Ulster University

Intelligent Systems Research Centre

Computational Neuroscience, Neurotechnology and Neuro-inspired Artificial Intelligence (ISRC-CN^3)

Autumn School

24-28 October 2022

Background

There have been rapid advancements and investments in research and development in brain sciences, neurotechnology, neural data modelling and neuro-inspired artificial intelligence (AI). These advancements have not only led to deeper understanding of brain functions and disorders, but also the development and application of powerful AI and machine-learning algorithms that affect our everyday life. In fact, historically, AI was inspired by how intelligence arises from the brain.

The Computational Neuroscience, Neurotechnology and Neuro-inspired AI (CN3) Autumn School (http://www.ulster.ac.uk/faculties/computing-engineering-and-the-built-environment/computing-engineering-intelligent-systems/isrc-cn3-autumn-school) aims to train the next generation of researchers on these state-of-the-art developments. This short course will touch on the areas of computational neuroscience, neural data science, neurotechnology and neuro-inspired AI. The School is unique in that important and timely topics either not delivered in other Schools or taught courses, or delivered only individually, will be delivered here in an integrated way, from pedagogical to advanced levels. These topics include computational modelling of neural-glial systems, neuromodulators, cognition, neurotechnology, self-repaired intelligent machines and cognitive robotics. Mathematical foundations, coding exercises, ethics and entrepreneurship will also be covered. Moreover, although neural computation and neuro-inspired AI research are conducted in the island of Ireland, there is very little relevant training and taught courses, especially for early career researchers, in the region; this School aims to bridge this gap.

On this note, the organising committee warmly welcome you for attending the Autumn School!

ISRC-CN^3 Autumn School

The Autumn School will be held at the Intelligent Systems Research Centre (ISRC: http://isrc.ulster.ac.uk/), a major research unit within the School of Computing, Engineering and Intelligent Systems at Ulster University in Derry Londonderry, Northern Ireland. This is the second ISRC-CN^3 Autumn School. The ISRC is dedicated to developing a bio-inspired computational basis for AI to power future cognitive technologies. This is achieved through understanding how the brain works at multiple levels, from cells to cognition and apply that understanding to create models and technologies that solve complex issues that face people and society. To accomplish this, a variety of research strategies and applications is used, including big data and machine learning, brain imaging and neural interfacing, human-computer interaction and robotics.

The ISRC is housed in a large, purpose-built facility, with state-of-the-art resources, including neuroimaging, neurotechnology and robotic facilities, and high-performance computing (HPC) facility for big data analytics and large-scale computational simulations. There will be a tour of labs for in-person attendees. The ISRC is multidisciplinary, with arguably the largest cluster of computational neuroscientists and neuro-inspired AI researchers in the island of Ireland, with strong collaborations with many clinical, biomedical, neuroscience, AI and mental health centres, and industrial partners, allowing its research output to quickly translate into applications.

Academic researchers at the ISRC and invited external speakers will contribute to the delivery of this 5-day School, which consists of lectures and labs. Labs will consist of modelling and analysing data related to the lectures, resulting in 'mini' projects to consolidate the lectures' content and encourage active and creative participation. Attendees will have the opportunity to present and share their research work on the final day, and awards will be given to the top presenters. Class materials will be made available in advance of the event. Required software (Python and MATLAB) should be downloaded and configured before the event. Foundational topics in mathematical techniques and computer programming will be provided.

Although the School will focus on research communities especially within the Island of Ireland due to its lack of such training, wider participations are welcomed. We particularly encourage applications from advanced undergraduate, masters, graduate diploma, early-stage career (Ph.D. students and postdoctoral) researchers, and research scientists and engineers in industrial and clinical sectors. Ideally, participants will have some mathematical background at the UK GCE A level / Irish Leaving Certificate level, some familiarity in computer/scientific programming in languages such as Python or MATLAB, or some background knowledge in biology, neuroscience, medicine or psychology.

The School aims to be inclusive by providing high accessibility including those who are underrepresented and/or with caregiving responsibilities, disabilities, and limited funds, and bursaries may be available. In light of the ongoing pandemic, the School will adopt a hybrid (physical and virtual) format.

Autumn School Structure

Given the tight schedule, this booklet and class materials, including mathematical and programming notes, have been made available in advance of the event for attendees to review or refresh (see GitHub link below).

Required software (Python and MATLAB) can be downloaded and configured before the event.

Blackboard Learn web links for joining online will be sent closer to the dates and prior to the sessions. Hence, please check your email regularly. Guest wi-fi accounts will be provided on Day 1 for online access to materials while on-campus.

Unless mentioned for a last-minute change, the location of lecture room will be in the ISRC Boardroom (Room MS105) within the MS building. Computer lab sessions will be held in MF124/125 (MF building) at Magee campus (see more information at the end of this document).

Online attendees are themselves responsible for the access of reliable internet. When not speaking online, please remember to turn off the microphone and video camera to avoid echo effects and hanging up during video streaming. During the end of the lecture/talk, for questions and answers, you may turn on your microphone and video camera to ask questions or speak to the lecturer/speaker. You can also ask through the chat platform. During lab sessions, you can ask Teaching Assistants questions throughout the lab session either verbally or through chat. But please be mindful that we have limited Teaching Assistants per lab session. Both lecture sessions and lab sessions will be recorded for attendees' viewing.

Towards the end of the Autumn School, feedback from attendees will be requested. Anonymity of feedback is optional. This will be used in reviews and reporting, and for improving future versions of the Autumn School. Certificate of participation can be requested upon completion of the Autumn School.

Lectures:

Lectures, including external speakers, will be delivered during the day, from about 9am to 5pm, with several breaks within this period. Each day of lectures will be categorised based on general themes.

Day 1 lectures will be on general topics such as introductory neuroscience, introductory cognitive neuroscience, mathematical techniques and programming.

Day 2 will be focused on modelling biological neurons and neuronal networks, neuron-glial systems, and neuroscience-based theories of cognition e.g. decision-making and learning.

Day 3 will discuss topics on neural signal processing, neural data science, neuroimaging data analysis, neurotechnology and their applications.

Day 4 will be focused on neuro-inspired artificial intelligence algorithms, especially artificial neural networks, neuromorphic computing, learning and their applications and ending with a discussion on research ethics.

Day 5 will start with attendees presenting their micro-talks (5 minutes each) on their own research or some of the work done during the lab sessions, and awards will be given for the top presentations. It will also cover research translation and entrepreneurship, and an industry talk.

Attendees are encouraged to attend as many of the lectures as possible, as the content of the presentations may be built on that of previous presentations. Lectures will be delivered both physically and online (live streaming). Physical lectures will be broadcast live to those attending the fully online version. Those attending online may ask questions via their own computer's videocam, microphone or type in the chat box in the web link. Lectures will be recorded to allow those who were unable to attend (e.g. due to different time zones, work-related or other personal responsibilities) or for revisits. We will provide the video clips' information on our GitHub link (see below).

Lecture Room:

- **Room MS105 (Boardroom)** (Note: MS105 is in the MS building, the ISRC building).

Labs:

Each computer lab session, held in the evening from about 5pm to 6:30pm, aims to consolidate and reinforce the lectures' topics delivered during that day. Lab sessions, to be led by Teaching Assistants, will consist of 'mini' project-like assignments that involve computational modelling and data analysis. Additional exploration by attendees is highly encouraged, and they may be presented during the project pitches on the final day.

Computer labs will be conducted in Python and MATLAB. If MATLAB is not available, students joining online can download MATLAB's 30-day free trial version or MATLAB's online version (https://uk.mathworks.com/products/matlab-online.html). Codes will be provided by the Teaching Assistants and available on GitHub (see below). Data will be provided when needed. See Day 1 lab notes (provided in advance) for further details. We recommend attendees, especially online attendees, to download the relevant software to their own personal computer before the Autumn School. Attendees with limited mathematics and computer programming experience should check out the prepared mathematical notes or other sources such as https://www.datacamp.com/ before the Autumn School.

Attendees are recommended to attend as many of these lab sessions as possible. Labs will be delivered physically and broadcast online live. It will also be recorded. Those who are attending physically will be able to access our computer lab's machines and other computing facilities. Guest accounts will be provided for in-person attendees.

Physical lab sessions will be broadcast live to those attending online. Those who are attending online will be able to join live via Blackboard Learn and may ask questions

via their own computer's videocam, microphone or type in the chat box of Blackboard Learn. Online attendees can also use Slack (see the link below) to for questions and discussions after the talks.

Lab sessions will be partially recorded (especially at the beginning and during demonstrations) to allow those who were unable to attend (e.g. due to time zone differences, work-related or other personal responsibilities) or for revisits. We will provide the video clips' information on our GitHub link (see below).

Computer Lab:

- Room MF124/125 (Note: MF124/125 is in the MF building, not MS building).

ISRC-CN^3 GitHub link:

Notes, codes, datasets and video clips will be made available at our ISRC-CN^3 GitHub link https://github.com/ISRC-CN3 .

For those who are not familiar with computer programming or mathematics, it is advisable that they read, refresh or practise the provided materials (see Day 1 and References in GitHub) prior to the start of the Autumn School.

Project pitches:

On the final day (28th October, Friday), attendees will have the opportunity to present either their own ongoing research projects (e.g. M.Sc./Ph.D. theses or company based) or present a specific study explored during the Autumn School's lab session. Awards will be given for the top presentations.

