NEURAL DATA TOOLBOX (NDTB)

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Abstract: Neural Data Toolbox (NDTb) is MATLAB toolbox for functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) data processing. Toolbox now features tools for anonymizing data sets and visualizing fMRI images in 3D. In this contribution basics of each modality and features of each tool from NDTb are described and future development of toolbox is outlined.

Keywords: neuroscience, functional, magnetic resonance, imaging, MRI, fMRI, electroencephalography, EEG, MATLAB, SPM, neural, data, toolbox, NDTb, anonymization, 3D, visualization, EEICT

1 INTRODUCTION

This contribution is about MATLAB toolbox named Neural Data Toolbox (NDTb) which is developed for neuroscience data processing. These data are from functional magnetic resonance imaging and electroencephalography modalities. Toolbox now features tools for anonymizing MRI, fMRI and EEG data sets and 3D visualizing of fMRI scans. In this contribution basics of each modality and features of each tool from NDTb are described and future development of toolbox is outlined.

1.1 FUNCTIONAL MAGNETIC RESONANCE IMAGING

Functional magnetic resonance imaging (fMRI) is a powerful noninvasive neuroimaging technique that uses standard MRI scanners to investigate changes in brain function over time. Functional neuroimaging studies can identify the different parts of the brain where particular mental processes occur and fMRI studies can build maps that link brain activation to mental function. This is done by measuring changes in blood oxygenation levels over time, so called BOLD signal, which is changed rapidly following the activity of neurons in a brain region and fMRI allows researchers to localize brain activity. [1]

1.2 ELECTROENCEPHALOGRAPHY

Electroencephalography (EEG) is a classical method to study dynamic properties of brain circuits; the EEG reflects a summation of extracellular potentials of synchronized populations of neurons. Electroencephalography is used to passively record continuous electrical brain activity. The EEG shows the spontaneously generated aperiodic as well as slow and fast oscillatory brain activity recorded by the electrodes. [2]

1.3 SIMULTANEOUS EEG-FMRI

The combination of electroencephalography with functional magnetic resonance imaging forms a powerful tool for the investigation of brain function since fMRI offers high spatial resolution while EEG provides a direct measurement of neuronal activity with high temporal resolution, but concurrent implementation of EEG and fMRI poses many technical challenges. [3]

One of the artifacts encountered when performing simultaneous EEG-fMRI is gradient artifact, which is caused by the electromotive force induced in the conductive loops where artifactual electrical voltages can be induced by rapid switching of magnetic field gradients. [4] Tool for removing this type of artifact is in development for NDTb as it will be mentioned in conclusion of this contribution.

2 NEURAL DATA TOOLBOX (NDTB)

Neural Data Toolbox and its features are realized in MATLAB environment by MathWorks and it is easily expandable with new tools. NDTb has graphic user interface but it can also be used with each tool's commands. Menu of Neural Data Toolbox can be seen on figure 1. NDTb is using some functions from SPM toolbox, which is described in the next part.

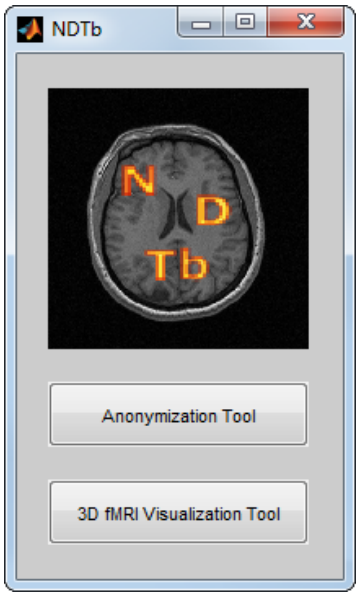

Figure 1: Menu of NDTb

2.1 STATISTICAL PARAMETRIC MAPPING

The SPM (Statistical Parametric Mapping) software by Welcome Trust Centre for Neuroimaging at University College London is MATLAB package designed for the analysis of brain imaging data sequences. The sequences can be a series of images from different cohorts, or time-series from the same subject. The current release is designed for the analysis of fMRI, PET, SPECT, EEG and MEG. NDTb uses some tools from this package for choosing files, loading MRI images from different data formats, analyzing MRI images, etc.

