Learning to predict cutting angles from histological human brain sections

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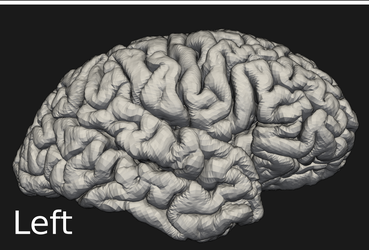
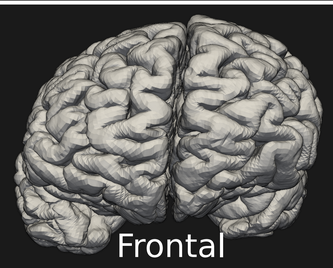
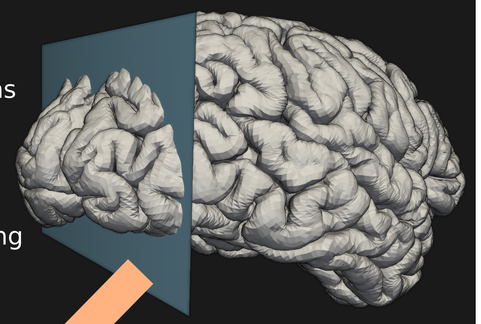
Problem
Identification of obliquely cut regions in histological human brain sections

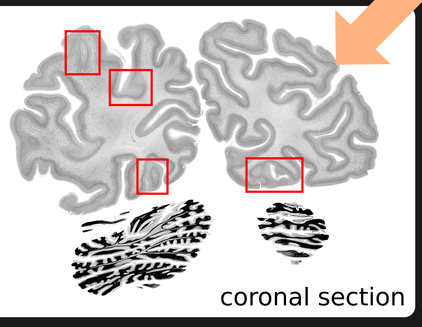




Histological processing

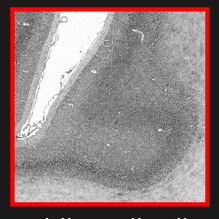
- Postmortem human brains
- ~7000 coronal sections
- Cell body staining
- Light microscopic scanning
- Resolution: 1µm / pixel



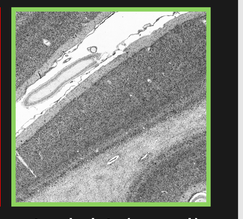


Challenge: Oblique cuts

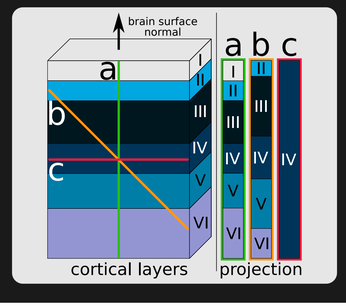
- Cytoarchitecture analysis relies on cortical layers
- Layers not visible if cutting angle is too oblique



oblique (bad)



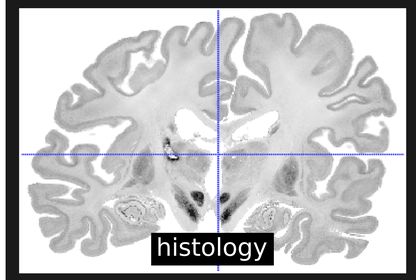
straight (good)

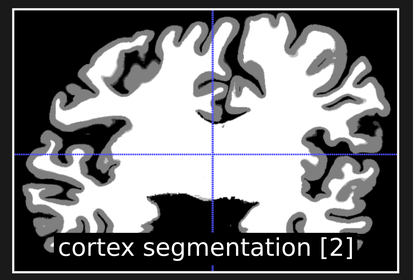


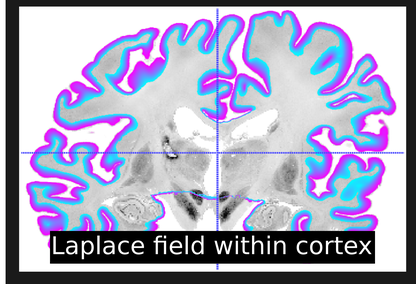
Method
Convolutional Neural Networks for automatic cutting angle prediction

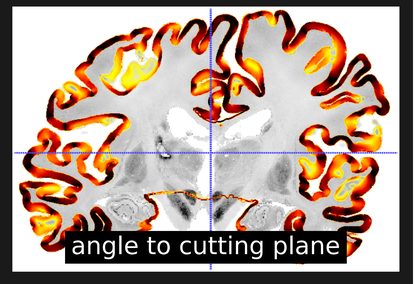
Cutting angle computation in BigBrain [1]

- BigBrain: High-resolution 3D brain model reconstructed from 7404 sections (20µm isotropic resolution)
- Exact cutting angle computation based on 3D context





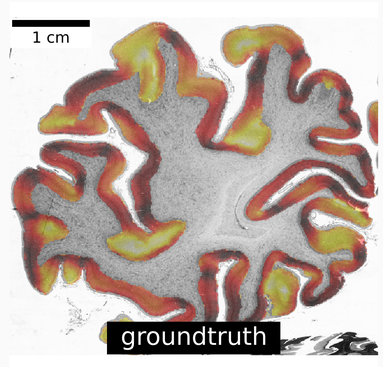


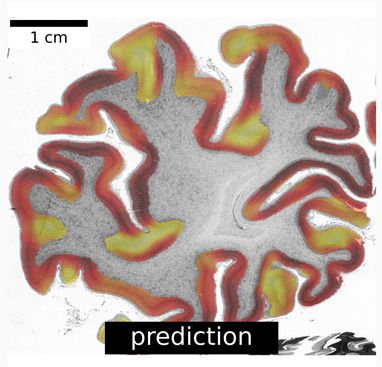


Convolutional Neural Network for angle prediction

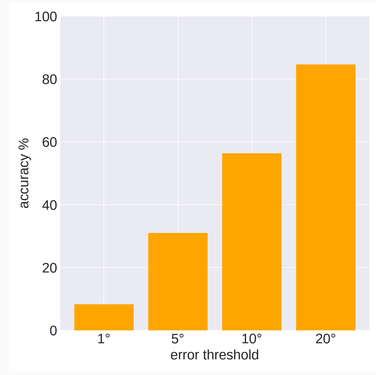
- Project cutting angles in BigBrain to unregistered sections
- Train U-Net [3] for regression [4] of angles from histology
- Patchwise processing: 512px at 64µm resolution
- Training: 384'000 patches from 55 sections
- Testing: 15 sections not seen during training
- L2 loss restricted to cortical ribbon
- Intensity+geometric augmentation promotes transferability

Result
Automatic identification of oblique cuts based on cutting angle prediction

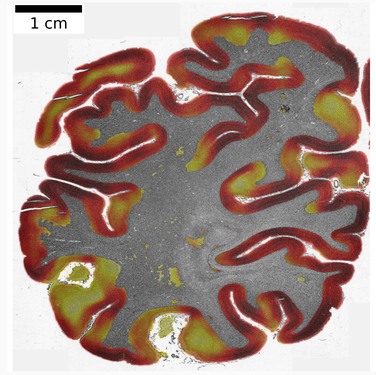




Qualitative results in BigBrain



Test error in BigBrain



Prediction in 2nd unseen brain

Conclusion

- Cutting angle prediction helps to identify oblique cuts
- Predictions on unseen brains demonstrate transferability
- Next: Excluding oblique cuts from downstream analysis tasks

References

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