Deep Learning and Unsupervised Clustering for Analysis of Cellular Structures in the Human Brain

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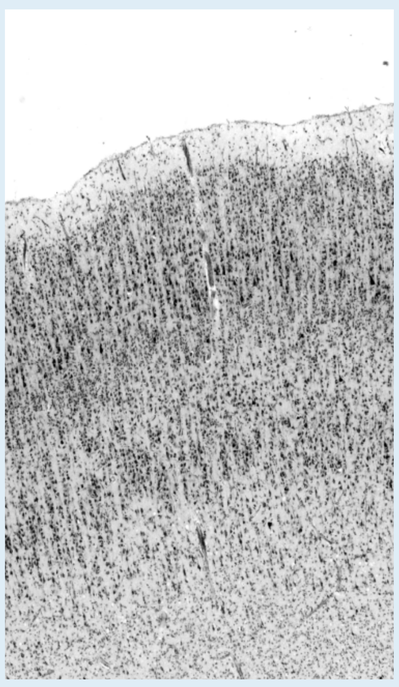
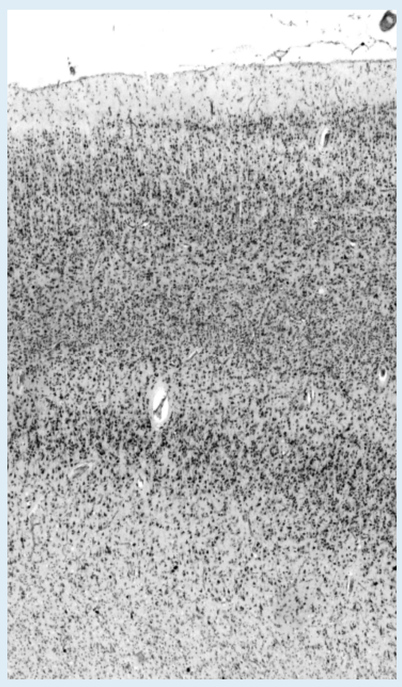


