Selected methods of biomedical signal analysis based on EEG records for cases of epileptic seizures

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Abstract
In the field of neurology ElectroEncephaloGraphic (EEG) measurements constitute one of the tools for today's clinical misdiagnosis. The interval years knowledge of specialists in the interpretation of individual disorders neurological dysfunction is based on collected records in both paper and electronic form. Even though the collected numerous databases records EEG interpretation and the fault finding procedure is a very big problem. Development of modern diagnostic technology allows you to reduce hardware limitations, which generate many artifacts (errors) which prevent correct diagnosis. One with a dynamically developing tools is the analysis and interpretation of EEG signals by applying spectral analysis techniques. These techniques allow visualization of signal power spectrum depending on frequency components. The article describes an experiment on samples actual registered spotting seizures EEG measurements collected in close cooperation of medical staff of the Ward of Neurology and Strokes of the Provincial Hospital of Zielona Góra.

Keywords: EEG signals, epileptic seizures, pattern recognition, medical diagnosis

1. Introduction
Difficulties in the interpretation and analysis are closely related to the nature and origin signal itself. EEG measurements are recorded by placing electrodes on the surface of the head to register electrical activity on the surface of neurons of cerebral cortex. The EEG is reinforced when the cylinder head to the appropriate software can be visualized on the monitor recording the results to further interpretation. As already mentioned EEG signals are very difficult to interpret. One of the problems of non-stationary signal that is interpreted EEG signal. It is known that epileptic seizures cause sudden and unexpected jumps in the measured amplitude of the electrical activity of neurons on the surface of the cerebral cortex. Another problem is the number of artifacts caused by physiological disturbances such as heart rate, movements induced mobility when measuring patient (movement of limbs, eye movement, jaw movement, breathing). Artifacts contaminants analyzed signal are also relevant due to the bad placement of electrodes, multiple exposure to electromagnetic fields produced by equipment in the environment such as PC monitors, air conditioning. As a result of all these disturbances can cause electromagnetic devices and they have an impact on the quality and results of Electroencephalographic measurements. Attempting to search for new techniques measurements on the surface of cerebral cortex and analyze complex neurological diseases, such as seizure incidental may allow answer how human brain works and what processes may be responsible for presence of certain disorders. A very popular tool are artificial neural networks [6,7]. They allow you to isolate specific patterns of EEG signal, eliminating artifacts which are intended to assist fault finding on neurology. The experiments are performed on full measurements bipolar 16-channel EEG. For the extraction of characteristic signal features in the experiments used transform discrete wavelet technologies. In the process of classification is based on different methods, including analysis (Discrete Wavelet Transform called, DWT), k nearest neighbor based on artificial neural networks and Matching Pursuit algorithm.

2. Epileptic seizures
During registration, one of the characteristic EEG recordings is a epileptic seizure [9,10], which is a sudden and high discharge potential, Resulting in a sudden increase in the amplitude of the signal. Such discharges can occur locally or in many areas of the brain. Causes of these small problems occur as a result of various factors, dry as the human body physiological, hormonal changes, fever, hypoxia, fatigue, damage to the brain for instance the open surgeries due to brain tumor, aneurysm, brain hemorrhage, or as a result of various type of external stimuli, changes in the severity of their frequency, intensity of color [8]. To this day, it is not known
when an epileptic seizure. In developing diagnostic tools based on the latest technology and analyzing signals of ground paroxysmal may be able to finally answer many of the questions that contain the secrets of how the human brain works.

3. EEG signal processing

The study used data from the Provincial Hospital of Zielona Góra. Data were stored in close consultation with neurologists and EEG techniques in order to minimize any kind of operating noise characteristic of this type of signal records. These data are stored in the system in a standard bipolar montage 10/20 to 16 channels of electrode leads:1.FP1-F3; 2.FP2-F4; 3.F3-C3; 4.F4-C4; 5. C3-P3; 6.C4-P4; 7.P3-O1; 8.P4-O2; 9.FP1-F7; 10.FP2-F8; 11.F7-T3; 12.F8-T4; 13.T3-T5; 14.T4-T6; 15.T5-O1; 16.T6-O2. Low frequency filter was set at 35Hz.

4. Wavelet transform

In the case of discrete EEG signal can be used discrete wavelet transform (Discrete Wavelet Transform called, DWT) [1]. The DWT is closely related to the multi-resolution analysis [4], which consists of multi-level representation of the signal [5]. At each level of the analyzed signal is presented as the sum of the approximate and detailed analysis. For each of the following levels of coarse representation of the previous level again is presented as the sum of a coarse and detailed.

