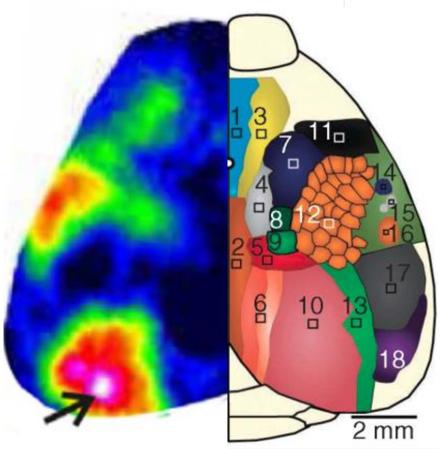
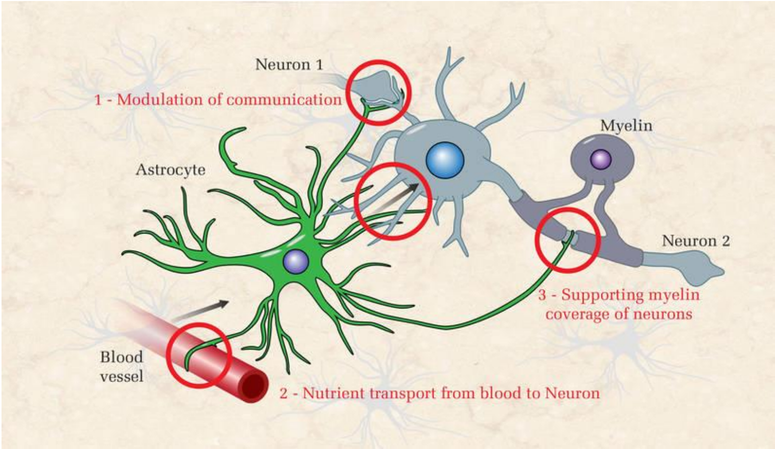


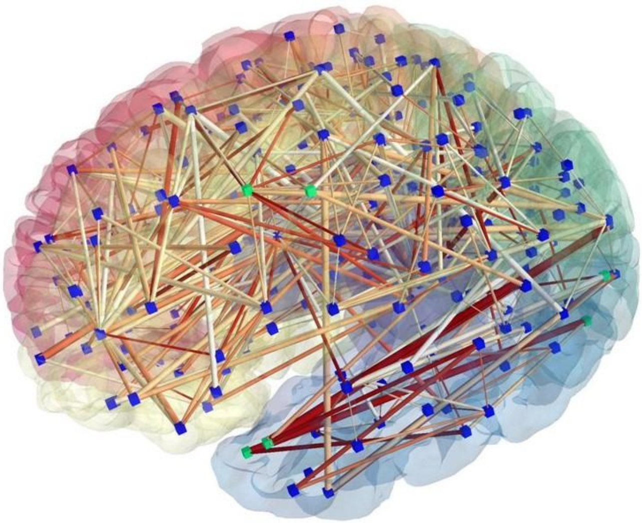
Bridging function and anatomy in wide-field data - Masters Project
Multiple experiments carried out in the Neuronal Circuit Dynamics Lab acquire in vivo full brain wide-field optical recordings of mouse cortex during behaviour. The measurements are mesoscopic, which means that each recorded pixel carries signal averaged over multiple neurons. Such recordings are being actively used to uncover context and task-specific activation patterns in mouse brains. However, the nature of wide-field signals is far from fully understood. We seek a talented and motivated student to help study the following questions: (1) The observed activation patterns frequently cover parts of multiple anatomical areas. Student would use unsupervised machine learning tools to identify effective functional areas, as well as construct mappings between functional and anatomical areas. (2) Student would use information-theoretic metrics to study the information content in wide-field recordings, as well as identify the information overlap between pixels, functional and anatomical areas. (3) It has been hypothesized that wide-field signals in the cortex may loosely follow local propagation laws similar to those of water waves. Student would propose a few model propagation laws, fit them to the data and thus report on the plausibility of this hypothesis.