Reimbursements, claims and refunds:

If the pandemic situation becomes worse, the Autumn School will be made fully online and fees will be refunded to each in-person attendee.

If you are seeking (e.g. travel) reimbursements and claims, or refunds, please remember to save hard copies of your receipts. Then contact Louise Gallagher (see below) for a claim form to be filled.

Please note that in-person attendees who are attending only for a few days will still be paying the full fee.

Food and social activities:

Lunch and coffee/tea will be provided every day. Dinner will be provided on Day 1 (24th October) and Day 2 (25th October). On Day 1 (24th October), a city walking tour (social activities) will be provided. On Day 4 (27th October), a formal dinner will be provided at the nearby Bishop's Gate Hotel in the city centre. Please contact Louise Gallagher (below) if you wish to join the walking tour and/or formal dinner.

In-person and online participants will be invited to join the ISRC-CN^3 Slack (https://join.slack.com/t/isrc-cn32022/shared_invite/zt-1fbqlpmo7-lRWB78QvCGkQYUR_OsQg9Q) to interact and network with fellow attendees and lecturers/speakers. In-person attendees may use the Slack platform for planning share accommodation.

Certification:

Certificate of Attendance will be emailed to attendees after the end of the Autumn School.

Organising committee and contacts:

- Dr. KongFatt Wong-Lin (chair) (k.wong-lin@ulster.ac.uk)
- Prof. Damien Coyle (deputy) (dh.coyle@ulster.ac.uk)
- Dr. Cian O'Donnell (scientific) (c.odonnell2@ulster.ac.uk)
- Dr. Saugat Bhattacharyya (scientific) (s.bhattacharyya@ulster.ac.uk)
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- Eoghan Tucker (secretary) (e.tucker@ulster.ac.uk)

ISRC-CN^3 logo design:

- Niall McShane
- KongFatt Wong-Lin

Web design and development:

- Roisin McCart
- Dorothy McIlroy
- Cheryl Mullan
- Mark Millar
- Roger James
- KongFatt Wong-Lin

IT Support

- Chris O'Connell

Lecturers and speakers:

- Dr. Saugat Bhattacharyya (ISRC, Ulster University)
- Assistant Professor Áine Byrne (University College Dublin)
- Amanda Fullerton (Knowledge Transfer Partnership, Ulster University)
- Prof. Arleen Salles (Institute of Neuroethics, Uppsala University & Neuroethics Program, Centro de Investigaciones Filosoficas)
- Dr. Cian O'Donnell (ISRC, Ulster University)
- Prof. Damien Coyle (ISRC, Ulster University)
- Dr. Elaine Murray (Northern Ireland Centre for Stratified Medicine, Ulster University)
- Prof. Eleni Vasilaki (University of Sheffield)
- Prof. Girijesh Prasad (ISRC, Ulster University)
- Prof. Hava Siegelmann (University of Massachussetts Amherst)
- Prof. J. A. Scott Kelso (Florida Atlantic University & ISRC, Ulster University)
- Prof. Jim Harkin (ISRC, Ulster University)
- Dr. KongFatt Wong-Lin (ISRC, Ulster University)
- Prof. Liam Mc Daid (ISRC, Ulster University)
- Marinus Toman (ISRC, Ulster University)
- Mark Gorman (Seagate)
- Assistant Professor Maria Dauvermann (University of Birmingam)
- Prof. Nikola Kasabov (Auckland University of Technology & ISRC, Ulster University)
- Associate Professor Simon Kelly (University College Dublin)

See web links and later in the document for profiles.

Teaching assistants (ISRC, Ulster University):

- Day 1 - Brendan Lenfesty, Senhui Qiu
- Day 2 - Marinus Toman, Brendan Lenfesty, Senhui Qiu
- Day 3 - Abdoreza Asadpour
- Day 4 - Aqib Javed

See later in the document for profiles.

DAY 1 (24TH OCTOBER 2022, MONDAY)

Morning Session

08:30 - 09:00	Welcome package and information at MS building's lobby
09:00 - 09:10	Welcome – *KongFatt Wong-Lin (Organiser)*
09:10 - 09:30	Opening speech – *Liam Maguire (UU PVC Research)* and *Damien Coyle (ISRC Research Director)*
09:30 - 11:00	Introductory neuroscience – *Elaine Murray (UU)*
11:00 - 11:15	Break (coffee/tea/snacks provided at MS building)
11:15 - 12:45	Cognitive neural systems and behaviour – *Simon Kelly (UCD)*
13:00 - 15:00	Lunch (provided at MS building) and/or Derry∼Londonderry walking/biking tour

Afternoon Session

15:00 - 16:30	Mathematics for neuroscience – An overview (notes provided in advance) – *Áine Byrne (UCD)*
16:30 - 16:45	Break (coffee/tea/snacks provided at MS building)
17:00 - 18:00	Lab session 1 (at MF124/125) – Fundamentals of Python & MATLAB programming (notes provided in advance) – *Senhui Qiu* & *Brendan Lenfesty*
	Dinner (provided at MS building)

DAY 2 (25TH OCTOBER 2022, TUESDAY)

Morning Session

09:30 - 11:00	Computational modelling of plasticity and learning in brains – *Cian O'Donnell (UU)*
11:00 - 11:15	Break (coffee/tea/snacks provided at MS building)
11:15 - 12:45	Ionostasis at the tripartite synapse: Computational modelling of neuronal and glial interactions – *Liam McDaid (UU)*, *Marinus Toman (UU)*
12:45 - 14:15	Lunch (provided at MS building) and Tour of ISRC labs (in MS building)

Afternoon Session

14:15 - 15:45	Modelling the dynamics of decision-making – *KongFatt Wong-Lin (UU)*
15:45 - 16:00	Break (coffee/tea/snacks provided at MS building)
16:00 - 17:00	Understanding behaviour and the brain the perspective of a dynamical theory of coordination – *J.A. Scott Kelso (FAU & UU)*
17:00 - 17:15	Break (coffee/tea/snacks provided at MS building)
17:30 - 18:30	Lab session 2 (at MG MF124/125) – Modelling neurons, glial cells, neural networks & cognition – *Marinus Toman*, *Senhui Qiu* & *Brendan Lenfesty*
	Dinner (provided at MS building)

DAY 3 (26TH OCTOBER 2022, WEDNESDAY)

Morning Session

09:30 - 11:00	Investigating time series neural data: Experimental design & signal processing practices – *Saugat Bhattacharyya (UU)*
11:00 - 11:15	Break (coffee/tea/snacks provided at MS building)
11:15 - 12:45	Fundamentals of functional and effective connectivity and their applications to mental health conditions – *Maria Dauvermann (U Birmingham)*
12:45 - 14:15	Lunch (provided at MD Minor Hall) and Campus Tour

Afternoon Session

14:15 - 15:45	Non-invasive brain-computer interfaces: Enhancing applicability using computational intelligence and technological advances – *Girijesh Prasad (UU)*
15:45 - 16:00	Break (coffee/tea/snacks provided at MS building)
16:00 - 17:00	Decoding mental imagery from electroencephalography (EEG) and applications of AI-enabled wearable neurotechnology for communication and rehabilitation – *Damien Coyle (UU) [online]*
17:00 - 17:15	Break (coffee/tea/snacks provided at MS building)
17:30 - 18:30	Lab session 3 (at MG MF124/125) – Neural data processing, neural data science & applications – *Abdoreza Asadpour*
	End of Day 3

DAY 4 (27TH OCTOBER 2022, THURSDAY)

Morning Session

09:30 - 10:30	Brain-inspired spiking neural network models for life-long and explainable learning – *Nikola Kasabov (AUT & UU)*
10:30 - 10:45	Break (coffee/tea/snacks provided at MS building)
10:45 - 11:45	Sparse reservoir computing – *Eleni Vasilaki (U Sheffield)*
11:45 - 13:15	Lunch (provided at MS building)

Afternoon Session

13:15 - 14:45	Building reliable and secure embedded systems with neuromorphic computing – *Jim Harkin (UU)*
14:45 - 15:00	Break
15:00 - 16:00	Lifelong learning AI via neuro-inspired solutions – *Hava Siegelmann (U Massachusetts, Amherst) [Distinguished external speaker]*
16:00 - 16:15	Break (coffee/tea/snacks)
16:15 - 17:15	Ethical and regulatory issues in neurotechnology - *Arleen Salles (Institute of Neuroethics, Uppsala University & Centro de Investigaciones Filosoficas) [online]*
17:30 - 18:30	Lab session 4 (at MG MF124/125) – Neuro-inspired AI and applications – *Aqib Javed*

Evening Session

19:30 -	Dinner provided at Bishops Gate Hotel Derry, Derry Halloween dressing up, social event, etc.

DAY 5 (28TH OCTOBER 2022, FRIDAY)

Morning Session

09:30 - 12:15	Attendees' micro-talks (each 5 minutes + 1 minute Q&A)
12:15 - 13:45	Lunch (provided at MS building)

Afternoon Session

13:45 - 14:15	KTPs – Bridging academia and business and supercharging graduate careers – *Amanda Fullerton (KTP, UU)*
14:15 - 14:45	Translating AI-enabled, neurotechnology research and experiences of developing an award winning neurotech startup – *Damien Coyle (NeuroConcise CEO & UU) [online]*
14:45 - 15:00	Break (coffee/tea/snacks provided at MS building)
15:00 - 15:30	Time series analytics of IoT sensor data - An industry challenge perspective – *Mark Gorman (Seagate Technology)*
15:30 - 15:45	Prize-giving for top attendees' micro-talks
15:45 - 16:00	Closing remark

See link (https://www.ulster.ac.uk/faculties/computing-engineering-and-the-built-environment/computing-engineering-intelligent-systems/isrc-cn3-autumn-school) and below for synopses of lectures and talks.