5. K – Nearest neighbors

K nearest neighbor algorithm is a method for classification based on the patterns of the nearest examples in the feature space [2]. The pattern is classified by a Majority vote of its neighbors, with the pattern being assigned to the class most common amongst its k nearest neighbors. If k = 1, then the pattern is simply assigned to the class of its nearest neighbor.

6. Matching pursuit

This method is a numerical technique to set a best-fit function from the set D to multidimensional data [3]. This assumption is based on the representation of a signal \( f \) Hilbert space \( H \) as a weighted sum of function \( g_\eta \) (called atoms) from the set \( D \).

\[
 f(t) = \sum_{\eta \in D} a_\eta g_\eta(t) \tag{1}
\]

where \( n \) indexes the atoms that have been chosen, and an \( a_\eta \) weighting factor (an amplitude) for each atom. Given a fixed dictionary, matching pursuit will first find the one atom that has the biggest inner product with the signal, then subtract the contribution due to that atom, and repeat the process until the signal is satisfactorily decomposed. Matching pursuit builds a sequence of sparse approximations to the signal stepwise and is a greedy algorithm that computes the best nonlinear approximation to a signal in a complete, redundant dictionary. To demonstrate and illustrate how the algorithm Basic Matching Pursuit proposed implementation uses the latest environmentally Matlab. For example, to illustrate selected to compare the case of one sample for determining epileptic seizure as well as for the corresponding standard EEG for the healthy.

7. Results and visualizations

7.1 K nearest neighbours

KNN - generate attributes based on wavelet analysis and statistical parameters: mean value and standard deviation. Reply to the system after 5 tri es, at 100, 500 and 1000 iterations (mean, max, min). Best results are listed in bold (tab.1).

<table>
<thead>
<tr>
<th>Tab. 1. Result Classification</th>
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<tbody>
<tr>
<td>Correct classifications (%)</td>
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<tr>
<td>kNN 5 tries 100 iter.</td>
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<tr>
<td>kNN 5 tries 500 iter.</td>
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<tr>
<td>kNN 5 tries 1000 iter.</td>
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7.2 Wavelet transform and multi-resolution

Example of decomposition of the signal to a level 5 for the recording of a epileptic seizure using db3 wavelet.

Fig. 1. Multiresolution signal decomposition (epileptic)
Fig. 2. Statistics and histogram (epileptic)

Fig. 3. Compression (conservation of energy (epileptic))

Fig. 4. Residuum and FFT Spectrum (epileptic)

7.3 Matching pursuit

Example of visualization application with Basic Matching Pursuit algorithm for pattern signal with a known epileptic attack compared to normal recording signal.

Fig. 5. Signal with the Basic Matching pursuit approximation superimposed (epileptic)

Fig. 6. Percentage of retained signal energy and the relative error percentages norms over the algorithm iterations (epileptic)

Fig. 7. Superposition of selected vectors from the sub-dictionaries (epileptic)

For the purposes of comparison visualization algorithm efficiency Matching Pursuit for EEG recording for a healthy patient in defining standard trace.

Fig. 8. Signal with the Basic Matching pursuit approximation superimposed (healthy)

Fig. 9. Percentage of retained signal energy and the relative error percentages norms over the algorithm iterations (healthy)
Fig. 10. Superposition of selected vectors from the sub-dictionaries (healthy)

Analyzing the graphs presented in this paper for cases of seizures and healthy we come to two very important aspects. The first concerns the classification process, in which the biggest problem in EEG signal analysis and diagnostic process automation is a huge amount of generated data (attributes). After the joint analysis of neurology specialists Provincial Hospital in Zielona Góra, action will be taken which will be carried out to reduce the dimensionality of the data in such a way so as not to lose valuable information in the EEG recorded measurements. There are many ways you can perform data dimensionality reduction, for example: Principal Component Analysis, Simple PCA, Probabilistic PCA, Independent Component Analysis (ICA), Sammon Mapping, Locally Linear Embedding, Linear Discriminant Analysis, Kernel PCA, Generalized Discriminant. Another aspect which should be noted is the elimination of artifacts. The range of years, a number of works in which the authors have struggled with this problem, but it still represents a very great difficulty and a challenge for researchers because of both the nature of the signal that is EEG and constraints in the implementation and hardware [11].

Activities which are related to the improvement of diagnostic tools using the latest technology to improve the accuracy in the process of clinical diagnosis by physicians neurology. Close cooperation with the Provincial Hospital in Zielona Góra and numerous consultations with doctors Ward of Neurology and Stroke will make a software tool support to recognize the disadvantages of said.

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Bibliography


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