Requirements: Experience in programming (Python/Matlab), statistics and/or machine learning.
Contact: Philipp Bethge (bethge@hifo.uzh.ch)



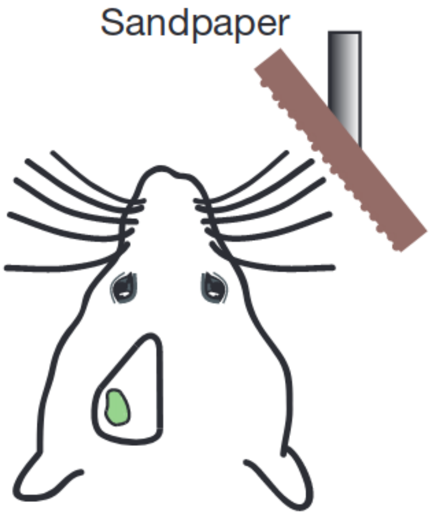
Exploration of Hypothetical Astrocyte Functions – Semester Project
Alongside with neurons, a mammalian brain also has glial cells in comparable quantities. So far mostly neglected by computational neuroscience, a specific type of glial cells called astrocyte has recently been attracting increasing attention. Clasically, astrocytes have mainly been attributed auxiliary functions in the brain, such as mechanical support and management of the blood-brain barrier. While controversial, recent literature suggests that astrocytes may take active part in neuronal computation. Experimental efforts in uncovering the exact nature of neuronal-astrocytic interaction are in process, but will probably take a few more years to deliver conclusive results. In the meantime, we propose to investigate the potential effect of neuronal-astrocytic coupling computationally. The student will construct a simple top-down hypothetical neuronal-astrocytic model, and investigate the effect of different neuronal-astrocytic and astrocyte-astrocytic coupling functions on the dynamics of the model. The student will also design a metric to categorize the effective observed dynamics and thus report the set of astrocytic models for which the dynamics is distinguishable from purely neuronal model.

Requirements: Experience in programming (Python/Matlab), statistics and/or machine learning.
Contact: Philipp Bethge (bethge@hifo.uzh.ch)



Model-Based estimators of Functional Connectivity for Calcium Data – Masters Project
Multiple measurement techniques, such as multifiber implant and wide-field imaging are used to acquire in vivo full brain mesoscopic optical recordings in mice. This data can be used to identify functional connections between different brain areas, and the connections between individual brain areas and behavioural variables such as paw or whisker movement. We are currently carrying out a study to compare the performance of most prominent model-based and model-free functional connectivity estimators using simulated and real data, with emphasis on calcium indicator-based optical measurement data. A student will help adapt a few model-based functional connectivity estimators to the calcium indicator forwards model, test them against existing simulated benchmarks, as well as compare their performance to model-free estimators which we have already implemented. Finally, the student will proceed to design fitness criteria for the above model-based estimators to evaluate and compare the feasibility of using the models to describe mesoscopic calcium data. A significant contribution would guarantee the student a place on the publication following this study.

Requirements: Experience in programming (Python/Matlab), statistics and/or machine learning.
Contact: Philipp Bethge (bethge@hifo.uzh.ch)



Deep Learning for Time-Dependent Behavioural Data – Semester Project
With recent advances in deep learning it is now possible to significantly automatize tracking of animal behaviour. For example, DeepLabCut (DLC) has been successfully used by many labs to automatically identify selected points from behaving animal videos with a training set of just a few hundred human-labeled frames. The main assumption of DLC is that the features of interest can be identified from individual frames, so the algorithm considers only one frame at a time. However, there exist other tracking-related questions, such as event detection, for which the above assumption is insufficient for good performance. Several of our experiments require precise detection of the first moment in time the whiskers of a mouse touch a certain object. This task is challenging to solve on a frame-by-frame basis, since occasional false positives of touch estimation can have devastating effects on the estimate of the first touch moment. Further, our human labelers report using information from previous frames, such as velocity of the whisker or rate of change of its angle to estimate if a touch has occurred.

A student will design a deep learning pipeline which will consider multiple frames simultaneously to decide on the timing of the first touch event. The student will then apply the method to our labeled and unlabeled data, validating and optimizing the pipeline. The exact implementation details of the pipeline will be the creative work of the student.

Requirements: Experience python and Deep Learning
Contact: Philipp Bethge (bethge@hifo.uzh.ch)