Quality Assessment of the Spatial Co-Registration of PET and MRI Data

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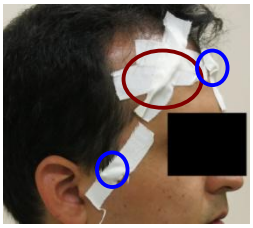
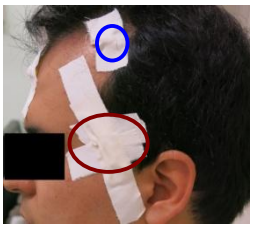
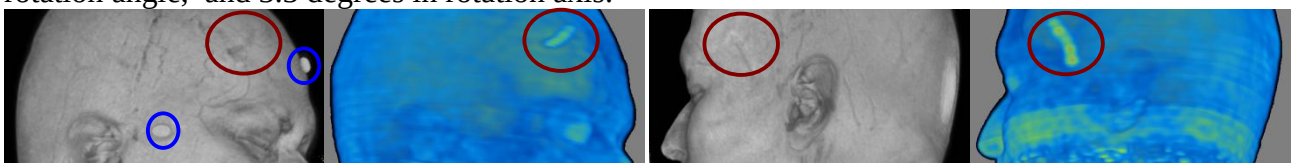
Introduction: In some patients the brain abnormalities related to the epileptic focus are subtle and difficult to be detected in the conventional visual analysis of the MRI studies. Overlaying a blurry functional positron emission tomography (PET) scan to the high-resolution structural images may improve the accuracy in the localization of epileptogenic focus. Nevertheless, because of the different contrasts between functional and anatomical images, to assess the registration quality is a necessary, but not easy, task. In this work we present a procedure we performed to evaluate a mutual information based rigid registration algorithm we developed [1].

Materials and Methods: We devised two methods: (1) a visual comparison of the fiducial markers attached to the head, as shown in the figures, and (2) a numerical comparison with the rigid transformation matrix delivered by one of the most known 3D medical image visualizer, Amira [2]. The fiducial markers are four oval capsules of vitamin E 400UI and two house-made pieces of thin catheters filled with a mixture of vitamin E and a small amount of the radiotracer 18F-fluorodeoxyglucose. To carry out numerical comparisons, we edited the values of the image origin (0020,0032) and the image orientation (0020,0037) in the DICOM files, such that the volumes are loaded into Amira in the initial state that is accessible in our registration program. Then, we extract from the obtained matrices the displacements, the rotation axis and the rotation angle around it, in order to reduce 4x4 matrix comparisons into scalar and vector comparisons. The magnetic resonance (MR) images were acquired in the Philips Achieva 3T scanner and the CT/PET volumes in the Siemens PET/CT s5vb20b multimodal imaging scanner.





Results: Both the capsules (inside a blue outlined circle) and the catheters (inside a red outlined circle) are visible in MRI, while in PET scan only the catheters are visible, as shown in the images below. To be distinguishable, we present the registered volumes in two separate images from which we can better observe how the markers are tightly overlaid. Concerning the numerical evaluation, the differences between the matrix transformations are 1.5mm in displacements, 0.2 degrees in rotation angle, and 3.3 degrees in rotation axis.



Discussion: Besides the tests reported, we also assessed visually the registration quality of CT and MRI from the six markers. Both the visual and the numerical methods let us state that our registration algorithm presents a high accuracy for these three modalities.

Conclusion: We plan to apply our registration algorithm to align the ictal, inter-ictal single photon emission computed tomographies (SPECT), PET/CT and MRI, and to register the diffusion weighted images (DWI) for building diffusion tensor images (DTI).

References: [1] Valente AC, Wu S-T. http://www.decom.ufop.br/sibgrapi2012/eproceedings/wtd/102959_2.pdf. Accessed Feb2015; [2] Amira 3D Software for Life Sciences. http://www.fei.com/software/amira-3d-for-life-sciences/. Accessed Feb 2015.