PhD offer 2017-2020

On the radiome determination using multimodality imaging and its role for personalized management of cancer patients

Hosting lab : Unité Imagerie Moléculaire In Vivo (IMIV), UMR 1023 Inserm/CEA/Université Paris Sud – ERL 9218 CNRS, CEA-Service Hospitalier Frédéric Joliot, Orsay

Superviser : Irène Buvat, DR CNRS

Doctoral School : EOBE, Université Paris Sud

Thesis context and objectives

Cancer is currently the leading cause of death in France and worldwide. Cancer treatment is most often selected based on one or several biopsies, from which the anatomopathological characteristics of the tumor are identified and determine the best therapeutic strategy. However, due to tumor heterogeneity, more than 60% of the abnormalities present in the cells present in the tumor tissue are not found everywhere throughout the tumor and are therefore unlikely to be detected when using a single biopsy (Gerlinger et al, New Engl J Med 2012). Unlike biopsies, medical images provide anatomical, functional and molecular information pertaining to the whole tumor, or even all the tumor foci, as well as the tumor environment. The computation of biomarkers from different medical images and their analysis to predict the nature of the tumor and its therapeutic response are thus the subject of an emerging discipline, radiomics, which consists in extracting a large number of parameters such as intensity, shape, texture, from medical images and to co-analyze this radiome with other data (histology, survival, therapeutic response, genetics, etc.) in order to determine if it is possible to define radiomic features useful for patient management (Lambin Eur J Cancer 2012, Gillies Radiology 2016). The extraction of advanced biomarkers from images is a complex task (Buvat et al J Nucl Med 2015), which requires standardization and quality control steps yet to be developed. Once biomarkers have been extracted (possibly several tens or even hundreds per tumor), statistical methods must be used to develop predictive models, either based on classical statistical approaches (generalized linear model, for example) or on machine learning methods (random forests, deep learning, etc.).

In the past four years, IMIV has been highly involved in the field of radiomics. We have established the complementary or redundant nature of some forty measurable biomarkers from positron emission tomography (PET) images. The sources of biomarker variability have been identified and robust computational methods have been proposed. For the first time in the literature, a link was found between some radiomic biomarkers measured in vivo in PET and the histological characteristics of the same tumors measured ex vivo in a murine model of breast cancer. The evolution of radiomic biomarkers as a function of the macroscopic characteristics of the tumors has been analyzed. Finally, we have identified a promising radiomic model to identify "triple negative" breast tumors.

In this context, the PhD thesis project will focus on: 1) the determination of an image-based phenotype, or radiome, of tumors, including a comparison between parsimonious and plethoric approaches; 2) the design and validation of exportable models, ie models that will be robust with respect to the multicentric variability of the radiome induced by the large variety of imaging devices and imaging protocols. This work will be carried out in close collaboration with clinical departments and organizations (Avicenne Hospital, Institut Curie, LYSA) using different types of data (breast tumors explored by PET-MRI, lung tumors in PET-CT, lymphomas in PET-CT), so as to develop methodologies that might be translated to other types of tumors.

Prerequisites

- Master in Statistics, Signal and Image processing, Applied Mathematics, Medical Imaging
- Programming skills in C or C++ or Java or Python or alike
- Enthusiasm to work in a multidisciplinary environmenet with MDs, computer scientists, biologists, physicists, etc
- High level knowledge of English, written and spoken

Location of the lab : CEA-Service Hospitalier Frédéric Joliot, Orsay

Bibliographic references of the hosting lab on the thesis topic

Orlhac F, Soussan M, Maisonobe JA, Garcia CA, Vanderlinden B, Buvat I. Tumor texture analysis in 18F-FDG-PET: relationships between texture parameters, histogram indices, SUVs, metabolic volumes and total lesion glycolysis. J Nucl Med 55: 414-422, 2014.

Buvat I, Orlhac F, Soussan M. Tumor texture analysis in PET: where do we stand? J Nucl Med 56: 1642-1644, 2015.

Orlhac F, Soussan M, Chouahnia K, Martinod E, Buvat I. ^{18}F-FDG PET-derived textural indices reflect tissue-specific uptake pattern in non-small cell lung cancer. Plos One 10(12):e0145063, 2015.

Orlhac F, Thézé B, Soussan M, Boisgard R, Buvat I. Multi-scale texture analysis: from 18F-FDG PET images to pathological slides. J Nucl Med 57: 1823-1828, 2016.

Orlhac F, Nioche C, Soussan M, Buvat I. Understanding changes in tumor textural indices in PET: a comparison between visual assessment and index values in simulated and patient data. J Nucl Med 58: 387-392, 2017.

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