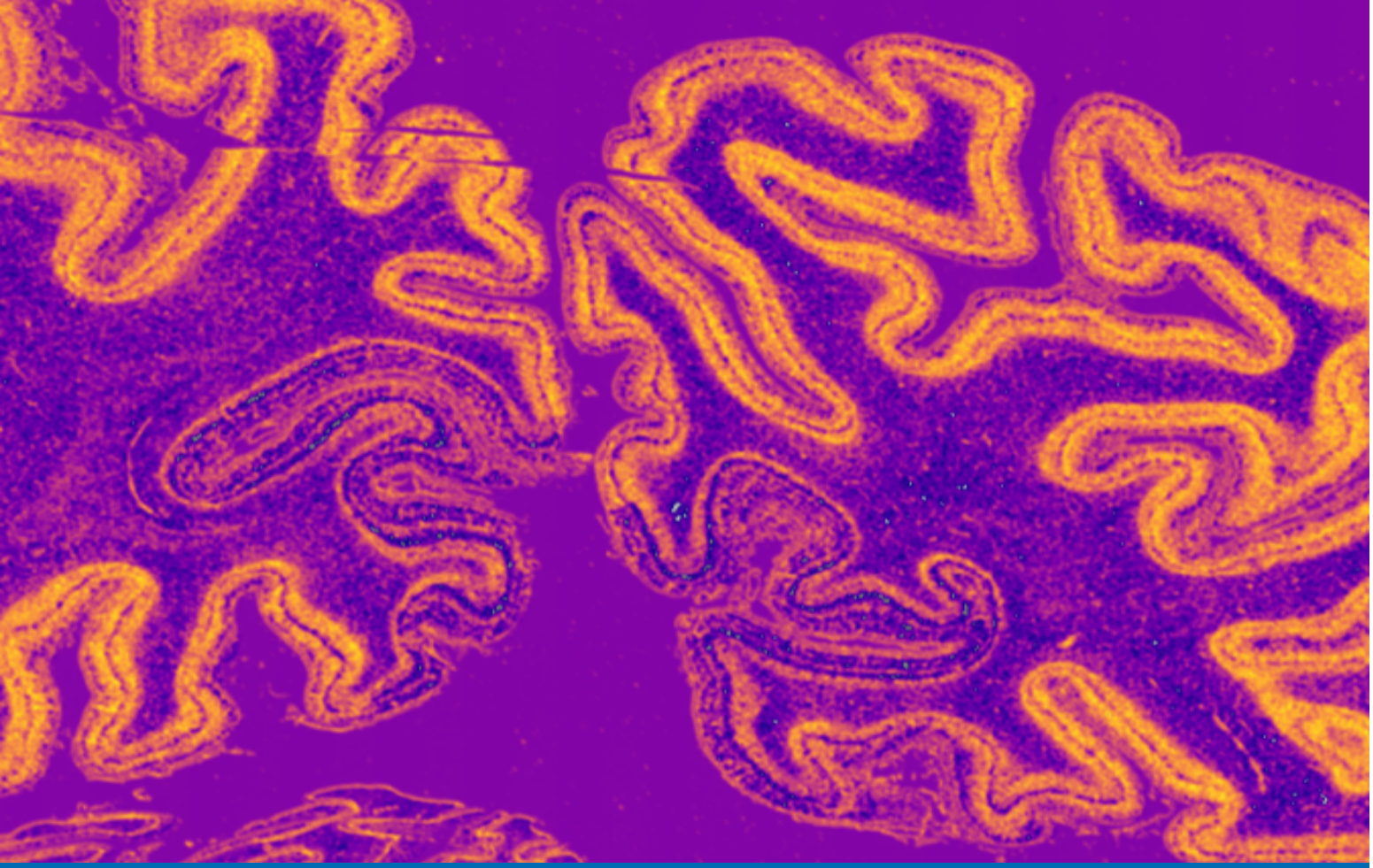


HEINRICH HEINE
UNIVERSITÄT DÜSSELDORF

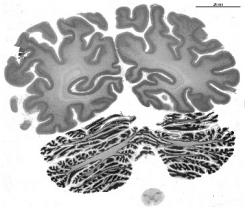
Deep Learning Networks Reflect Cytoarchitectonic Features Used in Brain Mapping

Kai Kiwitz
Cécile and Oskar Vogt Institute of Brain Research
Heinrich-Heine University Duesseldorf
University Hospital Duesseldorf

