

Registration and visualization of transcranial magnetic stimulation on MR images

O. Cuisenaire¹, M. Ferrant², Y. Vandermeeren³, E. Olivier³ and B. Macq²

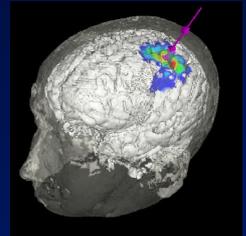
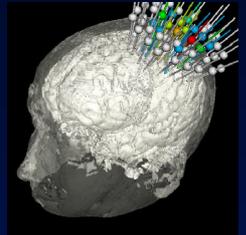
Goal

Visualize TMS motor evoked potentials registered onto the patient's brain surface extracted from MR images



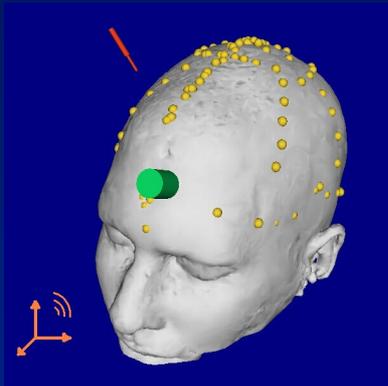
Visualization

- Written using VTK
- Brain surface segmented using interactive threshold and mathematical morphology, then marching cubes
- Magnet orientation is used to project stimulation points onto the scalp and brain surfaces
- Centers of gravity of the stimulation are computed on the scalp and brain surfaces
- Motor evoked potentials are color coded
- MEP values are interpolated on the brain surface



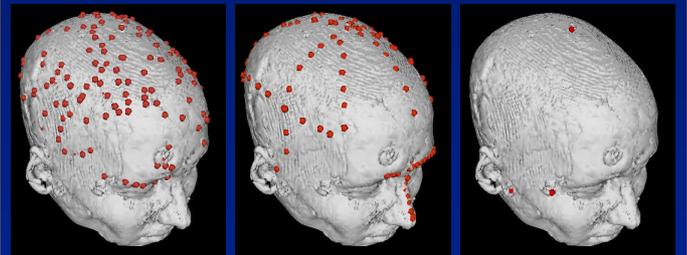
Material

Points in the physical space are acquired using a MF digitizer (Polhemus Isotrak II). One receiver is fixed on the patient's forehead and the other is a hand held stylus. The scalp surface is characterized by acquiring approximately 150 points following the illustrated pattern. The coil location and orientation are determined from 3 measures, one at the coil center and the other two in the coil plane.



Validation

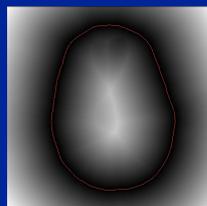
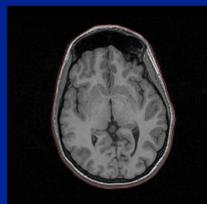
- Synthetic digitized points from the scalp surface: 0.17 mm
- 5 manual digitizations on the same patient: 1mm
- Location of markers with those 5 digitizations: 3.8 mm
- Reproducibility of centers of gravity: 1mm



Registration

Registration between the fixed referential and the moving referential on the forehead is straightforward. Registration between the moving referential and the MRI is performed in 3 steps:

- Segmentation of the head surface using a threshold and mathematical morphology
- Euclidean distance transformation to compute the distance from any point to this surface
- Minimization of the mean distance from the digitized points to the head surface in order to find the best rigid transform this is done using a gradient descent algorithm



Conclusions

- Accuracy is similar or better than previously reported work
- Scalp digitization requires between 1 and 3 minutes, each coil location approx. 30 seconds. Both the semi-automatic segmentation and the registration take less than a minute. This is orders of magnitude faster than reported in the literature.

References

- [1] Bastings et al., Co-registration of cortical magnetic stimulation and functional magnetic resonance imaging. NeuroReport 9 (1998) pp. 1941-1946
- [2] Ettinger et al.: Experimentation with a Transcranial Magnetic Stimulation System for Functional Brain Mapping. CVRMed/MRCAS'97, Grenoble, France
- [3] Potts G.F. et al.: Visual Hemifield Mapping Using Transcranial Magnetic Stimulation Coregistered with Cortical Surfaces Derived from Magnetic Resonance Images. J Clin Neurophysiology, 15 (1998) pp. 344-350
- [4] Wang et al., Head surface digitization and registration: a method for mapping positions on the head onto magnetic resonance images. Brain Topography, 6 (1994) pp. 185-192
- [5] Cuisenaire O.: Distance transformation, fast algorithms and applications to medical image processing. Ph.D. Thesis, October 1999, Université catholique de Louvain