Course: mathematical methods for neuroscience

Part I

1. Introduction (21.02.2023)

A general description of the concepts that we will follow during the course
Why each of the separate fields is important
What's the advantage of a holistic view of data

2. Statistics (28.02.2023)

How can we analyze a dataset using statistics
Which are the basic concepts and how we can choose
Examples of using statistics wrong and how we can avoid it
1. Data Detective Methods for Revealing Questionable Research Practices

3. Basic I (07.03.2023)

Introducing key concepts in neuroscience: Single cells and Networks
1. Synaptic Connectivity and Neuronal Morphology
2. Dendrites: bug or feature?

4. Basic II (14.03.2023)

Introducing key concepts in neuroscience: Plasticity and learning
1. Are Dendrites Conceptually Useful?
2. Impact of Active Dendrites and Structural Plasticity on the Memory Capacity of Neural Tissue

Part II

5. Machine Learning I (21.03.2023)

Classification problems
Applications in Neuroscience
1. New insights into the classification and nomenclature of cortical GABAergic interneurons
2. A Systematic Evaluation of Interneuron Morphology Representations for Cell Type Discrimination

6. Machine Learning II (28.03.2023)

Clustering problems
Applications in Neuroscience
1. Phenotypic variation of transcriptomic cell types in mouse motor cortex
2. Sparse reduced-rank regression for exploratory visualisation of paired multivariate data
Project assignments

7. Algebraic Topology I: Introduction (04.04.2023)

Introduction to Topological Data Analysis and basic topological concepts
1. Extracting insights from the shape of complex data using topology

8. Algebraic Topology II: Networks (18.04.2023)

Dr Daniela Egas Santander

Part III

9. Algebraic Topology III (25.04.2023)
Topological Representation of Persistence
Projects discussion

10. Algebraic Topology IV (02.05.2023)
Classification of neuronal morphologies based on topology
1. A Topological Representation of Branching Neuronal Morphologies
2. Objective Morphological Classification of Neocortical Pyramidal Cells

11. Random walks I (09.05.2023)
Introduction to random walks
Mathematical formulation
Applications in neuroscience

12. Generative models of neurons (16.05.2023)
Grow Neuronal morphologies using stochastic processes, minimum spanning tree and topology
1. One Rule to Grow Them All: A General Theory of Neuronal Branching and Its Practical Application
2. Computational synthesis of cortical dendritic morphologies

13. Invited speakers (23.05.2023)
Dr Stolz-Pretzer Bernadette
TBD
Delivery of project reports

Part IV

14. (30.05.2023)
Project presentations

Presentation of the projects by groups