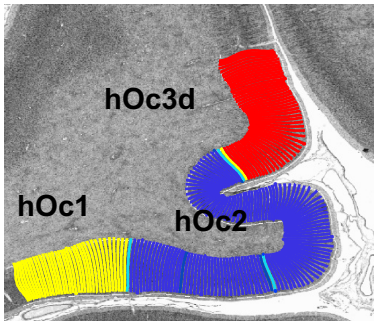
CNNs for Cortical Area Segmentation

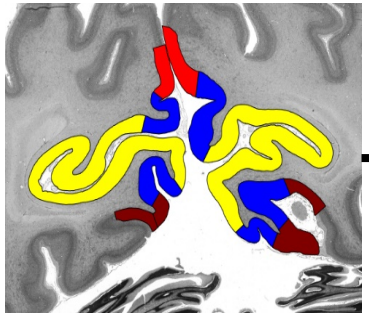
HEINRICH HEINE
UNIVERSITÄT DÜSSELDORF

Cutting



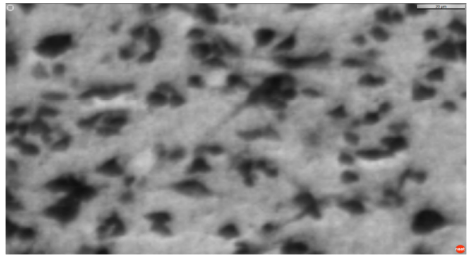
Current Gold-Standard
Cytoarchitectonic Mapping



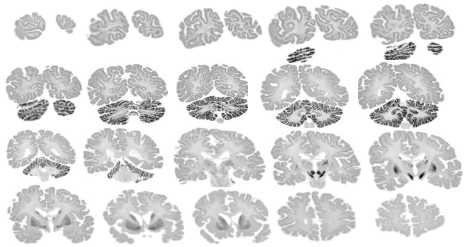


infeasible for

The BigBrain dataset[1]



ca. 20 GByte per section



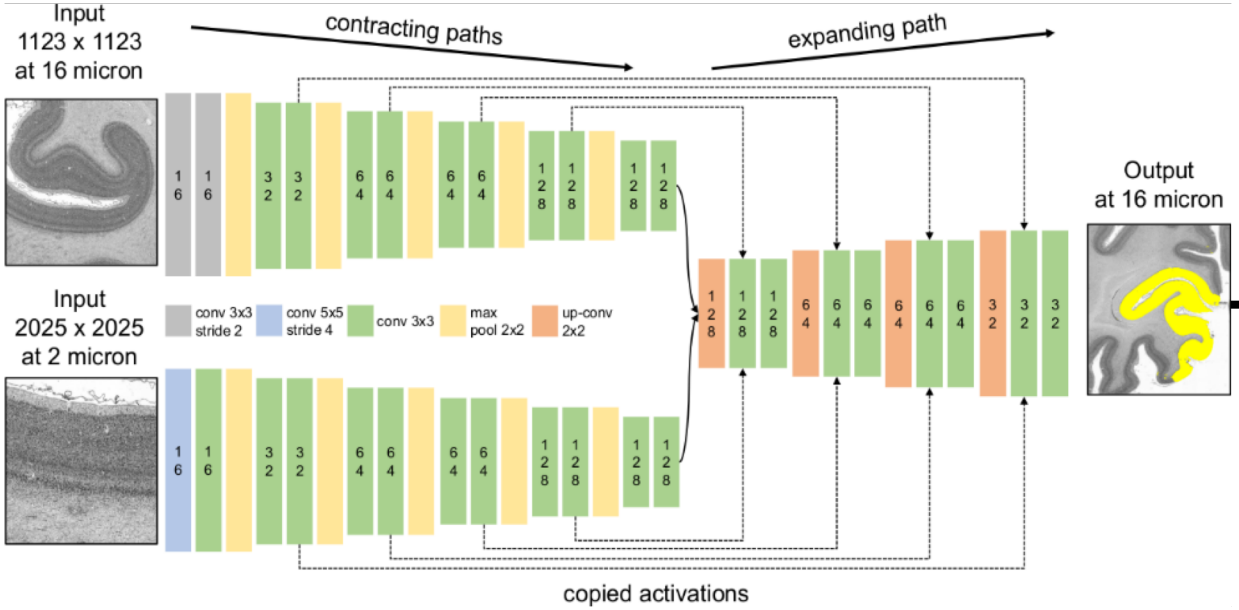
7404 sections,
ca. 65 TByte of data

[1]Amunts, K. *et al.* BigBrain. An Ultrahigh-Resolution 3D Human Brain Model. *Science* **340,** 1472–1475; 10.1126/science.1235381 (2013).

CNNs for Cortical Area Segmentation

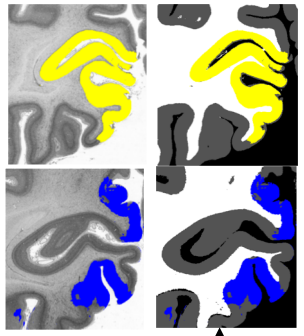
HEINRICH HEINE
UNIVERSITÄT DÜSSELDORF

Deep Learning Based Tool[1,2]



