CHANGE DETECTION IN INTRACRANIAL EEG SIGNALS

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Abstract

The aim of our research is to create algorithms suitable for detecting the presence, localization and determine the extent of epileptogenic focus. We developed experimentally methods for providing view of the diagnostic symptoms. The methods are based on search and evaluation of relations between the monitoring intracranial EEG signals. This paper shows our first approach to the problematic and also our preliminary results.

1 Introduction

Evaluation of intracranial EEG waveforms is done subjectively by neurosurgeon, in the present. He has a set of linear filters, which are applied to the reference signal and visually looking for typical patterns indicating epileptogenic bearings, where the genesis of impulses causing seizures. Sometimes filters are used to complex frequency characteristics for highlighting areas with the typical patterns (ictal discharges). Occurrence, location and extent are determined solely on the basis of subjective evaluation by the specialist. The location and resection extent determination of brain tissue in patients is very complex procedure that largely depends on the experience of the evaluator in most cases. To reduce subjectivity in assessment practices are used on an independent evaluation procedures of different specialists.

Surgical treatment is mostly the only hope for improving the quality of life of patients with pharmaco-resistant epilepsy. The aim of our workgroup is to create algorithms for intracranial EEG evaluation and remain the uncertainty of the standard subjective evaluation of the records.

2 Methods

The 88 intracranial EEG leads with a sampling frequency 200 Hz were used for experimental determination of the beginning of an epileptic seizure. Detection algorithm involves three main steps:

a. Rough determination of epileptic seizure using broadband spectrograms and signal energy of each channel [1].

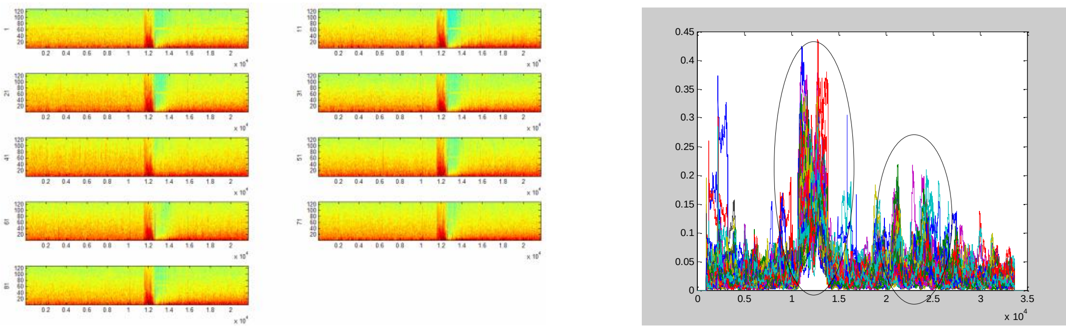

Figure 1: Example of spectrograms and energy localization in first step. Left are spectrograms (energy vs. time vs. frequency); right is channel signal energy (energy vs. time).

b. The more precise time and space localization using the Bayesian step change-point detector BSCD [2], [3]. The using of BSCD supposes that signal segments are modeled by constants in a noise, thus the BSCD requires a signal to be modeled by jumps, so the signal has to be rectified. BSCD detectors are sensitive to the energy changes. Detectors were used in sliding window.

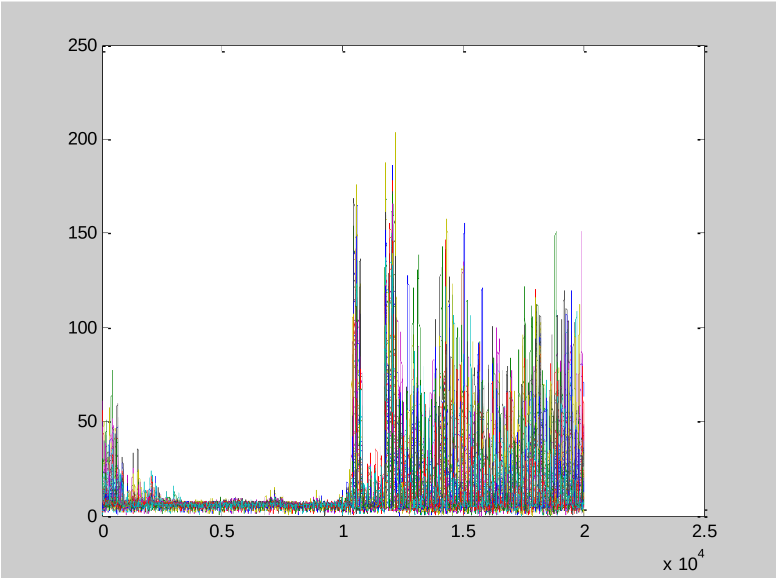

Figure 2: Example of BSCD output used in the second step (a posteriory probability of change position vs. time)

c. Accurate detection using recursive Bayesian autoregressive change-point detector BACD [4]. For BACD using we assume, that signal segments are modeled by two autoregressive processes. Important property of this detector is its sensitivity to spectral changes rather than to energy changes.

