Université de Rennes

Appel à projets - Année 2024

Contrats doctoraux «Ordinaires»

Direction de la Recherche et de l'Innovation

ECOLE DOCTORALE : Matisse **POLE DE RECHERCHE : Mathématique-Numérique**

Unité de recherche d'accueil

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Equipe : EMPENN / LACODAM

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Sujet

Titre : **Multimodal Segmentation of Chronic Stroke Lesions**

Mots clés : chronic stroke lesions, medical imaging, segmentation, deep learning

Cotutelle internationale (~~oui~~/non) : **Si oui, préciser l'établissement et le pays de rattachement** :

Descriptif (15-30 lignes) :
Contexte socioéconomique et scientifique ; Les hypothèses et questions posées ; Les grandes étapes de la thèse et démarche ; Approches méthodologiques et techniques envisagées

Research motivation. Stroke, a leading global cause of morbidity and mortality, results from the sudden disruption of blood supply to the brain, causing severe neurological impairments [1]. In both acute and chronic stroke evaluation phases, MRI is crucial. Integrating chronic stroke lesion segmentation into clinical practice, has the potential to significantly enhance rehabilitation management, providing a better understanding of the impact on brain function and aiding clinicians in formulating effective plans. Our

goal is to leverage deep learning and available data for an accurate and robust automated chronic stroke lesion identification and segmentation, assisting clinicians in planning effective rehabilitation strategies.

Challenges and Objectives. Manual segmentation is time-consuming and error-prone due to brain complexity, diverse lesion patterns, and patient variability. While notable progress has been made in automating acute stroke lesion segmentation, advancements in chronic stroke lesion segmentation remain limited due to, among others, a lack of standardized clinical imaging protocols and diverse, well-annotated datasets [2]. To bridge this gap, our research focuses on advancing chronic stroke lesion segmentation approaches using deep learning and open-access [3] and in-house datasets.

Current Progress and Preliminary Results. We have developed a pipeline based on the nnU-Net framework [4] with T1w and FLAIR MRI modalities, showing improved chronic stroke lesion segmentation compared to existing solutions and single-modality approaches. Our findings have been submitted to the World Stroke Congress 2024. Next, we aim to investigate transform-based architectures [5], aligning with the latest computer vision approaches. This will be part of a Master Internship starting in March 2024, ideally continuing in the funded PhD program.

Methodological Challenges. The methodological investigation will concern the following challenges:

i. Multimodal Integration. The primary objective is to improve segmentation by combining information from different MRI modalities. We will employ advanced fusion strategies like attention mechanisms and feature-level fusion.

ii. Labeled, Partially Labeled, and Unlabeled Data. Our focus is to develop methodologies capable of handling varying levels of annotation. Therefore, we will employ semi-supervised learning techniques, leveraging both labeled and unlabeled data to improve the accuracy and robustness of the model.

iii. Addressing Missing Modality. Our objective is to formulate an approach capable of handling situations where specific imaging information is absent. This involves learning both unique and common features across modalities, enabling the model to maintain accuracy even in the absence of a modality.

Candidate profile. We seek a motivated candidate with a background in image processing, data analysis, and deep learning. Key skills include proficiency in Python programming and hands-on experience managing medical imaging data. Adaptability, a commitment to continuous learning, and a genuine interest in the medical domain are highly valued qualities for this role.

References

[1] Gerstl, J. V., Blitz, S. E., Qu, Q. R., Yearley, A. G., Lassarén, P., Lindberg, R., ... & Bernstock, J. D. (2023). Global, regional, and national economic consequences of stroke. *Stroke*, *54*(9), 2380-2389.

[2] Ahmed, R., Al Shehhi, A., Hassan, B., Werghi, N., & Seghier, M. L. (2023). An appraisal of the performance of AI tools for chronic stroke lesion segmentation. *Computers in Biology and Medicine*, 107302.

[3] Liew, S. L., Lo, B. P., Donnelly, M. R., Zavaliangos-Petropulu, A., Jeong, J. N., Barisano, G., ... & Yu, C. (2022). A large, curated, open-source stroke neuroimaging dataset to improve lesion segmentation algorithms. Scientific data, 9(1), 320.

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[5] Xiao, H., Li, L., Liu, Q., Zhu, X., & Zhang, Q. (2023). Transformers in medical image segmentation: A review. *Biomedical Signal Processing and Control*, *84*, 104791.

Ce document est à renvoyer par la direction de l'unité de Recherche aux animateurs du Pole Recherche et à l'école Doctorale pour le 9 février 2024 au plus tard