INTERACTIVE SPATIAL VISUALISATION OF EEG PARAMETERS FROM DEPTH INTRACRANIAL ELECTRODES IN CT/MRI IMAGES

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Abstract: Standard procedure with patients with focal farmacoresistant epilepsy is partial brain resection. Signals from intracranial EEG are analyzed to find the patological area. This paper presents method for interactive spatial visualisation of EEG parameters in native, three-dimensional CT/MRI images as a tool for displaying pathological areas directly in native MRI or CT images. Software with graphical user interface is programmed and implemented at St. Anne's University Hospital in Brno (FNUSA). This program is also connected to MySQL database, where parameters from EEG analyses are stored.

Keywords: intracranial EEG, visualisation, 3D Slicer, image registration

1 INTRODUCTION

Approximatelly 1/3 of epileptic patients with focal epilepsy do not respond to medical treatment [1]. The only way to achieve seizure freedom is removal of the patological parts of the brain. The localization of seizure generating tissue is currently done solely by locating seizure onset zone. Data, which shows whether a part of the brain is producing seizures or not, are gained from intracranial EEG (iEEG). According to recent studies, high frequency oscilations (HFOs) are a promising electrophysiological biomarker of epilepsy [1]. Automated HFO detectors can provide information about number of HFOs in electrode contacts. There is, however, a gap between HFO detection and fast and convenient way of interpreting the data. This paper presents a new tool for interactive visualisation of HFO count in native, three-dimensional MRI or CT scans. HFO rate is transformed to color scale and displayed to the exact anatomical location.

The process of finding exact location of all electrode contacts in native scan consists of several non–trivial steps. For MRI image transformations which play crucial role here, the 12-parameter affine transform and nonlinear cosine transform is performed with SPM software [2]. CT image transformations are not implemented yet, but use of Elastix software is in progress [3]. Computed coordinates are stored together with HFO detections in MySQL database. The tool for visualisation of HFOs detections is programmed as a module in 3D Slicer, that is connected to MySQL database [4].

2 CONTACT LOCATION

Since the visualisation is needed in native MRI scan and coordinates of electrode contacts are extracted from scan with implanted electrodes, the coordinates have to be recalculated. Whole process of coordinate determination is represented by block "Coordinate extraction" in figure 1. Before electrode implantation, native high–resolution scan is obtained. Then electrodes are implanted to the patient's brain and a low resolution MRI scan is made. This low resolution MRI image is coregistred to the native high–resolution scan and normalized into MNI space with SPM software. This

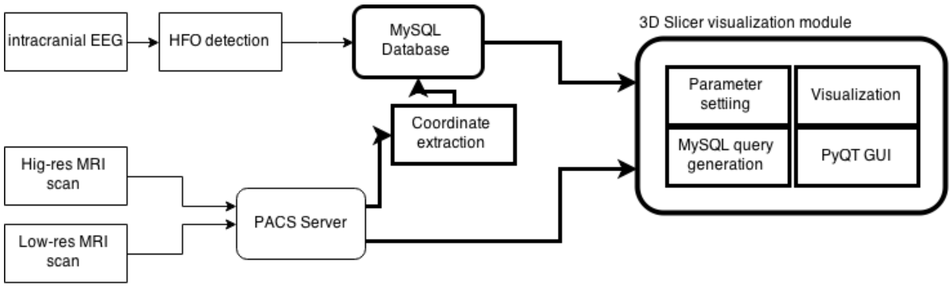


Figure 1: Whole process of visualization implemented in FNUSA. Blocks and arrows with thick line are processes designed within this project. Other blocks are standard parts of hospital infrastucture or does not have any connection to this paper.

image is used to manually extract coordinates of electrode contacts. These coordinates are located in MNI space, so they are tranformed back into “real world” space based on parameters of affine and cosine transforms used during previous normalization. Result of these operations are coordinates of electrode contacts transformed into patients high–resolution MRI image without electrodes and loaded into MySQL database in order to be used in visualisation program. At the present stage of the project, everything needs to be done manually, only recalculation of coordinates and work with MySQL database is automated by custom made MATLAB scripts.

