Automatic Scan Prescription for Brain MRI

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Background: Clinical MRI is generally performed with manually prescribed slice orientations by trained MR technologists. However, manual scan prescription is time consuming and often suboptimal, because the operators do not utilize all available degrees of freedom for the best possible scan. For example, 3-D rotations of the imaging plane are often kept at their default value. This results in non-standardized scan orientations that vary from one patient to another.

Objective: To develop a software algorithm that allows the automatic prescription of brain MRI scans. This involves determination of the orientation of the current patient's brain, by matching his/her brain surface with a template brain surface. A desired scanning volume, orientation, and boundaries from the brain template can then be automatically adjusted to suit the current patient's position.

Design and Methods: Studies were done on a 1.5T GE scanner, using 3 volunteers with intentionally tilted head positions (see Figure). First, a single-shot axial pilot FSE scan with fat suppression was acquired (TE=900 ms; 5 mm slices; 1 mm gap, 256*256), showing only CSF signal. After determining optimized scan parameters from this pilot scan, a second scan with user-controllable rotations was acquired (segmented spin-echo EPI; TE/TR=100/3000 ms; 5 mm slices; 1 mm gap, 256*256) to assess the quality of the automatic prescription algorithm.

The spatial relationship between the current and the template brain was determined using an adaptation of a coregistration program developed in our laboratory (1, 2). First, the current brain surface was extracted automatically from the pilot scan. Next, this surface was matched iteratively to the pre-processed template surface, using translations, scaling, and rotations. Finally, using the matching transformation, a new set of optimized scan planes was determined for the current subject.

Results: The algorithm to extract the brain surfaces from the current pilot scan, as well as the surface matching, worked reliably in all 3 subjects. Processing time was 5 s on a Compaq/DEC Alpha workstation (XP1000). The Figure shows MR images from a volunteer with grossly tilted head position (A). The matching algorithm revealed rotations of 13, 16, and 70 degrees (X/Y/Z) between the current scan and the template scan. A repeat scan, acquired with new, optimized scanning parameters showed symmetric brain structures (B), and closely resembled the template scan (C).

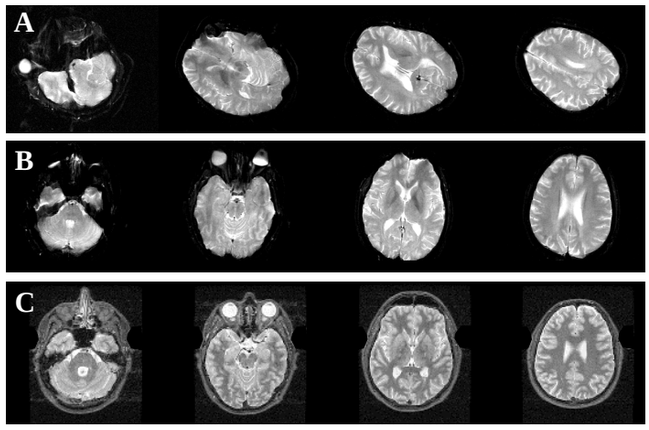

Figure: MRI scans from a subject with markedly tilted head position, before (A) and after (B) adjusting the scan plane. Note that the optimized scan (B) mirrors the slight rotation about the z-axis present in the template scan (C).

Discussion: This study shows that it is feasible to automatically prescribe scan planes for brain MRI. The total time for the auto-prescription (pilot scan plus image processing) was 10-20 seconds, short enough for an automated prescan protocol. The use of single-shot FSE images, showing CSF only, allows efficient extraction of the brain surface of the current subject. The surface matching algorithm is very robust, and most likely will be unaffected by most brain lesions. Our algorithm also provides a quality control measure, the generalized distance (in mm) between the current and the template brain surfaces.

Compared to manual prescription, automatic scan prescription promises many improvements, including reduced scan times, reproducible scan orientations along anatomically preferable orientations (such as the anterior-commissure posterior-commissure (AC-PC) line) among different patients, and better reproducibility for repeat studies within patients.

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References

1. Itti, L., Chang, L., Mangin, J.F., et al., *Human Brain Mapping*, 5, 3-17, 1997.

2. Itti, L., Chang, L., Ernst, T., et al., *Human Brain Mapping*, 5, 379-388, 1997.