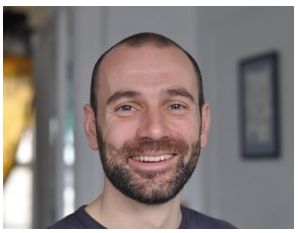
Profiles and presentation synopses of lecturers and speakers

Elaine Murray

Bio: Elaine Murray is a Lecturer in Personalised Medicine (Mental Health) at Ulster University. She received her undergraduate degree in Biomedical Sciences from Ulster University and her PhD in Neuroscience and Behaviour at the University of Massachusetts, Amherst, where she demonstrated that perinatal disruption of histone acetylation leads to long lasting changes in sexually dimorphic regions of the brain. She then joined the Translational Neuroscience group at the University of Aberdeen as a research fellow, where she worked on the genetic basis of major mental illness as part of a Pfizer Neuroscience Grand Challenge project. Elaine returned to Northern Ireland in 2013 to take up her current post within the Northern Ireland Centre for Stratified Medicine. Elaine's current research focuses on identifying novel biomarkers to improve diagnosis and treatment of psychiatric disorders. Elaine is a council member of Neuroscience Ireland, Northern Ireland local group representative for the British Neuroscience Association and is currently leading a CHITIN project investigating mental health among at-risk young people in a cross-border region funded by the EU's INTERREG VA Programme.

Lecture title: Introductory neuroscience

Synopsis: This session will provide an overview of the structure and function of the nervous system. The lecture will start with a review of the divisions of the nervous system and the main cell types, neurons and glia. An introduction to basic neuroanatomy will follow covering key external and internal structures of the brain and the main components of systems controlling movement, learning and memory, and emotional regulation. To understand neuronal processes and pathologies it is important to understand how neurons work. An overview of the action potential, the electrical signal used by neurons to carry information to their target, will be provided. Finally, the main steps involved in synaptic transmission, including the neurotransmitters responsible for chemical signalling in the nervous system, will be reviewed.



Simon Kelly

Bio: Simon Kelly is an Associate Professor in the School of Electrical and Electronic Engineering at University College Dublin. In his research he studies the perceptual and cognitive brain processes that allow people to interact effectively with their environment. He mainly employs a combination of electrophysiology, psychophysics and computational modeling to study the neural computations underlying perception, attention and decision making. Simon received his B.E. and Ph. D. degrees in Engineering from UCD in 2001 and 2005, respectively. He then worked as a postdoctoral researcher in the Nathan S. Kline Institute for Psychiatric Research, New York, and in the Columbia University Department of Neuroscience, and held an Assistant Professor position in the Department of Biomedical Engineering in the City College of the City University of New York for four years before joining UCD in Jan 2015.

Lecture title: Cognitive neural systems and behaviour

Synopsis: Our knowledge of the brain processes underlying perception, cognition and action has come from research using a spectrum of levels of analysis from the molecular, through single neurons and circuits, to behaviour. This lecture provides an introduction to the behavioural end of this spectrum. I will give a broad overview of basic methods of psychophysics - the systematic measurement of behaviour - and how these methods provide insights into properties and mechanisms of the neural systems for basic sensation and for cognitive functions such as attention, decision making and memory and learning. I will discuss how the principled measurement of behaviour helps to make sense of even the lowest-resolution forms of neural activity measurements amenable to human research, and conversely, how such neural activity measurements, once well-characterised functionally, can inform simple mathematical models that capture not just the observed patterns of behaviour but also the underlying algorithms the brain is using to generate them. A core thread running through all of these themes will be the importance of careful task design - what we ask our subjects to do and under what conditions.

Aine Byrne

Bio: Aine Byrne is an Assistant Professor in the School of Mathematics and Statistics, at University College Dublin. She obtained her PhD from the University of Nottingham in 2017, before receiving a Swartz Fellowship for her postdoctoral studies at the Center for Neural Sciences, New York University. Her research focus is coarse-grained models of neural activity. Starting with large networks of interacting neurons, she employs mean-field techniques to arrive at low-dimensional descriptions of these systems. Her next generation neural mass model successfully links the average population activity to the level of synchronisation within the underlying network of neurons, providing an explicit link between the microscopic and macroscopic dynamics. Byrne employs this model to study event-related changes in EEG/MEG spectral power and neurological disorders, such as schizophrenia, epilepsy and Parkinson's disease.

Lecture title: Mathematics for neuroscience: An overview.

Synopsis: The use of mathematics has many historical successes, particularly in the realm of physics and engineering, where mathematical concepts are regularly employed to address challenges far beyond the context in which they were originally developed. More recently, mathematics has been employed to further our understanding of biological systems, such as the brain. Despite the immense complexity of the brain, mathematical modelling has allowed for major advances to be made towards understanding behaviour, consciousness and disease. This lecture introduces the mathematical tools needed for mathematically modelling the brain. We will review concepts from linear algebra, vector calculus and differential equations. We will learn how to describe neural systems using differential equations and how to simulate these equations computationally.

Cian O'Donnell

Bio: Cian O'Donnell did a B.Sc. in Applied Physics at Dublin City University, followed by an M.Sc. and Ph.D. in Neuroinformatics at University of Edinburgh where he studied biophysical models of electrical noise and synaptic plasticity in single neurons. He then worked for 3 years as a postdoc in the Salk Institute in La Jolla, California modelling synaptic plasticity in neural circuits, and analysing neural population activity data from mouse models of autism. From 2015-2021 he was a lecturer at the University of Bristol, then in October 2021 he joined Ulster University at Magee as a Lecturer in Data Analytics. His research group has 3 postdoctoral RAs and 6 PhD researchers, working on three topics: 1) learning and memory in the brain; 2) neural circuit dysfunction in autism; 3) statistical methods for neuroscience data. Website here: https://odonnellgroup.github.io.

Lecture title: Computational modelling of plasticity and learning in brains

Synopsis: This lecture will introduce the basics of how we think learning works in the brain, and common computational models of synaptic plasticity at the single synapse, single neuron, and neural circuit levels. It will cover classic models of Hebbian plasticity, spike-timing-dependent plasticity, and attractor networks. Finally, we will briefly discuss modern attempts to link brain learning to backpropagation and deep learning in artificial neural networks.

Liam McDaid

Bio: Liam McDaid, BEng, PhD (Liverpool), is Professor of Computational Neuroscience at Ulster University. His research focuses on hardware/software implementations of neural based computational systems with particular emphasis on modelling glia-neural interactions. He has secured funding from Higher Education Authority of Ireland, which focuses on inter-neuron on-chip communications and was Co-PI for the EPSRC project (EP/F05551X/1) to develop compact low power spiking neuron cells. Prof. McDaid was PI for a recent EPSRC eFutures (EFXD12011) project and CI on SPANNER (EP/N00714X/1). He also secured funding from the Human Science Frontiers Programme (HFSP) to model G-Protein signaling in astrocytes. He is guest editor for a special issue in the International Journal of Neural Systems and has co-authored over 120 publications.

Marinus Toman

Bio: Marinus Toman received a B.Sc. (Hons.) degree in Cloud Computing from Letterkenny Institute of Technology, Donegal, Ireland in 2018, and a PhD degree in Computational Neuroscience as part of the Computational Neuroscience and Neural Engineering Research Team at Ulster University, Derry, Northern Ireland in 2022. His primary research interests include modelling of glial and neuronal cells in the brain to investigate how memory and learning occurs at a cellular level in the brain. His other research interests include computer science, specifically indoor positioning and localisation.

Lecture Title: ***Ionostasis at the Tripartite Synapse: Computational Modelling of Neuronal and Glial Interactions***

Synopsis: Computational models of neuro-glia interactions are an important tool for researchers studying different levels of the central nervous system; from network level to single cell and sub-cellular. Astrocytes are the most abundant glial cell in the brain and

in many brain regions, they come in close proximity to synapses and provide supporting roles like homeostasis. The tripartite synapse is a recent concept that acknowledges both the close proximity and the important contribution of astrocytes to neuronal synapses. The tripartite synapse is currently too small a region for experimentalists to probe, therefore, computational models of the tripartite synapse can provide an insight, and possibly predictions, into the signalling dynamics between astrocytes and neurons at the point of information transfer between neurons.

In this tutorial, we will construct a neuron-astrocyte model of ionic homeostasis (ionostasis) at the tripartite synapse, using the MATLAB language. First, the popular Hodgkin-Huxley action potential model will be solved using MATLAB's built-in ODE solver. Then, an astrocyte model will be constructed and solved using Euler's method. The full model will be simulated and results plotted to show the neuron-astrocyte interactions during periods of neuronal activity. By the end of the tutorial, participants will be familiar with some computational modelling techniques and will leave with a working model of astrocytic ionostasis at the tripartite synapse.