CNNs for pixel-wise segmentation

Cortical Segmentations



generates

depends on

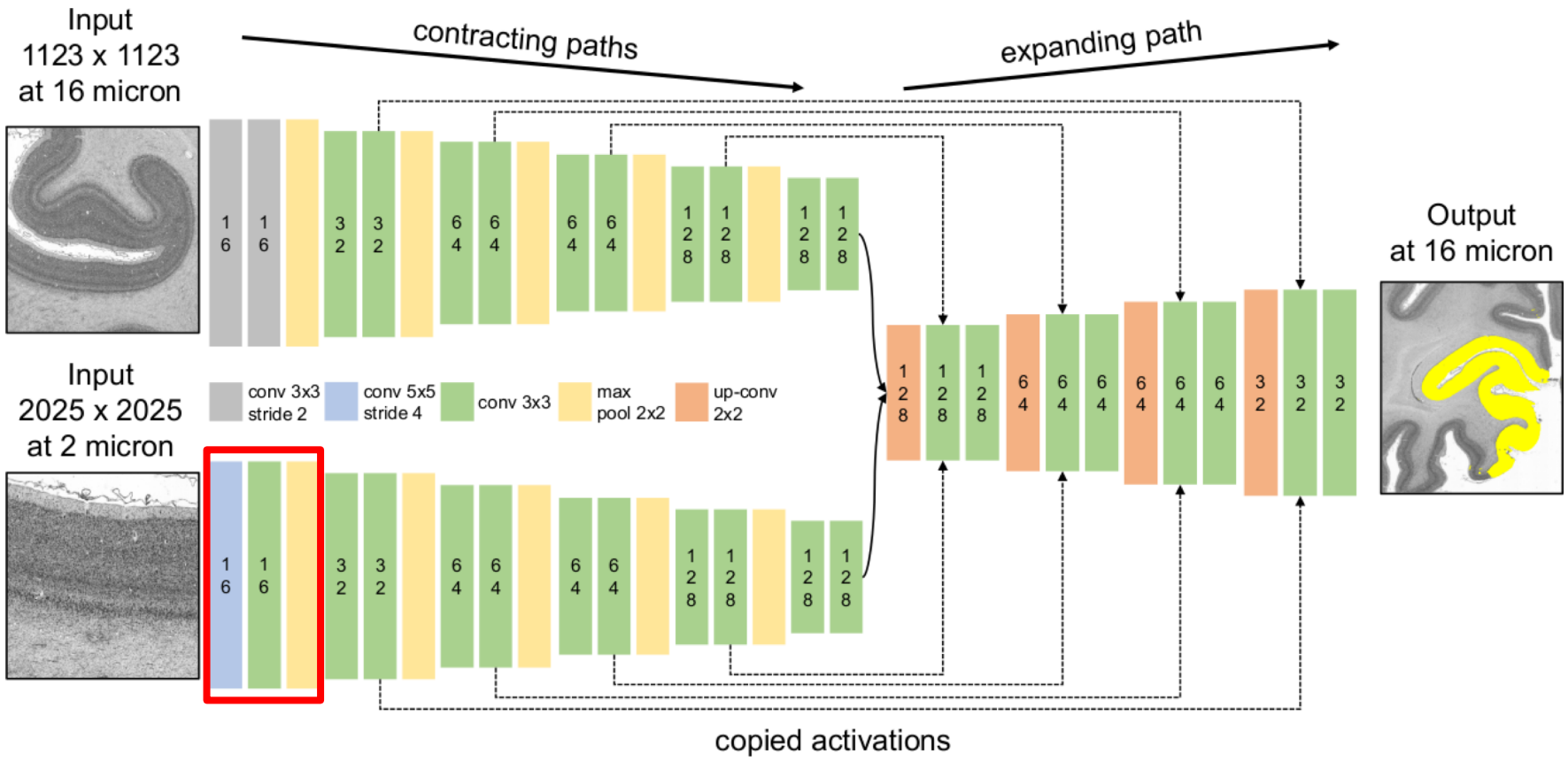
HPC-resources

CPUs: 24 x 2.5 GHz
GPU: 4 x NVidia K80 (12 GByte video memory)
Training time: 2 – 5h

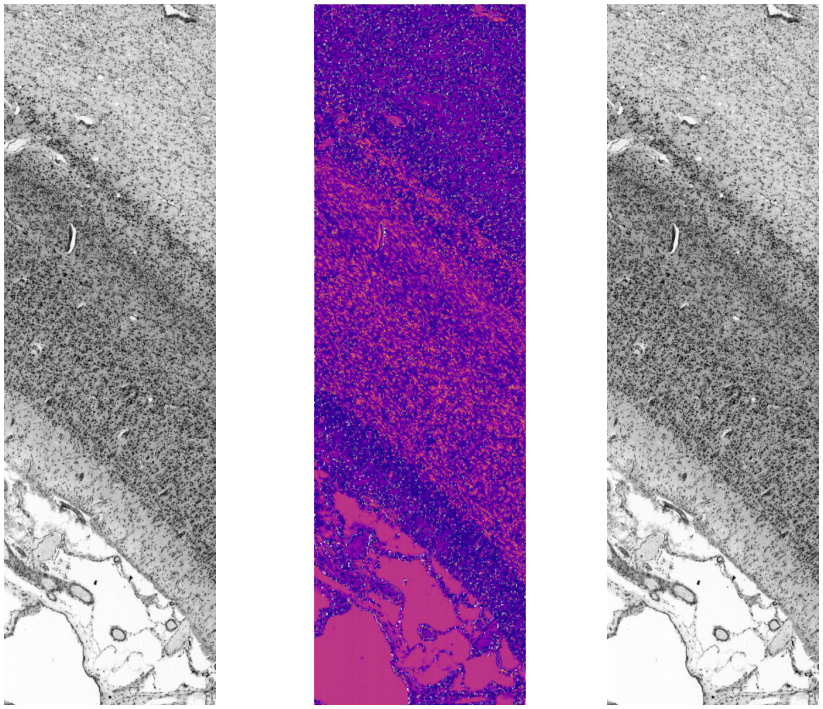
[1]Spitzer, H., Amunts, Katrin, Harmeling, S., & Dickscheid, T. (*ISBI* 2017)
[2]Spitzer, H., Kiwitz, K., Amunts, Katrin, Harmeling, S., & Dickscheid, T. (*MICCAI* 2018)

