AbstractID: 4525 Title: Intra- and Inter-Modality Registration of Four-Dimensional (4D) Images

Purpose: 4D-imaging techniques such as 4D-CT/MRI/PET reveal spatial and temporal details of patient's anatomy. Here we develop a 4D-4D registration method to utilize the 4D data acquired under different conditions or using different modalities.

Method: A 4D input (model or reference) consists of a number of 3D sets of images, each representing the patient's anatomy at a phase point. When the patient's breathing pattern is repeatable, the task of 4D-4D matching is to find the appropriate 3D dataset in the model input for each phase in reference. Instead of exhaustively searching for the best match for each phase, a search algorithm was implemented, which can simultaneously find the matches for all phases with consideration of temporal relationship between the 3D image sets in the inputs. An interpolation scheme capable of deriving an image set based on two temporally adjacent 3D-datasets was implemented to deal with the situation where the discrete temporal points of the two inputs do not coincide. Digital phantom and patient studies were performed to illustrate the inter-/intra-modality 4D-4D registration technique.

Results: In the phantom study where the optimal match is known, the proposed technique was able to reproduce the "ground truth" with high spatial fidelity (<1.5mm). In addition, the technique regenerated all deliberately introduced "missing" 3D images at different phase points in one of the inputs because of the temporal interpolation. In a registration of gated-MRI and 4DCT, the technique enabled us to optimally select the corresponding CT phase. The technique was also found useful for the registration of two sets of 4DCTs acquired at different time points. In this situation, a spatial accuracy of less than 2.5mm was achieved in all three cases.

Conclusions: Automated 4D-4D registration can find the best possible spatio-temporal match between the two 4D datasets and may have significant implication for IGRT.