Monte-Carlo simulation of SPECT imaging

https://www.creatis.insa-lyon.fr/site7/fr/node/45914

Context

Prompt Gamma imaging is a promising modality for dose verification in Proton Therapy. However, Prompt Gamma production is a rare physics process and therefore detection is challenging. Monte Carlo simulations allow us to study such detectors without building them and without having to take up valuable beam time at accelerator institutes.
Recently, an accelerated method for Prompt Gamma simulations (vpgTLE) was developed at Creatis/IPNL to facilitate fast clinical simulations. In 10-30 minutes, a Prompt Gamma signal can be produced for a given patient CT and associated treatment plan. Even in this accelerated method, most Prompt Gammas are still emitted in all directions, while the detector only covers about 5% of the solid angle of the space around the patient. Also recently a Fixed Forced Detection (FFD) method was developed at Creatis. This method only simulates photons going into a detector: their directions are Forced. Since Prompt Gammas are photons, we would like to apply the method to our accelerated Prompt Gamma simulations, to make them even faster then they already are.
Our group has several years of expertise in Monte-Carlo (MC) simulations of particle-matter interactions. We are deeply involved in the OpenGate international collaboration that provides and supports the Gate Monte-Carlo software, very useful in medical physics.

Goal

The goal of this master thesis training period is to validate Fixed Forced Detection in combination with vpgTLE Prompt Gamma simulations in the Gate Monte-Carlo package.

Task

The training student will have to perform PG simulations for a set of patient CTs. These simulations are with and without Fixed Forced Detection, in order to study the difference, if any. If no (large) differences are found, the student has proven the Fixed Forced Detection method for Prompt Gamma simulations, and it will become part of the next general release of Gate.
The FFD is drop-in ready, starting with a voxellized patient CT, but it will have as an implementation detail that it forces detection towards the centers of 2D pixels in a 2D detection plane, from which photons with a correct weight would be propagated further into the PG detector. this introduces some choices into pixel sizes, alignment with the collimator and perhaps the addition of the PG-energy dimension to the supported voxellized source image. The student would validate the PG simulations with respect to vpgTLE Stage 2, and gain experience with MC studies, C++ programming, PG detection. Perhaps there's some time to validate on various PG camera configurations as well.

Details

- Prerequisites: Background in physics, detector development, medical physics, medical imaging or computer sciences.
- Language Skills: English or French fluent
- Programming Skills: some experience is required.
- Period: According to the master, about 6 months ; Location: Centre Leon Berard, Lyon, FRANCE, Creatis Team ; Compensation: about 554€

Supervisors

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