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Grid Computing and Data Sonification tools as SaaS for supporting neuroscientists in analysing EEGs of patients affected by drug-resistant epilepsy

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Impact

From a technical point of view, data sonification is quite data intensive and requires enormous amounts of networking and processing power to produce results. Sonifying and analysing just a few MB of data using, for example, 100 different configurations would require a few hours on a standard laptop (2.4 GHz Intel Core 2 Duo, 2 GB RAM) and just a few minutes on the grid. These performances can be further improved depending by the amount of computational resources available. High quality audio files and animations (displaying the evolution of the melody) need in fact to be generated for each EEG data sequence. Sonification techniques are the most appropriate tools for extrapolating temporal-correlated properties in time series as musical patterns. In order to let neuroscientists involved in epilepsy research to use the data sonification tool in a distributed computing environment, a multi-domain Science Gateway based on the Liferay portlet container has been set up using the Catania Scinece Gateway Framework. This framework uses a sophisticated authentication and authorization mechanism and different software components based on standards (e.g.: Liferay as portlet container, Identity Federations based on the SAML 2.0 standard and on its implementation based on Shibboleth, JSAGA to run applications in a middleware-independent way, PKCS#11 and JAX-RS to deal with robot certificates stored on USB smart cards). The portal platform also integrates with most used packages such as YUI3 and jQuery and with the JavaScript library of the portal developers. The primary requirements that drove the design and implementation of the Science Gateway were: the use of standards; the simplicity; the easiness of use and the re-usability. The Science Gateway and the Identity Federation paradigms have been adopted for allowing its registered users to benefit the data sonification technique according to the main aspects of the Software as a Service (SaaS) model and provide a dedicated production quality service for computer-aided diagnosis and research in the field of epilepsy disease. The easy-to-use "web -2.0"interface, combined with AJAX and other presentation layer technologies, allows neuroscientists from hospitals to access transparently to the distributed computing resources of the European Grid Infrastructure without requiring any additional software. To support neuroscientists in this work, the MIDI Toolbox, a compilation of functions for analysing and visualizing MIDI files in the Matlab computing environment, has been installed on the computing grid resources. This software package, distributed under GNU license, does not require any additional extra toolboxes to be installed and run.
The whole work described here consequently relied on the pan-European GÉANT network, which operates at a speed of up to 100 Gbps, and on the EGI distributed computing service. Grid computing works by linking together multiple computers at different locations through high speed networks, combining their processing power to deliver faster results when analysing huge volumes of data. Among EGI sites, the most used one in the present analysis have been those belonging to the Italian Grid Infrastructure (IGI)

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Summary

Notwithstanding the recent improvement of technology in the pharmacological approach, epilepsy is still one of the most common, though serious, neurological disorders. One of the main characteristics of epilepsy is represented by seizures and each type of epilepsy has its own unique combination of seizure type, typical age of onset, EEG findings, treatment, and prognosis. In this work, "inter-ictal"EEGs (i.e., EEG recording done sufficiently far from a seizure) have been analysed for the first time using a sonification technique and exploiting the European Grid Infrastructure in order to identify a baseline condition (hopefully, a marker). The identification of this marker through data sonification may help highlighting and characterizing the temporal patterns embedded in the EEGs of epileptic patients, providing a powerful tool for seizure prevention, hence improving the quality of life of people and promoting the research for new therapeutic interventions.

URL

The multi-domain Science Gateway hosting the Data Sonification tool used in this study is available at http://gw.ct.infn.it/.

Description

A key concept in neurosciences is the brain functioning as a synchronised activation of neuronal networks belonging to different cerebral areas, thus becoming temporally correlated. The spatial extent of these neuronal networks as well as the duration of their rhythmic activation may vary according to the underlying physiological as well as pathological states. As far as it concerns epilepsy, growing evidence suggests a 'route to seizure'as a consequence of a progressive loss of synchronisation among neuronal networks. This leads the system close to a state which is particularly prone to generate a seizure. In this work, the "inter-ictal"EEGs have been analysed on the Grid using for the first time the sonification technique to identify a baseline condition (a marker). Data Sonification is an effective alternative for representing any data set using sound signals and melodies instead of visual signs and provides data analysis with a different perspective. The human ear is naturally trained to analyse series of data, detect anomalies and spot (ir-)regularities. Preliminary results show the existence in the EEGs of epileptic patients of long-range temporal correlations of the brain electrical activity which may be differently expressed depending on the EEG state they belong to. This finding supports and extends the concept of epilepsy as a disease related to the space-time interactions of complex neuronal networks which may give rise to dynamics expected to be different according to how far the brain is from a seizure-generating critical state. For this purpose, sonification techniques are one of the most appropriate tools for extrapolating temporal-correlated properties in time series as musical patterns. These patterns may hopefully be used as markers denoting specific epileptic EEG states, hence giving rise to the possibility to forecast an incoming seizure far in advance by just listening to how the musical patterns embedded in the ongoing EEG change.

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