UNIVERSITÉ DE LYON

CREATIS

Research engineer/ Post-doc in artificial intelligence for medical image analysis

Scientific context and project description

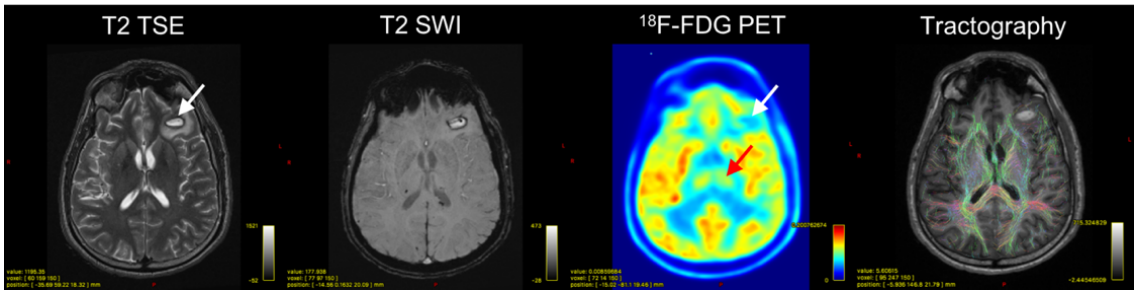

Figure 1: Preliminary results assessing the feasibility of the PET-MR imaging in acute comatose patients. White arrow: focal cortical 18F-FDG PET hypometabolism centred on a left orbito-frontal lesion. Red arrow: global thalamic hypometabolism ipsilateral to the lesion. courtesy : CERMEP

In recent years, deep machine learning has received a lot of attention to explore and structure multidimensional and multimodality medical imaging data, with very promising results compared to standard medical image analysis methods. Performance of deep network architectures, however, is highly controlled by the quality of the training datasets, which are generally characterized by :

- their small size (ranging from 30 to ~500 patients) with respect to other applications in computer vision,
- high dimensionality (multimodal and 3D datasets),
- class imbalance (few pathological cases compared to normal data)
- weak (eg : diagnostic at the patient level with no localization of the pathology in the image) and sometimes uncertain annotations (usually assessed by consensus among radiologists).

Much research interest is focusing on methods that can leverage such imperfect datasets to go beyond the performance plateau reached by standard convolutional architectures.

We propose to tackle some of them in the specific context of an innovative clinical project funded by the french National Research Agency (ANR) whose aim is to understand the physiopathological mecanisms of consciousness disorder and design efficient diagnosis and prognosis tools of patients being in acute coma based on multimodality imaging (see figure above). As a partner of this project, our team is in charge of :

- developing an automated diagnosis tool that will evaluate the patient coma status (degree of consciousness disorder quantized by the Coma Recovery Scale (CRS), a reference score associated to each patient by the clinicians) by combining the information provided by multimodal imaging with the most advanced machine learning methods
- providing visual insights about the origin of the model predictions that could be compared to physiopathological hypotheses underlying the different states of consciousness.

The coma patient database that is being acquired and shared among partners of this project is unique but, as listed above, it is of small size (around 50 patients), highly dimensional (around 10 image volumes per patients, including multiparametric MRI and PET acquisitions), weakly annotated (one CRS value per patient, no lesion annotation at the image level), with uncertain labels (CRS is prone to errors), and highly imbalanced.

A non-exhaustive list of the different axes that may be investigated during this one-year contract includes, e.g.:

- Evaluating atypical loss terms, that may leverage more information from the data than standard loss terms, such as cross-entropy. We may indeed account for correlations between the different classes (CRS value) with rank ordering type losses, or for uncertainty in the CRS estimation with kappa losses.
- Leveraging curriculum learning that refers to sequences of data or concepts to learn that produce better performance than learning items in a random order. Curriculum learning has indeed shown promising results in the domain of medical image analysis.
- Implementing attention mechanisms which are well adapted to high dimensional and low sampling problems to allow the networks to focus on the discriminating areas of the image for the considered task.
- We also plan to approach the problem within the weakly supervised anomaly detection paradigm to map brain lesion localisations responsive to the patient coma status.

The research axes to explore will be defined and prioritized according to prevailing methodological challenges to tackle at the beginning of the project and according to the candidate's experience.

Activities

- Conduct scientific bibliography analysis to gain expertise in the machine learning domains related to this project (atypical loss, weakly supervised learning, curriculum learning, attention models..)
- Propose innovative methods leveraging the state-of-the art methods
- Design and implement data processing pipelines with python and deep learning libraries
- Contribute to the dissemination of research results through scientific publications and making tools openly available
- Contribute to the academic life of the group through attendance and presentation at seminars, journal clubs, meetings and undertaking training, as appropriate

Work ressources, coordination and collaborations

The position holder will be supervised by Carole Lartizien from CREATIS who has an acknowledged experience with multi-modal medical image processing and have developed skills in machine learning for medical imaging (creatis.insa-lyon.fr/∼lartizien).

He/she will benefit from ongoing collaborations with external experts in the machine learning domain, neurologists from Hospices Civils de Lyon (HCL).

She/he will have access to the unique image database of coma patient exams collected as part of the ANR project, to open neurological imaging datasets (ADNI..), if needed as well as to the code that has been developed so far.

She/he will have access to high performance computing (HPC) resources through the partnership of CREATIS with the IDRIS lab that hosts the Jean Zay supercomputer (http://www.idris.fr/jean-zay/) and the IN2P3 national research computing center (https://cc.in2p3.fr/)

Profile of the applicant

The post holder will combine responsibilities for proposing innovative methods leveraging the state of the art method as well as developing processing pipelines. Applicants should be proficient in the theoretical foundations of deep learning as well as their implementation with standards libraries such as PyTorch. Some prior experience with medical image processing would be appreciated but is not required. Very good programming skills are also required. We are

looking for an enthusiastic and autonomous candidate with strong motivation and interest in multidisciplinary research.

Work environment and salary

- The doctoral position will take place at the CREATIS laboratory (www.creatis.insa-lyon.fr). The successful candidate will join the MYRIAD team which currently explores the potential of machine and deep learning for medical image processing and analysis.
- Employment would ideally start in **Sept-Oct 2021** and is funded by the french national scientific research (CNRS)
- Salary ranges from around 1700 euros net per month for a young graduate engineer, around 2100 euros net per month for a post-doctoral fellow with less than 2 years experience and up to 3000 euros net per month for an experienced researcher.

Application

- For more details on the position, please contact **carole.lartizien@creatis.insa-lyon.fr**
- Interested applicants are required to send a cover letter, CV and any other relevant documents (reference letter, recent transcripts of marks,...) to **carole.lartizien@creatis.insa-lyon.fr**.
- Deadline for application is **July 9 2021**.