Computational Neurology in Epilepsy: Data Science for Researchers

THURSDAY 5TH OCTOBER 2023

BOILER HOUSE, NEWCASTLE UNIVERSITY, NEWCASTLE UPON TYNE, UK

CNNP www.cnnp-lab.com Computational Neuroscience, Neurology & Psychiatry

Newcastle University

ILAE BRITISH BRANCH

UKRI UK Research and Innovation

Contents

Welcome

It is our great pleasure to welcome you to the meeting Computational Neurology in Epilepsy: Data science for clinical researchers.

This meeting is designed as a satellite event to the ILAE British Branch Annual Scientific Meeting (2nd to 4th October 2023, Gateshead). It will be focused on computational methods for epilepsy research and will highlight opportunities for computational approaches to epilepsy research and showcase ongoing research using these techniques. We aim to build a community of epilepsy researchers, students, and clinicians interested in the use of computational techniques for patient benefit.

The field of computational neurology has grown tremendously in recent years, offering new insights into the mechanisms of epilepsy, and providing promising avenues for diagnosis, treatment, and management of this complex disorder. Our meeting brings together experts from diverse fields to share their knowledge, present their research findings, learn new skills, and engage in discussions about the future of computational neurology in epilepsy.

The meeting will feature tutorial talks on advanced computational methods in epilepsy research, with live code demonstrations. We will also have talks from investigators presenting real-world examples of advanced computational analyses being used in the clinic. We also invite rapid fire presentations from PhD, postdoc and early career researchers that are looking for collaborations. Posters presentations will also be present to showcase some of the latest original research in the field. The programme has been designed to foster new collaborations and partnerships and share knowledge to advance our understanding of epilepsy and improve methods in the field.

We would like to thank all our sponsors, speakers, and attendees for making this meeting possible. We hope that you will enjoy the programme and make the most of this opportunity to network, learn, and exchange ideas.

We look forward to meeting in you Newcastle upon Tyne in October.

Dr Yujiang Wang and Dr Peter Taylor

Principal Investigators, CNNP lab, Newcastle University

On behalf of the organising committee

About the Meeting

There is currently a skills shortage in the understanding of machine learning (ML), artificial intelligence (AI), and statistics, particularly in neurology. The aim of this one-day session is to highlight opportunities for computational approaches to epilepsy research and showcase ongoing research using these techniques. With the one-day workshop as a starting point, we aim to build a community of epilepsy researchers interested in the use of computational techniques for patient benefit.

Our one-day session will have three key types of educational content. First there will be tutorial talks, where epilepsy research is presented alongside real time demonstrations of the ML/AI methods used to generate the results. Code and resources will be made freely available at the session and can be used by attendees for their own research. These tutorial talks will assume little or no prior experience and will be accessible to a clinical audience. Second, there will be talks from senior investigators presenting real-world examples of advanced computational analyses being used in the clinic. Third, to build a community, we will invite rapid fire presentations from PhD, postdoc and early career researchers that are looking for collaborations. The talks will either present on new ML/AI methods or on clinical research questions that may benefit from ML/AI methods. Finally, we will facilitate regular opportunities for networking across disciplines through regular breaks. The meeting will be supported by a digital platform such as slack/discord to ensure that participants can continue networking and building a community after the event.

More information can be found on our website: https://conferences.ncl.ac.uk/ilae/datascience/

Venue

The meeting will take place in the recently restored Boiler House, located in Newcastle University's historic campus in the heart of Newcastle upon Tyne, UK. It is a 20-minute walk from the train station. Maps of the city and of university campus can be found here.

Address: The Boiler House, Newcastle University, Newcastle upon Tyne, UK, NE1 7RU

what3words: ///hedge.glitz.soda

Registration and abstract submission

Registration for this event is **free**. Registration closes at midnight on **10th September 2023**. Spaces are limited so please register early to avoid disappointment.

