

Master internship 2023 in Lyon, France.
Monte Carlo simulation model of innovative SPECT systems.

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This work is a collaboration between researchers from CREATIS lab and the nuclear medicine department of the Léon Bérard cancer center (Lyon, France).

Context. In nuclear medicine during the last ten years, cancer treatment by Molecular Radionuclide Therapy (MRT) has been growing rapidly. As an example, peptide receptor radionuclide therapy (PRRT) has been shown to be an alternative treatment for neuroendocrine tumors (NETs) when surgery is not indicated [1]. MRT consists in intravenous administration of a molecular vector labeled with a radionuclide. The vector's goal is to accumulate the compound in target organs and β or α -emitting radionuclide provides cytotoxic effects. Lutetium-177 is one of the most used radionuclides. In addition to β particles, it also emits γ rays that allows to quantify the radionuclide concentration in the tumors and healthy organs with SPECT/CT images acquisitions repeated at different point-times after treatment injection.

Patient-personalized dosimetry [2], [3] is a key notion that allows to optimize tumor control by administering the highest possible activity in target volume while limiting complications due to irradiation to organs at risk. The principle is to estimate the biodistribution and the pharmacokinetic of the activity inside the patient from SPECT/CT images. This image-based estimation is however impaired by numerous effects (attenuation, scatter, breathing motion...) that must be corrected or accounted for [4]–[6]. Monte Carlo simulation of SPECT imaging systems, which consists in building a virtual model of the imaging process in the most accurate way possible [7], is an essential tool to optimize the acquisition parameters, calibrate the images, perform research in image reconstruction or estimate the dose distribution.

Recently, a new type of CZT-based digital camera (VERITON-CT, Spectrum Dynamics) was acquired by Léon Bérard cancer center. This system is characterized by its unique scanning geometry which allows independent radial and swivel motion of the detectors [8]. A Monte Carlo model of this innovative system will have to be developed and validated to be applied in this medical context.

Keywords: SPECT, Monte Carlo simulations, CZT detectors

Objectives of the master internship.

The main objective of this internship is to develop a Monte Carlo model of a new type of multi-CZT detector SPECT system and validate the model against experimental data.

1. Reproduce scanning geometry of acquisitions (including radial and swivel motion)
2. Develop a Monte Carlo model of the system with GATE (python-based version)
3. Compare Monte Carlo model predictions with experimental data
4. Design new measurements, if needed, to further validate the model.
5. Reconstruct the activity distribution from simulated projection data with RTK [9]

Environment. The student will work in a multidisciplinary team composed of nuclear physicians, medical physicists, researchers, and computer scientists of CREATIS laboratory and Leon-Bérard Cancer Center.

Expected skills and other information

- Expected skills: medical physics, computer sciences, image processing
- Technical skills: Python is required, experience with GATE would be an asset.
- English and French
- Location: Léon Bérard cancer center, Lyon, France

Supervisors:

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