EE-619

Advanced topics in network neuroscience

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Cursus	Sem.	Type
Computational and Quantitative Biology		Obl.
Electrical Engineering		Opt.
Neuroscience		Opt.

Language of teaching	English
Credits	2
Session	
Exam	Written
Workload	60h
Hours	**28**
Courses	28
Number of positions	**60**

Frequency

Every year

Remark

Next time: TBA

Summary

The main goal of this course is to give the student a solid introduction into approaches, methods, and tools for brain network analysis. The student will learn about principles of network science and how to implement and develop methods and tools for graph theoretical analysis of brain data.

Content

1- Introduction to Networks and Brain Networks (2 hours)
I will introduce fundamentals of graph theory and network science, with a focus on the application of these concept to brain networks.
2- Observing the brain: basics of neuroimaging (2 hours)
I will give an overview of the main instruments to study *in vivo* human brains, and the physics behind it: magnetic resonance imaging (MRI) and electroencelography (EEG).
3- Fundamentals of Brain Connectomics (2 hours)
I will introduce the concepts of functional and structural brain networks, and how to define links and nodes from brain data.
4- Node Degree and Strength (1 hour + 1 hour exercise)
I will show how to define and extract brain node measurements. One hour of hands-on session will follow.
5- Centrality and Hubs (1 hour + 1 hour exercise)
I will explore the connectivity distribution of brain networks, and the existence of hub and peripheral nodes. We will learn how to quantify the importance or influence of a node on network function. One hour of hands-on session will follow.
6- Paths, Diffusion, and Navigation (1 hour + 1 hour exercise)
I will introduce the main tools to study information transfer and communication in brain networks, such as path, diffusion and navigation of brain connectomes. One hour of hands-on session will follow.
7- Modules and community structure of brain networks (1 hour + 1 hour exercise)
I will define concepts of modules and will explore the community structure of functional and structural brain networks. One hour of hands-on session will follow.
8- MIDTERM EXAM
9- Individual differences and brain fingerprinting (1 hour + 1 hour exercise)
I will show how to detect individual differences from brain graphs, and how to maximize the â€œfingerprintâ€# of functional and structural brain networks. One hour of hands-on session will follow
10- Introduction to dynamic functional connectivity (1 hour + 1 hour exercise)
I will teach the basics of how to look at dynamical properties of functional brain connectomes. One hour of hands-on session will follow.
11- Consciousness and brain connectomics (1 hour + 1 hour exercise)
I will overview the state of the art of scientific study of consciousness, and go through definitions and ways to assess levels of consciousness through the lens of neuroimaging and brain networks.

12- Invited lecture (1 hour + 1 hour exercise)
An expert in brain connectomics lecturing us on some cutting-edge topic (TBD). One hour of hands-on session will follow.
13- Invited lecture (1 hour + 1 hour exercise)
An expert in brain connectomics lecturing us on some cutting-edge topic (TBD). One hour of hands-on session will follow.
14 - FINAL EXAM

Keywords

Brain Networks, Network Science, Brain Connectomics.

Learning Prerequisites

Recommended courses

Basic knowledge of MATLAB is preferred, but not required.

Learning Outcomes

By the end of the course, the student must be able to:

- Exploit functional and structural brain graphs from neuroimaging data, to master and extract advanced network science methodologies on brain networks, and to in-terpret the results.

Assessment methods

One Midterm exam, at the end of the 8th week. At the end of the course there will be a Final Exam. Each of these two exams (the Midterm and the Final) will impact 1/2 on the final grade.

Resources

Bibliography

Fornito, Alex, Andrew Zalesky, and Edward Bullmore. *Fundamentals of brain network analysis*. Academic Press, 2016.

Références suggérées par la bibliothèque

- Fornito, Fundamentals of brain network analysis