KongFatt Wong-Lin

Bio: KongFatt Wong-Lin is a Reader at the Intelligent Systems Research Centre, School of Computing, Engineering and Intelligent Systems, Ulster University. Dr. Wong-Lin's research interests lie at the interface of computational modelling and mathematical analysis of systems and cognitive neuroscience, psychology, brain disorders, neural computation and engineering, AI and data science. Dr. Wong-Lin is Editorial Member for the Journal of Neuroscience Methods, and Associate Editor for Frontiers in Integrative Neuroscience. Before joining Ulster University, he was a research associate at Princeton University, USA, with affiliation to The Program in Applied and Computational Mathematics, Center for the Study of Brain, Mind and Behavior, and Princeton Neuroscience Institute. Prior to that, he received his Ph.D. in Physics with focus on Computational Neuroscience at Brandeis University, USA, with affiliation to the Volen National Center for Complex Systems. He received the 2011 IJCNN Best Paper Award (Overall), the 2016 Ulster University's Distinguished Research Fellowship Award, and the 2019 Ulster University Research Excellence Award. In 2017, he received the Moore Institute Visiting Research Fellowship at the National University of Ireland Galway, and from 2020, a Visiting Fellowship at University College at the University of Oxford.

Lecture title: Modelling the dynamics of decision-making

Synopsis: This lecture will first discuss neural network models that are conducive for theoretical analysis and conceptual understanding. Then examples of how different neural network dynamics can lead to different cognitive functions will be discussed. A primary focus of this lecture is on understanding the network mechanism of decision-making, and it shall be demonstrated how neural network models can be adapted to produce different decision-making behaviour.

J. A. Scott Kelso

Bio: J. A. Scott Kelso's research aims to understand how human beings (and human brains)—individually and together—control and coordinate their behavior on multiple levels, from cells to cognition to (most recently) social settings. Kelso's approach is to look for commonalities and differences in the way such complex systems are coordinated across scales with the goal of identifying common principles and mechanisms—an empirical, theoretical and computational modeling framework called Coordination Dynamics. From 1978 to 1985 Kelso was Senior Research Scientist at Yale University's Haskins Laboratories in New Haven, Connecticut. Since then, he has held the Glenwood and Martha Creech Eminent Scholar Chair in Science at Florida Atlantic University (FAU) in Boca Raton, Florida where he founded The Center for Complex Systems and Brain Sciences, obtaining the first NIH National Training Grant in this new interdisciplinary field. Kelso is also a Professor at The University of Ulster's Intelligent Systems Research Centre in his hometown of Derry where he continues to collaborate with colleagues and students. In 2016, Kelso was elected an Honorary Member of The Royal Irish Academy (Hon. MRIA). Trained in a specifically interdisciplinary setting, Kelso's PhD students and Postdoctoral fellows have gone on to careers in some of the top academic and research institutions in the world.

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Talk title: Understanding behavior and the brain from the perspective of a dynamical theory of coordination

Synopsis: As the last talk in the Autumn School, participants will be invited to consider the following question: what does it mean to "understand" a phenomenon regardless of the level of description one chooses to investigate it (e.g., micro-, meso-, macro- etc.)? Given that the usual categories of describing behavior and cognition are suspect with respect to their neural underpinnings (see, e.g. "The brain doesn't think the way you think it does", Quanta, August 24, 2021), the focus here will be on coordination– assumed to be crucial for complex systems regardless of how we categorize behavioral and cognitive function and their relation to structure. In that context, we will explore some of the main concepts, methods and messages of Coordination Dynamics. I offer a strategy aimed at understanding coordination and show how it can be implemented at both behavioral and brain levels.

Saugat Bhattacharyya

Bio: Saugat Bhattacharyya is a Lecturer in Computer Science in the School of Computing, Engineering & Intelligent Systems. His research interests are in the area of Cognitive Neuroscience, Artificial Intelligence, Data Analytics and Machine Learning and its application in Human-Machine Interaction and Neuro-Rehabilitation. His research is primarily focused on developing brain-computer interfacing systems based on robust signal processing, quantitative and machine learning algorithms to draw inference into an users' state of mind through their neural and other physiological signals. He has publications in 17 peer-reviewed journals, 32 international/national conferences, and 17 book chapters. He is also a recipient of GCRF pump-priming as co-investigator in and two PhD fellowships by CSIR, India and Erasmus Mundus. He is also an associate editor/section board member in Frontiers in Medical Technology and MDPI Brain Sciences, and served as guest editors in Frontiers in Neuroscience, MDPI Sensors and International Conference on Intelligent Robots and Systems (IROS).

Lecture title: Investigating time series neural data: Experimental design & signal processing practices

Synopsis: Recent advances in neuroscience technologies have paved the way to innovative applications in healthcare, rehabilitation, biometrics and brain-computer interfacing. These technologies are tuned to observe and influence brain activity to augment or assist in human motor or cognitive development. The neural activities are recorded using invasive or no-invasive technologies, albeit non-invasive technologies, such as electroencephalography (EEG), magnetoencephalography (MEG), functional near-infrared spectroscopy (fNIRS) and functional magnetic resonance imaging (fMRI) are the most popular form of recording amongst researchers and users. Non-invasive neural signals recorded from EEG or MEG devices are non-stationary, complex signals. Hence, it is vital to follow standard experimental design practices to evoke or induce the necessary task response among users and apply time-/frequency-/time-frequency domain processing methods to extract meaningful information about those task responses from the neural signals (EEG/MEG). In this lecture, you will be introduced to some standard practices and consideration while designing an experiment involving EEG/MEG recording, necessary pre-processing methods including temporal and spatial filtering, and artefact removal, and finally signal processing using time-frequency and inter-trial phase clustering techniques.

Maria Dauvermann

Bio: Maria Dauvermann is Assistant Professor in Youth Mental Health in the Institute for Mental Health at University of Birmingham. Her research focusses on the identification of risk and resilience markers in young people who are at high risk of developing neurodevelopmental and mental health conditions, and is also interested in the characterisation of biopsychosocial prognostic markers of clinical and functional outcome. She uses cognitive neuroscientific and interdisciplinary methods to integrate neurobiological, psychological and psychosocial factors to better understand how youth vulnerability can influence and be influenced by neurodevelopmental and mental health conditions.

Lecture title: Fundamentals of functional and effective connectivity and their applications to neurodevelopmental and mental health conditions

Synopsis: Progress in functional brain imaging allows us to noninvasively investigate human brain activity in vivo with optimised spatial and temporal resolution. Such neural maps enable the examination of functional large-scale networks leading to a better understanding of cognitive functions. For optimised clinical practice, greater insight into functional networks in individuals with mental health conditions is important since it is thought that dysfunctional networks may underlie clinical symptoms and cognitive deficits in neurodevelopmental disorders, such as psychosis and autism spectrum disorders. In the first part of this lecture, I will discuss the theoretical basis of functional connectivity and provide an overview of different approaches across neuroimaging techniques of functional Magnetic Resonance Imaging (fMRI), electroencephalogram (EEG) and magnetoencephalogram (MEG). In the next step, I will cover the fundamentals of effective connectivity and different methodologies across fMRI, EEG and MEG. Advantages and disadvantages of both functional and effective connectivity will be discussed. Then, functional and connectivity approaches during resting state and cognitive tasks will be reviewed focussing on psychosis and autism spectrum disorders. This will be followed by a discussion of how functional and effective connectivity may contribute to clinical and cognitive diagnostic, predictive and treatment interventions in neurodevelopmental and mental health conditions.

Girijesh Prasad

Bio: Prof. Girijesh Prasad is Professor of Intelligent Systems in the School of Computing, Engineering and Intelligent Systems, Ulster University (UU), UK. He is Director of Northern Ireland Functional Brain Mapping (NIFBM) facility at UU's Intelligent Systems Research Centre, where he leads the Cognitive Neuroscience and Neurotechnology research team.

He received a BTech in Electrical Engineering from Regional Engineering College (now National Institute of Technology) Calicut, India in 1987, an MTech in Computer Science and Technology from University of Roorkee (now Indian Institute of Technology Roorkee), India in 1992, and a PhD in Electrical Engineering from Queen's University of Belfast, UK in 1997. He is a Chartered Engineer, a Fellow of IET, a Fellow of Higher Education Academy, a Senior Member of IEEE, and a founder member of IEEE Systems, Man, and Cybernetics society's Technical Committee on Brain-Machine Interface Systems. In 2017, he was awarded the Fellowship of International Academy of Physical Sciences (IAPS) India, and the Senior Distinguished Research Fellowship of Ulster University. Prof. Prasad joined Ulster University, as a Lecturer in 1999; he was promoted to Senior Lecturer in 2007, Reader in 2008, and Professor in 2011. Previously he worked in industry first as a Digital Systems Engineer and then as a Power Plant Engineer in India, and as a Research Fellow on an EPSRC/industry project at Queen's University of Belfast, UK.

His research interests are in intelligent systems, data engineering, brain modelling, brain-computer interface (BCI) & neuro-rehabilitation, and assistive technology. Under his supervision, an advanced rehabilitation protocol has been developed incorporating an active physical practice stage followed by a mental practice stage, using a neuro-rehab system consisting of a robotic hand exoskeleton and an EEG/EEG-EMG based BCI, which has been trialled on groups of chronic stroke patients in UK as well as India, resulting in transformative change in patients' quality of life. He has published over 285 research papers in journals, edited books, and conference proceedings. He has supervised to completion 22 PhD students. His research has attracted 18 research grant awards amounting to over £10M funding from national and international agencies including Invest Northern Ireland, Department of Employment and Learning, Research Councils UK (RCUK), Leverhulme Trust, Royal Society, UK India Education and Research Initiative (UKIERI), UK Research and Innovation (UKRI) and Irish industry.

