MOTION DETECTION AND CORRECTION FOR IMAGE GUIDED RADIATION THERAPY

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Motion, the geometrical discrepancy between the treatment planning and the treatment delivery, strikes at the very foundation of conformal radiotherapy. Motion detection and correction becomes crucial in the further development of radiotherapy towards full Image Guided Radiation Therapy (IGRT). This thesis provides fundamental research on motion detection and correction for IGRT. Six standalone, but related, techniques are developed in this thesis.

Tomographic motion detection and correction. This technique targets on intra-fraction respiratory motion. It utilizes the fact that motion is encoded in sinogram. Motion is modeled as time dependant scaling along two dimensions. It is detected and corrected directly in sinogram space.

Registration from (partial) projection data. Tomotherapy uses projection-based patient registration for set-up verification. We developed a technique for 2-D/3-D image/patient registration. We investigated registration based on partial projection data, such as sparse angle sampling, limited arc ranges, etc.

Feature-point detection and tracking. Motion can be well represented by feature-point. We developed an automatic technique to reliably detect and track feature-points on 3-D medical images. Feature-points are either anatomical features or extrinsic markers.

Registration based on feature-point mappings. We developed an automated 3-D image registration technique. Neither fiducial markers nor human interaction are required. It deals with affine, as well as rigid-body transformation. RANSAC was used for outlier reduction.

Segmentation and localization. We developed a deformable-reference-based algorithm. It relies on a pre-segmented reference image. The information about global region, grey level profile, and global shape similarity is incorporated into the model. Boundary correspondence is maintained in this algorithm.

Deformable registration. We use an elastic model to describe organ deformation. Deformable registration is modeled as a boundary value problem with feature-point mappings as soft constraints. By solving the elliptic partial differential equations, we obtain the registration vector for each voxel. Synthetic images, phantom studies, and clinical data have been used to test each technique. A case study using CT data of a prostate patient was performed. The results show feasibility, reliability, robustness, as well as limitations of the developed techniques. Future work towards Adaptive TomoTherapy (ATT) was discussed.