Multiscale Image Registration

D. C. Paquin, D. Levy, L. Xing
Stanford University, Stanford, CA

Purpose/Objective(s): Often in medical image processing, images must be spatially aligned to allow practioners to perform quantitative analyses of the images. The process of aligning images taken, for example, at different times, from different perspectives, or from different imaging devices is called image registration. Although numerous successful image registration techniques have been published, ordinary techniques are shown to fail when one or more of the images to be registered contains significant levels of noise. The purpose of this work is to develop image registration algorithms that produce accurate registration results in the presence of noise.

Materials/Methods: Sample brain proton density slice and brain mid-sagittal slice images were obtained from the Insight Segmentation and Registration Toolkit (ITK), and known rigid and deformable transformations were applied to the images. Synthetic impulse (salt and pepper) and speckle (multiplicative) noise was added to the images, and image registration simulations were conducted to determine the precise noise levels at which image registration using ordinary techniques fails. Multiscale image registration algorithms were developed using the hierarchical multiscale image decomposition of E. Tadmor, S. Nezzar, and L. Vese, A multiscale image representation using hierarchical $(BV,L2)$ decompositions, Multiscale Modeling and Simulations, vol. 2, no.4, pp. 554–579, 2004. Image registration simulations were conducted to demonstrate the accuracy and efficiency of the multiscale registration algorithms.

Results: The multiscale image registration algorithms produced accurate registration results for noise levels significantly greater than those at which ordinary registration techniques failed. The multiscale techniques enable both rigid and deformed registration of noisy images, and the accuracy of the multiscale techniques is independent of the registration method used. Iterative multiscale registration techniques improved the computational efficiency of the registration algorithms.

Conclusions: The multiscale image registration techniques are a significant improvement over ordinary registration techniques, and enable accurate and efficient registration of noisy images.