Title: AI characterization of the MR SWI-DWI ischemic mismatch for hyperacute ischemic stroke patients

Partners: IBISC (Univ Évry, Université Paris-Saclay), CHSF Corbeilles, CHRU de Tours
Basic AI and Data Science: statistical training in big dimensions
Specialized ML and AI: signal, image, vision
Application domain: precision medicine, imagery by MR
Mots-clés deep learning, multi-modality imaging, semi-supervised learning
Key-words machine learning, deep tech, neuroimaging, precision medicine, stroke, multimodality, template standadization
Total duration of internship: 6 months (graduate) or 3 months (undergraduate)
Working period: From 2024/02/01 to 2024/09/01

Context and objectives

According to the World Health Organization, stroke is the second cause of death, the first for women, and the leading cause of chronic functional disability in adults, with 17 million victims, 31% of whom were under 65.
In France, around 150,000 people are hospitalized yearly for a stroke, one every 4 minutes. It represents a financial burden of about 2.8 billion €/year; in reality, 10 billion over five years due to the cost of disability.
Ischemic stroke is caused by a blood clot (thrombus) that blocks a brain artery, causing a lack of oxygen to brain tissue supplied by that artery. There is an urgent need to diagnose and determine the choice of treatment.

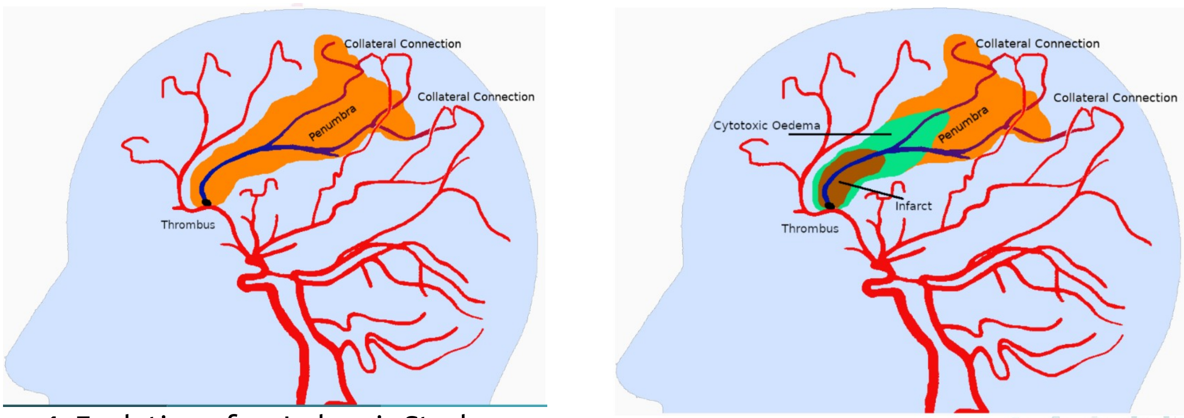

Figure 1: Evolution of an Ischemic Stroke

Neuroimaging plays a decisive role in demonstrating acute ischemia with the concept of ischemic penumbra. It has been shown that the growth, duration, and infarct volume of ischemic stroke directly influences the amount of irreversible tissue loss. There is a need for a quantitative penumbra-assessment stroke protocol with the minimum possible imaging time that delivers the maximum possible information. Today, this assessment is made with perfusion imaging, with the risk of exposure to radiation and use of
iodinated contrast medium, which may affect renal-impaired patients. For this reason, finding other solution have been a focus of research. An MR-based fast, non-invasive stroke protocol such as T2* gradient-echo and susceptibility-weighted imaging (SWI) are proposed solutions in the literature to quantitatively measure the penumbra.

Objectives

The solution we want to implement is based on automatically segmenting the area of already dead tissue (infarct) and ischemic tissues at risk (penumbra), as seen in Figure 1. The penumbra assessment can be obtained through the mismatch ratio obtained from the MR perfusion-weighted imaging (PWI) and the diffusion-weighted imaging (DWI) modalities. Recent studies

have proposed a framework for accurate quantitative assessment of penumbra using SWI-DWI and its validation with PWI-DWI-based quantification [1].
These assessments depend heavily on the user expertise. The current study aims to develop an automated image-processing framework for quantifying penumbral volume using SWI and/or DWI [2]. Applying AI algorithms to the analysis of MR images makes it possible to work on large amounts of data in a more relevant way than conventional statistical methods. The objectives are (1) to validate the results on an extensive patient database (2) to integrate the model into clinical application software with a user-friendly interface. The current study also includes the study of the penumbra volume as a prognosis tool in the case of revascularization.

Methodology

No automatic method of quantification of penumbra volume using SWI and DWI has been published to date. There are a few publications on semi-automatic segmentation of the lesion by angiography [4, 10, 7, 12, 11]. Only the last three relate to the segmentation of the lesion in the brain. These studies all have in common that they need a "manual" seed to run the algorithm, meaning they cannot find the position of the lesion on their own.

Expected results

The expected solution will better characterize the ischemic mismatch by associating multiple weak MRI signals with the definition of pathology. The MR mismatch will improve the reading quality of current images by performing analyses that are not currently carried out because they take too long to execute manually, such as the volumetric measurement of the penumbra. Moreover, the MR mismatch solution without a contrast agent will make this analysis quicker and available to all types of patients.
This solution will determine what information in the image implies specific treatments leading to a better patient prognosis. AI can help the radiologist prioritize urgent cases by deciding which imaging tests to assess first. Ultimately, radiology experts should give more information than the human eye on the texture of the thrombus and its accessibility for recanalization treatments.

Expected performance criteria:

Evaluating the new procedure against a referenced approach raises many methodological difficulties. The expected performance indicators are (1) the repeatability of the deterministic segmentation process in a degraded situation or not, (2) the efficiency of the tool to be tested on a ground truth basis and quantified with DICE [3] to measure performance in segmentation, (3) a speed of execution of a few minutes.

References

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Profile and skills required

Ability to understand and develop adaptive learning algorithms and process medical data, index it, and use it in an operational system to achieve the abovementioned mission. Programming skills: Python or C / C ++. A practice of Tensorflow and Pytorch would be a plus. The practice of French is not compulsory. His(her) English is fluent. The work will be carried out at the IBISC Laboratory on the Evry campus of the Université Paris-Saclay. IBISC develops multidisciplinary, theoretical, and applied research in the field of information sciences and engineering, with a strong orientation towards health applications. The selected candidate will be integrated into an interdisciplinary team with a consortium of data scientists and clinicians from the CHSF and the CHRU in Tours. The project is multidisciplinary, at the interface of machine learning, computer science, and medicine.

Scientific and material conditions

The student will be supervised by Mariana Brejo, Hichem Maaref, and Vincent Vigneron from the IBISC laboratory (Université d'Évry, Université Paris-Saclay). All master machine learning, signal, and image processing.

Contact: send resume and grades of bachelor+master to Vincent Vigneron, Hichem Maaref and Mariana Brejo {mariana.goncalvesbrejo,hichem.maaref,vincent.vigneron}@univ-evry.fr
Phone: +33 1 694 775 45