Contribution ID: **6** Type: **Talk**

CytoNet: A Deep Neural Network for Whole-brain Characterization of Human Cytoarchitecture

Tuesday 10 September 2024 14:30 (15 minutes)

The characterization of cytoarchitecture in the human brain provides an essential building block for the creation of a high-resolution multi-modal brain atlas. Cytoarchitecture is defined by the spatial organization of neuronal cells, including their shape, density, size, cell type, as well as their columnar and laminar arrangement, which differ between brain regions. High-throughput light-microscopic scanning of large, cell-body stained histological sections obtained by sectioning postmortem human brains enables detailed examination of cytoarchitectonic organizational principles across multiple brain samples, which is mandatory to capture the highly variable cytoarchitectonic organization. The limited scalability of existing methods to image and analyze datasets in the terabyte to petabyte range motivates current developments of AI methods for data-driven characterization and classification of human cytoarchitecture at large scale.

In this work, we present CytoNet, a deep neural network model that enables data-driven characterization of cytoarchitecture in the human brain. CytoNet is a convolutional neural network that is trained on 200 000 image patches (2048px@2µm/px) extracted from 4115 histological sections of 9 postmortem brains. The model is trained using a novel contrastive learning objective that derives the similarity relationship between image samples from their spatial distance in a common reference brain space. Using this loss, CytoNet is trained to map spatially close image samples, which likely show similar cytoarchitectonic structures, to similar feature representations.

We demonstrate that feature representations extracted by CytoNet allow classifying cytoarchitectonic areas, predicting spatial and morphological features, studying inter-individual variations, and enabling data-driven quantification and query-based exploration of microstructural principles at whole-brain level. Moreover, we show that the latent space learned by CytoNet exhibits an anatomically highly plausible structure that facilitates intuitive exploration of brain organization. CytoNet significantly extends existing methods for cytoarchitecture analysis and thus provides the foundation for novel analysis workflows that have the potential to facilitate studies relating the brain's microstructure to connectivity and function.

Primary author: SCHIFFER, Christian (Forschungszentrum Jülich)

Co-authors: AMUNTS, Katrin; DICKSCHEID, Timo (Forschungszentrum Jülich)

Presenter: SCHIFFER, Christian (Forschungszentrum Jülich)

Session Classification: Contributed Talks - Segmentation and AI (co-Chairs: Claire Walsh, Jussi Tohka)