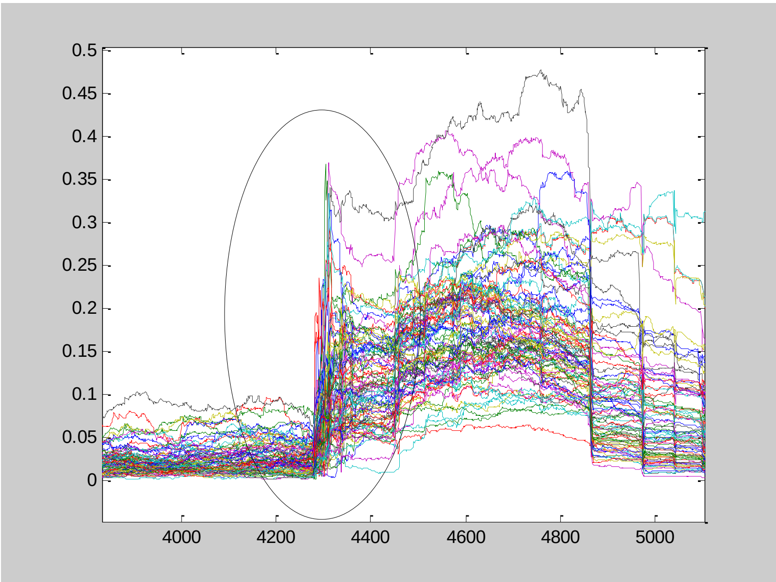

Figure 3: Example of BACD output in third step (a posteriory probability of change position vs. time). Seizure onset zone is highlighted.

3 Implementation

The implementation of all non-standard processing procedures of detectors was done in Matlab environment as script of standard functions. The procedures such as the spectrogram or FFT were used from standard Matlab functions or Signal processing toolbox. The visualisation functions used for export of the results to videos were also implemented using the standard image and video Matlab functions.

4 Results

Using the above described algorithm the exact time of the beginning of the seizure was determined, the sources leads were located, and the seizure space and change propagation were also marked (see screenshot in Fig.4). The present case report of child patient showed unusual method of resources localization followed by seizure spreading visualization. Using appropriate methods of analysis of intracranial EEG we can achieve greater distinctiveness perspective of events and links between them. We are also able to create a more objective view of the evaluator diagnostic symptoms. Interpretation remains uncertain with seizures during sleep and aura.

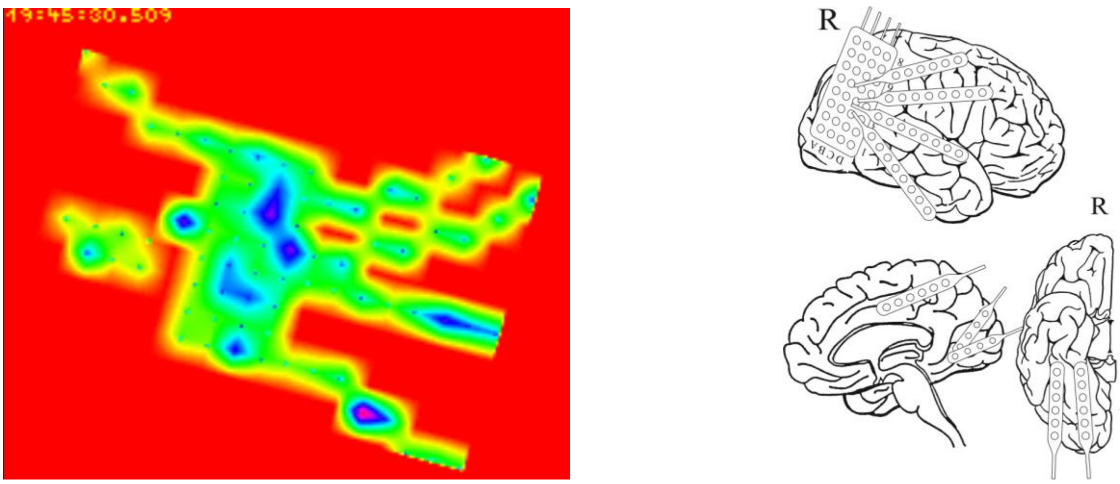

Figure 4: Example of brain mapping using signal changes detectors. Screenshot of BACD visualization on left and physical placement of visualized signal electrodes at the brain on right.

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