Imaging for Neuroscience

HOMEWORK 2– GROUP 2

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HOMEWORK'S GOAL

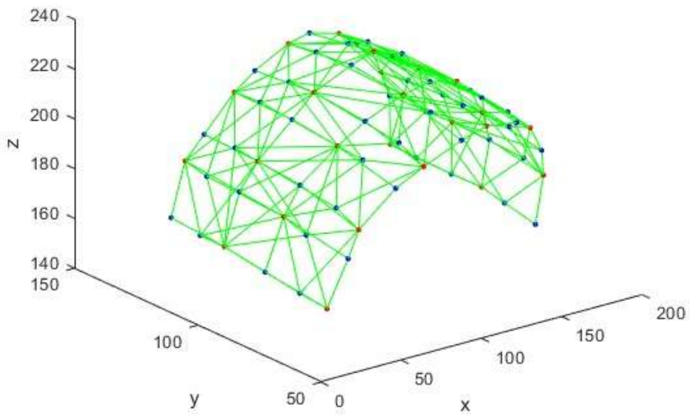
- The aim of this homework is to decide the **best motion correction technique** for the available data and to **perform image reconstruction from DOT data** acquired in one adult human participating in an experiment evaluating the different activation pattern between texting on a mobile phone using the right hand and texting on a mobile phone using the left hand, while seated.

DATA

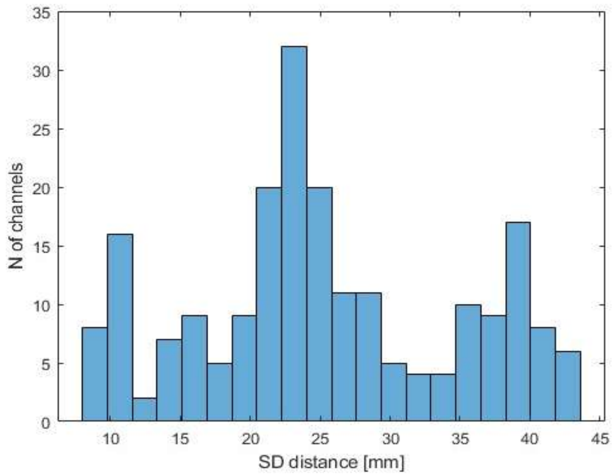
- Nirs data file
- MNI: folder containing meshes and cranial landmark coordinates
- Jacobian matrix for the given array registered on the atlas
- vol2gm: matrix for the mapping from volumetric mesh to GM surface mesh

3D ARRAY CONFIGURATION AND ''BAD'' CHANNELS REMOVAL

a)



b)

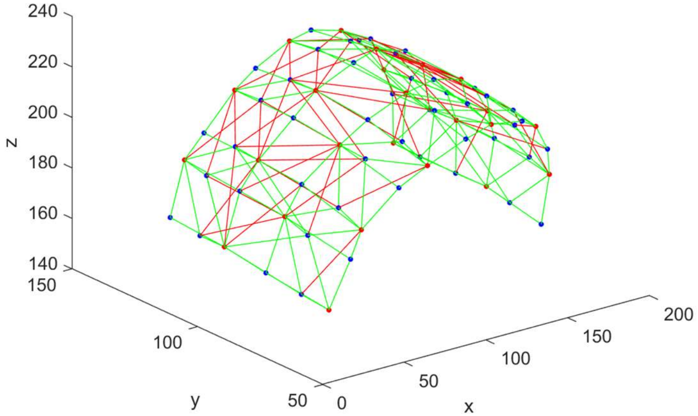


a) Array 3D plot

b) histogram of source-detector distance for each channel

Removal criteria:

- Average intensity <500 or >1e10
- Signal-to-noise ratio (SNR) < 0



57 channels are removed (114 considering both wavelengths)