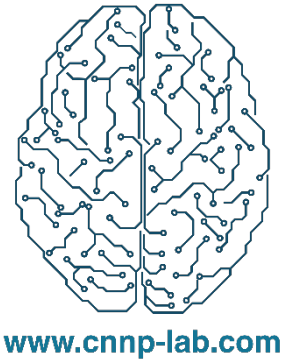
Abstract submissions for posters and talks will close at midnight on **13th August 2023**. We encourage you to submit your abstracts early to secure your spot in the meeting programme.

You can register for the event and submit your abstract on our website.

About us

Organisers

The meeting is organised and hosted by the CNNP Lab, a group of interdisciplinary researchers working on Computational Neurology, Neuroscience, and Psychiatry (psychology). We apply theoretical and computational approaches to questions in the neuroscience domain. The lab members come from a colourful mix of backgrounds, ranging from computing, mathematics, statistics, and engineering to biology, psychology, neuroscience, and neurology.



We are based in the School of Computing at Newcastle University, and we have a diverse range of close collaborations and affiliations with local and national research centres for neuroscience, neurology, and psychiatry.

Take a look on our website to learn more about our work: www.cnnp-lab.com

Organising committee

- Dr Yujiang Wang, Principal Investigator, CNNP lab, Newcastle University
- Dr Peter Taylor, Principal Investigator, CNNP lab, Newcastle University
- Beth Little, Research Associate, CNNP lab, Newcastle University
- Karoline Leiberg, PhD student, CNNP lab, Newcastle University
- Jonny Horsley, PhD student, CNNP lab, Newcastle University
- Heather Woodhouse, PhD student, CNNP lab, Newcastle University

Contact

Contact us on our meeting website: https://conferences.ncl.ac.uk/ilae/datascience/contact/

Email us at: ILAE.Data.Science@ncl.ac.uk

Partners

We would like to thank our partners for their support in organising this meeting:

- School of Computing, Newcastle University
- Newcastle University Centre for Transformative Neuroscience
- ILAE British Branch
- UK Research and Innovation

Programme Overview

Time	Speaker	Topic
09:00	Peter Taylor / Yujiang Wang	Arrival, coffee and welcome
09:20	Jonny Horsley	Tutorial: Relating structural brain abnormalities in epilepsy
09:40	Gerard Hall & Callum Simpson	Tutorial: Automation of tasks and handling 'big' epilepsy datasets
10:00	Aswin Chari	Contributed "early career" presentation
10:15	Chris Thorton	Contributed "early career" presentation
10:30		Morning break
11:00	Konrad Wagstyl	Real-world example of ML/AI for neurology: AI for FCD and lesion detection in presurgical evaluation in epilepsy
12:00		Lunch
13:20	Beth Little	Tutorial: Assessing brain-cognition relationships in clinical populations using Canonical Correlation Analysis (CCA)
13:40	Karoline Leiberg	Tutorial: Novel cortical feature identification and getting the most from epilepsy structural imaging data
14:00	Hester Garrant & David Lewis-Smith	Contributed "early career" presentation
14:15	Isabella Marinelli	Contributed "early career" presentation
14:30		Afternoon break
15:00	Adria Tauste-Campo & Manel Vila-Vidal	Real-world example of ML/AI for neurology: Navigating the BrainFocus platform – Automatic detection of seizure onset zone and patterns from SEEG recordings
16:00		Drinks & networking

Refreshments and lunch will be provided (please specify dietary requirements when registering).

Please contact us if you require any adjustments to be made on the day.

Abstracts

Tutorials

Tutorial: Relating structural brain abnormalities in epilepsy

Speaker

Jonny Horsley, CNNP lab, Newcastle University, UK

Abstract

People with epilepsy often have structural brain abnormalities detectable by both T1w MRI and diffusion-weighted MRI (dMRI). These abnormalities may occur in grey matter (e.g. atrophy) and in white matter (e.g. reduced FA). An improved understanding of the relationship between these abnormalities may improve our knowledge of the mechanisms of epilepsy, and therefore impact future treatment.