Websites: https://pure.ulster.ac.uk/en/persons/girijesh-prasad ; https://scholar.google.com/citations?view_op=list_works&hl=en&hl=en&user=xPw66a0AAAAJ

Lecture title: Non-invasive brain-computer interfaces: Enhancing applicability using computational intelligence and technological advances

Synopsis: A Brain-Computer Interface (BCI), also known as Brain-Machine Interface (BMI), utilizes neuro-physiological correlates of voluntary mental tasks to facilitate direct communication between human brain and computing devices without the involvement of neuro-muscular pathways. The BCI research is, in general, progressing in two main areas: augmentative & alternative communication (AAC) by replacing neuromuscular pathways and neuro-rehabilitation by helping to activate desired cortical areas for targeted brain plasticity. Current BCI systems however, lack sufficient robustness and performance variability among users is quite high. One of the critical limitations is because of the non-stationary characteristics of brain's neurophysiological responses, which makes it hard to extract time-invariant stable features unique to voluntary mental tasks.

In this talk, the presentation will first briefly review state-of-the-art BCI research and then discuss our computational intelligence supported R&D towards robust BCI design using multi-modal neuroimaging techniques and our current application focus in post-stroke neuro-rehabilitation. In particular, it will be discussed how integrating an EEG-EMG based BCI and hand exoskeleton results into a personalized post-stroke neuro-rehabilitation system that ensures active and engaging exercises and leads to enhanced recovery of the paralyzed upper limbs. Also to take advantage of MEG's highest spatiotemporal resolution (306 channels, Elekta Neuromag TRIUX, recorded at 1k Hz) of all neuroimaging modalities, the development of an MEG-based BCI controlling an MEG compatible hand exoskeleton located in a magnetically shielded room (MSR) will be discussed. It will be discussed how using multi-modal neuroimaging modalities facilitates understanding the neuronal mechanisms involved in motor recovery of stroke patients. Finally the remaining R&D challenges will be highlighted.

Damien Coyle

Bio: Damien Coyle, Professor of Neurotechnology, is Director of the Intelligent Systems Research Centre at Ulster University's Magee Campus. He has published over 150 research papers in areas such as computational intelligence/AI, bio-signal processing, computational neuroscience, neuroimaging, neurotechnology and brain-computer interface (BCI) applications and has won a number of prestigious international awards for his R&D including the 2008 IEEE Computational Intelligence Society (CIS) Outstanding Doctoral Dissertation Award, the 2011 International Neural Network Society (INNS) Young Investigator of the Year Award and the IET and E&T Innovation of the Year Award 2018. He was an Ulster University Distinguished Research Fellow in 2011, a Royal Academy of Engineering/The Leverhulme Trust Senior Research Fellow in 2013, a Royal Academy of Engineering Enterprise Fellow in 2016-2017 and is currently a UKRI Turing AI Fellow 2021-2025. He is a founding member of the International Brain-Computer Interface Society, a Senior member of the IEEE, chairs the IEEE Computational Intelligence Society (CIS) UKIreland chapter, is the IEEE CIS representative and member on the steering committee of the IEEE Brain Technical Community and UK KTN Neurotechnology Innovation Network advisory board member. He is Ulster lead of the Spatial Computing and Neurotechnology Innovation Hub (SCANi-hub) and the Northern Ireland High Performance Computing Facility (NIHPC) and co-investigator in Northern Ireland Functional Brain Mapping Facility (NIFBM) and lead a number of industry led data analytics projects via Ulster's Cognitive Analytics Research Laboratory (CARL). He is Founder and CEO of NeuroCONCISE Ltd, an award-winning, AI-enabled, wearable neurotechnology company.

More information: https://pure.ulster.ac.uk/en/persons/damien-coyle; https://www.neuroconcise.co.uk/

Lecture title: Decoding mental imagery from electroencephalography (EEG) and applications of AI-enabled wearable neurotechnology for communication and rehabilitation

Lecture synopsis: Research in the field of brain–computer interfaces (BCIs) and neurotechnology has proven that electrical signals in the brain, modulated intentionally by mental imagery, can relay information directly to a computer, where it is translated by intelligent algorithms (some inspired by the brain's neural networks) into control signals that enable communication and control without movement or can improve self- regulation of brain activity. This talk will present results from research at Intelligent Systems Research Centre that shows people with restricted abilities resulting from disease, injury or trauma may benefit from neurotechnology, including those who have prolonged disorders of consciousness or locked-in syndrome following traumatic brain injury, spinal injury, stroke and post-traumatic stress disorder. Neural activity can be modulated

by many kinds of mental imagery e.g., classical motor imagery BCIs distinguish between imagined hand/arm movements. This presentation will also show recent results in decoding imagined three-dimensional limb movements, imagined primitive shapes, emotion inducing imagery and silent/imagined speech from EEG. The presentation will attempt to address the question is it feasible to expect high and robust performance with these types of imagery in EEG-based BCIs and will highlight results which indicate user proficiency in BCI control is a matter of training time, machine learning/AI ability, application of the technology and maintenance of stable affective states. A number of neurogaming applications that enhance BCI user training will be demonstrated.

Talk title: Translating AI-enabled, neurotechnology research and experiences of developing an award winning neurotech startup

Talk synopsis: Training over multiple sessions is certainly key to learning how to modulate brain activity via a motor imagery and this involves the collection of large dataset from multiple users. An award-winning AI-enabled wearable neurotechnology platform that may enable this, developed by NeuroCONCISE Ltd, will be presented along with an overview of the challenges and opportunities of developing a neurotech startup.

Nikola Kasabov

Bio: Nikola Kasabov is Fellow of IEEE, Fellow of the Royal Society of New Zealand, Fellow of the INNS College of Fellows, DVF of the Royal Academy of Engineering UK. He is the George Moore Chair Professor of Data Analytics at the Intelligent Systems Research Center of the University of Ulster and also Professor of Knowledge Engineering at the School of Engineering, Computing and Mathematical Sciences at Auckland University of Technology, New Zealand. Kasabov is the Past President of the Asia Pacific Neural Network Society (APNNS) and of the International Neural Network Society (INNS). He is Editor of Springer Handbook of Bio-Neuroinformatics, Springer Series of Bio-and Neurosystems and Springer journal Evolving Systems. He is Associate Editor of several journals, including Neural Networks, IEEE TrNN, Tr CDS, Information Sciences, Applied Soft Computing. Kasabov holds MSc and PhD from TU Sofia, Bulgaria. His main research interests are in the areas of neural networks, intelligent information systems, soft computing, bioinformatics, neuroinformatics. He has published more than 650 publications. He has extensive academic experience at various academic and research organisations in Europe and Asia, including: TU Sofia Bulgaria; University of Essex UK; University of Otago, NZ; Advisory Professor at Shanghai Jiao Tong University and CASIA China, Visiting Professor at ETH/University of Zurich. Prof. Kasabov has received a number of awards, among them: Honorary Professor of the University of Auckland, NZ; Honorary Professor at the Teesside University UK; Doctor Honoris Causa from Obuda University, Budapest; INNS Ada Lovelace Meritorious Service Award; NN Best Paper Award for 2016; APNNA 'Outstanding Achievements Award'; INNS Gabor Award for 'Outstanding contributions to engineering applications of neural networks'; EU Marie Curie Fellowship; Bayer Science Innovation Award; APNNA Excellent Service Award; RSNZ Science and Technology Medal; 2015 AUT Medal; Honorable Member of the Bulgarian, the Greek and the Scottish Societies for Computer Science. More information: https://academics.aut.ac.nz/nkasabov;https://www.ulster.ac.uk/staff/nk-kasabov

Lecture title: Brain-inspired spiking neural network models for life-long and explainable learning

Synopsis: The lecture introduces the third generation of artificial neural networks, the spiking neural networks (SNN), as the latest methods and systems for neuro-inspired computation, along with their numerous applications. SNN are not only capable of deep learning of temporal or spatio-temporal data, but also enabling the extraction of knowledge representation from the learned data. Similarly, to how the brain learns, these SNN models do not need to be restricted in number of layers, neurons in each layer, etc. as they adopt self-organising learning principles of the brain [ref. 1,2].

The lecture consists of 3 parts:

1. Fundamentals of SNN
2. Brain-inspired SNN architectures. NeuCube.
3. Algorithms for life-long and explainable learning in NeuCube
4. Design and implementation of selected applications

The material is illustrated on an exemplar SNN architecture NeuCube (free software and open source available from www.kedri.aut.ac.nz/neucube). Case studies are presented of brain and environmental data modelling and knowledge representation using incremental and transfer learning algorithms. These include: predictive modelling of EEG and fMRI data measuring cognitive processes and response to treatment; prediction dementia and AD [3]; understanding depression; predicting environmental hazards and extreme events; moving object recognition and control; brain-inspired audio-visual information processing.

It is also demonstrated that SNN allow for knowledge transfer between humans and machines through building brain-inspired Brain-Computer Interfaces (BI-BCI) [4]. These are used to understand human-to-human knowledge transfer through hyper-scanning and also to create brain-like neuro-rehabilitation robots. This opens the way to build a new type of AI systems – the open and transparent AI.

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Eleni Vasilaki

Bio: Eleni Vasilaki is Professor and Chair of Bioinspired Machine Learning and the head of the Machine Learning Group in the Department of Computer Science at the University of Sheffield, UK. Inspired by biology, Prof. Vasilaki and her team design novel machine learning techniques with a focus on reinforcement learning and reservoir computing. She also works closely with material scientists and engineers to design hardware that computes in a brain-like manner.

