Ph.D. Thesis Abstract for David C. Westerly

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Strategies for Improved Accuracy and Efficiency with Advanced Intensity Modulated Radiation Therapy Techniques

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At the University of Wisconsin-Madison
2009

The development of advanced intensity modulated radiation therapy (IMRT) techniques has led to significant improvements in our ability to treat complicated target volumes with minimal collateral damage to the surrounding healthy tissue. These techniques however, come at the cost of increased complexity; which translates into increased sensitivity of the optimized treatment plans to inaccuracies in the planning and delivery processes, and can also result in longer treatment times. The aim of this work is investigate various strategies designed to improve the accuracy and efficiency of two advanced forms of IMRT: helical tomotherapy and intensity modulated proton therapy (IMPT).

Helical tomotherapy is form of X-ray IMRT that uses a compact linear accelerator mounted on a CT ring gantry to rotationally deliver intensity modulated fan-beams of radiation to a patient for treatment. Failure to select judicious values for certain planning parameters can result in plans with long treatment times that are difficult for the machine to accurately deliver. This situation was observed for a series of patients scheduled for treatment at the University of Wisconsin. Treatment planning methods designed to avoid these difficulties have been investigated and are discussed. While the vast majority of IMRT treatments are performed using mega-voltage X-rays, there has recently been a great deal of interest in the use of IMPT for a variety of clinical indications. Current methods of IMPT are limited in their applicability however, due to restrictions imposed by the current delivery paradigm. An alternative method for IMPT delivery using a fan-beam geometry has been examined. Another challenge with IMPT pertains to the accuracy of proton dose calculations in the presence of complex tissue heterogeneities. Monte Carlo methods provide the most accurate means of dose calculation; however, the computational requirements of current radiation transport codes makes Monte Carlo methods unsuitable for routine treatment planning. As an alternative, analytical pencil beam algorithms are used to calculate dose. For this work, an analytical proton dose calculator was developed. Two heterogeneity correction schemes have been incorporated into the algorithm and the accuracy of these methods compared with Monte Carlo is examined in a variety of heterogeneous phantom geometries.

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