Automatic Alignment for Tumor Assessment

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Target audience – Researchers working on data post-processing, radiologists, and clinicians studying brain tumors.

Purpose – The assessment of brain tumor progression or regression is an important task in neuroradiology. This is required to evaluate the effectiveness of a treatment and to make treatment decisions [1]. Recent advances in MRI enable an increasing number of studies to be performed in 3D with isotropic voxel resolution. However, in the past, this comparative assessment of current and prior scans have been performed using a manual 'best guess' slice-by-slice alignment of two data sets (**Fig. 1**), but this assessment is complicated by differences in patient positioning and field-of-view prescription. Here, we propose a novel 3D registration approach of baseline and follow-up studies to facilitate a faster and more accurate assessment of serial imaging studies in brain tumor patients.

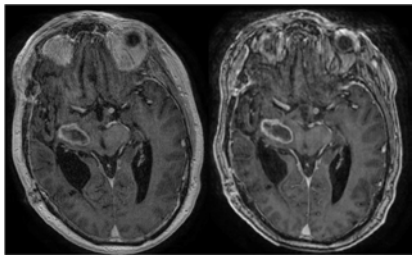

Fig. 1 – Manually aligned (best-guess slice alignment) 3D SPGR post contrast sequences of a brain tumor patient at baseline (left) and follow-up (right) demonstrate a similar appearance between scans which was interpreted as stable.

Methods – To standardize orientation, baseline 3D MRI brain scans (3D T2W CUBE, 3D FLAIR CUBE, 3D IR-SPGR) were first registered to the MNI atlas and kept in a research PACS system (RAPID) developed in-house [2]. When brain tumor patients presented for follow-up studies, these follow-up MRIs were registered to the re-aligned baseline data set [3, 4]. Once follow-up data sets were aligned, they were displayed next to each other so that the corresponding anatomy can be reviewed at the same slice level and slice angle (**Fig. 2**) from any of the three cardinal planes. RAPID's ability to co-register longitudinal data was evaluated in a consecutive series of 34 brain tumor cases who presented for baseline studies between October 2011 and May 2012 and who had follow-up exams between January 2012 and July 2012 with a median time interval between baseline and follow-up of 82 days. One board-certified radiologist and one board-certified neuroradiologist rated the quality of registration and the degree of change in enhancement, FLAIR/T2 abnormality, and lesion outcome based on a 5-point Likert scale. The level of confidence regarding these changes was also evaluated on a 5-point Likert scale.

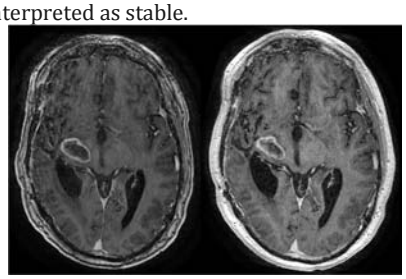

Fig. 2 – Automatically co-registered sequences of the same data sets at baseline (left) and follow-up (right) clearly demonstrates decrease in size of the lesion along the right thalamus.

Results – Compared to the manual 'best guess' re-alignment (which often has to be completed in the radiologist's mind due to the lack of 3D registration tools on PACS workstations), the automatic 3D registration facilitates a faster assessment of change. In addition, image interpretation time decreased for the aligned as compared to the non-aligned images. The aligned images were comparable in quality and did not suffer from artifacts introduced during the registration process. Comparison of tumor behavior between the two scans was also more accurate and interpreted with higher confidence, and this was confirmed by comparison to the outcome assessment for each patient.

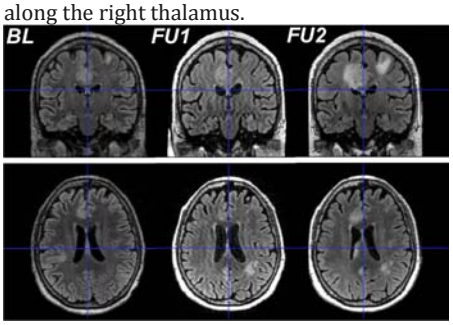

Fig. 3 – Example of the co-registration in coronal and transversal view for baseline and two follow-ups.

Discussion – The automatic registration for tumor assessment resulted in a faster and more accurate evaluation regarding any changes in tumor size, edema, or enhancement on serial imaging studies. Physicians were no longer required to spend time identifying the most closely corresponding slices of the two sets, rendering interpretation faster. The registration process ensured that similar or identical scan levels were always compared, and this facilitates assessment of any change. Although several MR manufacturers offer now functions to automatically plan and realign patient studies to a preset slicing template, this feature is still not widely available or is poorly adopted by technologists. A simple 3D/3D registration as presented in this work and which is widely used in the neuroscience community can make a considerable impact on the diagnostic speed of radiologists and their confidence to detect change/stagnation in brain tumor follow-up scans.

Conclusions – Automatic registration of 3D data for image alignment on serial studies offers a faster and more accurate assessment of changes in tumor size than the standard clinical assessment. This may have considerable consequences for the subsequent treatment trajectory of brain tumor patients. In all 34 cases evaluated, the tool performed well and improved diagnostic performance. Future studies will investigate scenarios when this approach can fail, e.g. brain tumors with huge mass effects/midline shifts, large resection cavities, etc.

Acknowledgements — NIH (2R01 EB00271108-A1, 5RO1 EB008706, 5R01 EB01165402-02), the Center of Advanced MR Technology at Stanford (P41 EB015891), Lucas Foundation, Oak Foundation.

References – [1] P. Freeborough, R. Woods, and N. Fox. *J Comput Assist Tomogr*. 1996; 20(6):1012-22. • [2] M. Straka, G. Albers, R. Bammer, J Magn Reson Imaging, 2010; 32(5):1024-37 • [3] M. Holden, D. Hill, E. Denton, *et al. IEEE TMI.* 2000; 19(2): 94-102. • [4] C. Studholme, D. Hill, and D. Hawkes. *Medical Physics. 1997;* 24(1): 25-35.