Lecture title: Sparse reservoir computing

Synopsis: "Sparse" neural networks, in which relatively few neurons or connections are active, are common in both machine learning and neuroscience. Whereas in machine learning, "sparsity" is related to a penalty term that leads to some connecting weights becoming small or zero, in biological brains, sparsity is often created when high spiking thresholds prevent neuronal activity. Here we introduce sparsity into a reservoir computing network via neuron-specific learnable thresholds of activity, allowing neurons with low thresholds to contribute to decision-making but suppressing information from neurons with high thresholds. This approach, which we term "SpaRCe", optimises the sparsity level of the reservoir without affecting the reservoir dynamics. The read-out weights and the thresholds are learned by an online gradient rule that minimises an error function on the network's outputs. Threshold learning occurs by balancing two opposing forces: reducing inter-neuronal correlations in the reservoir by deactivating redundant neurons while increasing the activity of neurons participating to correct decisions. We test SpaRCe on classification problems and find that threshold learning improves performance compared to standard reservoir computing. SpaRCe alleviates the problem of catastrophic forgetting, a problem most evident in standard echo state networks and recurrent neural networks in general, due to increasing the number of task-specialised neurons that are included in the network decisions.

Jim Harkin

Bio: Jim Harkin holds a Bachelor of Technology, MSc and PhD in Electronic Engineering. He was employed as a post-doctoral researcher in embedded system design at Ulster for 3 years before taking up the post of Lecturer in 2004. He is currently Head of the School of Computing, Engineering and Intelligent Systems at Ulster University on the Magee Campus. His research investigates the design of highly efficient, secure, and reliable embedded systems that emulate bio-inspired computational and fault tolerance capabilities. In particular, he focuses his efforts on the development of the brain-inspired EMBRACE architecture which aims to address electronic reliability challenges by investigating new paradigms of Networks-on-Chip interconnect and harnessing the principles of brain-like repair. His work also explores how neural networks in hardware can be used in Networks-on-Chip interconnect for security and traffic congestion awareness.

Lecture title: Building reliable and secure embedded systems with neuromorphic computing

Synopsis: The demand for increasingly more 'intelligent' computing systems has to be viewed through the explosion of their complexity. An important knock-on effect however, is degradation in reliability: designing reliable electronic systems is a major challenge. Self-repair is critical in hardware systems where long-term reliable performance is not guaranteed. Increasing gate densities, scaling to sub-nanometer geometries and variations in silicon manufacturing result in additional challenges.

Current self-repairing hardware approaches rely on a central controller, with constraints placed on the type and number of faults (e.g. open/short-circuits) and repair granularity. There is a pressing need to progress beyond these concepts and look for inspiration from biology.

While state-of-the-art hardware devices and neuromorphic chips replicate to an extent a brain information processing paradigm, they are not fault-tolerant and can develop faults due to incorrect operations in post manufacturing, wear-out failures, or radiation effects. Nonetheless, the human brain does exhibit high levels of distributed repair and more recently it has emerged that interactions between astrocyte cells and spiking neurons provide a distributed repair paradigm that has the potential to advance progress in establishing new approaches to reliable information processing in hardware.

This lecture establishes the current challenges in capturing self-repair capabilities in electronic hardware and outlines progress in addressing the interconnect complexity in the communication of vast quantities of information while enabling large-scale hardware implementations of self-repairing neural networks. In addition, methods for the acceleration of such neural networks in hardware will be discussed and remaining challenges in future deployment. Example applications of SNNs in hardware security for the detection of anomaly traffic and in the prediction of traffic congestion will also be presented.

Hava Siegelmann *(Distinguished External Speaker)*

Bio: Hava Siegelmann is an internationally known professor of Computer Science and a recognized expert in neural networks. She is core member of the Neuroscience and Behavior Program, and director of the Biologically Inspired Neural and Dynamical Systems (BINDS) Laboratory at the University of Massachusetts. She is particularly known for her ground-breaking work in computing beyond the Turing limit, and for achieving advanced learning capabilities through a new type of Artificial Intelligence: Lifelong Learning.

Siegelmann conducts highly interdisciplinary research in next generation machine learning, neural networks, intelligent machine-human collaboration, computational studies of the brain - with application to AI, data science and high-tech industry. She is a leader in increasing awareness of ethical AI and in supporting minorities and women in AI and STEM fields all over the world. Siegelmann has been a visiting professor at MIT, Harvard University, the Weizmann Institute, ETH, the Salk Institute, Mathematical Science Research Institute Berkeley, and the Newton Institute Cambridge University.

Her list of awards includes the Obama Presidential BRAIN Initiative award, the Donald O. Hebb Award of the International Neural Network Society (INNS) for "contribution to biological learning"; she was named a Distinguished Lecturer of the IEEE Computational Intelligence Society and was given DARPA's Meritorious Public Service award. Siegelmann is a Fellow of both the IEEE and the INNS.

Lecture title: Lifelong Learning AI via neuro inspired solutions

Synopsis: AI embedded in real systems, such as in satellites, robots and other autonomous devices, must make fast, safe decisions even when the environment changes, or under limitations on the available power; to do so, such systems must be adaptive in real time. To date, edge computing has no real adaptivity – rather the AI must be trained in advance, typically on a large dataset with much computational power needed; once fielded, the AI is frozen: It is unable to use its experience to operate if environment proves outside its training or to improve its expertise; and worse, since datasets cannot cover all possible real-world situations, systems with such frozen intelligent control are likely to fail.

Lifelong Learning is the cutting edge of artificial intelligence - encompassing computational methods that allow systems to learn in runtime and incorporate learning for application in new, unanticipated situations. Until recently, this sort of computation has been found exclusively in nature; thus, Lifelong Learning looks to nature, and in particular neuroscience, for its underlying principles and mechanisms and then translates them to this new technology. Our presentation will introduce a number of state-of-the-art

approaches to achieve AI adaptive learning, including from the DARPA's L2M program and subsequent developments.

Many environments are affected by temporal changes, such as the time of day, week, season, etc. A way to create adaptive systems which are both small and robust is by making them aware of time and able to comprehend temporal patterns in the environment. We will describe our current research in temporal AI, while also considering power constraints.

Arleen Salles

Bio: Arleen Salles is a Senior Researcher in philosophy at the Center for Research Ethics and Bioethics (CRB) at Uppsala University, Director of NeuroeticaBA (Buenos Aires, Argentina), a tenured professor of philosophy at Universidad Argentina de la Empresa (Buenos Aires, Argentina), Principal Investigator in FLACSO (Facultad Latinoamericana de Ciencias Sociales), and also affiliated to Weill Cornell Medical College (NY, United States). She is the Deputy Leader of the Responsible Research and Innovation Work Package of the EU-flagship Human Brain Project where she is a researcher and leads the task Neuroethics and Engagement. She is also member of the executive board of the International Neuroethics Society, founding board member of the Institute of Neuroethics, and member of the International Brain Initiative's Neuroethics Working Group. Salles received her M.A and Ph.D in philosophy from State University of New York at Buffalo, USA.

Salles' scholarship focuses on: (a) the ethical, social, and epistemological issues related to neuroscientific findings and its diverse applications, (b) disciplinary issues such as the nature of neuroethics and its potential for collaborating with other disciplines, and (c) methodological issues regarding how to integrate ethical and societal considerations into brain research and emerging technologies. In particular, she is interested in responsible innovation, engagement, and the development of a culturally engaged neuroethics.

Lecture title: Ethical and regulatory issues in neurotechnology

Synopsis: The development and use of a large variety of invasive and non-invasive technologies that interface with the brain show promise in a number of contexts. At the same time, as neurotechnologies continue to advance and the range of applications increase, so has awareness of the ethical and societal issues raised, including questions about their potential impact on our belief system and our humanness itself. A few articles and documents describing salient ethical issues and articulating approaches to understanding them have been published, as have some general recommendations and guidelines intended to help find a regulatory solution to some of ethical issues raised. In this talk, I present an overview of these attempts, discussing their promises and challenges.

Amanda Fullerton

Bio: Amanda Fullerton In 2004, Amanda Fullerton joined Ulster University's Knowledge Transfer Partnerships Office (KTP) to work with Northern Ireland industry partners and the University's research experts to help them develop high-quality, fundable, KTP proposals. Amanda was later appointed as the University's KTP Programme Manager (2013) where her main role has been to develop and grow the University's KTP portfolio, aligned with the University's overall focus to stimulate and support the development of commercial partnerships between academics and businesses, with particular emphasis on research capabilities and academic resources. Amanda continues to play a leadership role in the generation and management of KTPs across the University, and to manage the business and academic relationships during the delivery of each project.

Talk title: KTPs – Bridging academia and business and supercharging graduate careers

Synopsis: For 45 years, Knowledge Transfer Partnerships (KTPs) have been helping businesses innovate for growth. They do this by connecting businesses that have an innovation idea with the university expertise to help deliver it. In effect, they link forward thinking businesses with world-class University researchers to deliver innovation projects led by inspired graduates.

Ulster University has been engaged in KTP since its inception, having continuously regarded the KTP programme as an excellent pathway for generating strategic knowledge transfer opportunities with business partners to improve their performance whilst also demonstrating the impact of the University's research.

The presentation will demonstrate the key benefits of KTPs for businesses, academic researchers and will have a particular emphasis on how the programme helps graduates in their careers by managing a challenging, innovative project central to a business's strategic development and long term growth. The presentation will conclude with a profile of a current KTP Associate who has been selected as a finalist in the 'Future Leaders' category of this year's National KTP Awards.

