3iA Côte d'Azur

Interdisciplinary Institute
for Artificial Intelligence

Postdoctoral research topic

- Title of the proposed topic: **Deep learning for the diagnosis of brain tumor recurrence based on ^{18}F-DOPA PET images**
- Research axis of the 3IA: Axe 2 (computational medicine)
- **Supervisor: Dr Olivier HUMBERT**, Imaging department of the Lacassagne Comprehensive Cancer Center, Nice, France / TIRO Laboratory, CEA. Email: olivier.humbert@univ-cotedazur.fr
- **Co-supervisor:** Fanny Orlhac, Institut Curie/Inserm, U1288 – Laboratoire d'Imagerie Translationnelle en Oncologie (LITO), Orsay. Email: fanny.orlhac@inserm.fr
- Laboratory: TIRO, UMR E 4320, CEA, Université Côte d'Azur

Apply by sending an email directly to the supervisor.
The application will include:

- Letter of recommendation of the supervisor indicated above
- Curriculum vitæ including the list of the scientific publications
- Motivation letter
- Letter of recommendation of the thesis supervisor

- **Description of the topic:**

High-grade gliomas and brain metastases are the most common malignant brain tumors and both have poor outcomes. Brain metastases arise in 10%–40% of systemic cancers and high-grade gliomas represent about 15% of primary brain tumors. Conventional treatments are based on different therapeutic modalities, including surgery, chemotherapy, and radiotherapy.

Brain Magnetic Resonance Imaging (MRI) is the first-line imaging exam to diagnose and monitor patients with brain tumors. However, the sensibility and specificity of brain MRI to differentiate between brain tumor recurrence and treatment-induced changes of brain tissues (i.e. radiation necrosis or oedema) is limited. In this challenging setting of recurrence suspicion, ^{18}F-DOPA Positron Emission Tomography (PET) imaging is recommended and outperforms brain MRI. But despite a high negative predictive value, the positive predictive value of the visual analysis of the DOPA-PET exam remains low. Misdiagnosis is not rare, with the physician wrongly concluding that there is a recurrence, leading to further inappropriate surgery or chemotherapy.

The nuclear medicine department in Antoine Lacassagne Center is a national and European reference center for this DOPA-PET exam. The aim of this post-doc project is to develop a computer-aided diagnosis system using artificial intelligence to differentiate

between patients with brain tumor recurrence from those with radiation necrosis (for whom no new treatment is to be programmed). The goal is to refine the analysis of PET images that is currently only visual in clinical practice in order to avoid misdiagnosis and improve the management of patients with brain tumors. Deep learning algorithms will be used to analyze "real-life" PET images and Convolutional Neural Networks will learn representations of a data set of two hundred 3-D brain DOPA PET images to perform:

1. a classification task: tumor-recurrence versus radiation necrosis.
2. a disease prediction task (overall survival)

Performance will be compared with those obtained using the current visual analysis and with handcrafted radiomic criteria supplemented with clinical informations (age, treatment, delay since the last radiotherapy, etc…).

These developments will be carried out on a prospective multicentric cohort of patients with high-grade gliomas (PHRC Poseidon) for the training and the validation sets and applied on prospective DOPA-PET images from our hospital (test set). In order to assess the generalizability of the results, the final prototype will also be evaluated on a monocentric cohort of patients with brain metastases

In deep learning approaches, we will investigate the specific patterns guiding the classification to get insights about the PET image features and possibly the biological effects that make it possible to distinguish recurrence from radionecrosis. The impact of multicentric imaging protocols will also be studied and harmonization approaches involving Generative Adversarial Networks (GAN) will be tested.

This project will be co-supervised by the LITO team from Institut Curie/Inserm that specializes in the quantitative analysis of medical images and is a member of the International Image Biomarker Standardization Initiative (IBSI).