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Grid Computing for Electrophysiology

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Overview

In electrophysiology many diagnostic processes are based on digital signal detection and processing procedures. In epilepsy diagnosis and treatment the electroencephalography (EEG) signals are one of the main tools. However the inspection of EEG in a "manual way" is very time consuming. Automatic extraction of important EEG features provides an entire new level for doctors, for disease diagnostics and exploration, it also saves doctor's time. EEG analysis using data mining methods give powerful tools for disease further exploration. In this article methods to extract some of these features - drowsiness score and center-temporal spikes are analyzed. For spike detection a new method based on morphological filters is used. Also a database design is proposed in order to allow easy EEG analysis and provide data accessibility for data mining algorithms to be developed in the future. Grid computing platform is an efficient way for implementation of algorithms needed.

Impact

The Grid computing services designed and developed for EEG analysis, are implementing the operational process for electrophysiology. The segmented EEG parts, as initial object of database of EEG signals, together with suitable computational procedures, reflect following attributes: a) correlation of spike number in EEG and spike parameters with type of epilepsy and clinical data, b) spikes and segments clustering, c) locating damaged areas of the brain, d) numerical estimation of amount of waves of different rhythms (wave types of EEG) and their correlation with the type of epilepsy, sleepiness, etc. Thus Grid resources offer a possibility to manipulate data, to process big amounts of data and to produce various analysis on it. Grid computing procedures are produced on EEG segments (from database), on entire EEGs, primary and secondary attributes of them (such as KDS, KSS, spike index, slow eye movement recognition, distribution of spike appearance time, amplitude, duration, shape, others). Theoretical models of such data manipulation and computational modeling are based on attributed graphs representation, where nodes and edges have many parameters and precomputed attributes. In the case of full EEG data (for 1 patient) the computational model to be performed requires a lot of CPU
hours (simultaneuosly involving hundreds of cores). Grid technology allocates such resources dynamically, actually producing all such computing "on demand". Grid is also able to allocate enough resources for data mining analysis (data clusterization, pattern recognition, etc.) of all data accumulated in data repository.

Description of the work

One of the main subjects of research is measurement of brain activity recorded as electroencephalograms (EEGs). Multichannel EEG signal of one person usually is the collection of about 12 to 128 signals, which are recorded with 200 Hz rate or similar and may last from some minutes to some hours. These data require big amount of storage, sophisticated data manipulation, complex data transformations. EEG is a summation of

electrical activities generated by cortical neurons and it's widely used in diagnosis of neurological disorders related to epilepsy. The seizure of epilepsy leads to transient disturbances of the EEG signal. Thus usually epileptic EEG data contains transient components and background activities. The epileptic transient activity usually appears as sharp spikes in signal which occur randomly with short duration of 20-70 ms. One of main tasks in EEG signal processing is spike detection, as their recognition is significant for clinical diagnosis of epileptic disorders. In hospitals a method of visual/manual detection of spikes in EEG recordings by an experienced neurologist is widely used. In the case of long EEG recording, this process is much time consuming. Thus automatic spike detection methods are needed. Such spike detection method, based on mathematical morphology algorithms was developed by authors, EEG data being provided by Vilnius University Children's hospital. Input files are of European Data Format (EDF). The Grid infrastructure is used to create a virtual repository for such data, making data accessible for authorized manipulations by hospitals, doctors, computing processes. The functionality of virtual data repository include "raw"data storage (together with suitable indices), data anonymization, data segmentation into attributed segments, data warehousing for complex algorithms, which are required by doctors for diagnostics, selection of drugs, shortening decision time.

Conclusions

The Lithuanian Grid computing and technical resources together with the combination of grid technology and HPC procedures enabled us to use minimal amount of efforts and in a short range of time to create and develop the efficient model of electrophysiological processes as well as to support doctors in their diagnostics and drug selection processes, in saving the time. Such system is highly evaluated by medical researchers and doctors.

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