Title: Validation of inter-fraction dose accumulation using non-rigid registration algorithms

Authors: *G. Janssens[1], J. Orban de Xivry[1], S. Fekkes[2], A. Dekker[2], B. Macq[1], P. Lambin[2] and W. van Elmpt[2]*

[1]Communications and Remote Sensing Laboratory (TELE), Université catholique de Louvain, 1348, Louvain-la-Neuve, Belgium.

[2]Department of Radiation Oncology (MAASTRO), GROW-School for Oncology and Developmental Biology, University Medical Centre Maastricht, Maastricht, The Netherlands.

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Purpose: In the context of adaptive radiotherapy, there is a growing interest in evaluating the total dose received over the entire course of treatment. Such dose accumulation process needs to account for dose fluctuations and changes in patient anatomy. For this purpose, a strategy for accumulating the dose is assessed. Dose deformation based on non-rigid registration is validated and accumulation is performed by taking into account the radiobiological effects.

Material: In order to validate the use of deformation fields resulting from non-rigid registration for dose accumulation, experiments have been performed on a deformable silicon phantom with implanted MOSFET dose detectors. This phantom was subject to 5 arbitrary deformations and cone-beam CT images were acquired. A treatment planning system was used to perform dose calculations on these images. Non-rigid CT-based registration was performed using 2 different methods (Morphons and Demons), and the resulting deformation field was used to warp the dose distribution. MOSFET location, simulated and measured doses were then used for validating the dose correction process. In order to evaluate the importance of accurate dose accumulation, the method was applied on images of a rectal cancer patient. Inter-fraction registration was performed and corresponding dose distributions were warped accordingly. Dose accumulation was performed, using the LQ model to take into account radiobiological effects, and compared to the planned dose distribution using isodose lines and dose volume histograms (DVH) of the target volume and surrounding organs.

Results: A significant decrease in MOSFET position difference was observed after non-rigid registration of phantom images with both non-rigid registration methods ($p<0.001$). In the same way, the difference between accumulated and measured dose values was also significantly decreased using both methods ($p<0.001$). Experiments on rectal cancer patient data showed small variations in DVH of the planning target volume and over-dosage of some surrounding organs including the bladder.

Conclusions: Non-rigid registration on repeated CT imaging data allows accumulation of dose distributions to take into account organ deformations and radiobiological effects. This opens possibilities for adaptive radiotherapy to take into account dose variations due to anatomical deformations.