EFFECTS OF RESPIRATORY MOTION AND RISK-REGION MISCLASSIFICATION ON SUBVOLUME BOOSTING IN RADIOTHERAPY

Andrew G. Ellis

Under the supervision of Professor Wolfgang A. Tomé

At the University of Wisconsin-Madison

Functional imaging advancements have revealed that for many tumors, ideal treatment consists of a non-uniform dose prescription based on tumor subvolume radioresistance characteristics. This treatment has been proven beneficial in planning studies, but puts significant emphasis on accurate subvolume segmentation. Respiratory motion during imaging and treatment compounds this issue in thoracic tumors. This work aimed to assess these target definition challenges using an in-house designed and constructed programmable motion phantom. An FDG loaded PET target simulating distinct risk-regions was driven by twenty breathing patterns of varying shape and motion amplitude. PET and CT images were acquired for each unique motion scenario. There was a direct relationship between autocontoured subvolumes and respiratory motion amplitude, though it was poorly correlated on an individual patient basis due to limited data. Gated PET reconstruction has been shown previously to improve motion affected single-target autocontouring accuracy. This is useful to utilize standard risk-region autocontour thresholds in motion affected anatomy. In this work, gated PET subvolume images effectively eliminated motion artifacts, enabling use of static

target threshold guided autocontour thresholds. Spatial location accuracy of all PET autocontoured subvolumes, however, was poor. The high-risk subvolume was particularly misclassified, due to its size (1cc) leading to partial volume effect susceptibility. Clinically, additional tumor heterogeneity information for qualification of the PET defined risk-regions is rarely available. To assess the effects of risk-region misclassification on non-uniform radiotherapy, stereotactic body radiotherapy (SBRT) treatment plans were created targeting the misclassified subvolumes. The resulting DVH analysis showed suboptimal high dose in the true low-risk subvolumes, significantly underdosed high-risk subvolumes, and consistent underdose to the low-risk subvolumes. These effects of risk-region misclassification are evident even after the addition of treatment margins to the misclassified PET subvolumes. Although motion presents challenges for risk-adaptive radiotherapy, gated imaging can alleviate the effect of motion on autocontouring. This work concludes that subvolume size relative to image resolution is more limiting for accurate subvolume identification in this and similar scenarios.