and elimination motion artefact from EGG recording.

Recently advanced signal processing techniques such as wavelets and the possibility of combination them with the artificial neural network gives opportunity for alternative approach to analyse EGG signal as far as motion artefacts and their elimination from signal recording are concerned.

After preliminary signal preparation, as the first step of the analysis in wavelet- neural system (WNS) a new feature vector most suitable for the further processing is created. An important aspect of wavelet analysis is related to designing a wavelet that matches a class of signal.

The idea of using wavelets for detection motion artefacts in the EGG recording, based on cutting the part of original signal, which after visual inspection was decided to be an artefact, and create an appropriate wavelet which the best "matches" the waveshape of extracting artefact.

In this study four raw EGG signal recording from four different person were taken under consideration. From part of original signal which was visual decided as an artefacts were created four various wavelets named adequately: egg1, egg2, egg4, egg5, which are similar in the shape with distinguished artefacts. The egg1, and egg2 wavelets contain 20 samples while the other two wavelets contain 30 samples. Figures enclosed beneath display obtained wavelets. For wavelet egg4 there is also presented in figure 5b the fragment of original EGG signal from which the wavelet was created and there could be easy noticed that the shape of wavelet and original signal are really the same.

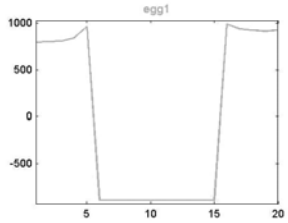

Figure 1: Wavelet (egg1) created from original signal Mal57 (20 samples).

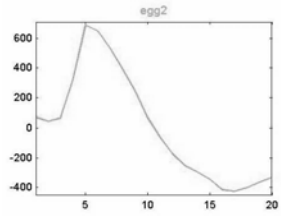

Figure 2: Wavelet (egg2) created from original signal Mal60a (20 samples)

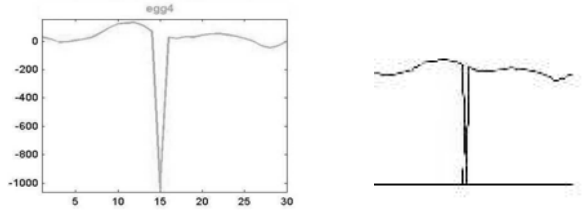

Figure 3: Wavelet (egg4) created from original signal Mal61a (30 samples) and the original part of signal

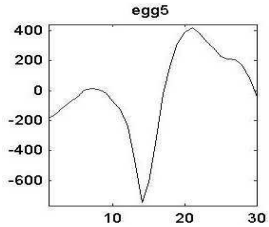

Figure 4: Wavelet (egg5) created from original signal Mal63a (30 samples)

ISSN: 1727-1983

As Continuous Wavelet Transform CWT can be stated mathematically by:

$$W_{\psi}\{f(x)\}(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{+\infty} f(x)\psi(\frac{x-b}{a})dx \qquad (3)$$

therefore in our case we can assume that the function *f(x)* is the raw EGG recording signal which should be cleaned from motion artefacts, and the function $\psi(\frac{x-b}{a})$ is created wavelet from the chosen artefact of original signal translated by *'b'* and scaled by *'a'*. In this study both *a* and *b* have been set equal to unity.

Using CWT as a tool for inspecting the EGG signal we can obtained totally control correlation process which means that the coefficients of wavelet transform obtain the maximum value for this part of original signal that are the most similar to using wavelet, which is equal with detection of motion artefact in the examining signal.

Results

The special software has been using Wavelet Toolbox in Matlab and the following results were achieved.

In the figure 5 the first box presents the original signal Mal78 which was taken for analysing with egg1 wavelet. It is easy to notice some artefacts in this recording. The second box displays the results obtained after applying CWT with the mother wavelet egg1, for detecting motion artefact. As we can see in the box two there are clearly exposed the areas where the artefacts similar in the shape with egg1 wavelet was recognized and detect.

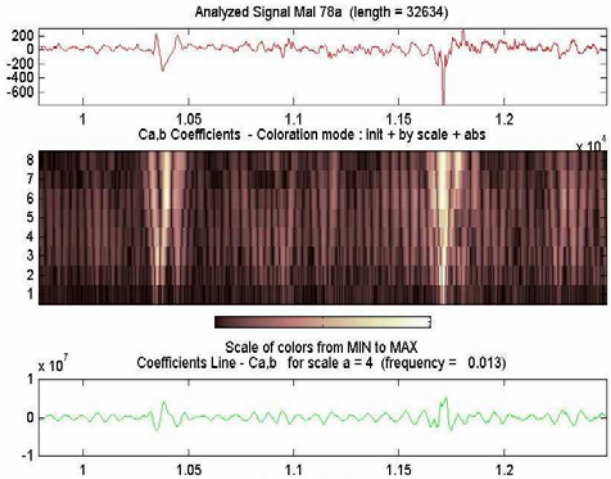

Figure 5: Signal Mal78a analysed with the egg1 wavelet and some artefacts that were detected by egg1 wavelet.

For the comparison in the figure 6 are shown the effects of detection motion artefacts applying CWT with mother wavelet egg4. Also in this case we obtained satisfactory results.

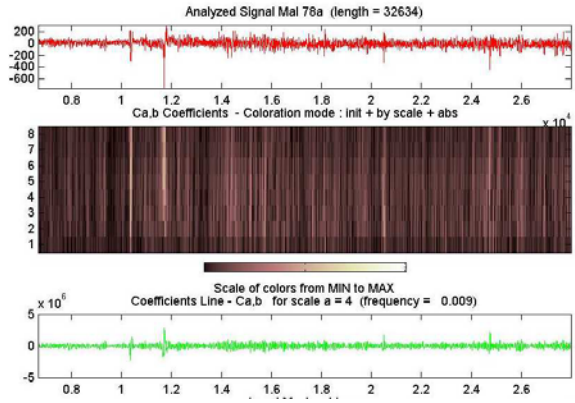

Figure 6: Signal Mal78a analysed with the egg4 wavelet and some artefacts that were detect by egg4 wavelet.

The further studies which were conducted for different EGG date, analysed for detecting motion artefacts, using CWT with various mother wavelet, created as we depict in this paper, confirm that this approach to the problem of detection motion artefacts from EGG recording gives a very good tools for effective application.

Discussion

The WT performed in the first layer of WNS allows to extract the most crucial information for classification problem. A proper action of wavelet layer is a condition of correct learning process, where in parallel with the neural network the optimal wavelet coefficient has been computed. A second step of signal analysis in WNS is performed in neural network structure, which complete the classification idea .

References

[1] METIN AKAY, 'Nonlinear biomedical signal processing', (2000): Vol.1, pp 233-253, 2000

[2] LIANG, J., CHEUNG, J. Y., CHEN, J. D. Z., (1997): ,'Detection and Deletion of Motion Aritfacts in Electrogastrogram Using Feature Analysis and Neural Network' Annals of Biomedical Engineering, Vol.25, pp.850-857, 1997

[3] ZHIYUE LIN, CHEN, J. D. Z., (2000): 'Application of feed-forward neural network in the electrogastrogram in [1], Vol.1, pp 233-253 ,2000

[4] E. J. TKACZ, P. S. KOSTKA, B. MIKA, (2005): ' Supervised and unsupervised learning systems as a part of hybrid structures applied in EGG signals classifiers', 27th Annual International Conference of the IEEE Engineering in Medicine and Biology Society 1.09-04.09.2005, Shanghai, China, (CD-ROM Conference Proceedings)

ISSN: 1727-1983