

PET imaging, quantification, and partial volume correction of tumor heterogeneity

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Solid tumors are known to vary spatially and temporally in their biological characteristics. Tumor subvolumes experiencing similar characteristics are frequently referred to as tumor heterogeneities. These tumor heterogeneities are frequently observed in positron emission tomography (PET) imaging as non-uniform radiotracer uptake. The intensity and distribution of tumor heterogeneity has been shown to be a prognostic indicator of patient outcome. In addition, tumor heterogeneity could potentially be exploited for biologically optimized treatment planning in radiation therapy (dose painting). However, the limited resolution of PET imaging produces partial volume effects (PVE) which create quantitative errors when imaging non-uniform distributions. These errors are increased when imaging steep activity gradients over small volumes or distances, as in the case of tumor heterogeneity.

This dissertation studies several aspects of tumor heterogeneity imaged using PET. The quantitative impact of PVE on imaged heterogeneities is characterized by imaging and reconstructing a novel phantom mimicking non-uniform tumor uptake. Spatial statistics are introduced as a possible method for the quantification of tumor heterogeneity. Quantitative errors due to PVE are then reduced with the introduction of a partial volume correction (PVC) method designed specifically for heterogeneous tumors. Finally, the impact of PVC on biologically optimized treatment planning is assessed by comparing tumor dose prescriptions and optimized deliveries generated with and without PVC.