Mark Gorman

Bio: Mark Gorman joined the Data Science Group (DSG) at Seagate in 2020, working on improving the value extracted from the data collected in the semiconductor wafer manufacturing process. Mark received his B.Sc. in Mathematics from Queen's University Belfast in 2013, M.Sc. in Computational Intelligence from Ulster University in 2014 and is currently enrolled as a part-time PhD Researcher within the ISRC Ulster University, Magee campus. His Ph.D. project is focused on unsupervised anomaly detection applied to multivariate time series semiconductor multi-modal datasets. Prior to his current role in Seagate, Mark was the lead Data Scientist for The LYCRA Company, Equipment Data Scientist and Factory Analytics and Control Systems Engineer from 2014 to 2020.

Lecture title: Time series analytics of IoT sensor data – An industry challenge perspective

Synopsis: : Industry 4.0 [1] and Smart Manufacturing [2] are initiatives that accurately capture the disruption within the manufacturing sector as a result of improving technological availability and the increasing adoption rate of said technologies. Intelligent manufacturing is an important contributor to the advancement of modern industries and economies [3]. Specifically, the Semiconductor sector, with its highly competitive market, has embraced these initiatives to drive operational efficiency, yield improvement and deliver best-in-class product quality for customers. Important interconnected areas of interest are the application of Machine Learning (ML) [4] and Deep Learning (DL) [5] to datasets generated through the Industrial Internet of Things (IIOT) [6]. Time series anomaly detection is a methodology of detecting anomalous equipment operating behaviour using data collected through sensors installed within the process equipment. Application of statistical methods, ML [4] and DL [7]–[10] to large time-series datasets highlight potential faults within the system that require further Engineering scrutiny. Initially, sensors can be used to detect and contain process deviations so that stability and quality can be restored through maintenance activities. However, signals may exist to predict and prevent fault occurrence, also referred to as Predictive Maintenance (PdM), so that Engineering teams may intervene further reducing the impact on the factory throughput and overall supply chain [11]. Furthermore, a significant challenge exists in the orchestration of models in a production environment. Model deployment, versioning, and continuous improvement in a high volume, high process mix facility requires significant resources and is the single largest restriction in continued value creation from DL and ML in the production environment. The presentation will explore Seagate's approach to these challenges, the technologies implemented and the subsequent value creation opportunities.

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Profiles of teaching assistants

Senhui Qiu

Bio: Senhui Qiu received his B.Sc. in Physics from Guangxi University for Nationalities, China in 2010. He received his M.Sc. in Circuits and Systems from Guangxi Normal University, China in 2013. He is currently a Ph.D. researcher at Ulster University's School of Computing, Engineering, and Intelligent Systems in the UK. His research focuses on predictive coding, time series classification and prediction.

Brendan Lenfesty

Bio: Brendan Lenfesty received his B.Sc. in Computer Science in 2021 from Ulster University, Magee campus. He is currently studying for a Ph.D. in Computational Modelling and Machine Learning in Decision Neuroscience at Ulster University's Magee campus. His research focuses on using computational modelling and machine learning to gain further knowledge of abstract decisions and the mechanistic processes that underly perceptual decisions.

Abdoreza Asadpour

Bio: Abdoreza Asadpour received his B.Sc. in electrical engineering from the University of Tehran, Iran in 2007, his M.Sc. in bioelectrical engineering from Sharif University of Technology, Tehran, Iran in 2010, and his Ph.D. in electrical engineering from the same institution in 2019. He is currently a postdoctoral research associate in computational neuroscience at Ulster University's School of Computing, Engineering, and Intelligent Systems in the United Kingdom. His research focuses on the neuroscience of decision-making, the effective connectivity of neuroimaging data, and biomedical signal and image processing.

Aqib Javed

Bio: Aqib Javed received the B.Eng. and M.Eng. degree in electrical engineering from the COMSATS Institute of Information Technology, Abbottabad, Pakistan, in 2014 and 2016, respectively. He is currently finalising his PhD in Computing Engineering from School of Computing, Engineering and Intelligent Systems at Ulster University, UK with the support of a Vice-Chancellor's Research Scholarship (VCRS). His research emphasis on HW/SW implementation and applications of spiking neural networks, and performance enhancement of on-chip interconnect networks.

Marinus Toman

Bio: ***Please refer to the profile above (Page 22).***

City of Derry ∼ Londonderry in Northern Ireland

Located in the Northwest of Ireland where The Wild Atlantic Way meets the Causeway Coastal Route, the vibrant city of Derry Londonderry is renowned for one of the finest Walled Cities in Europe and home to award winning museums, some of the islands best cultural attractions and a variety of lively festivals and events; Derry Londonderry offers a vibrant social scene where your visitors are guaranteed the warmest of welcomes and hospitality. For delegates looking to experience the local culture, the city walls surround cosy pubs with live music, award-winning museums that tell stories from times past, and vibrant eateries that serve up LegenDerry Food.

This is a special wee place like no other. Our unique geography and diverse climate create the ideal conditions for our food and drink industry to flourish. Our produce harvested and crafted locally from both 'land and lough' is influenced by the latest food trends worldwide. The shores of Lough Foyle provide a vast array of shellfish with the Lough Foyle Irish Flat Oyster being the jewel in the Foyle's crown.

Derry Londonderry offers a plethora of choice when it comes to choosing where to stay, with options available to suit everyone's budget and taste. So, whether you want to stay in the heart of the city action, or somewhere a little quieter, you'll have plenty to choose from. From international hotel brands, boutique designer hotels right through to five-star self-catering accommodation, including comfortable Bed & Breakfasts and guest houses – we've got them in abundance.

There's so much to discover in the Walled City with bucket loads of activities to suit

all tastes. Derry is home to it all! Discover our 400-year-old City Walls, award-winning museums and theatres or why not try your hand at one of our water attractions, like Stand-Up Paddle-boarding. Take a step through history and go on a walking tour – we promise they won't disappoint. Or perhaps you would like to discover all things Derry Girls – no problem. If it's a Derry Girls themed afternoon tea, or screen walking tour you're after then we've got that on offer too. There really is something for everyone in the city; be inspired by the options below or build your own itinerary from our planner. Don't forget to buy our Visit Derry pass which means you can explore the city and enjoy access to several of the city's top tourist attractions.

Further information:

- Visit Derry (https://www.visitderry.com/)
- Discover Northern Ireland (https://discovernorthernireland.com/information/product-catch-all/visit-derry-information-centre-p689591)
- Derry City and Strabane (https://www.derrystrabane.com/What-s-On/Tourist-Information)

Some nearby accommodations:

As the Autumn School is held in the middle of a semester, on-campus accommodation is usually no longer available. However, the city has ten 4-star hotels within a five-mile radius of the city centre, from award winning boutique hotels to larger hotel groups. For more information, please visit https://www.visitderry.com/accommodation

Ulster University has a rate with City Hotel, Derry of £85 Bed & Breakfast. If you would like to book, please email Louise at l.gallagher@ulster.ac.uk to let us know and we will forward your name to City Hotel so that you can avail of this preferred rate.

The Art House and Jazz House (both Clarence property), besides the campus, can be booked and shared among attendees.

Other nearby accommodation include:

- Shipquay Hotel
- Holiday Inn Express Derry
- Maldron Hotel Derry
- Da Vinci's Hotel
- Bishop's Gate Hotel Derry
- Premier Inn Derry Hotel

and others. There are also several economical Bed and Breakfasts and Hostels.

On campus eateries (opened during daytime):

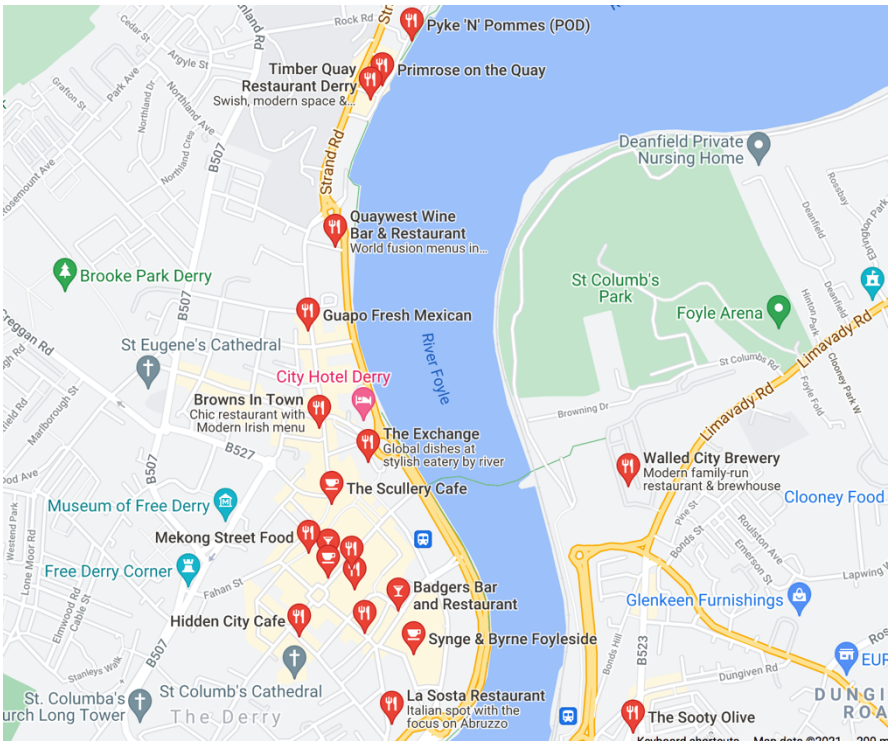
- Jitters (in MG building)
- Bunker Café (in MF building – entrance at the back)
- Scullery Magee (in MU building)

Nearby restaurants and eateries:

- Guapo (Fresh Mexican)
- Pyke 'N' Pommes (in a bus, along the Foyle River; or one along Strand Road)
- Florentini
- Quaywest
- Mama Masala
- Timber Quay Restaurant Derry
- Saffron Modern Indian Restaurant
- Mandarin Palace
- Browns in Town
- Browns Bonds Hill
- Primrose on the Quay (along Foyle River)

- Patricia's Coffee House (along Foyle River)
- Shipquay Restaurant
- The House / Entrada Restaurant
- Zora's
- Domino's Pizza (cityside)
- Mekong Street Food
- El Tapas Gra
- Walled City Brewery
- La Sosta Restaurant

etc.



