PhD fellowship – Investigating Y-90 digital PET imaging with Monte-Carlo simulations and machine-learning – Lyon – 2018

https://www.creatis.insa-lyon.fr/site7/en/node/46629

Medical and scientific context

Molecular imaging by Positron Emission Tomography (PET) techniques provides patient body information at the molecular and cellular levels thanks to β+ emitters radiopharmaceuticals.

Selective Internal Radiation Therapy (SIRT) or Y-90 microsphere radioembolization is a treatment for unresectable hepatic malignancies and metastases that can be monitored with PET imaging. This monitoring is of prime importance for patient safety and to move towards personalized dosimetry. However, only few β+ are emitted (32 positron per million decays), and high-energy prompt gamma (628 keV) are also emitted during decay. Both phenomena make quantitative PET images challenging.

Recent advance in Digital Photon Counting (DPC) technology that directly convert scintillation light into a digital signal has allowed to reduce tradeoff between sensitivity and resolution. Philips Medical System recently developed Vereos PET/CT system, announcing sensitivity gain up to 2x larger than conventional system. This system, a digital PET or dPET, will be installed mid-2018 at LUMEN.

The goal of the PhD is to investigate quantitative dPET Y-90 images thanks to Monte-Carlo simulations and apply the findings to clinical setting.

Objectives and research program

Monte-Carlo simulations will be used to perform *in silico* experiments of various acquisition configurations in order to assist medical physicist and clinicians to optimize image quality with clinical constraints. Because simulations are very time-consuming, acceleration methods will be investigated based on Variance Reduction Technique (VRT) and/or Machine Learning (ML) approaches. In particular, it is envisioned that complex detector response could be learnt by a neural network that will spare time-consuming particles tracking in the detector elements. Image reconstruction will be performed by Philips software. Developments will be performed and included in the open-source GATE platform [1].

This project is strongly linked with the clinical needs at LUMEN where SIRT therapy is regularly performed and will provide data for the study and clinical expertise. In particular, the personalized post-treatment planning and the treatment verification will be the main clinical expectations. In addition, the gain provided by the dPET over the acquisition time, noise reduction and the improvement of the detection of small hepatic lesions will be evaluated.

At the end of the project, we will provide insights on the feasibility to obtain quantitative images when monitoring SIRT treatment, and how to optimize the acquisitions parameters in various clinical situations.

Required skills:

- **Education**: master in medical physics, applied mathematics or image processing.

- **Scientific interests**: medical physics, applied mathematics, computer sciences (medical image processing), x-ray physics and imaging.
- **Programming skills**: Python, C++ (ITK, GATE).
- **Languages**: English required, French optional.

Practical information:

- **Supervisors**: David Sarrut (david.sarrut@creatis.insa-lyon.fr) and Jean-Noel Badel (jeannoel.badel@lyon.unicancer.fr)
- **Location**: CREATIS Lab, Centre Léon Bérard, Lyon, France
- **Salary (net)**: around 1400 euros/month.
- **Period**: three years starting between September-December 2018.

How to apply?

Send CV + letter to supervisors.

References:

- 90Y Digital PET/CT Imaging Following Radioembolization. Wright CL, Zhang J, Binzel K, Wuthrick EJ, Knopp MV. Clin Nucl Med. 2016 Dec;41(12):975-976.
- A GATE evaluation of the sources of error in quantitative 90Y PET. Strydhorst J, Carlier T, Dieudonné A, Conti M, Buvat I. Med Phys. 2016 Oct;43(10)
- Redesign of the GATE PET coincidence sorter. Strydhorst J, Buvat I. Phys Med Biol. 2016 Sep 21;61(18):N522-N531. 2016
- PET/CT-Based Dosimetry in 90Y-Microsphere Selective Internal Radiation Therapy: Single Cohort Comparison With Pretreatment Planning on (99m)Tc-MAA Imaging and Correlation With Treatment Efficacy. Song YS, Paeng JC, Kim HC, Chung JW, Cheon GJ, Chung JK, Lee DS, Kang KW. 2015 Jun;94(23)
- PET optimization for improved assessment and accurate quantification of 90Y-microsphere biodistribution after radioembolization. Martí-Climent JM, Prieto E, Elosúa C, Rodríguez-Fraile M, Domínguez-Prado I, Vigil C, García-Velloso MJ, Arbizu J, Peñuelas I, Richter JA. Med Phys. 2014 Sep;41(9):092503