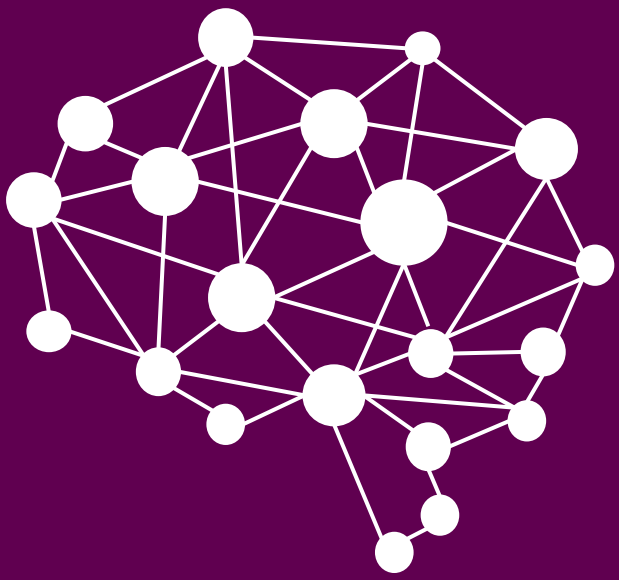
AI, Neuroscience and Aging



27th of November 2023

Eva & Georg Klein, Solnavägen 9, Karolinska Institutet, Stockholm, Sweden

Organization

The aim of this symposium is to unite top Swedish and Italian researchers in neuroscience and AI, encouraging a dynamic exchange of pioneering ideas and promoting a deep interdisciplinary collaboration. Our goal is to explore innovative intersections between neural mechanisms and AI, striving to unlock new applications in cognitive function and healthcare. Together, we will delve into real-world applications and the ethical issues that surround these cutting-edge fields. Through this event, we seek to forge lasting partnerships and set the stage for groundbreaking joint research initiatives that could redefine our understanding of intelligence, both human and artificial.

Associate Professor
Joana B. Pereira
Karolinska Institutet
(See Page 11)

Scientific Attaché &
Professor
Augusto Marcelli
Italian Embassy
(See Page 16)

Professor
Giovanni Volpe
Gothenburg University
(See Page 13)

Support

Clinical Neurosciences Department, KI
Strategic Area in Neuroscience, KI
Center for Cognitive and Computational Neuropsychiatry, KI

digital futures

Schedule

Monday, 27th of November

12:45 - 13:00	Registration	Biomedicum KI Solna
13:00 - 13:15	Welcoming words by:	
	Director of Strategic Area in Neurosciences	Konstantinos Meletis *Karolinska Institutet*
	Italian Minister Representative	Giuseppe Lauria *Counselor to the Italian Minister of Health*
	Levi-Montalcini Foundation	Piera Levi-Montalcini *President of the Foundation (will join by Zoom)*
13:15 - 13:20	Brief introduction to the event	Joana B. Pereira *Karolinska Institutet*
1st Part *- Chair: Daniel Lundqvist* *Director of Center for Imaging Research*		
13:20 - 13:35	Epidemiology of rare neurodegenerative diseases: relevance for science and public health	Giancarlo Logroscino *University of Bari*
13:40 - 14:00	Brain molecular imaging as predictive tools for precision medicine in prodromal stages of neurodegeneration	Silvia Morbelli *University of Genoa*
14:05 - 14:20	Abnormal cortical EEG rhythms of vigilance in Alzheimer's and related diseases	Claudio Babiloni *University of Rome*
14:25 - 14:40	Normative modeling for neuroimaging sciences	Mattia Veronese *University of Padua*
14:45 - 15:15	Coffee break	Biomedicum mingle room

***2nd Part** - Chair: Eric Westman* *Head of Clinical Geriatrics Division*		
15:15 - 15:30	Analysis of brain connectivity with multilayer networks and deep learning	Joana B. Pereira *Karolinska Institutet*
15:35 - 15:50	Modern AI and speech technology for a secure and private interpretation system	Shahid Jabbar *Mabel AI, Gothenburg*
15:55 - 16:10	DeepTrack: A deep learning framework for microscopy	Giovanni Volpe *University of Gothenburg*
16:15 - 16:30	AI as a tool in microscopy-based life science research	Carolina Wählby *University of Uppsala*
16:35 - 16:50	Beyond the Hype: a realistic look at AI in Neurosciences	Andrea Chincarini *Istituto Nazionale di Fisica Nucleare*
16:55 - 17:00	Conclusion	Giovanni Volpe *University of Gothenburg*

Registration

Due to limited space, only registered participants can attend the event.