Bars and pubs:

- Paedar O'Connell's
- Blackbird
- Sandino's Café Bar
- The Trinity Bar
- Guildhall Taphouse
- Bennigans Bar
- Granny Annie's
- Grand Central Bar
- The Diplomat Bar
- The Gweedore Bar

etc.

Derry Halloween (28-31 October, 2021):

- https://derryhalloween.com/
- https://www.visitderry.com/whats-on/derry-halloween-p754101
- https://www.independent.co.uk/travel/uk/derry-best-halloween-destination-world-europe-carnival-northern-ireland-a9156566.html

Ulster University, Magee campus

The Magee campus of Ulster University in the city of Derry Londonderry, is one of four campuses in Northern Ireland: https://www.ulster.ac.uk/campuses/magee

It is the oldest campus with a history, dating back to the year 1865.

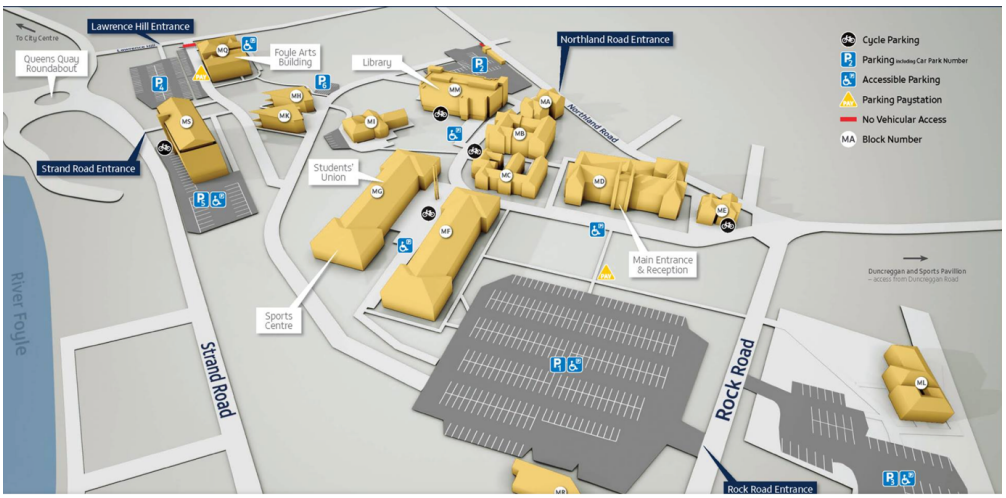
Magee campus map:

- https://www.ulster.ac.uk/pdf/campus-maps/magee-campus-map.pdf
- Google Map: https://www.google.com/maps/d/viewer?mid=1gdsugbd1SrO_vMTlhmyxvojrR-I&ie=UTF8&t=h&oe=UTF8&msa=0&ll=55.00240881516382%2C-7.321874999999995&z=16

How to get to Derry Londonderry and Magee campus?

The MS building at Magee campus lies on Strand Road opposite the Derry City and Strabane District Council.

By Air: The City of Derry airport (https://www.cityofderryairport.com/) is the nearest airport. Or you may fly to Belfast International Airport (https://belfastairport.com/), the next closest airport, or George Best Belfast City Airport (https://www.belfastcityairport.com/). The City of Derry airport (https://www.cityofderryairport.com/destinations/) is only 7 miles from Derry Londonderry city centre. Direct flights from London Stansted, Manchester, Liverpool, Glasgow and Edinburgh. From Belfast



International Airport (https://belfastairport.com/) or George Best Belfast City Airport (https://www.belfastcityairport.com/), it is 1 hour 15 minutes and 1 hour 30 minutes from Derry Londonderry city centre (see coach below), respectively. From Dublin airport (https://www.dublinairport.com), it is 2 hours 45 minutes to Derry Londonderry by car or bus.

By rail: Take the Translink (https://www.translink.co.uk/) NI Railways (https://www.translink.co.uk/corporate/monitoringresults/nirailways) and stop at Derry Londonderry train station. For example, from Belfast Great Victoria train station, to Derry Londonderry train station, it takes about 2 hours. To go from Dublin (Dublin City, Connolly Rail Station) to Derry Londonderry train station, you have to change trains at Belfast Lanyon Place (formerly Belfast Central) train station. There is (some) wifi service on the trains but no food service. It is better to consume or takeaway food at a train station.

By Bus: There are many buses. For example, bus 212 takes you from Belfast's Europa bus station (besides Belfast Great Victoria Station) to Derry Londonderry bus station in about 1.5 hours. There are also buses (Dublin Coach Services https://www.translink.co.uk/usingtranslink/specialoffers/dublincoachwebsaver) straight from Dublin Airport to Derry Londonderry bus station and back or from Dublin Busáras Bus (https://www.buseireann.ie/) to Derry Londonderry bus station. This is about 4 hours of journey with a break halfway. There is also an economic coach (Aircoach https://www.aircoach.ie/) from Dublin Airport straight to Belfast city, near the Belfast Great Victoria train station and Europa bus station (see above).

By Airporter (bus/coach): From the City of Derry and two Belfast airports, a convenient way to travel is to take the Airporter coach (https://airporter.co.uk/).

Car hire and taxi service available from airports.

By taxi: Ask the taxi driver to stop at The Gatelodge, which is besides the MS building.

Driving from Strand Road/from Quayside roundabout

After turning in from Strand Road, please slow down and take a first turn on the left after the roundabout and after the traffic lights.

Driving from Foyle Bridge: Pass the Derry City and Strabane District Council, then do a U-turn at a roundabout and slow down and take the first turn on the left right after the traffic lights.

On campus parking:

To park at the ISRC / MS building (parking space P5 – see campus map), collect a parking ticket and use an available parking space underneath the MS building.

Go back to the front entrance, please press the disabled door opener and register at the reception someone. Please take a seat and one of our team members will be with you shortly.

There are also other parking spaces. The largest on campus parking space is P1 facing the neo-gothic-looking MD building.

Off campus parking:

To park outside the campus, nearby parking spaces include the Strand Road Car Park, Quayside Shopping Centre & Car Park, and Foyle Street Car Park. However, for the evening lab sessions, it is advisable to park on campus. For instance, if you happen to park outside campus e.g. due to lack of available on-campus parking space, then during dinner break, for convenience, you may wish to move your car and park on campus when it becomes less crowded.

Intelligent Systems Research Centre & Autumn School

Address of our Research Centre:

Intelligent Systems Research Centre,
School of Computing, Engineering and Intelligent Systems,
Faculty of Computing, Engineering and the Built Environment,
Ulster University,
Magee campus
Northland Road,
Derry Londonderry,
BT48 7JL,
Northern Ireland, UK

Note: The Intelligent Systems Research Centre is also the MS building on Magee campus.

COVID-19 – Health and Safety Guidelines

We greatly appreciate those who are attending this event in person, despite the ongoing COVID-19 pandemic.

By attending the ISRC-CN^3 in person, you acknowledge that any interaction with the general public poses an elevated risk of being exposed to COVID-19. You further acknowledge that you will undertake all measures to protect your own health and well-being and those of others in attendance at the ISRC-CN^3 Autumn School, such measures include:
(a) wearing masks/facial coverings;
(b) maintaining social distance;
(c) washing/sanitizing hands frequently;
(d) adhering to United Kingdom guidelines at https://www.gov.uk/coronavirus, the Northern Ireland guidelines at https://www.nidirect.gov.uk/articles/coronavirus-covid-19-how-stay-safe-and-help-prevent-spread and https://www.nidirect.gov.uk/campaigns/coronavirus-covid-19 , Ulster University's guidelines at https://www.ulster.ac.uk/coronavirus , and laws, ordinances and mandates in the locale of the Autumn School at https://www.derrystrabane.com/Council/Corona-Virus-Advice/Updates

Within the campus, please remember to follow the directions in placed, use hand sanitizers frequently, and cover your face with a face mask when indoor. If you have symptoms of COVID-19, please self-isolate. COVID-19 vaccination is highly encouraged before in-person attendance of the Autumn School.

Finally, by attending ISRC-CN^3, you and any guests voluntarily assume all risks related to exposure to COVID-19 and agree not to hold ISRC-CN^3; Ulster University; or any of their affiliates, directors, officers, employees, agents, contractors, or volunteers are not liable for any illness or injury.

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