Laboratoire de Traitement de l'Information Médicale
Laboratory of Medical Information Processing

Post-Doctoral Fellowship:

Personalized internal dosimetry using deep learning and Monte Carlo approaches for radionuclide therapy

Scientific context

Unlike conventional external beam cancer therapy, radionuclide therapy (RNT) targets disease at the cellular level rather than on a gross anatomical level by injecting into the body a radioactive chemical compound linked to a cell-targeting molecule. In targeted RNT, the biological effect is obtained by the energy absorbed from the radiation emitted by the radionuclide.

Personalized therapies with RNT presuppose a patient-specific dosimetry. With the advent of hybrid SPECT/CT and PET/CT imaging techniques, detailed information of the in-vivo spatial distribution of tissue density and in-vivo activity is available. This detailed knowledge allows in principle to estimate the spatial distribution of the absorbed dose. For an accurate personalized treatment, voxel-based dosimetry using direct Monte Carlo simulations that can consider both heterogeneous activities and medium distributions is necessary.

Monte Carlo (MC) simulations generate and track particles at the voxel-level, allowing to calculate deposited energy and estimate voxel-level absorbed doses. Nevertheless, this approach requires extensive computational times and is therefore not compatible with clinical routine. Recent works in internal dosimetry [1], propose to substitute the Monte Carlo dose engine by a deep learning (DL) approach based on Convolutional Neural Networks (CNN), which have the potential to predict a personalized dose both rapidly and accurately.

The main limitation of such DL methods is their robustness and genericity. To maintain a sufficient level of accuracy, CNN models must be trained for each clinical protocol (according to the radionuclide, the disease, or the anatomical region of interest) leading to reduced robustness. This is further complicated by the small patient population used to train each model. Indeed, in RNT, especially for some innovative radionuclides, only few data from clinical trials are available. Therefore, the deployment of fast and accurate personalized dosimetry in a clinical RNT context remain a challenge.

We propose here to develop generic and robust methods for personalized dosimetry in radionuclide therapy that use DL and MC approaches. The LaTIM has already extensive experience in the combination of DL and MC approaches for external beam and intraoperative radiotherapy applications [2]. The aim is to develop a framework that allows training deep learning models from small patient population in combination with MC simulations. Innovative workflow that combines data augmentation, generic simulation and transfer learning will be explored.

Job description and missions

The main goal is to develop an accurate and robust deep learning framework to predict the personalized dose in the context of radionuclide therapy. The postdoctoral fellow will then investigate and propose new methods in the field of deep learning and MC simulations by following different steps:

- bibliographic review of the existing solutions,
- generic MC simulation using GATE [3] to simulate any radionuclide therapy (beta and alpha particle) from PET/CT acquired patient data. This simulation will be used to generate data for training and as reference for further evaluations,
- investigate different deep learning architectures and different schemes to train a model based on a small population of patient data (transfer learning, data augmentation, etc.),
- results to be compared with state-of-the-art approaches and standard MC simulations.

Profile

PhD in computer science, image processing, AI, applied mathematics. Good programming skills is an important requisite, especially in python. Autonomy, open-mindedness and motivation, as well as good English speaking/writing skills, are also expected. Some experience in deep learning within the context of medical physics and/or in MC simulations is appreciated but not mandatory.

Position context

The postdoc will join the INSERM UMR1101 Laboratory of Medical Information Processing (LaTIM, Brest, France, https://latim.univ-brest.fr). The future recruited postdoc will work in collaboration with different academic and hospital partners within the context of different European projects. Access will be given to the PLACIS infrastructure (http://placis.univ-brest.fr/english) and to clinical data from our partners.

The position is available as soon as possible (no later than the 1st of October 2022) for three years. Salary is around 2200 € net/month, depending on the candidate's experience.

Contact and additional information

For application, a CV that includes a complete list of publications have to be sent to the following e-mails:

Julien Bert (julien.bert@univ-brest.fr)
Dimitris Visvikis (dimitris.visvikis@inserm.fr)

References

[1] Kontaxis C, Bol G H, Lagendijk J J W and Raaymakers B W 2020 DeepDose: Towards a fast dose calculation engine for radiation therapy using deep learning Physics in Medicine & Biology 65 075013

[2] M. Villa, J. Bert, A. Valeri, U. Schick and D. Visvikis, "Fast Monte Carlo-Based Inverse Planning for Prostate Brachytherapy by Using Deep Learning," IEEE Transactions on Radiation and Plasma Medical Sciences, vol. 6, no. 2, pp. 182-188, 2022, doi: 10.1109/TRPMS.2021.3060191.

[3] Jan S, Benoit D, Becheva E, Carlier T, Cassol F, Descourt P, Frisson T, Grevillot L, Guigues L, Maigne L, Morel C, Perrot Y, Rehfeld N, Sarrut D, Schaart D R, Stute S, Pietrzyk U, Visvikis D, Zahra N and Buvat I 2011 GATE V6: a major enhancement of the GATE simulation platform enabling modelling of CT and radiotherapy Phys Med Biol 56 881–901