

Validation and Comparison of Non-rigid 3D Image-registration Algorithms

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ABSTRACT:

Introduction: This work presents a landmark-based method for assessing the accuracy of two nonlinear intersubject registration algorithms, AtamaiWarp fast nonlinear registration algorithm and Automatic Nonlinear Image Matching and Anatomical Labeling (ANIMAL) algorithm.

Materials and Methods: In this approach, MRI brain images of 12 subjects were employed and a computerized visualization and development environment, Atamai Surgical Planner (ASP), was employed to tag a set of 43 landmarks in each subject image and the reference brain template (CJH-27 dataset). Each set of landmarks was nonlinearly registered to the reference brain space according to a displacement vector file generated by warping each subject image to CJH-27 template, using each algorithm. The Euclidean distance between each landmark of a subject after warping and the homologous landmark on the standard image was considered as the registration error. The “gold-standard” coordinates of the 43 landmarks in the standard brain dataset were estimated by averaging their coordinates after 6 tagging sessions.

Results: The average standard deviation of localizing these points was 0.37mm, 0.78mm and 0.64mm in x, y and z directions respectively. After applying each non-rigid registration algorithm in turn to map 12 subject brains to the standard brain, the global average of registration errors of 43 landmarks identified in each brain was 1.04mm +/- 0.65mm for AtamaiWarp, and 1.59mm +/- 1.47mm for ANIMAL. With maximum registration errors of 2.78mm and 3.90mm respectively, AtamaiWarp and ANIMAL located 58% and 35% landmarks respectively with registration errors less than 1mm. A paired t-test demonstrated that the differences in registration error between AtamaiWarp and ANIMAL were significant ($t = 3.34$, degrees of freedom = 42, $P = 0.002$).

Conclusion: These results demonstrated that both algorithms performed well in nonlinear intersubject registration, but that AtamaiWarp, in addition to being over 60 times faster than ANIMAL, also provides more accurate results.

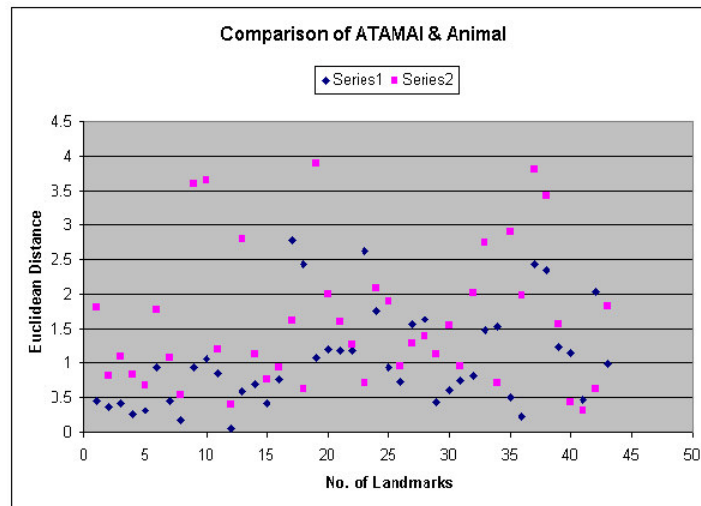


Figure 1. Comparison of AtamaiWarp and ANIMAL in registration error (Series1: AtamaiWarp; Series 2: ANIMAL)