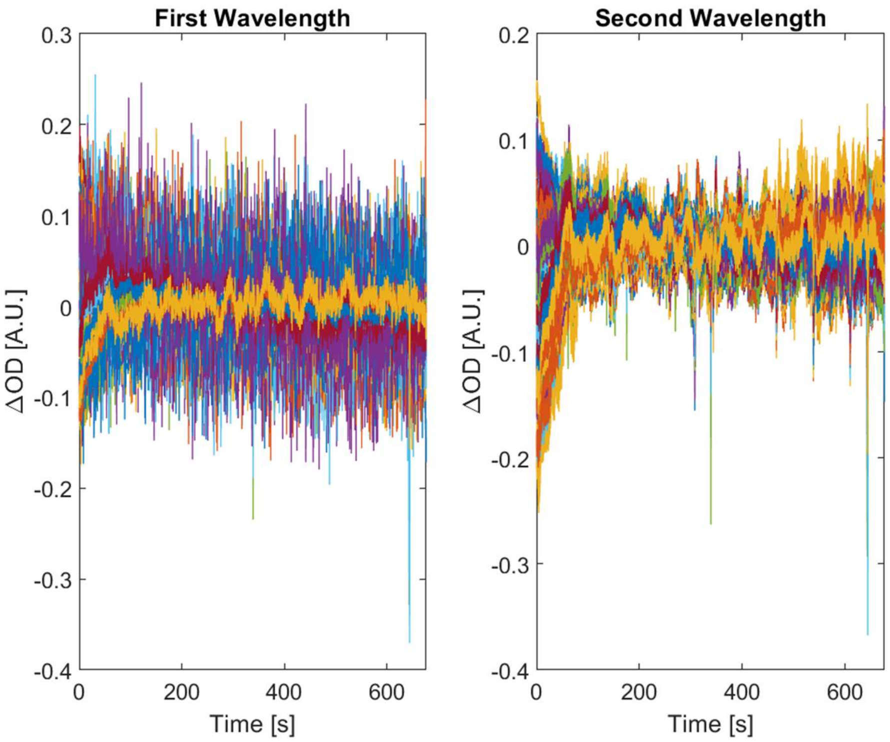
PRE-PROCESSING OF fNIRS DATA

1. Conversion to optical density changes

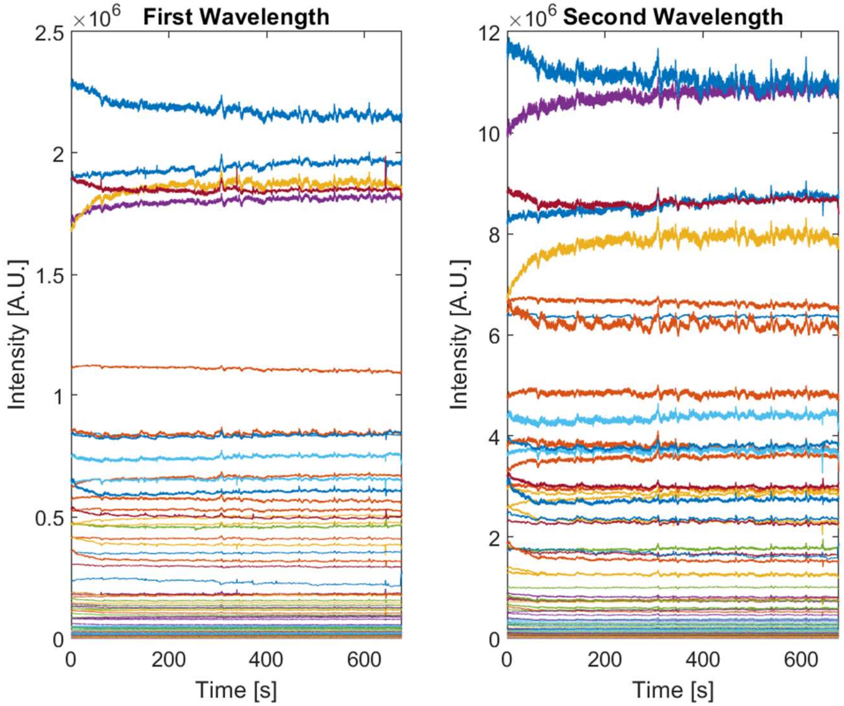
2. Motion correction

3. Band-pass filtering with cut-off frequency 0.01 and 0.5 Hz

