Examples of Data Science Applications in Neuroimaging" (EDSAN)

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2 ECTS

Open and reproducible science is an approach strongly emphasized to address the current reproducibility crisis revealed by the difficulty of reproducing published scientific experiments from fields ranging from machine learning to medicine. Initiatives have been conducted at all geographical scales to tackle this issue present globally: the European Commission published in December 2020 a report "Reproducibility of scientific results in the EU", the head of strategy of the Swiss National Science Foundation (SNSF) -- Katrin Milzow -- recently declared that "Open Science is a strategic priority in [their] multiannual program 2021-2024", the University of Geneva established in 2020 a roadmap until 2023 for Open Science and EPFL launched the Open Science Initiative in 2017 to promote open & reproducible research. The objective objective of **training on open science tools and practices** is emphasized in these initiatives and the two modules proposed below on data science and neuroimaging precisely aim at addressing it.

Two modules are proposed for participants as described below. **Module IORDS is independent of Module EDSAN, and, as it is self-contained, it can be attended without registering to Module EDSAN. Module EDSAN depends on knowledge of Module IORDS, but previous attendance to Module IORDS is not required.**

Module IORDS, "Introduction to Open & Reproducible Data Science", is aimed at students of all levels with a strong focus on computer science to train them in integrating the techniques that form the pillars of open & reproducible science. This module does not replace any computational course on any of the topic it features, and is meant instead as an overview of how the different computing pieces introduced fit together. As such, lectures on a given topic addressed during the course can be studied more in depth after the course to strive for mastery of that topic.

Module EDSAN, "Examples of Data Science Applications in Neuroimaging", illustrates the use of data science in neuroimaging which is a highly inter-disciplinary field pushing forward general computational tools: the well-known machine learning library scikit-learn in Python was developed largely by neuroimaging scientists, and so were Jupyter Notebooks and the most popular cloud solution to run them, Binder. As such, this module would benefit both students versed and not versed in neuroimaging and bioinformatics, as they would both discover applications in a highly dynamic field at the forefront of computational technologies, and learn how to collaborate within teams of varied expertise as they are typically found in research labs and the industry.

Detailed Curriculum in 2022 (provisional, subject to changes)

Module EDSAN (Examples of Data Science Applications in Neuroimaging)

Lecture	Date & Time
Introduction to NeuroImaging and MR Imaging	MON FEB 21, 09AM-11AM
FAIR data / BIDS	MON FEB 28, 09AM-11AM
Introduction to MRI data	MON MAR 07 , 09AM-11AM

Preprocessing pipelines	MON MAR 14 , 09AM-11AM
Structural MRI Part 1	MON MAR 21, 09AM-11AM
Structural MRI Part 2	MON MAR 28 , 09AM-11AM
Diffusion MRI	MON APR 04 , 09AM-11AM
Functional task MRI Part 1	MON APR 11 , 09AM-11AM
Functional task MRI Part 2	MON APR 25 , 09AM-11AM
Functional task MRI Part 3	MON MAY 02 , 09AM-11AM
Functional task MRI Part 4	MON MAY 09 , 09AM-11AM
Brain Connectivity / Networks Part 1	MON MAY 16 , 09AM-11AM
Brain Connectivity / Networks Part 2	MON MAY 23 , 09AM-11AM
Potential lecture for topic reinforcement	MON MAY 30 , 09AM-11AM

Syllabus

- Introduction to NeuroImaging and MR Imaging
- FAIR data / BIDS
  - FAIR data for reproducibility
  - Findable: usefulness of doi
  - Accessible: access rights, persistence
  - Inter-operable: metadata
  - Reusable: standards such as BIDS
  - Converting MRI data to BIDS structure
- Introduction to MRI data
  - Basic MRI principles
  - MRI modalities
  - MRI data structure and filetypes
  - Manipulating BIDS data with pybids
- Preprocessing pipelines
  - Pipeline engine
  - Tool / software interfaces
  - Creating a workflow
  - Deploying a workflow
- Structural MRI
  - Part 1
    - Preprocessing MRI data: templates & registration
    - MRI data segmentation and visualization
    - Brain tissue quantification
    - Data quality control
  - Part 2
    - Structural data group analysis: at ROI level
    - Group analysis: at voxel or vertex level
- Diffusion MRI
  - Preprocessing
  - Fiber orientation estimation
  - Microstructure quantification
  - Deterministic tractography
  - Probabilistic tractography
- Functional task MRI
  - Part 1
    - Signal generation
    - Signal processing
    - Preprocessing (manual)
    - Preprocessing (automated)
  - Part 2
    - Basic fMRI design to understand brain processes

        - Block design
        - Event design
    - Part 3
        - Estimating brain encoding with GLM analysis
        - Mass univariate analysis
        - Statistical contrast
        - Effect of BOLD signal
        - Design matrix
        - First level and second level analyses
    - Part 4
        - Machine learning for Brain decoding
        - Building features from MRI data
        - Regression task
        - Classification task
        - Searchlight
- Brain connectivity / brain networks
    - Part 1
        - Functional networks: resting state fMRI
        - Functional networks: dynamic resting state fMRI
        - Structural networks with diffusion MRI
        - Relating structural and functional networks
    - Part 2
        - ML applied to connectivity networks
        - Predicting behavioral score
        - Prediction subject group
- Multiple choice question exam

Course location and additional information

The two modules are taught in English in the main amphitheater of Campus Biotech. Each module ends with a multiple-choice question exam.

The course will be available in hybrid mode, with attendance either physically in the auditorium of Campus Biotech in Geneva or remotely. Having/ bringing a computer/ laptop is required to attend/ connect to the interactive lectures!

Please keep informed of the directives of your university to know when physical attendance to courses becomes globally required again.

Registration

An institutional email address is preferred from course attendees; else please clearly state your affiliation in the application form! Registration will be via the online registration form here (will be open soon; no need to write an e-mail in advance to register). Registration closes on February 11, 2022.