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BrainX^3: a virtual reality tool for neurosurgical intervention in epilepsy

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Keywords BX3 · Neurosurgery · Virtual reality · EEG

Purpose

Localizing functional regions of the cortex and deep-brain areas in epileptic patients is an important pre-surgical procedure prior to resection. This is often achieved using intra-cortical electrodes for both stimulation as well as recordings of Local Field Potentials (LFPs), concurrent to behavioral tasks related to language or motor function. To assist and improve accuracy in the identification of relevant brain networks associated to core cognitive functions, we present a novel interactive virtual reality system that aids in 3D visualization of precise electrode placement within cortical and sub-cortical regions of the patient and facilitates dynamical functional connectivity analysis of the aforementioned networks. The system is an extension of the BrainX^3 tool [1–3], developed at the Laboratory for the Synthetic, Perceptive, Emotive and Cognitive Systems (SPECS).

Methods

Data were collected from an epileptic patient implanted with 125 depth electrodes for monitoring purposes in the context of a study about active/passive navigation within a virtual maze. Electrode placement have been reconstructed in 3D within BrainX^3 and superimposed to the cortical brain structural network of 998 nodes obtained from [4], and a semi-transparent volumetric representations of anatomical regions (Fig. 1). Recorded EEG time-series are replayed on the reconstructed network and graph metrics analyzed with the embedded BCT toolbox [5].

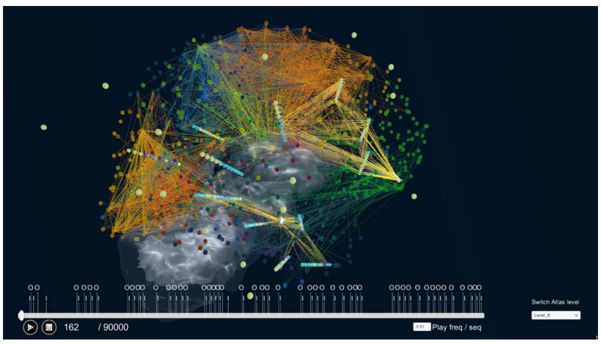

Fig. 1 The BrainX3 main interface and visualization. Electrode and anatomical data specific to the patient are reconstructed on top of a dense three dimensional representation of the human connectome. The figure shows 125 recording points from 15 electrodes inserted in a single patient. Each recording point records data from the LFP at one specific location. The bottom panel denotes a timeline in which the timings of stimulus presentation during the task are indicated

Results

The visualization of anatomical structures and the superimposed EEG time-series data on the reconstructed network enables the neurosurgeon to easily quantify the temporal dynamics of the recorded signal over different brain areas in an interactive way. Several functional connectivity metrics have been used to assess the dynamical changes of the reconstructed network during rest and while performing a spatial navigation/recognition memory task. Results show larger functional activation in a sub-network including middle frontal and superior temporal areas during the task which shows up in the reconstructed network (Fig. 1).

Conclusions

In this abstract, we have introduced a further extension of the interactive BrainX3 virtual reality application specifically targeting the reconstruction and correct identification of specific brain networks prior to neurosurgical intervention which is aimed to facilitate the workflow of pre-epileptic procedures.

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In vivo robustness analyses of intraoperative registration with fluorescent markers

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Purpose

While laparoscopic surgery provides many advantages over open surgery such as faster wound healing and reduced pain for patients, the orientation during such procedures and the identification of structures of interest remains difficult [1, 2]. Even though a lot of research has been invested into intra-operative registration methods [3], robust real-time Augmented Reality (AR) guidance is still an unsolved challenge. Some marker-based and surface-based approaches feature real-time capability but suffer from poor performance in the presence of smoke, blood or tissue in the field of view (FoV) of the endoscope [4, 5]. Based on a recently proposed concept for robust AR guidance in laparoscopy [5], this paper presents the first in vivo