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Pipeline for ECoG electrode localization on brain surface: towards a one click approach

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Introduction: Electrocorticographic (ECoG)-based Brain-Computer Interface (BCI) systems require to accurately localize implanted cortical electrodes with respect to the subject's neuroanatomy. Electrode localization is particularly relevant to understand the area recorded from, hence providing an optimal control of neuroprosthetic devices. Yet, this problem has been shown to be non-trivial, especially due to the brain surface shift that is likely to occur after a craniotomy [1]. Several procedures have attempted to solve this problem [2-3], however current procedures require either a time-consuming detection and transcription of the electrodes coordinates from the CT volume scan or combining several different software programs. Here we propose a new pipeline that automatically detects electrodes on the post-operative high-resolution 3D CT scan using AFNI (http://afni.nimh.nih.gov/afni) and projects the electrodes on the cortical surface by applying a brain shift correction [3] using a FreeSurfer (http://surfer.nmr.mgh.harvard.edu) individual anatomy surface. We are working on developing a completely integrated Matlab® GUI interface that would provide an automatic and standard tool of particular relevance for the BCI community.

Material, Methods and Results: The current pipeline consists of the following steps: 1) high-resolution post-operative CT alignment to the pre-operative MRI anatomy (Figure 1A) using the local Pearson correlation cost function implemented in AFNI; 2) automatic electrode localization on the aligned CT scan using 3D clustering detection function provided by AFNI (Figure 1B); 3) electrode coordinates extraction obtained by computing the center-of-mass of each cluster; 4) electrode labelling according to the electrodes leads layout; 5) brain shift correction by projecting the electrodes on the surface of the cortex [3] obtained by the FreeSurfer segmentation; 6) projected electrodes visualization on the brain surface rendering. Validation of the pipeline was carried out in five patients with intractable epilepsy implanted with standard clinical grids. Results were compared to the ones obtained with the currently available method developed by Hermes et al. [3] on the same subjects (e.g., Figure 1C). Mean Euclidean distance and standard errors between electrodes position were 1.03±0.10mm, 2.08±0.11mm, 1.39±0.11mm , 1.52±0.14mm and 2.7±0.1mm , for each subject respectively.

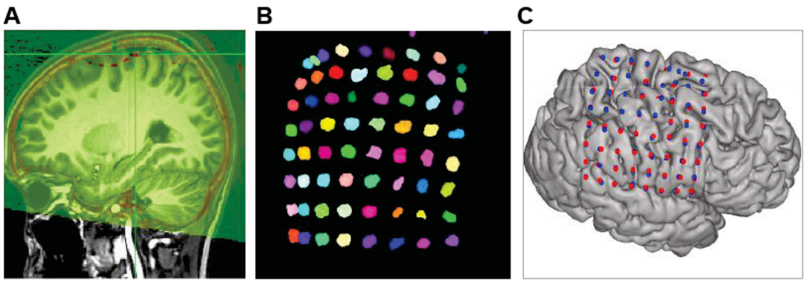

Figure 1. *Two steps of the coregistration pipeline. A) Post-operative CT aligned (red and green) to pre-operative MRI anatomy (gray scale). B) 3D clustering detection of the electrodes. C) Example of electrode prediction using both new (blue) and currently available (red) pipeline, for a representative subject.*

Discussion: The pipeline allows for automatic detection of electrodes position using high resolution post-operative CT and will ultimately consolidate the different software components into one Matlab® GUI interface. There are several limitations that still need to be tackled, such as faster extraction of clusters center-of-mass and labelling. However, the method has excellent potential to automatically detect electrodes on high-resolution ECoG grids using the post-operative CT scan, allowing for a more accurate projection.

Significance: We are developing a straightforward tool that allows the accurate localization of ECoG electrodes on the brain surface. This procedure will provide an important tool for ECoG in neuroscience and for the BCI field for developing optimal neuroprosthetics.

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References:

[1] D. L. Hill, C. R. Maurer, R. J. Maciunas, J. A. Barwise, J. M. Fitzpatrick, and M. Y. Wang, "Measurement of intraoperative brain surface deformation under a craniotomy.," *Neurosurgery*, vol. 43, no. 3, pp. 514–26; discussion 527–8, Oct. 1998.

[2] A. R. Dykstra, A. M. Chan, B. T. Quinn, R. Zepeda, C. J. Keller, J. Cormier, J. R. Madsen, E. N. Eskandar, and S. S. Cash, "Individualized localization and cortical surface-based registration of intracranial electrodes.," *NeuroImage*, vol. 59, no. 4, pp. 3563–70, Mar. 2012.

[3] D. Hermes, K. Miller, H. Noordmans, M. Vansteensel, and N. Ramsey, "Automated electrocorticographic electrode localization on individually rendered brain surfaces," *Journal of Neuroscience Methods*, vol. 185, no. 2, pp. 293–298, 2010.