4. Computation of block average in a time range of -2 to 40 s



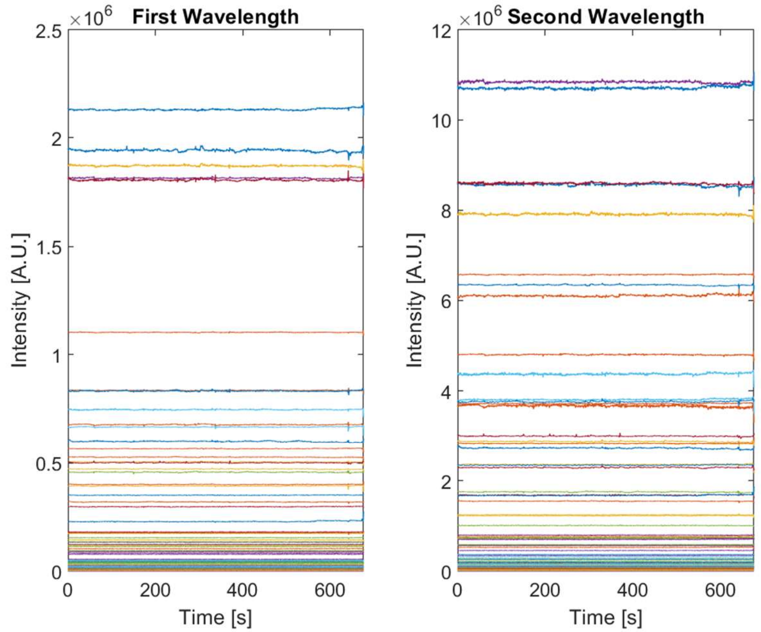
MOTION CORRECTION



1 st choice on theory basis :

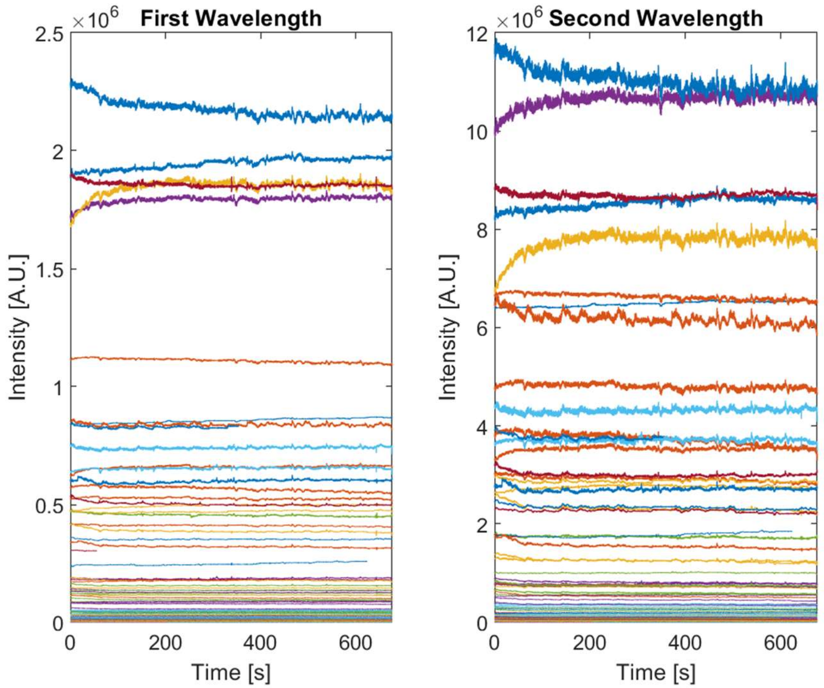
- Motion artifacts are common to all channels

