Internship in bioimage processing @ INRIA Rennes

Convolutional neural network for the segmentation of astrocytic endfeet in 2D electron microscopy images

Key-words: Electron microscopy, astrocyte, segmentation, CNN, generalization

Location: Centre Inria de l'Université de Rennes
Equipe SAIRPICO
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Teams: **AIstroSight** - https://team.inria.fr/aistrosight/
The AIstroSight team develops innovative computational methods for neuropharmacology and the discovery of new drug candidates to treat brain diseases.

SAIRPICO - https://team.inria.fr/serpico/ - https://www.inria.fr/fr/sairpico
The Sairpico team is specialized in the development of innovative methods for microscopy image restoration and reconstruction, motion analysis and computation of molecule trajectories in live cell imaging, and biophysical parameter estimation.

Duration: 6 months

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Context

This internship is part of a collaboration between two Inria teams, SAIRPICO and AIstroSight, which are developing innovative tools aimed at improving the understanding of complex biological mechanisms.

Astrocytes are glial cells of the central nervous system involved in several brain functions, such as the regulation of neurotransmission, synaptogenesis, maintenance of ionic and metabolic homeostasis, as well as participation in neurovascular coupling [1]. In particular, astrocytes mediate interactions between neurons and blood vessels through a specialized compartment referred to as the astrocytic endfoot. In addition to maintaining the integrity of the blood-brain barrier, astrocytic endfeet regulate local blood flow, nutrient absorption, and the removal of waste from the cerebrovascular system.

The study of astrocyte morphology is a growing field of research. Indeed, several studies suggest that alterations in their shape may compromise their ability to effectively support brain functions, thus contributing to the progression of neurodegenerative processes [2]. Understanding the morphology and connectivity of astrocytes, as well as their variability depending on cerebral and pathological context, is therefore essential to deepen our knowledge of the mechanisms involved in neurological diseases such as Alzheimer's. Recent advances in imaging, particu-

larly in electron microscopy (EM), now make it possible to observe astrocytes at the nanometric scale. High-resolution EM data have revealed that these cells exhibit extremely complex morphologies, connected to each other through very fine branches [2]. This complexity makes their segmentation extremely difficult.

While image segmentation methods have proven effective for structures such as neurons, which generally have more regular shapes, the segmentation of astrocytes remains a major challenge. To the best of our knowledge, no segmentation method has yet been specifically tailored to astrocytes, primarily due to the complexity of their morphology [3].

Goal of the internship

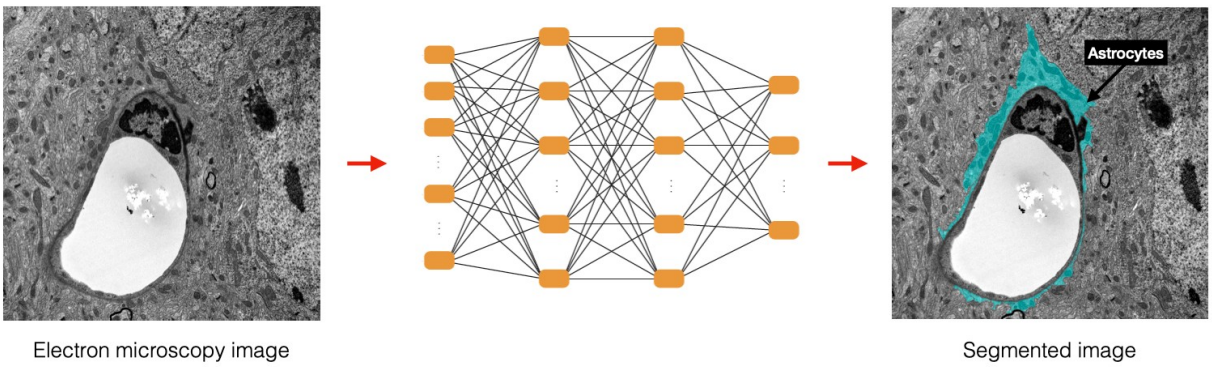

***Figure 1**: Proof of concept of a CNN segmenting astrocytic endfeet in an EM image.*

The goal of this internship is to leverage convolutional neural networks (CNNs) to develop a method for segmenting astrocytic endfeet from 2D transmission electron microscopy (TEM) data (see Figure 1). An annotated dataset is available for training and validating the model [4]. One of the main challenges will be to generalize this method to a second, unannotated dataset [5], acquired under different experimental conditions (microscope, fixation protocol, spatial resolution, pathological context, subject age), which leads to variations in astrocyte morphology as well as in the signal-to-noise ratio of the images.

In this context, the candidate is expected to:

- conduct a literature review on astrocyte segmentation approaches, particularly on EM data;
- develop a CNN-based segmentation method, building on the literature review;
- experimentally evaluate the algorithm on annotated EM data and quantitatively compare it to existing segmentation methods;
- study the generalization capability of the developed method on other EM datasets with different characteristics (signal-to-noise ratio, spatial resolution, etc.).

Requirements

- Image processing and analysis
- Machine learning
- Deep learning (CNNs)
- Python

References

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[3] SYED, Tabish A., YOUSSEF, Mohammed, SCHOBER, Alexandra L., *et al.*, “Beyond neurons: computer vision methods for analysis of morphologically complex astrocytes,” *Frontiers in Computer Science*, 2024, vol. 6, p. 1156204.

[4] BRAVO-FERRER, Isabel, GAASDAL-BECH, Katrine, COLVIN, Chiara, *et al.*, “Multiregional blood-brain barrier phenotyping identifies the prefrontal cortex as the most vulnerable region to ageing in mice,” *Brain Communications*, 2025, vol. 7, no 5, p. fcaf332.

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