# iMRI Data Repository for Validation of Brain Non-Rigid Registration Algorithms

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**Background:** Magnetic Resonance Imaging plays a central role in guiding brain tumor resections. However, the accuracy of neurosurgical navigation systems is seriously compromised by changes in the spatial position of the lesion and surrounding brain tissue, which inevitably occur during the surgical procedure, in response to surgical manipulation (resection, retraction, CSF leakage) and administration of anesthetic drugs. These spatial configuration changes, summarized under the generic term of brain shift, occur according to a non-linear pattern and lead to significant mis-registration between pre-operative image data (MR, CT) and the intra-operative brain configuration. In order to compensate for brain shift and maintain an accurate alignment between high-resolution, multi-modal MR-images acquired in advance of surgery and the rapidly changing brain configuration during surgery, non-rigid registration techniques are increasingly being employed. These techniques provide the ability to estimate transformations that model not only affine parameters (global translation, rotation, scale and shear), but also local deformations. Higher-order transformation models, with increased number of parameters and significant computing capabilities, as well as execution times compatible with the time constraints imposed by the surgical procedure are usually required for this purpose [1,3].

**Objective:** To develop a freely accessible, on-line repository of pre-and intra-operative MR-images derived from patients with hemispheric brain tumors, to serve as a validation platform for non-rigid registration algorithms.

**Material and Methods:** Ten consecutive patients with hemispheric, primary brain tumors were included in this IRB-approved study. There were three patients with low-grade, mixed oligoastrocytoma, five patients with low-grade oligodendroglioma, one patient with anaplastic oligodendroglioma, and one with glioblastoma multiforme. For each patient, we included a pre-operative MPRAGE (slice thickness 1.3mm, TE/TR=6/35 msec, FA=75º, FOV = 24cm, matrix=256x256**)**) and an intra-operative 3D-SPGR (TE/TR=700/29 msec, FOV 22-cm, matrix 256 X 256, 3-mm slice thickness), acquired after craniotomy and durotomy. The image headers were stripped of any patient-identifying information, and all images were stored as nrrd-files (http://teem.sourceforge.net/nrrd/format).

**Results:** The unprocessed image data is stored in a parent directory called ***Original***. Inside this directory, there are 10 subdirectories called **Case1**,…,**Case10.** Each of the ten subdirectories contains three files: 1) *caseX.xml* (where X is the case number) – a scene with pre-operative and intra-operative scans, that can be open with 3D Slicer [2] 2) *tp1.nrrd* –MRI scan acquired before surgery, and 3) *tp2.nrrd* –MRI scan acquired during tumor resection. Next, we created a second directory called ***Registered***. The purpose of this second directory is to store the rigid and non-rigid registration results obtained using the approach described in [1]. It has a structure similar to the ***Original*** directory: ten subdirectories (called **Case1**, …,**Case10**), and a set of four files: 1) *caseX.xml* (where X is the case #) – a scene with pre-operative and intra-operative scans, that can be open with 3D Slicer; 2) *tp1.nrrd* –MRI scan acquired before surgery; 3) *tp2.nrrd* –MRI scan acquired during tumor resection, and 4) *warped.nrrd* – the non-rigid registration between the brain extracted from the pre-operative scan, and intra-operative scan. All files were compressed as tar.gz, and appended to the SPL Publication Database (www.spl.harvard.edu/Special:publications), from where they can be downloaded free of charge. The images can be viewed and processed with the 3D-Slicer (http://www.slicer.org/). A comprehensive set of tutorials on Slicer is available online at: http://wiki.na-mic.org/Wiki/index.php/Slicer:Workshops:User_Training_101.

**Discussion:** To the best of our knowledge, this is the first Internet resource providing pre- and intra-operative MR images to the research community. Accessing the repository does not require user registration, and the data can be downloaded free of charge. While our primary goal was to set the foundation for the development of a common, standardized benchmark for testing non-rigid registration algorithms, the provided image data may serve as basis for other types of image processing applications as well.

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