HEINRICH HEINE
UNIVERSITÄT DÜSSELDORF

Filter Activations



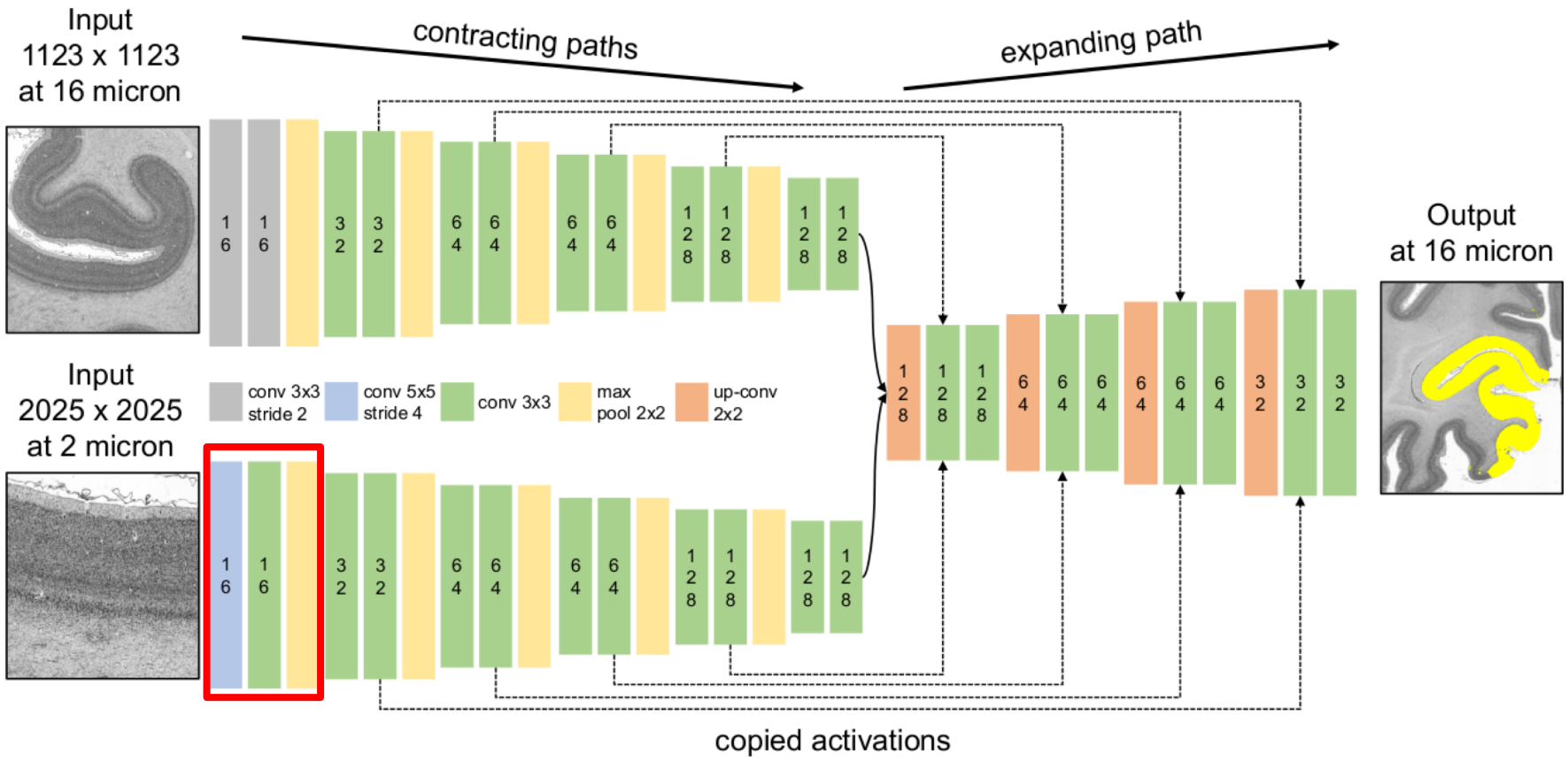
Resemblance of Learned Filters and Cytoarchitectonic Features