In order to register, please fill the following registration form: https://forms.office.com/e/PfMYJZuJXw no later than 20th of November 2023.

We would appreciate that you only register if you are sure you will be attending and unregister if you cannot make it by sending an email to nilla.karlsson@ki.se.

Giancarlo Logroscino

Professor in Neurology at the University of Bari

Giancarlo Logroscino (MD, PhD) is the director of the Neurodegenerative Diseases Unit of The University of Bari and Chair of the Center for Neurodegenerative Diseases and Aging Brain Uniba at Pia Fondazione Panico in Tricase (LE). He is a Full Professor of Neurology at University of Bari and has been trained in Neurology (University of Bari) and Epidemiology (PhD, Columbia University NYC). He was an Associate Professor of epidemiology and neurology at Harvard University (2002-2008). His primary research interests are natural history of neurodegenerative diseases and environmental risk factors for neurodegenerative diseases related to aging. He has conducted studies on Parkinson's disease, Amyotrophic Lateral Sclerosis, Alzheimer's disease, Fronto-temporal dementia, Lewy Body Diseases both in clinical settings and in population-based settings. He is leading projects and studies both within Europe and outside Europe.

Epidemiology of Rare Neurodegenerative Diseases: relevance for science and public health

Establishing frequencies of rare neurodegenerative diseases as frontotemporal dementias (FTD) and amyotrophic lateral sclerosis (ALS) is quite challenging, with new epidemiological methods (reconstructed cohort design) having been proposed and tested in several areas in the world. The role of the Global Burden of Disease Study (GBD) in this research area is key. The contrast between high-income countries (HIC) and low- and medium-income countries (LMIC) in studies of frequency of diseases and possible disease causation will be outlined in this talk. Defining numbers of individuals with ALS and FTD in large multinational cooperative studies is urgent in light of new therapies that are becoming available due to recent results of new randomized clinical trials. To address this issue EURALS (EU studies on ALS) and the FRONTotemporal dementia Incidence European Research Study (FRONTIERS) were established to assess ALS FTLD epidemiology across Europe. FRONTIERS and EURALS were based on the collaboration of the best clinical centres on these diseases across Europe. The research results of EURALS and FRONTIERS show that ALS and FTD are both more common than previously recognized, with a risk spanning a wide age range and presenting an incidence peak in the seventies. Improved knowledge of ALS and FTD epidemiology based on population-based collection of cases, may contribute to improve health and care planning, for patients in Europe and may help in the design of future clinical trials of innovative drugs. The relevant role of the epidemiology as science to investigate disease causation and frequencies will be described. Epidemiology is a pragmatic science with relevant consequences for programs of public health intervention and policy making. Recent advancements in the diagnosis of these diseases (particularly FTD) with the use of advanced analysis techniques, including AI, will be briefly mentioned.

Silvia Morbelli

Associate Professor in Nuclear Medicine at the University of Genova

Silvia Morbelli (MD, PhD) is an Associate Professor of Nuclear Medicine at the University of Genoa. She's been working as a Nuclear Medicine physician at IRCCS Ospedale Policlinico San Martino since 2007 and obtained a PhD in Applied Neurosciences in 2010. She has made contributions related to the use of neuroimaging tools as diagnostic and prognostic biomarkers in the earliest and preclinical stages of Neurodegenerative Dementias and Parkinsonian Syndromes. She is especially interested in the use of Molecular Imaging to disclose networks underlying different clinical phenotypes as well as brain reserve in Alzheimer's and Lewy Body Diseases. She has been a member of the Neuroimaging Committee of the European Association of Nuclear Medicine since 2015, where she also served as Chair of the Committee from 2020 to 2022.

