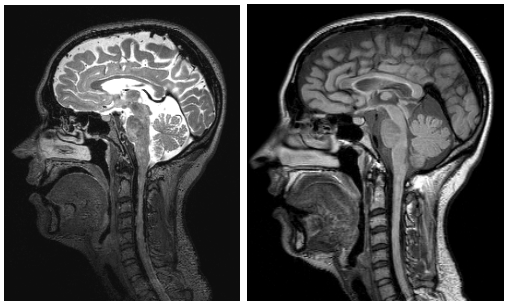
Automated System for Temporal Tracking of Multiple Sclerosis Lesions

M. Bilello[1], C. S. Rajapakse[2], N. Mehta[1], R. Verma[1], and E. R. Melhem[1]

[1]Division of Neuroradiology, Department of Radiology, University of Pennsylvania, Philadelphia, Pennsylvania, United States, [2]Laboratory for Structural NMR Imaging, Department of Radiology, University of Pennsylvania, Philadelphia, Pennsylvania, United States

Introduction As MRI has become the modality of choice for imaging multiple sclerosis (MS) patients, there have been efforts to standardize the imaging protocol [1]. The advent of new scanning technology, e.g., 3-Tesla scanners, in the clinical arena has allowed for increased image resolution, faster scan times, with a higher signal-to-noise ratio (SNR), improving significantly the quality of scans and hence their use in clinical diagnosis [2-3]. However, interpreting serial scans for MS studies continue to be a tedious and error-prone task for the neuroradiologist, primarily because of the need for quantitative assessment of disease load. In particular, studies have reported difficult inter-observer agreement on T2-weighted images [4]. These limitations highlight the need for a development of an integrated and automated system for the quantitative tracking of MS lesions over time, to clearly identify progressing and regressing lesions, regions of change, and occurrence of new lesions. Previously described systems in the literature [5-7], either require significant human intervention, or are not specifically designed to track lesions over time.

Methods Ten MS patients were scanned using the newly optimized 3D high-resolution isotropic, FLAIR (TR/TE = 6000/286 ms) and T2-weighted fast SE (TR/TE = 3200/458 ms) protocols at 3T (Figure 1). Acquired baseline and follow-up images were post-processed using the pipeline, which includes, in processing order: co-registration, skull-stripping, intensity normalization, and bias correction (Figure 2 shows a simplified workflow). The follow-up scans, both T2 and FLAIR, as well as the baseline FLAIR scan were then affinely registered to the baseline T2 scan of the same patient. False positive removal used both T2 and FLAIR intensity information. Due to the minimum change in lesions in the small pool of preliminary data, phantom lesions were manually inserted in some of the scans (Figure 3). A GUI tool was developed to perform preprocessing, and compute and display the subtraction maps (Figure 4). The tool measures lesion changes by counting subtraction voxels that satisfy T2 and FLAIR intensity criteria. Performance was assessed by comparison with a human expert.



a) b)

Figure 1. Images from 3D, high resolution, isotropic MS protocol: T2 (a) and FLAIR (b) .

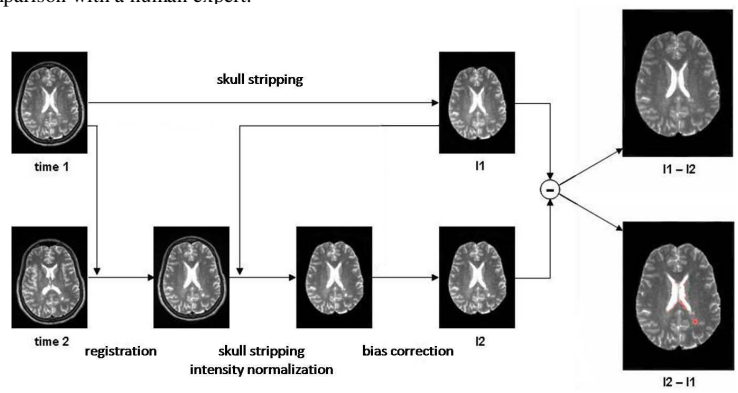
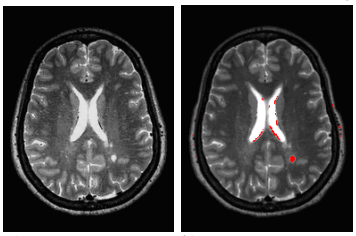


Figure 2. Simplified processing workflow for computing subtraction images: co-registration, skull-stripping, intensity normalization, and bias correction (FLAIR processing not shown).



a) b)

Figure 3. This left fronto-parietal lesion was removed from original scan to create a "new" lesion (a). The lesion was automatically detected (indicated in red in b).

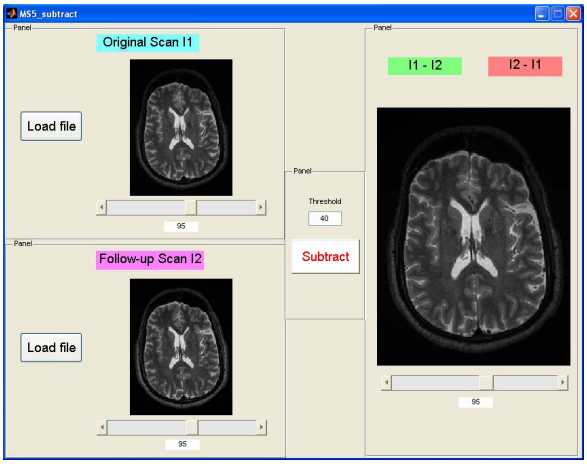


Figure 4 GUI tool that computes and displays subtraction maps.

Results and Conclusions Figure 4 shows a view of the GUI tool built to detect temporal changes. Following accurate registration and establishment of consistency with respect to voxel intensities, forward and backward difference images across pairs of serial scans were created, using image subtraction that permit detection of lesion change. The two-way subtraction allows tracking of both progressing and regressing lesions. Utilization of both T2 and FLAIR allows elimination of false positive detection of lesions arising from registration and intensity normalization errors. Preliminary experiments on the data demonstrate detection sensitivity greater than 90% for new and resolved lesions. False positives occur mainly at the edges of volumes. We are working on recruiting more cases, and are planning to perform ROC analysis. We feel that this system will aid not only neuroradiologists in everyday clinical care of MS patients, but also in research areas, such as in drug response trials, as large amount of imaging data could be analyzed reliably, accurately and objectively for lesion change over time.

References

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