Brodmann Area 18



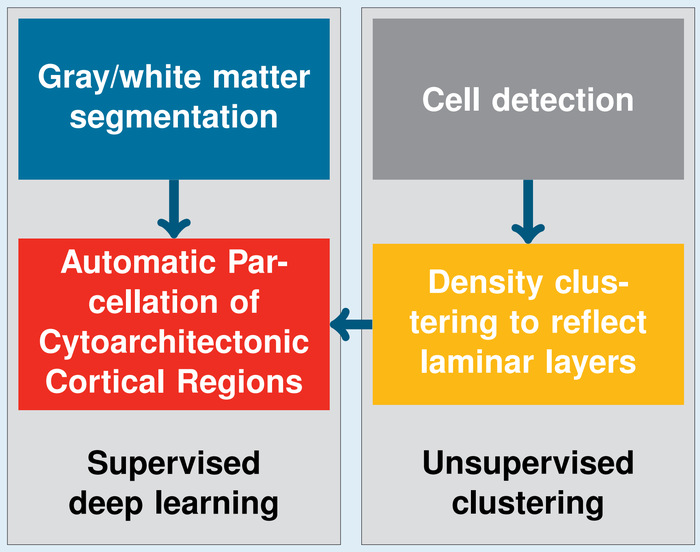
Brodmann Area 17

Cytoarchitectonic Mapping

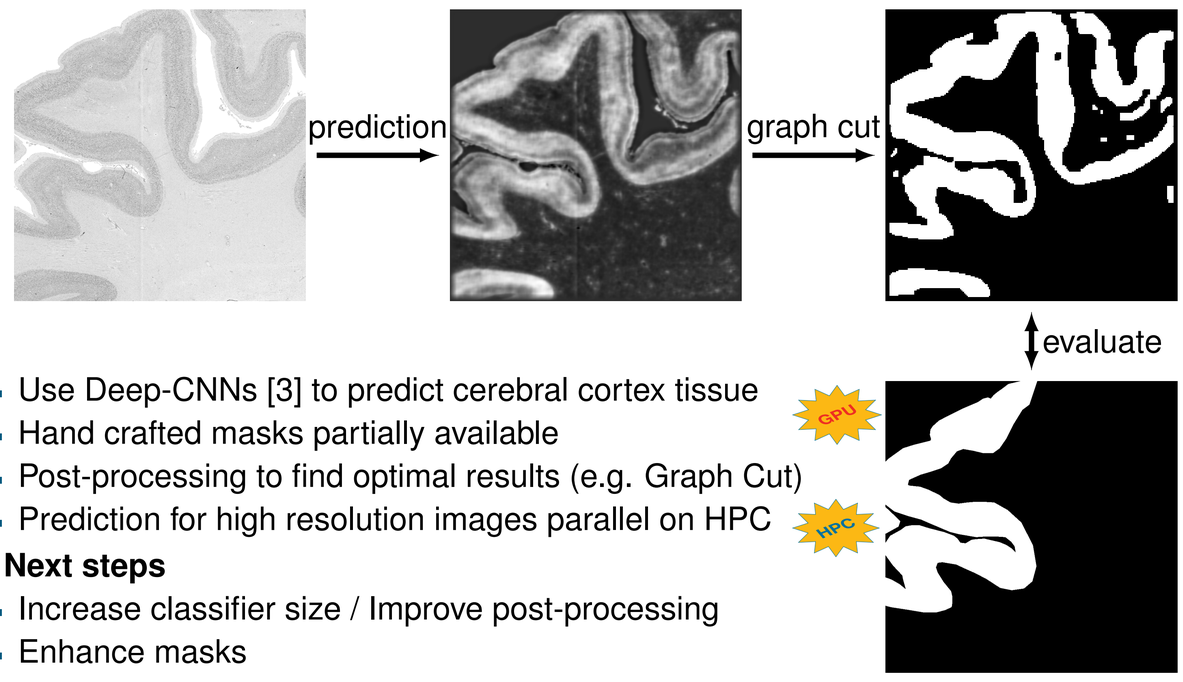
Layer structure differs between cytoarchitectonic areas [5]. Classical methods to locate borders include image segmentation, mathematical morphology, and correlation of local intensity profiles.

Goals:

- Investigate the potential of modern **machine learning techniques** to support the analysis
- Increase degree of automatization (towards **high throughput processing**)
- Find qualitative and quantitative measures for cellular distributions



Gray/white matter segmentation

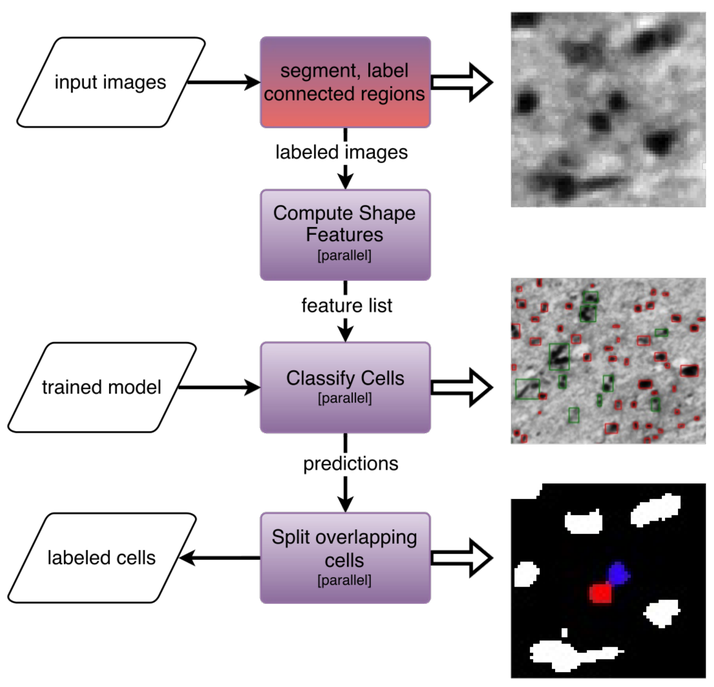


- Use Deep-CNNs [3] to predict cerebral cortex tissue
- Hand crafted masks partially available
- Post-processing to find optimal results (e.g. Graph Cut)
- Prediction for high resolution images parallel on HPC

Next steps

- Increase classifier size / Improve post-processing
- Enhance masks

Cell detection



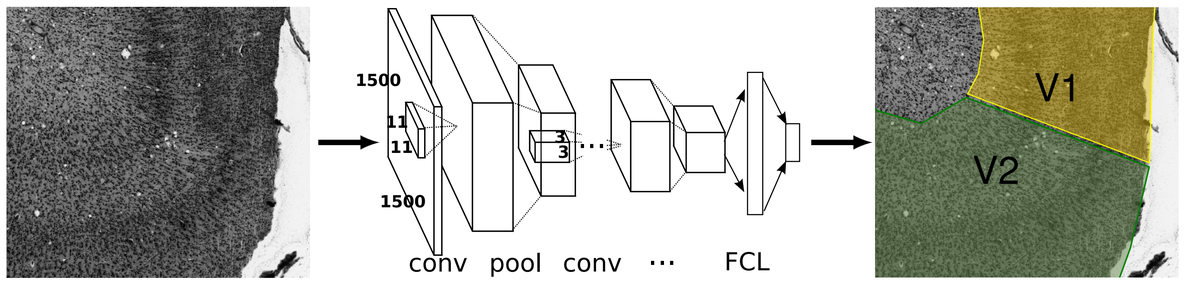
- Compute shape attributes for each connected region
- Random Forest / SVM for prediction