Brain Molecular imaging as a predictive tool for precision medicine in prodromal stages of neurodegeneration

Neurodegenerative diseases such as Alzheimer's Disease (AD), Lewy Body Disease (LBD) and Amyotrophic Lateral Sclerosis (ALS) are characterized by high diagnostic complexity and wide phenotypic heterogeneity. Based on their sensitivity, multi-modal and multi-organ nature, in recent years molecular imaging using PET and SPECT with different tracers has been increasingly to capture this relevant heterogeneity, favouring early diagnosis and prognostic stratification within the spectrum of these disorders. Indeed, functional/structural imaging, neurophysiological, cerebrospinal fluid (CSF), plasma and genetics biomarkers are cornerstones in research on neurodegenerative diseases, representing a dynamically evolving field and providing opportunities at all levels of translational research from the understanding of physiological human brain states to diagnostic instruments in clinical practice. This cross-cutting area of research needs unprecedented efforts in terms of post-processing analyses, single markers' measures and added value, cross-validation and multi-modal diagnostic algorithms. Finally, to increase statistical power and to overcome critical challenges such as outliers and overfitting, rather smallish samples available at single centres are typically problematic and an increasing number of consortia and multicentre repositories have been implemented in recent years. The talk will be focused on the role of molecular imaging as biomarker in prodromal stages of neurodegenerative diseases and on the use of post-processing methods including radiomics and machine learning to maximize its predictive value and to investigate the interplay with other biomarkers.

Claudio Babiloni

Professor in Physiology at the University of Rome

Prof. Claudio Babiloni received a PhD in Biomedical Sciences (Aalborg University, Denmark) in 2001, after which he was appointed Associate Professor in Physiology at the University of Foggia (Italy) in 2007, and became Full Professor in Physiology at the Sapienza University of Rome (Italy) in 2022. His research group investigates the brain rhythms underlying the regulation of vigilance/consciousness level, cognitive functions imaging, and the main progressive neurodegenerative diseases leading to dementia (e.g., Alzheimer's disease, etc.). The primary methods of this research are quantitative EEG and neuroimaging. He founded and leads The PDWAVES Consortium (www.pdwaves.eu) to promote that research line. He is a Member of the Alzheimer's Association International Society to Advance Alzheimer's Research and Treatment (ISTAART). He is also a Senior Chair of the Working group of the International Federation of Clinical Neurophysiology (IFCN) for promoting "IFCN Guidelines on EEG" since 2018. He is a co-leader of the Dementia Workgroup in the Global Brain Consortium since 2019. His scopus Metrics are the following 384 documents; 16,647 citations in 10,206 documents; and H index of 72.

Abnormal Cortical EEG Rhythms of Vigilance in Alzheimer's and Related Diseases

According to the US-National Institute of Aging (NIA)-Alzheimer's Association (AA) Framework (Jack et al., 2018; Alzheimer's & Dementia), the in-vivo diagnosis of Alzheimer's disease (AD) for research purposes should be based only on biomarkers of brain amyloidosis/tauopathy, derived from the analysis of cerebrospinal fluid or amyloid/tau positron emission tomography (PET). Furthermore, biomarkers of neurodegeneration, derived from the analysis of structural magnetic resonance imaging or FDG-PET, should be used for monitoring the disease progression.
Surprisingly, the NIA-AA Research Framework does not explain the neurophysiological interplay between AD neuropathology/neurodegeneration, significant clinical manifestations such as cortical neuron overexcitability, and the relative abnormalities in regulating vigilance and consciousness level often observed in AD. Notably, those abnormalities may be related to EEG epileptiform activities observed in many patients with mild cognitive impairment or dementia due to AD, even without any diagnosis of Epilepsy. The overall aim of the talk is to: (1) Introduce a neurophysiological brain model from EEG activity explaining the brain network hyperexcitability possibly related to AD neuropathology; (2) Discuss the translational and clinical significance of abnormal cortical arousal and vigilance/consciousness levels in AD; (3) Raise the awareness of the negative consequence to neglect EEG biomarkers and Clinical Neurophysiology in the diagnostic and assessment criteria for managing AD patients according to the NIA-AA Research A-T-N Framework; (4) Update how artificial intelligence – machine learning tool can be used to predict cognitive decline in AD patients based on EEG biomarkers.