2.2 ANONYMIZATION TOOL

This tool is for anonymizing fMRI, MRI or EEG data sets, so they could be published or shared without danger of breaking laws or ethical norms.

Anonymization Tool is anonymizing patient secure data on level filename and also on level of its content (e.g. SPM.mat file which is generated by SPM). User will choose part that is intended to by anonymized (e.g. patient's name, date of birth...) and algorithms are anonymizing these data sets until rules of naming of files are changed. If that happens program asks user again which part should be anonymized. Output are new anonymized files which are created in folder specified by user. This tool also saves look up tables, so it's possible to reversely identify anonymized data sets.

2.3 3D FMRI VISUALIZING TOOL

This tool visualizes transverse slices of functional images and sagittal slices of anatomical images in high resolution. User selects data which will be preprocessed and then he can choose which slices will be shown. Thanks to preprocessing it's possible to rotate and zoom shown images in 3D seamlessly. Algorithms developed for this tool allow to visualize fMRI scans exactly how they had been acquired by MRI system (e.g. under angle). This feature can be seen on figure 2.

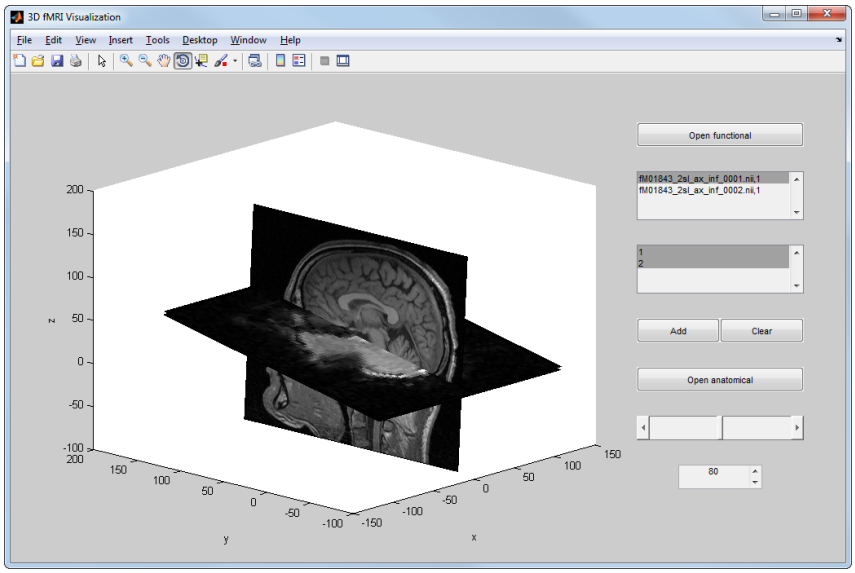

Figure 2: 3D fMRI Visualizing Tool

3 CONCLUSION

In the future there will be developed tools for signal extraction, gradient artifact removal from simultaneous fMRI-EEG and tool for EEG data conversion.

First tool will be extracting signals from chosen voxels of defined shape (ball, cube, cuboid...) of fMRI scans for their further analysis. Next tool will be removing artifacts related to MRI gradient switching from electroencephalography data recorded during functional magnetic resonance imaging as it was mentioned in introduction. To remove gradient artifacts channel-wise filtering based on singular value decomposition (SVD) will be used. [4] EEG Format Conversion Tool will be able to convert data in rare old format into format which is compatible with modern software for analyzing EEG data.

First release of toolbox will be used by neuroscientist at Department of Biomedical Engineering FEEC BUT and 1st Department of Neurology, St. Anne's University Hospital Brno, so it will be possible to discuss problems personally and to develop new features. Next releases with English manual will be downloadable from the Internet, so other neuroscience research teams could use it.

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