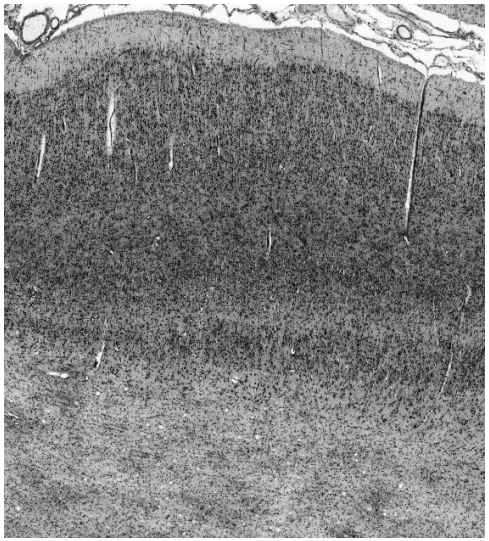
Filter activations for **cells** (right) and cortical layer I plus white matter (middle)

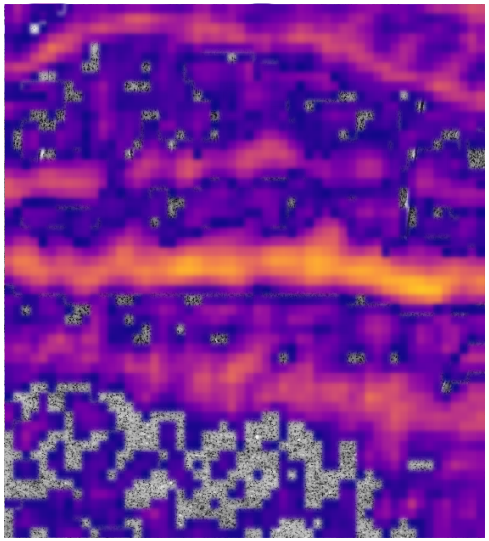
HEINRICH HEINE
UNIVERSITÄT DÜSSELDORF

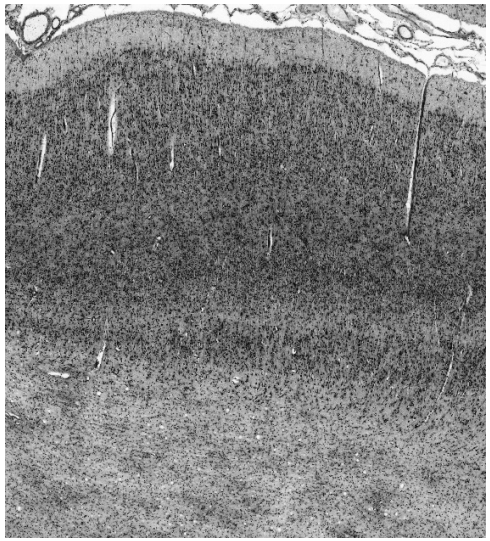