Mattia Veronese

Associate Professor in Biomedical Engineering at the University of Padua and at the Neuroimaging Department of King's College London

Mattia Veronese is Associate Professor in Biomedical Engineering at the Department of Information Engineering, University of Padua and Honorary Senior Lecturer in Neuroimaging at King's College London. He is a biomedical engineer by training and holds a PhD in PET kinetic modeling. His main research interest is related to the development and validation of molecular neuroimaging biomarkers and their use for drug development and precision medicine. In the first 10 years of his research career, he has been involved in more than 20 experimental medicine studies across neurological and psychiatric disorders, participating in the analysis of thousands of neuroimaging scans.

Normative Modelling for Neuroimaging Sciences

Normative modelling (NM) is an emerging statistical framework, which uses the between-subject variability expressed by covariates of interest (e.g., demographics or clinical measures) within a reference cohort as foundation to identify deviations from the expected variability on an individual basis (e.g., patient sample). The method has general applicability, can help understanding heterogeneity of patient population, and its applicable beyond case control studies. This talk wants to present the use of normative modelling for neuroimaging sciences, and how it can be effectively applied to investigate the underlying neurobiology of brain disorders.

Joana B. Pereira

Associate Professor at the Karolinska Institutet

Joana B. Pereira is a Principal Researcher, Group Leader and Associate Prof. at the Clinical Neurosciences Department of Karolinska Institute, where she leads the Brain Connectomics Lab (https://ki.se/en/cns/joana-pereiras-research-group). Her group combines the latest imaging techniques with cerebrospinal fluid/plasma biomarkers and AI approaches to detect the earliest signs of AD. She has published more than 81 articles and reviews on neurodegenerative disorders, brain connectivity, graph theory and deep learning. She is a co-developer of an open-access software for the analysis of brain connectivity (BRAPH—Brain Analysis Using Graph Theory) and a co-author of the upcoming book "Deep Learning Crash Course" (No Starch Press, 2024). She is also the scientific coordinator of NeurotechEU (https://ki.se/en/collaboration/neurotecheu), a European alliance that aims to strengthen the collaborations between different universities, and a member of the KI Research Incubator. Finally, Joana has been one of the chairs of a highly interdisciplinary conference "Emerging Topics in Artificial Intelligence" since 2020.

Brain connectivity analysis with multilayer networks and deep learning methods

The human brain is a complex, interconnected network known as the connectome. The conventional approach to its analysis with graph theory relies on constructing a brain graph that couples brain regions through anatomical or functional connections derived from a single neuroimaging modality. However, the ever-increasing availability of large-scale, high-resolution, and multimodal neuroimaging datasets requires novel and more flexible methods that can assess the complex nature of brain organization, going beyond what is possible with conventional approaches. To address this need for more advanced tools, I will introduce BRAPH 2.0, an open-source MatLab-based software for brain connectivity analysis with conventional graph theory, multilayer graphs and deep learning. BRAPH 2.0 is provided with an extensive set of ready analysis pipelines, accessible both via graphical user interface (GUI) and via sample scripts. Furthermore, BRAPH 2.0 allows its users to easily develop new specialized analysis pipelines, by introducing, e.g., new input data types, pre- and postprocessing steps, graph measures, visualization tools and deep-learning analyses. Finally, I will demonstrate the capabilities of BRAPH 2.0 in several studies.

Shahid Jabbar

CTO, Mabel AI

Dr. Jabbar Shahid is an AI expert with a passion for using technology to solve real-world problems. He has worked on a variety of projects, including airline crew scheduling software, educational technology, and computer vision for dental care. He is now the founder of a healthtech startup, Mabel AI, in Gothenburg. He holds a PhD in AI from Technical University of Dortmund.

