Imaging for Neuroscience (last 3 CFU)

Homework 4-b

The aim of this homework is to decide the best motion correction technique for the available data and to perform image reconstruction from DOT data acquired in one adult human looking at a checkerboard pattern rotating counterclockwise.

The toolboxes required for this homework are: Homer2, iso2mesh

DATASET

CCW1.nirs: nirs data file of one subject. During the experiment, subjects were asked to either do nothing (condition 1) or to look at a screen showing a checkerboard pattern rotating counterclockwise.

MNI: folder containing the head volume mesh, the grey matter (GM) and scalp surface meshes, the cranial landmark coordinates and the 10-5 positions of the asymmetric MNI152 atlas

CCW.jac: Jacobian matrix for the given array registered on the atlas. This file can be downloaded from here:

https://www.dropbox.com/scl/fi/1duowuybxa3jgf4ywelcx/CCW.jac?rlkey=e3xl3ns969te3fh4m733kpbj9&dl=0

vol2gm: matrix for the mapping from volumetric mesh to GM surface mesh

ANALYSIS TO BE PERFORMED

1) Plot the 3D array configuration (sources, detectors and channels).
2) Compute the source-detector distance for each channel and plot all distances with a histogram.
3) Identify “bad” channels as those channels with signal-to-noise ratio (SNR) lower than 20. The output of this step should be a column vector with 0 for channels to be removed and 1 for channels to be kept. This vector should be placed in the SD.MeasListAct field.

   Plot the 3D array configuration highlighting the bad channels with a different color. Plot again the array configuration keeping in the plot only the good channels.

4) Pre-process the fNIRS data and compute the average optical density hemodynamic response across trials for each condition. Pre-processing should include:
    a. Conversion to optical density changes
    b. Motion correction
    c. Band-pass filtering with cut-off frequency 0.01 and 0.5 Hz
    d. Computation of the average optical density hemodynamic response for each channel and condition in a time range of -2 to 36 seconds from stimulus onset with the block average approach
5) Concerning motion correction (4b), decide which is the best motion correction technique for this type of data by looking at the type, amount and distribution of motion artifacts. Discuss and justify your choice.
6) Test all motion correction approaches on the data and establish whether your choice based on theory (the one at point 5) did provide good qualitative results.
7) Display the whole array sensitivity for the first wavelength on the volumetric GM mesh with all channels and, in a separate figure, by removing the “bad” channels as defined in step 3).
8) Reconstruct HbO and HbR images for condition 2 mapped to the surface GM mesh. Use lambda1 = 0.1 for the regularization. Plot the reconstructed images for both HbO and HbR at the following time points: 0 s, 10 s, 15 s and 20 s. Discuss pattern of activation of HbO and HbR obtained at the different time points.

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Submit your homework in the e-learning page of the course in the Homeworks section (there will be a separate submission folder for this and Prof. Bertoldo's homeworks). The submission MUST be completed by June 19th 2024. You are required to do the homework in English (report, codes etc.). In a .zip folder (named Hwnumber_Name_Surname) you are required to turn in a copy of your own commented code(s), as well as:

1) a brief and complete presentation in power point/pdf of the performed analysis (critical evaluation of what you have done, problems and issues, results, discussions, explanation of your choices...). Mandatory maximum 10 slides (excluding the first slide with title and your name)

2) A .mat file with the vectors/matrices generated at points 3 and 8 of the analysis (for point 8, only the reconstructed images at the selected time points)