To accurately model the relationship between abnormalities within patients, appropriate statistical methods are required. Hierarchical (mixed effect) modelling is a statistical approach which is particularly useful when data are organized at more than one level (e.g. many brain region values within a single patient). In this tutorial, we will outline a recent publication which used hierarchical models to analyse the relationship between grey and white matter abnormalities in epilepsy. Additionally, we will demonstrate how to apply these models in R.

Learning objectives

- Improved understanding of grey and white matter abnormalities in epilepsy
- Improved knowledge of when and where hierarchical models are appropriate
- Experience of practically applying hierarchical models in R

Prerequisites

- R skills would be useful (but not required)
- Knowledge of basic statistics (means, standard deviation, z-scores)

Tutorial: Automation of tasks and handling 'big' epilepsy datasets

Speakers

Gerard Hall, CNNP lab, Newcastle University, UK

Callum Simpson, CNNP lab, Newcastle University, UK

Abstract

Impactful research in neuroimaging can often require large patient numbers and high-quality data. This can lead to large datasets that can be time-consuming to organise and process. Scripting techniques have allowed our lab to automate and parallelise tasks that would normally be time consuming to conduct manually. This has led us to develop automated tools, some specific to the field of epilepsy.

The tutorial will be based on MRI processing and begin with basic bash scripting techniques that can be valuable in organising and processing large datasets. We will show some of our pipelines including our resection mask tool that can automatically create masks of post-surgical resection sites. We will also briefly cover how these scripts can be used on high-performance computers.

Learning objectives

- Understand scripting techniques in bash.
- Create a simple script to organise and process data.
- Show a tutorial of the automated resection tool.
- Have brief understanding how these techniques can be used in advanced pipelines and ran high clustering computers.

Prerequisites

- Knowledge of using terminal and basic bash commands (not required)
- Knowledge of neuroimaging toolboxes like FSL (not required)

Tutorial: Assessing brain-cognition relationships in clinical populations using Canonical Correlation Analysis

Speaker

Beth Little, CNNP lab, Newcastle University, UK

Abstract

Identifying associations between brain abnormalities and cognitive dysfunction in epilepsy will help to advance our understanding of the disorder, aid predictions of cognitive outcomes, and inform the development of targeted interventions. Investigating brain-cognition associations is challenging due to the complex multivariate nature of this data (i.e., multiple brain abnormalities and multiple cognitive measures). Canonical Correlation Analysis (CCA) is a statistical method that identifies the strongest associations between two sets of variables, overcoming the multivariate problem. This tutorial talk will focus on how CCA can be leveraged to explore relationships between brain imaging data and neuropsychological data in epilepsy.

We will first provide an overview of the importance of exploring the brain-cognition associations in epilepsy and the fundamental principles of CCA. Then, we will work through a live demonstration of applying CCA to real data using R, including data pre-processing, fitting the CCA model, and interpretation of results. R code and instructions will be made available for attendees to run the analysis themselves if they wish. Finally, we will discuss some limitations associated with this method. Our overall aim is to provide background and practical guidance for researchers interested in applying CCA to their own research.

Learning objectives

- Understand the importance of multivariate methods for assessing brain-cognition relationships
- Understand the fundamental principles of CCA and its strengths and limitations
- Practical application of CCA in R using publicly available data
- Interpretation of brain-cognition associations using CCA results

Prerequisites

- R skills would be useful (but not required)
- Knowledge of basic statistics (e.g., correlation/regression)
- Knowledge of Principal Components Analysis would be useful (but not required)

Tutorial: Novel cortical feature identification and getting the most from epilepsy structural imaging data

Speaker

Karoline Leiberg, CNNP lab, Newcastle University, UK

Abstract

Cortical thickness, volume, and surface area are metrics frequently used as a biomarker for epilepsy in surface-based morphometry. However, to get the most out of the data, the covariance of these measures needs to be accounted for. This tutorial will introduce a set of new, independent morphometrics to quantify cortical shape, that has been shown to be more sensitive to subtle changes in cortical shape caused by processes such as ageing or epilepsy. It will include a demonstration of the computation of these new morphometrics and their application in an example data set.

