SENSORS DAY 2023

ROBINSON COLLEGE

OCTOBER 11TH

SENSOR CDT

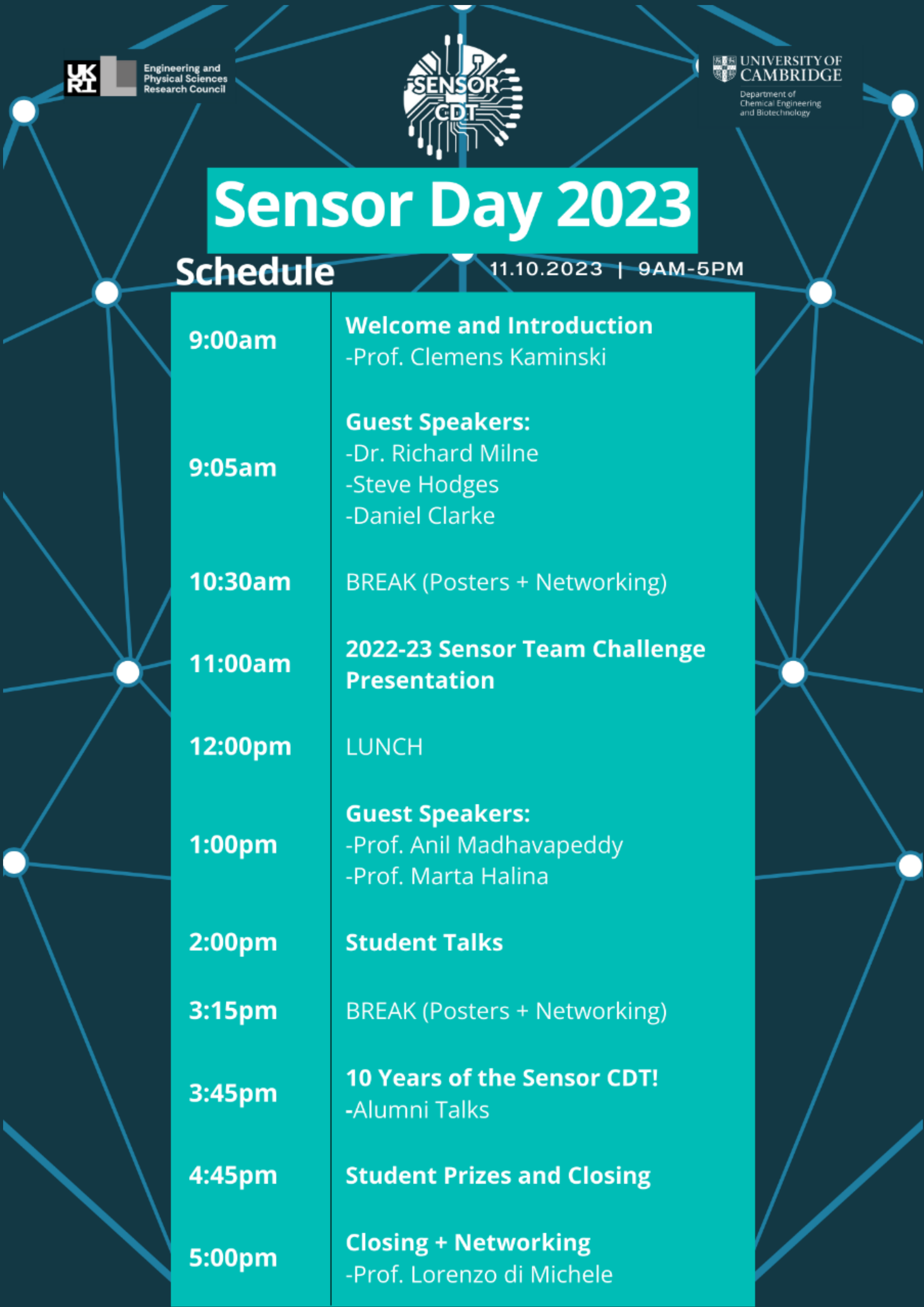
SENSOR ETHICS AND MACHINE INTELLIGENCE

UKRI Engineering and Physical Sciences Research Council

UNIVERSITY OF CAMBRIDGE

Contents

Schedule



Sensor Day 2023

Schedule 11.10.2023 | 9AM-5PM

9:00am	**Welcome and Introduction** -Prof. Clemens Kaminski
9:05am	**Guest Speakers:** -Dr. Richard Milne -Steve Hodges -Daniel Clarke
10:30am	BREAK (Posters + Networking)
11:00am	**2022-23 Sensor Team Challenge Presentation**
12:00pm	LUNCH
1:00pm	**Guest Speakers:** -Prof. Anil Madhavapeddy -Prof. Marta Halina
2:00pm	**Student Talks**
3:15pm	BREAK (Posters + Networking)
3:45pm	**10 Years of the Sensor CDT!** -Alumni Talks
4:45pm	**Student Prizes and Closing**
5:00pm	**Closing + Networking** -Prof. Lorenzo di Michele

Keynote Speakers

Dr.Richard Milne

What role for the public in Sensor Ethics?