- PCA

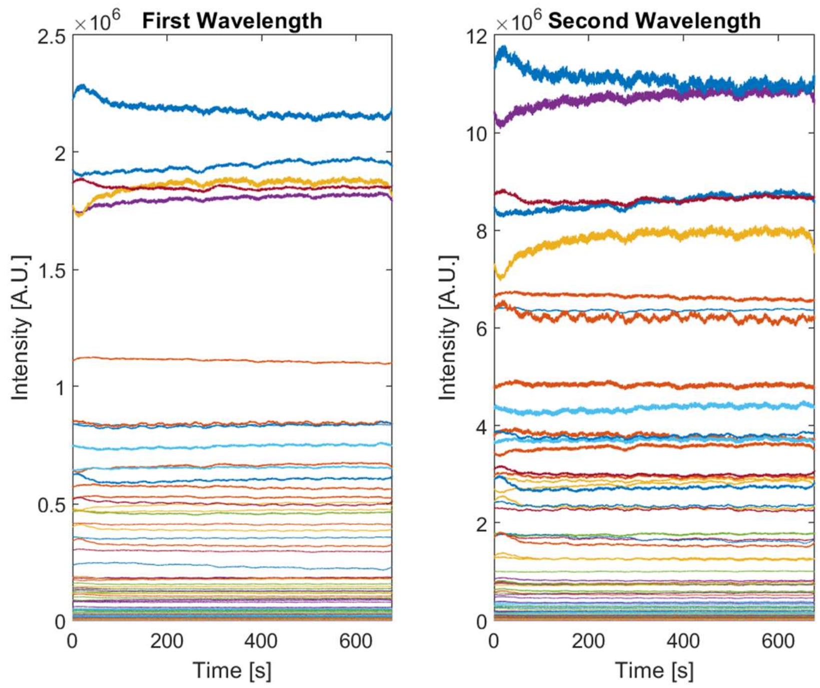


MOTION CORRECTION

Spline:



Wavelet: Th = 0.5



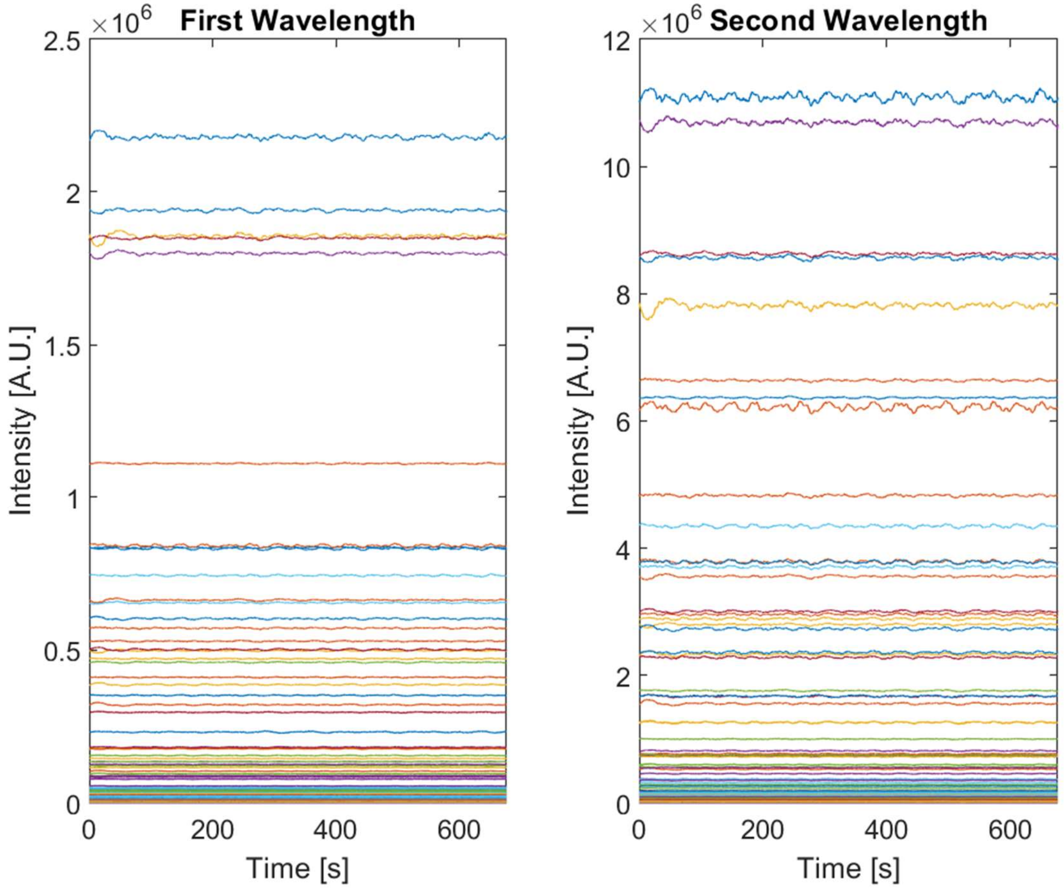
Best choice: Wavelet

PCA is too aggressive

With Wavelet MAs are correctly removed

BAND-PASS FILTERING

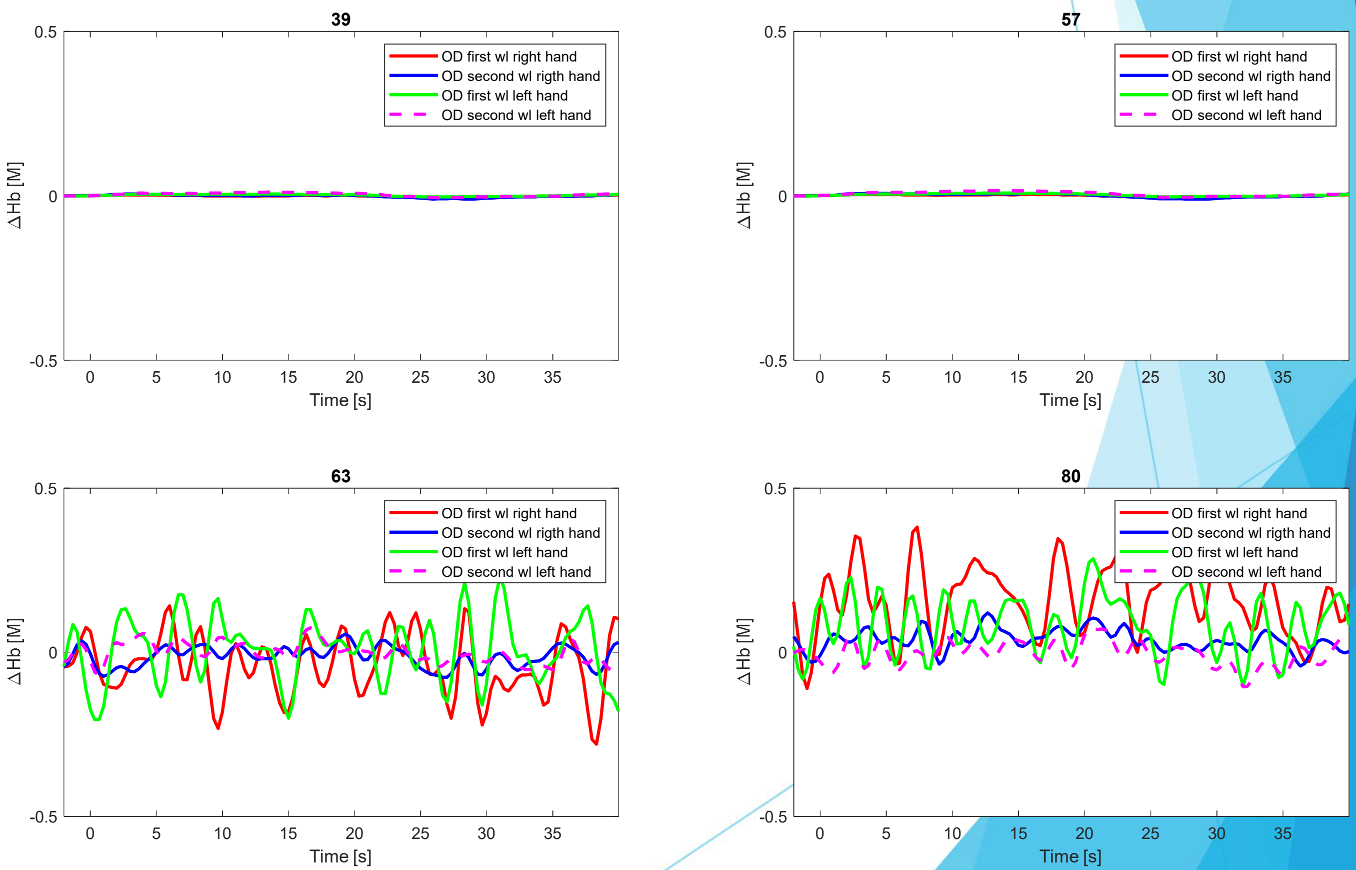
- High-pass filter at 0.01Hz: cut the low frequency oscillation due to strumentation drift (laser heating)
- Low-pass filter at 0.5Hz: cut the cardiac activity and instrumental noise