Modern AI and speech technology for a secure and private interpretation system

Language barriers in health care are a major obstacle to national and global sustainable development goals for public health, health equality, and integration. Interpreters in healthcare are a non-regulated industry, with less than 5% of the interpreters being certified in medical interpretation in Sweden. Often the interpreter knows the patient, making it difficult for the patient to have a private conversation with the doctor. Language barriers can affect not only newly arrived immigrants but also people who are proficient in the local language. For example, dementia can cause people to forget acquired languages and revert to their mother tongue. In this talk, we will look at how modern AI and speech technology can be used to create a secure and private interpretation system.

Giovanni Volpe

Professor in Physics at the University of Gothenburg

Giovanni Volpe is a Professor at the Physics Department of the Gothenburg University, where he leads the Soft Matter Lab (http://softmatterlab.org). His research interests include soft matter, optical trapping and manipulation, statistical mechanics, brain connectivity, and machine learning. He has authored more than 100 articles and reviews on soft matter, statistical physics, optics, physics of complex systems, brain network analysis, and machine learning. He has developed several software packages for optical tweezers (OTS — Optical Tweezers Software), brain connectivity (BRAPH—Brain Analysis Using Graph Theory), and microscopy enhanced by deep learning (DeepTrack). He co-authored the books "Optical Tweezers: Principles and Applications" (Cambridge University Press, 2015), "Simulation of Complex Systems" (IOP Press, 2021) and the upcoming book "Deep Learning Crash Course" (No Starch Press, 2024).

AI and Deep Learning for Microscopy

Video microscopy has a long history of providing insights and breakthroughs for a broad range of disciplines, from physics to biology. Image analysis to extract quantitative information from video microscopy data has traditionally relied on algorithmic approaches, which are often difficult to implement, time consuming, and computationally expensive. Recently, alternative data-driven approaches using deep learning have greatly improved quantitative digital microscopy, potentially offering automatized, accurate, and fast image analysis. However, the combination of deep learning and video microscopy remains underutilized primarily due to the steep learning curve involved in developing custom deep-learning solutions. To overcome this issue, we have introduced a software, DeepTrack 2.1, to design, train and validate deep-learning solutions for digital microscopy. We use it to exemplify how deep learning can be employed for a broad range of applications, from particle localization, tracking and characterization to cell counting and classification. Thanks to its user-friendly graphical interface, DeepTrack 2.1 can be easily customized for user-specific applications, and, thanks to its open-source object-oriented programming, it can be easily expanded to add features and functionalities, potentially introducing deep-learning-enhanced video microscopy to a far wider audience.

Carolina Wählby

Professor in Quantitative Microscopy at Uppsala University

Carolina Wählby is a Professor in Quantitative Microscopy at the Dept. of Information Technology, Uppsala University. She is also the Scientific Director of the Swedish National SciLifeLab Bioimage Informatics Unit, and member of the steering group of a 300M€ effort on Data Driven Life Science, funded by the Knut and Alice Wallenberg Foundation, with the ambitious goal of training the next generation of life scientists. She has a MSc in molecular biotechnology, a PhD in digital image analysis, and did a postdoc in genetics and pathology at Uppsala University. She held a position as PI at the Imaging Platform of the Broad Institute of Harvard and MIT in Boston, USA, 2009-2015. Her research is focused on developing computational approaches, including AI, for extracting information from image data with applications in life science; primarily at the microscopy scale.

AI as a tool in microscopy-based life science research

Visual assessment of microscopy image data becomes limiting as dataset size and complexity grows. It can also be difficult to draw confident conclusions if the observed processes are subtle and the samples are heterogenous. This is where digital image processing and analysis may be used to automate assessment and extract quantitative measurements. In the past ten years, AI, and particularly learning-based approaches relying on deep convolutional neural networks, have gained enormous popularity in all fields of image-based science. The methods have great potential, but they must also be used with care, not to fool us in our findings. We apply AI to understand cell and bacterial dynamics, to screen drug effects in model organisms, and to decode and explore spatially resolved gene expression in tissue. Furthermore, we use AI to segment time-lapse images of unstained cells and run unsupervised feature extraction for efficient tissue segmentation. We also see that learning-based approaches have their limitations, both when it comes to training, data handling and quality control – these factors all become crucial for successful methods implementation. At the same time, new learning-based techniques, such as generative networks and self-supervised learning, hold great promise for the continued development.

