AbstractID: 1713 Title: Implementation and validation of a deformable image registration algorithm for in-room CT-guided radiotherapy

Deformable image registration is essential for CT-guided adaptive radiotherapy. In this investigation, a grayscale-based fully automatic deformable image registration algorithm, known as the "Demons" algorithm (Thirion, *Med Image Anal*, 2(3), 1998) is studied. We accelerated the algorithm by introducing an "active force" in the original implementation, along with an adaptive force strength adjustment during the iterative deformation. The results showed a 40% improvement in speed and high tolerance to large deformations. To validate the accuracy and robustness of the algorithm, we designed three types of tests. We first used an alternative point-match based manual deformable registration technique to create a set of artificially deformed test images of known shifts. This provides the "ground truth" for quantitative evaluation. Test results showed that 96% of the voxels were within 2 mm of intended shifts for a prostate case. The mean errors and standard deviations were -0.45mm ± 0.92mm and 1.26mm ± 2.28mm, respectively, for the prostate case and a head and neck case which had a large deformation due to the irradiation of the neck lymph nodes. Secondly, measurements with a deformable pelvic phantom showed a tracking accuracy of better than 1.5mm for 23 seeds implanted in the phantom prostate and deformed by an inflated rectal balloon. Lastly, the deformable registration algorithm was applied to generate new anatomical structures based on previous contours on the original CT images. Visual inspection of the positions of these auto-contoured structures agreed well with human judgment. The algorithm shows a significant potential for clinical application for CT-guided radiotherapy.