AVERAGE OPTICAL DENSITY

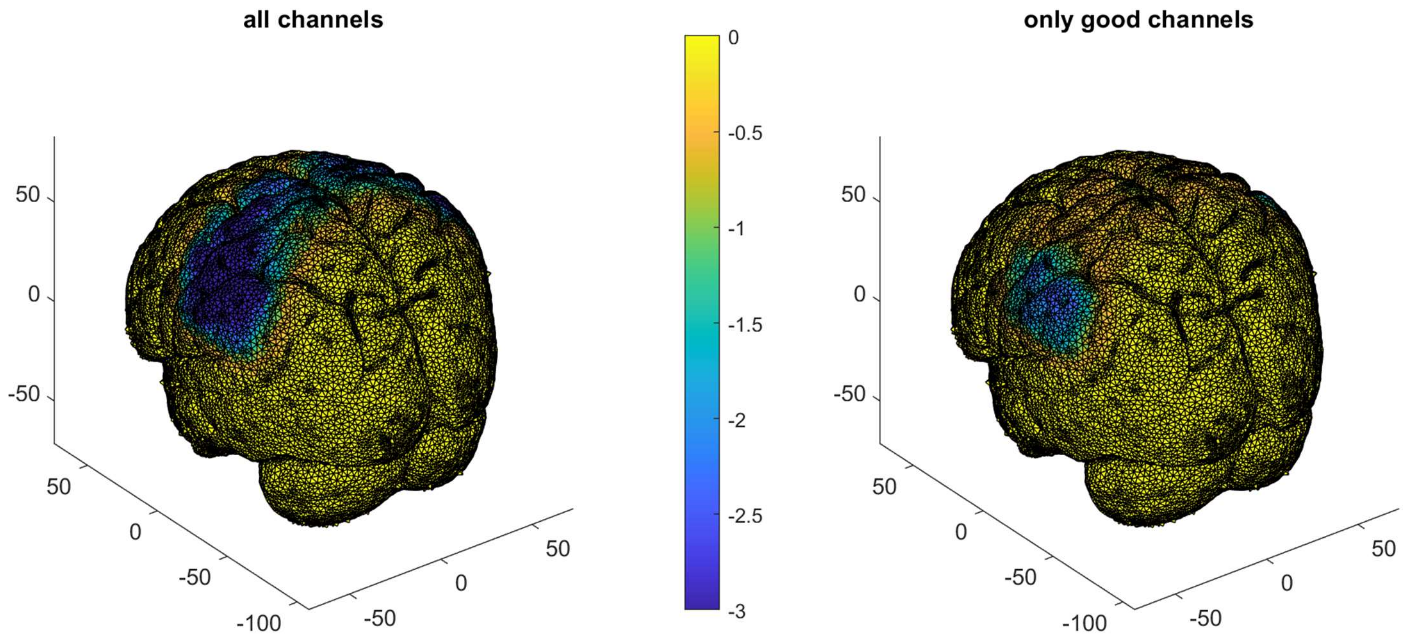
Average between each block of [-2, 40] around the stimulus impulse for both the conditions (rigth hand, left hand)

Display of the average optical density for the channels 39, 57, 63, 80. It si possible to notice how channels 39 and 57 seems to be inactive. (channels are taken randomly only for display porpouses)



ARRAY SENSITIVITY (first wavelength)

The **jacobian matrix J** (n channels x n nodes) is the result of the forward problem. It contains the **PMDF** (photon measurament density function) for each channel in each thtrahedal node of the mesh. The **sum of all the PDMFs gives the sensitivity map.**



RECOSTRUCTION OF HbO – HbR IMAGES (inverse problem)

- The **inverse problem** is about the reconstruction of the image (optical properties of the tissue) from the **forward operator: $Y = A(X)$.**

- Under the assumption of small changes in the tissue properties it is possible to invert the system related to the **changes of the optical density: $\Delta X = J^{-1} * \Delta Y$**.