We will give an introduction into the theory that underlies the novel measures and their physical interpretation. We will then perform a comprehensive demonstration of their computation and use in an example application in MATLAB, for which code and data will be provided for attendees to follow along. The tutorial will equip attendees with the background knowledge and resources (code) to carry out an analysis in these new, independent morphological metrics on their own data sets.

Learning objectives

- Understanding of theory behind independent morphometrics
- Experience in computation local morphological measures
- Application and interpretation in example data set

Prerequisites

- MATLAB skills would be useful (but not required)
- Knowledge of surface-based morphometry would be useful (but not required)

Talks: Real-world examples of ML/AI for neurology

AI for FCD and lesion detection in presurgical evaluation in epilepsy

Speaker

Konrad Wagstyl, University College London, UK

Abstract

Focal cortical dysplasias (FCDs) are a common cause of drug-resistant epilepsy that can be challenging to identify on MRI. However, when detected, they can often be treated effectively through surgical resection. The Multi-centre Epilepsy Lesion Detection (MELD) Project is an international collaboration dedicated to improving the detection of FCDs in patients with drug-resistant epilepsy. In this talk, I will present our work on developing and training a neural network to detect FCDs using a large cohort of 1015 MRI scans from 22 epilepsy centres worldwide. Our algorithm achieved an overall sensitivity of 67% and was able to detect 63% of lesions previously considered MRI-negative. I will also discuss how our pipeline generates individual patient reports that identify the locations of predicted lesions and their imaging features and relative saliencies to the classifier. Finally, I will share updates on how the MELD pipeline is being integrated into presurgical planning for epilepsy at Great Ormond Street Hospital (GOSH) and other centres around the world.

Navigating the BrainFocus platform – Automatic detection of seizure onset zone and patterns from SEEG recordings

Speakers

Adria Tauste-Campo, BrainFocus lab, Universitat Politècnica de Catalunya (UPC), Spain

Manel Vila-Vidal, BrainFocus lab, Universitat Politècnica de Catalunya (UPC), Spain

Abstract

The standard pre-surgical diagnostic procedure in drug-resistant epilepsy usually involves visual inspection of long stereo-EEG (sEEG) recordings to identify epileptogenic regions. This is a very time-consuming and demanding procedure that might lead to inconclusive interpretations, resulting in mistakes and incomplete diagnosis. In this context, can computational tools unravel epileptogenic significant information that is invisible to the human eye? Further, is the application of these tools equally effective across different epilepsy types, such as temporal and extratemporal epilepsies? To address the above challenges, we have recently designed a software platform called BrainFocus to assist clinicians in the diagnosis of epileptic patients with EEG, extracting epileptogenic relevant information that might be hidden to the human eye in challenging cases. Specifically, the BF platform combines an own developed automatic epileptogenic detection algorithm and frequency-dependent visualization maps of sEEG recordings and outputs a final report including a description of the seizure onset patterns and a list of regions that most likely lie or are connected to the seizure onset zone. In this presentation, we will navigate through the platform and will illustrate its application with a few showcases including the results of an ongoing validation study with one of our clinical collaborators.

Selected abstract presentations

Morning session

Speaker	Title
Aswin Chari	Longitudinal analysis of structural connectomes in drug resistant focal epilepsy
Chris Thorton	Diminished circadian and ultradian rhythms in pathological brain tissue

Afternoon session

Speaker	Title
Hester Garrant & David Lewis-Smith	Harmonisation of multidimensional phenotypic data for quantitative analysis
Isabella Marinelli	A mathematical framework to unpack factors underlying circadian distributions of epileptiform activity

Notes