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Registration of serial brain MRI scans from multiple sclerosis patients. Analysis of 3D intensity-based methods

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Background: Registration is a crucial task in serial MRI. Although many methods exist, the most simple ones (Rigid and Affine) are commonly used. This happens mainly because the automatic evaluation of registration results is still an unsolved problem. As a result, the strengths and weaknesses of each particular method for a given application are not widely known.
Aim: To study the performance of intensity-based registration methods for temporal registration of MRI images from multiple sclerosis (MS) patients.
Materials And Methods: 30 MS patients from two different hospitals with two temporal MRI studies (baseline and twelve months) were used to evaluate the registration methods. Manual lesion annotations done by expert radiologists were available for all patients. Regarding the methods, a total of 10 state-of-the-art intensity-based registration techniques were evaluated: Rigid, Affine, Bsplines, Demons (Diffeomorphic and classic), SPM8 (DARTEL and HDW), IRTK, ART and SyN. To assess the performance and quality of registration we used different evaluation measures: 1) Distance Values: Mutual Information (MI) and Sum of Squared Distances; 2) Difference Image Regularity measures: Mean, Standard Deviation, Entropy; 3) Measures on distance between lesions: Area Overlap (AO), Dice coefficient. The first two criteria groups are multi-purpose and image-based. The third is included to provide insight in the suitability of registration methods for serial analysis of MS lesions. All criteria were studied using descriptive statistics and hypothesis tests.
Results: Experiments show how, for all criteria, not only the initial values could be improved, but also those of commonly used methods (Affine, Rigid and Bsplines). For example, for MI metric, the average improved from an initial 0.58 to 1.12 for Rigid, 1.18 for Bsplines and a best value of 1.43 for Diffeomorphic Demons. We also saw how registering images helped bringing MS lesions closer. Specifically, the area overlap between MS lesions was improved on average from an initial 0.10 for Rigid to a best value of 0.41 by SyN.
Conclusion: We have provided insight in different aspects on the quality of the registration methods studied and the improvements brought by non-rigid methods. More important, we have also seen how registration helps bringing MS lesions closer. This shows the potential for state-of-the-art registration methods to help improve semi-automatic and automatic monitoring of MS lesion evolution.

The authors have nothing to disclose.