IMAGE-GUIDED RADIATION THERAPY FOR TREATMENT DELIVERY AND VERIFICATION

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Target conformity and normal tissue sparing provided by modern radiation therapy techniques often result in steep dose gradients, which increase the need for more accurate patient setup and treatment delivery. Image guidance is starting to play a major role in determining the accuracy of treatment setup. A typical objective of image-guided radiation therapy (IGRT) is to minimize differences between planned and delivered treatment by imaging the patient prior to delivery. This step verifies and corrects for patient setup and is referred to as setup verification. This dissertation evaluates the efficacy of daily imaging for setup verification and investigates new uses of IGRT for potential improvements in treatment delivery.

The necessity of daily imaging can first be determined by assessing differences in setup corrections between patient groups. Therefore, the first objective of this investigation was to evaluate the application of IGRT for setup verification by quantifying differences in patient positioning for several anatomical disease sites. Detailed analysis of setup corrections for brain, head and neck, lung, and prostate treatments is presented. In this analysis, large setup errors were observed for prostate treatments. Further assessment of prostate treatments was performed, and patient-specific causes of setup errors investigated.

Setup corrections are applied via rigid shifts or rotations of the patient or machine, but anatomical deformations occur for which rigid shifts cannot correct. Fortunately, IGRT provides

images on which anatomical changes occurring throughout the course of treatment can be detected. From those images, the efficacy of IGRT in ensuring accurate treatment delivery can be evaluated and improved by determining delivered doses and adapting the plan during treatment. The second objective of this dissertation was to explore new applications of IGRT to further improve treatment. By utilizing daily IGRT images, a retrospective analysis of delivered doses to normal tissues during hypofractionated prostate treatments was performed and is presented. Uncertainties in dose calculations on daily images and recommendations for reducing these uncertainties are discussed. Finally, the potential to improve normal tissue sparing was examined by comparing dose distributions achievable by emerging IGRT systems using the treatment of left-sided breast cancer as a clinical example.