Multiscale Registration of Medical Images with Applications to Adaptive Radiation Therapy

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Abstract

Often in image processing, images must be spatially aligned in order to perform quantitative analyses of the images; the process of determining the optimal transformation that maps one image to another is called image registration. Image registration has important applications in computer vision, pattern recognition, target identification, remote sensing, and medicine (the focus of the current research). Although numerous successful registration techniques have been published, I will show that ordinary methods fail when one or more of the images to be registered contains significant levels of noise. I will present a novel multiscale image registration technique using the hierarchical multiscale (BV, L^2) image decomposition of E. Tadmor, S. Nezzar, and L. Vese (*A multiscale image representation using hierarchical* (BV, L^2) *decompositions*, Multiscale Modeling and Simulations, vol. 2, no.4, pp. 554-579, 2004), and I will demonstrate that this new technique provide accurate registration of images that contain noise levels significantly greater than those at which ordinary registration fails. I will present several examples using both clinical and synthetic medical data.

Adaptive radiation therapy (ART) is the incorporation of daily images in the radiotherapy treatment process so that the treatment plan can be evaluated and modified to maximize the amount of radiation dose to the tumor while minimizing the amount of radiation delivered to healthy tissue. Registration of planning images with daily images is thus an important component of ART. I will also report the results of our research on multiscale registration of planning CT images with daily CBCT images.

Finally, I will discuss possible areas of further research, including topics of particular interest to computer scientists.

This is joint work with Doron Levy (Department of Mathematics and Center for Scientific Computation and Mathematical Modeling, University of Maryland) and Lei Xing (Department of Radiation Physics, Stanford University Medical Center).