3 VISUALISATION PROGRAM

New module in 3D Slicer was programmed in python programming language that uses one built–in module named “Markups”. Module “Markups” is used to display fiducial markers at positions of electrode contacts, where color of every marker represents number of HFOs on the specific electrode. Pattern for color range is jet MATLAB color scheme and was chosen after discussion with doctors in FNUSA. Red color represents the highest value and dark blue color the lowest one. PyQT library was used for graphical user interface (GUI), which was also designed in cooperation with doctors in FNUSA and can be seen in the figure 2. This module is connected to MySQL database using python MySQL connector. Database is accessible directly from GUI using username and password, while database query is generated automaticaly from parameters set in GUI.

4 RESULTS

New visualisation program, that can be installed on Windows, Linux and MacOS, has been implemeted at FNUSA and implementation at Mayo Clinic in USA is in negotiations. User can display MRI image with electrode contacts either in two–dimensional slices (coronal, transverzal and sagital) or can use for exam-

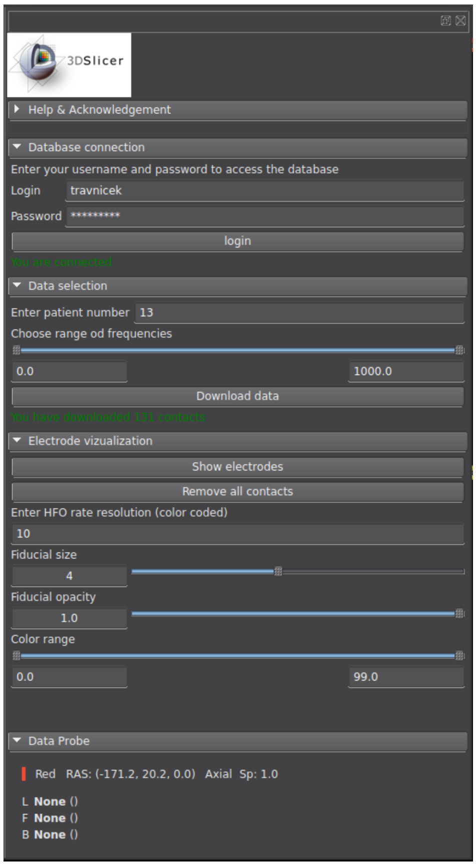
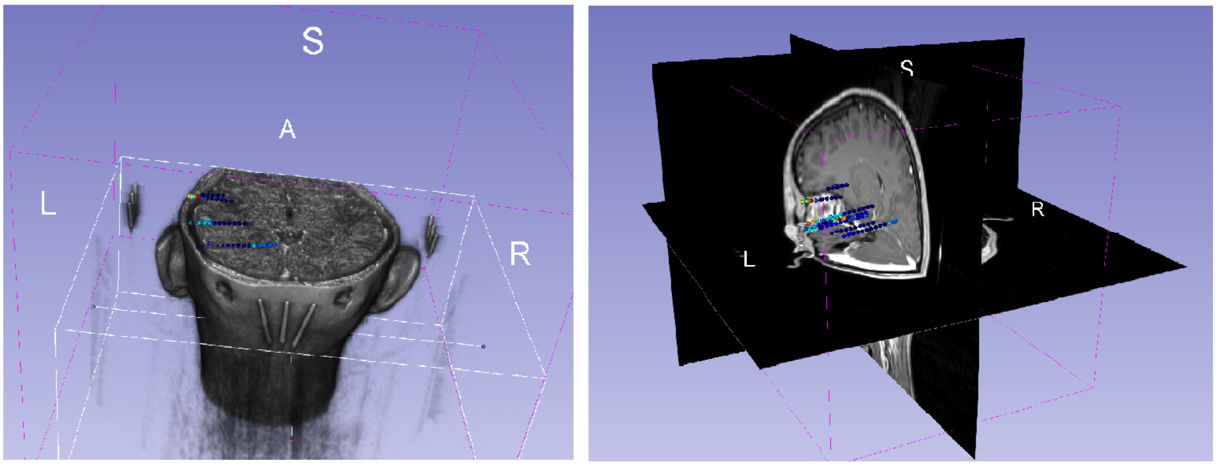


Figure 2: Graphical user interface.

ple volume rendering, which is shown in the figure 3A. User can also change fiducial size, opacity or since different frequencies have different diagnostic information the user can also choose range of frequencies of HFOs (see figure 2.). Important information is, that this program is not designed to show, whether the part of the brain is epileptogenic or not, but to effectively visualize any electrophysiological biomarkers of epilepsy to simplify orientation in large amount data. Considering this, program fulfills it's requirements completely.



A B

Figure 3: Illustration of 3D visualisation. Volume rendering function from 3D Slicer is used in A, in B is standard 3D display.

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