Publications


PROGRAMME
The Final Oral Examination for the Degree of
DOCTOR OF PHILOSOPHY
(Department of Physics and Astronomy)

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2010 University of Victoria BSc

“Enhancing the Speed of Radiotherapy Dose Calculation with Applications in Dose Verification”

Monday, March 9, 2015
1:00PM
Elliott Building, room 105

Supervisory Committee:
Dr. Andrew Jirasek, Department of Physics and Astronomy, University of Victoria (Co-Supervisor)
Dr. Sergei Zavgorodni, Department of Physics and Astronomy, UVic (Co-Supervisor)
Dr. William Ansbacher, Department of Physics and Astronomy, UVic (Member)
Dr. Dean Karlen, Department of Physics and Astronomy, UVic (Member)
Dr. Valerie King, Department of Computer Science, UVic (Outside Member)

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Dr. Jan Seuntjens, Department of Oncology, McGill University

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Dr. Frank van Veggel, Department of Chemistry, UVic
Abstract

Monte Carlo (MC) methods for radiotherapy dose calculation are widely accepted as capable of achieving high accuracy. In particular, MC calculations have been demonstrated to successfully reproduce measured dose distributions in complex situations where alternative dose calculation algorithms failed (for example, regions of charged particle disequilibrium). For this reason, MC methods are likely to play a central role in radiotherapy dose calculations and dose verification in the future. However, clinical implementations of MC calculations have typically been limited due to the high computational demands. In order to improve the feasibility of using MC simulations clinically, the simulation techniques must be made more efficient.

A number of approaches to improve the efficiency of MC dose calculations are presented. One of the most time consuming parts of source modeling is the simulation of the secondary collimators, which absorb particles to define the rectangular boundaries of radiation fields. An approximate model of the secondary collimators was evaluated for accuracy and efficiency using both graphics processing unit (GPU)-based and central processing unit (CPU)-based MC approaches. The new dose calculation engine, gDPM, that utilizes GPUs to perform MC simulations was developed to a state where accuracy comparable to conventional MC algorithms was attained. However, in GPU-based dose calculation, source modeling was found to be an efficiency bottleneck. To address this, several novel phase-space source implementations were considered, as well as a hybridized focal/extra-focal source model, and variance reduction techniques. The most successful methods produced results comparable with standard CPU-based MC simulations in mere minutes, rather than hours of calculation time. Additionally, a novel CPU-based MC dose reconstruction algorithm was developed for specific applications in pre-treatment dose verification, utilizing electronic portal images.

Presentations

2. Townson, R. and Zavgorodni, S. “Pre-treatment radiotherapy dose verification using Monte Carlo doselet modulation in a spherical phantom.” Annual Meeting of the American Association of Physicists in Medicine, Indianapolis, IN. August 2013. (poster)
4. Townson, R. “Medical linear accelerator focal spot full width half maximum measurements and Monte Carlo modeling of the experimental setup.” Canadian Undergraduate Physics Conference, Edmonton, AB. 2009. (oral)