Filter Responses



Resemblance of Learned Filters and Cytoarchitectonic Features



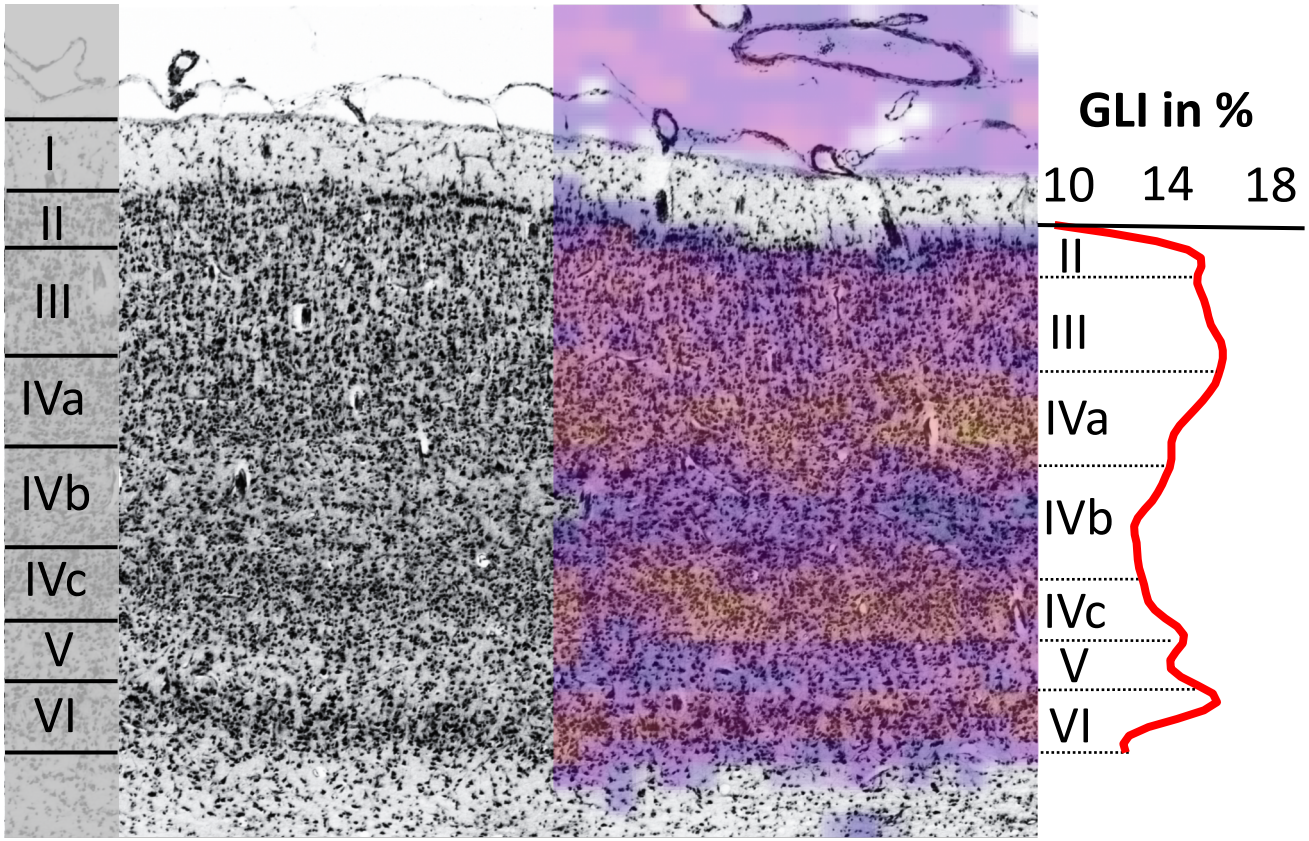




Filter activations for **cortical layers**

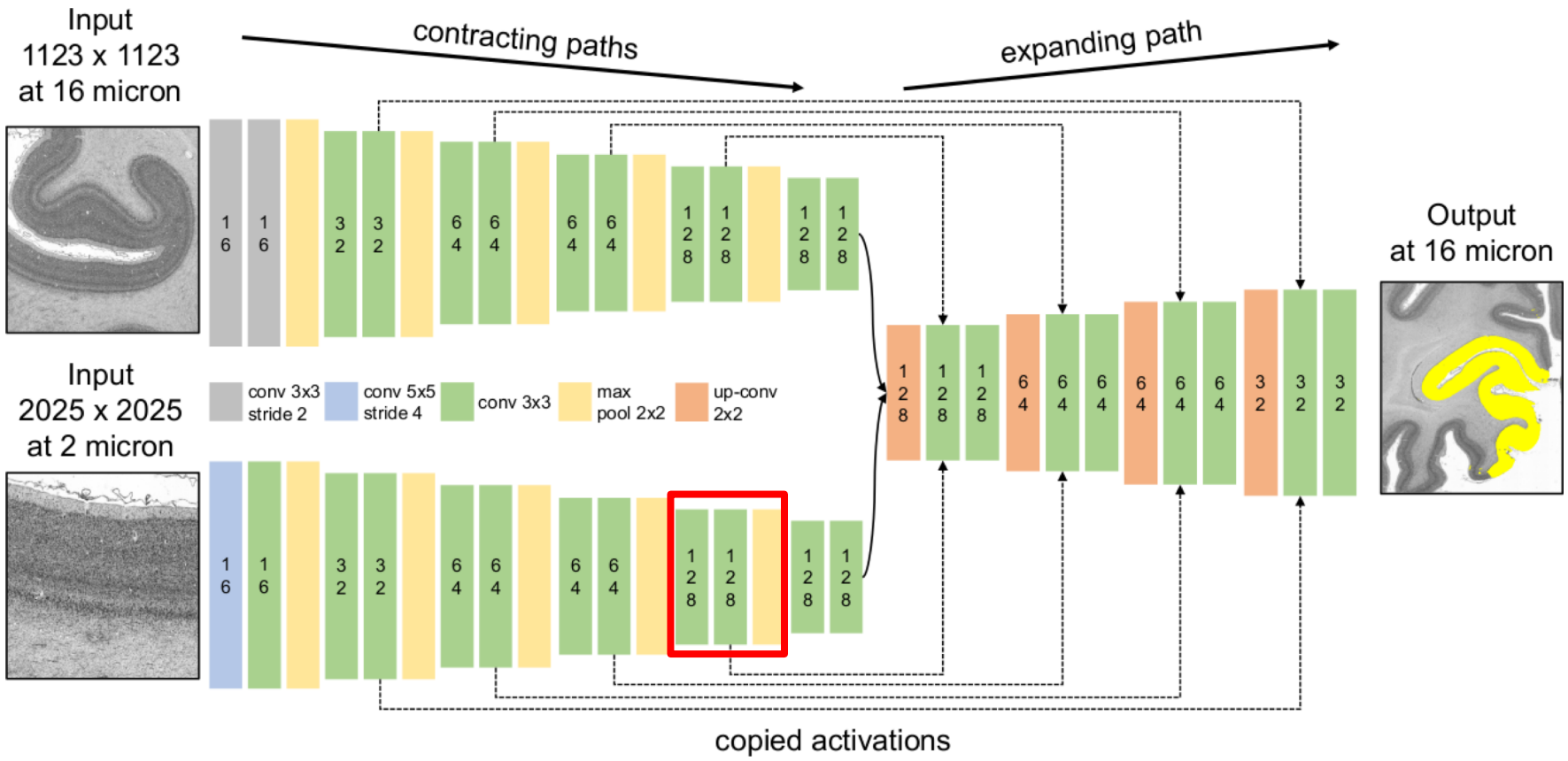
(left: cell-sparse layers; right: cell-dense layers)