Next steps

- Split cells using clustering, parallel for each label
- Create a unicore workflow

HPC

Parcellation of cytoarchitectonic cortical regions

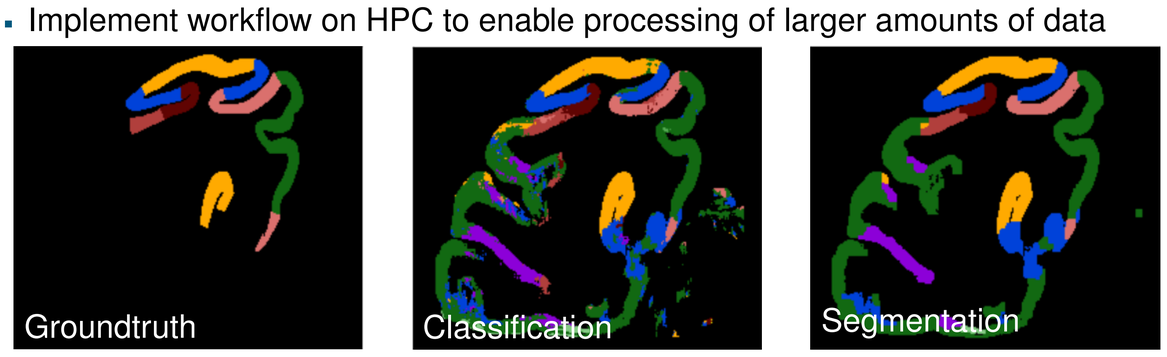


- Feasibility study with deep learning [3, 4] finished - promising findings

GPU

Next steps

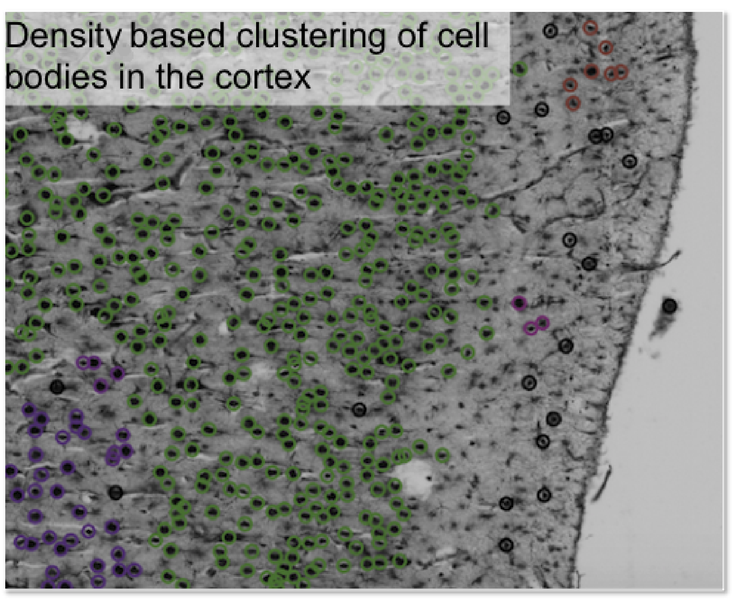
- Implement workflow on HPC to enable processing of larger amounts of data



Density clustering to reflect laminar layers

- Cortical areas show different cell densities
- Using density based clustering (DBSCAN [1]) to find regions of different density
- Scalable and parallel HPDBSCAN [2] implementation to cluster large number of cells

HPC



Next steps

- Compare results with different clustering techniques
- Find relations to cytoarchitectonic cortical regions

References

[1] Martin Ester, Hans-Peter Kriegel, Jörg Sander, and Xiaowei Xu. A density-based algorithm for discovering clusters in large spatial databases with noise. In *Kdd*, volume 96, pages 226–231, 1996. **[2]** Markus Götz, Christian Bodenstein, and Morris Riedel. Hpdbscan: highly parallel dbscan. In *Proceedings of the Workshop on Machine Learning in High-Performance Computing Environments*, page 2. ACM, 2015. **[3]** Yann LeCun and Yoshua Bengio. Convolutional networks for images, speech, and time series. *The handbook of brain theory and neural networks*, 3361(10):1995, 1995. **[4]** Yann LeCun, Yoshua Bengio, and Geoffrey Hinton. Deep learning. *Nature*, 521(7553):436–444, 2015. **[5]** A Schleicher, Katrin Amunts, Stefan Geyer, P Morosan, and Karl Zilles. Observer-independent method for microstructural parcellation of cerebral cortex: a quantitative approach to cytoarchitectonics. *Neuroimage*, 9(1):165–177, 1999.

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