Andrea Chincarini

Senior Researcher at the National Institute of Nuclear Physics

Andrea Chincarini is a senior researcher in physics with over 20 years of experience in academia and industry. Besides a post-degree specialization in Surface Science, he obtained a PhD in Neuroscience from the University of Genoa, Italy, and a Master's degree in Physics from the same university. He is currently a Senior Staff Researcher at the National Institute of Nuclear Physics (INFN) in Genoa, where he leads a research team in data analysis, focusing on a wide range of applications: from gravitational waves to neurodegenerative diseases. His current research interests are linked to neurodegenerative diseases and medical imaging and methodological development in data-driven biomarkers. He published over 300 papers in peer-reviewed journals, and ha an h-index of over 80. He also contributed to several books.

Beyond the Hype: a realistic look at AI in Neurosciences

Artificial intelligence (AI) is rapidly transforming many fields, including medicine. However, it is important to be aware of the potential dangers and challenges of AI, especially in the sensitive field of neurosciences. Rather than delving into a list of apparent and claimed success cases, I will try to underline some challenges and dangers derived from the application of AI methods to some typical cases in neuroscience. I shall briefly touch on some methodological aspects of AI and their consequences when applied to medical data: from hidden dataset biases to minority inclusions. For instance, a peculiar aspect of medical data - and in particular of the neuroimaging field - is the data heterogeneity. Data heterogeneity comes in many flavours as Neuroscientists collect data from a variety of sources, including brain scans, medical records, and patient surveys. However - despite some notable exceptions and efforts - these data are often biased by different formats and collected using different protocols. Data harmonization is a non-trivial problem, and it might well be one of the major challenges in training large AI models. Other more common and known challenges include privacy and the potential for misuse of data and AI results; autonomy, that is the tendency of letting models make decisions about patient care without human intervention; ethics concerns about who is responsible for decisions and how to ensure that they are made in the best interests of patients; transparency, trustworthiness and the rather complex world of explainable AI (XAI). Despite these challenges, AI has the potential to revolutionize neurosciences and there are several successful examples hinting at a promising future. I will try to balance the potential dangers and challenges of AI in neurosciences by discussing some stereotypical case studies. I shall argue that we need to learn a new skill set to deal and understand the current and future tools, while growing and adopting a critical mindset to ensure that AI is used in a responsible and ethical way.

Augusto Marcelli

Scientific Attaché at the Italian Embassy & Senior Scientist at the National Institute of Nuclear Physics

Augusto Marcelli has been a senior scientist at the Laboratori Nazionali di Frascati of the INFN since the early '80s, where he has been involved in synchrotron radiation (SR) studies. He contributed to the construction of SR beamlines at ADONE, DAFNE and ESRF. In particular, he proposed and built the first Italian Infrared/THz SR beamline and was the scientist responsible for its operation till 2006. His research interests cover: correlation phenomena in x-ray absorption spectroscopy, circular magnetic x-ray dichroism investigations, x-ray absorption in elements of geophysical interest, dust and aerosol characterization and ultra-trace detection for indoor and outdoor environmental researches, FTIR microspectroscopy and imaging, time resolved concurrent experiments and SR instrumentation. In these four decades of activity, he has been responsible for several experimental programs in different facilities all around the world: ALBA, BESSY, BSRF, Diamond, NSRL, PF, LURE, SSRL, SRS, UVSOR and ESRF. He has been cooperating with the Institute of High Energy Physics in Beijing since 2001 and several times has been Visiting Professor at the University of Science and Technology of China at Hefei. In 2018, the Italian Ministry of Foreign Affairs appointed him as a scientific expert on bilateral policies and activities for the internationalization of scientific and technological research. More recently, in September 2022, he started working as a scientific attaché at the Embassy of Italy in Stockholm.