Resemblance of Learned Filters and Cytoarchitectonic Features

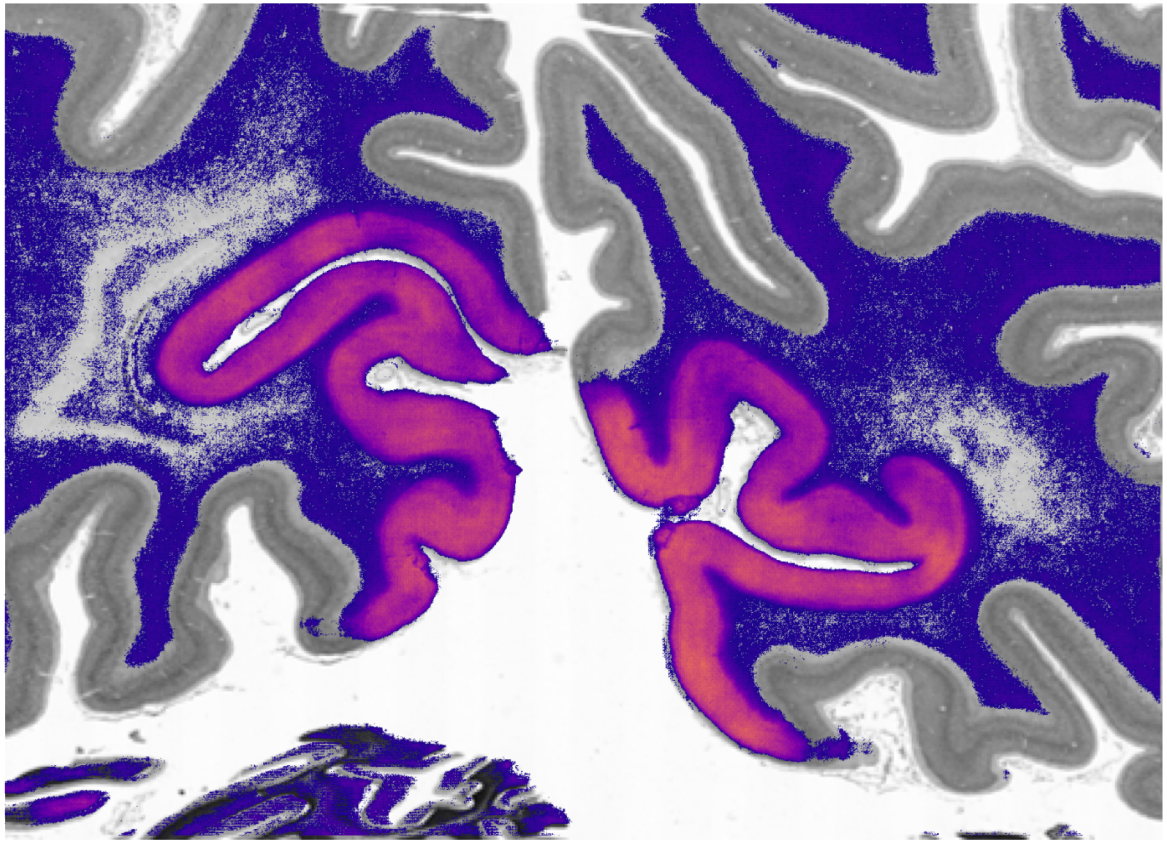


Comparison of a **filter activation** with the corresponding GLI **profile shape**