The development and implementation of new machine learning tools offers the possibility to 'democratise AI', expanding access to both models and tools and the potential benefits of the new technology. In addition, however, there have been calls to democratise decision making around AI, to bring wider society into discussions around the governance and direction of research in machine learning. In this talk, I will discuss what potential roles the wider public might play in 'sensor ethics'

Dr Richard Milne is Deputy Director of the Kavli Centre for Ethics, Science and the Public at the University of Cambridge and Head of Research and Dialogue in the Engagement and Society group at Wellcome Connecting Science. He is a sociologist of science, technology and medicine and his research focuses on social and ethical questions associated with new and emerging science and technology, particularly related to genomics, biodata and digital health

Steve Hodges

TBC

Steve will speak about his more than 20 years' experience working at Microsoft Research. In his work he identifies, develops, and delivers hardware + software experiences that provide lasting value to users and society, and inspires and empowers future generations of creative technologists to do the same.

Steve Hodges is a Senior Principal Researcher at Microsoft Research, Cambridge.
He combines hardware engineering and creative design skills with knowledge of emerging and established technologies to conceive novel, inclusive solutions. He works at all scales from prototype to production, and his work has contributed to millions of devices with tens of millions of users spanning domains such as education, assistive technologies, mobile devices and the internet of things. He is also a passionate proponent and communicator of technology.

Daniel Clarke

The Role Of Sensors In Helping To Create Better Places

The way that Local Authorities plan, deliver and evaluate services and infrastructure is becoming more data driven. To support this work councils are beginning to deploy sensors into urban and rural locations. This has presented a number of challenges, understanding the performance of sensors and understanding the quality of data they produce, physical deployment including connectivity, device management, data management and how to draw intelligence and insight from data. Key to this ensuring that operatives have the right skills and that systems are easy to use for people whose jobs haven't traditionally been data focussed.

The talk will focus on some of the challenges the Smart Cambridge programme has faced in the deployment of sensors that have collected a range of data including water level data, air quality and movement. It will also cover some of the challenges in understanding the data collected and in making data usable. As well as emerging work that is look at how are looking at combining data in digital twins to gather greater understanding of city systems.

Dan Clarke is the Head of Innovation and Technology for the Greater Cambridge Partnership and leads the organisations 'Smart' work, exploring how emerging technology and data can support the delivery of mobility. He has experience of working on automated vehicle projects and recently delivered the UKs first purpose built automated vehicle pilot as part of public transport system. His team have deployed sensors to better understand movement in the city and have developed early-stage Digital Twins to gain insight into how mobility inter-relates to other city systems. Current projects are using data, AI and Machine learning to better manage the road network. Dan has been working on behaviour change projects that use data and information to support travellers using more sustainable modes of transport.

Prof. Anil Madhavapeddy

Quantifying the world's tropical forests with remote sensing

The rate of tropical deforestation is continuing to increase, and with it comes an enormous loss of biodiversity and natural resources. Ideally we need a massive number of new conservation projects that will provide alternatives to deforestation in the regions worst affected in the tropical equatorial belt. How can we figure out where to focus our efforts, and to verify their progress?

I will discuss how we are using satellite remote sensing to construct a global view of tropical rainforests, and to measure the effectiveness of conservation interventions from a viewpoint of the additionality gained vs natural forest dynamics, the tracking of leakage due to negative externalities, and the permanence of resulting changes. We use these measurements to build up a quantitative model of the conservation efforts that share common baselines globally, and then combine with qualitative metrics such as biodiversity, local livelihood and justice to build up a complete project assessment that can be used as the basis for trustworthy, verifiable carbon credits.

Anil Madhavapeddy is the Professor of Planetary Computing at the University of Cambridge Computer Laboratory. He directs the Cambridge Centre for Carbon Credits (4C), which aims to increase the supply of high integrity natural climate solutions that contribute towards ending deforestation and improving biodiversity globally, via the application of modern remote sensing and statistical quantification techniques to reduce the overheads of creating and verifying interventions. He has decades of experience with constructing Internet-scale systems, and has contributed to open-source projects such as OCaml, Docker, Xen, and OpenBSD, with users ranging from cloud computing providers to financial institutions to governments worldwide.