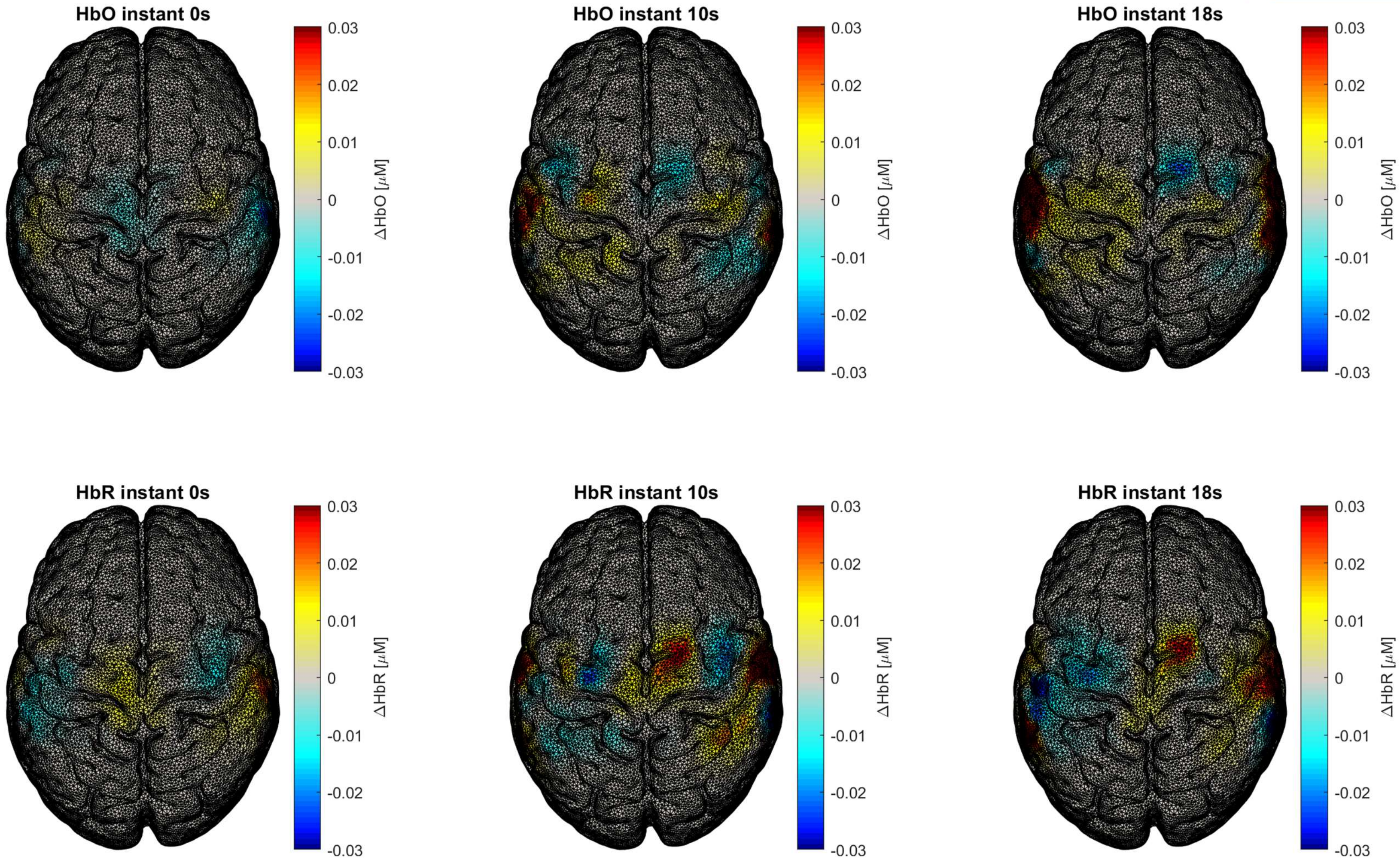
- Using the **MLBL (modified Lambert Bear law)** node wise it is possible to retrive the concentration changes from the optical density changes. The specific absobrtion coefficents are retrived using a specific function.

- Then The **concentration changes are mapped to the grey matter mesh.**

- From the sequent images it is possible to see how the concentration chances of HbO are the opposite of the concentration changes of HbR.

RECOSTRUCTION OF HbO – HbR IMAGES (inverse problem)

Condition 1: rigth hand



RECOSTRUCTION OF HbO – HbR IMAGES (inverse problem)

Condition 2: left hand