Filter Responses

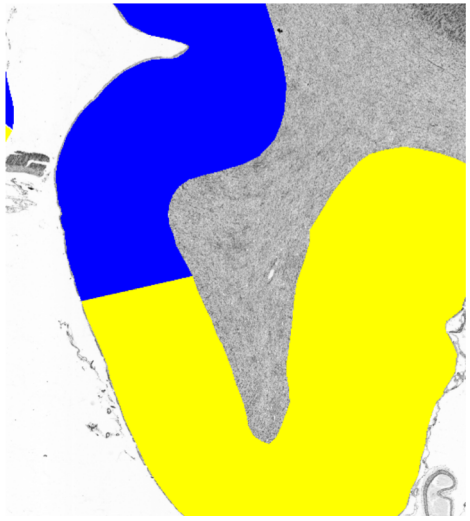


Resemblance of Learned Filters and Cytoarchitectonic Features

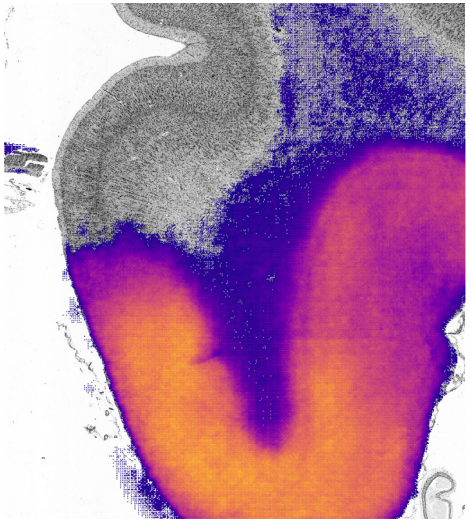


Filter activation of **a cortical area**
(primary visual cortex, hOc1)

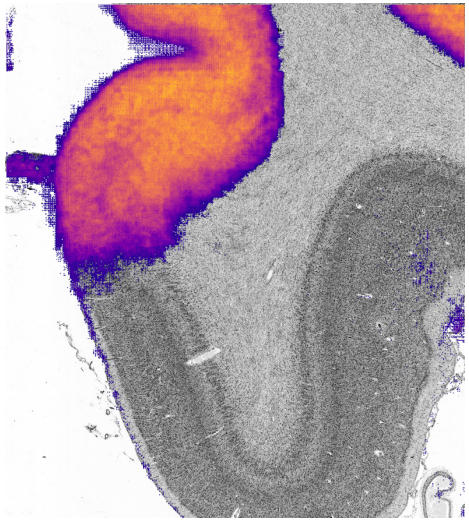
Resemblance of Learned Filters and Cytoarchitectonic Features



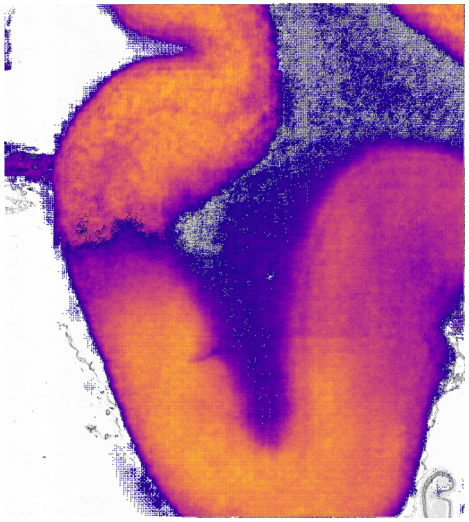
Delineations based on the GLI approach by Schleicher et al (1999)[1]



Filter activation for cortical area hOc1



Filter activation for cortex around hOc1



Combined filter activations

[1]Schleicher, A., Amunts, K., Geyer, S., Morosan, P. & Zilles, K. Observer-Independent Method for Microstructural Parcellation of Cerebral Cortex. A Quantitative Approach to Cytoarchitectonics. *NeuroImage* **9,** 165–177; 10.1006/nimg.1998.0385 (1999).

HEINRICH HEINE
UNIVERSITÄT DÜSSELDORF

Conclusion

- Filter activations of the deep learning approach indicate a resemblance between learned filters and traditional cytoarchitectonic features
- The filter activations compare well to the current GLI-profile approach
- These findings validate deep learning-based brain mapping as a semi-automatic alternative for high-throughput mapping workflows

[1]Amunts, Katrin, Lepage, C., Borgeat, L., Mohlberg, Hartmut, Dickscheid, T., Rousseau, M.-É., . . . Evans, A. C. (2013) https://doi.org/10.1126/science.1235381

HEINRICH HEINE UNIVERSITÄT DÜSSELDORF

Thank you very much for your attention!

Human Brain Project

JÜLICH Forschungszentrum

MAX PLANCK SCHOOL of cognition

Prof. Dr. med Katrin Amunts

Director of the Institute of Neuroscience and Medicine (INM-1), Forschungszentrum Jülich and Director of the Cécile and Oskar Vogt Institute of Brain Research, Univ. Hospital Düsseldorf, Heinrich-Heine University Düsseldorf

Dr. Timo Dickscheid

Group Leader: "Big Data Analytics"
Institute of Neuroscience and Medicine (INM-1), Forschungszentrum Jülich

M.Sc. Christian Schiffer

PhD-student: "Big Data Analytics" Group
Institute of Neuroscience and Medicine (INM-1), Forschungszentrum Jülich

I would like to thank my colleagues at the Institute for Medicine and Neuroscience I (INM-1) at Forschungszentrum Jülich for their collaboration and support of this work!