Prof. Marta Halina

AI systems as explanatory models

Can AI systems serve the role of explanatory models in science? If so, is model transparency a necessary criterion for explanatory success? In this talk, I draw on contemporary philosophy of science and sensor research to address these questions.

Marta Halina is University Associate Professor in the Department of History and Philosophy of Science at Cambridge. Her recent publications include "Transitions in Cognitive Evolution" (Proceedings of the Royal Society B) and "Insightful Artificial Intelligence" (Mind & Language).

Student talk abstracts

Bioconjugation of Electrochemical Transistor Biosensors for Alzheimer's diagnostics

Stefany J. Kissovsky [a,b] (*right*)

George Malliaras [b], Gabriele S. Kaminski Schierle [a]
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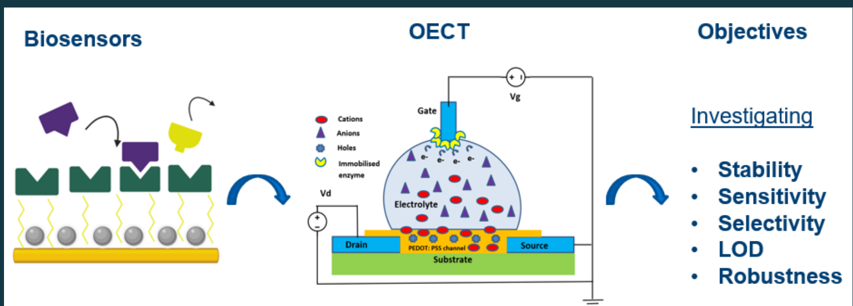
Alzheimer's disease (AD) is a progressive disease in the form of dementia, which affects more than 50 million people worldwide and is expected to impact three times more by 2050 [1]. Although Alzheimer's disease has been linked to the misregulation of biomarkers in the brain [2], its cause and means of progression are still not fully understood. Due to the sub-nanomolar concentrations of these biomarkers, current methods for their quantification require expensive equipment, specific experience, and time-consuming analysis. A much faster, cheaper, and more convenient *in vitro* method with comparable sensitivity is needed to facilitate Alzheimer's research and diagnostics.
Organic electrochemical transistors (OECTs) have emerged as a promising point-of-care platform for enzymatic biosensing due to their high amplification properties, stability in aqueous media and biocompatibility [2]. However, OECT's high sensitivity leads to signal drifts due to changes in the surrounding environment such as pH effects, temperature changes, and interfering analytes. New OECTs configuration has been microfabricated and investigated to achieve real-time calibration to compensate for external factors affecting the output signal. To achieve good sensitivity, varying bioconjugation techniques have been investigated for the attachment of an enzyme to the gold surface of the OECT. Atomic force microscopy, frequency analysis, cyclic voltammetry, and enzymatic assays methods have been used to analyze and verify the attachment of the enzyme. After an enzyme was immobilized on the device, the output current was recorded to test the system in real-time upon addition of varying analyte concentrations in the electrolyte. This is a new promising platform for achieving output signal stability and robustness against signal drifts in the OECTs, outlining the pathway to super high sensitivity and low limit detection of brain biomarkers.



1. Naomi A Fineberg et al. The size, burden, and cost of disorders of the brain in the UK. *Journal of Psychopharmacology* 27.9, 761–770 (2013).

DNA nanotechnology enables single-molecule sensing of blood pathogens

Mohammed Alawami (*right*)

Sepsis (blood poisoning) is a leading cause of death worldwide. It is caused by the body's strong, systemic response to infection from bacteria, fungi or other pathogens. In the United States, 1.7 million people are diagnosed with sepsis annually, from which 1 in 7 dies. Treating sepsis has two major challenges: course of treatment identification and testing speed. The current gold standard for sepsis diagnosis and species identification, blood culture, typically takes 1-3 days for bacteria and 3-5 days for fungi, but every hour delay in treatment increases the probability of death by 8%. We are developing a quick, multiplexed detection assay to detect microbes from blood and other biological samples. We combined nanopore sensing and DNA nanotechnology for direct single-molecule RNA detection to speed up the test to a few hours. For proof-of-concept, animal blood was spiked with cultured E. coli DH5α to mimic a blood infection and total RNA was extracted. Custom-designed, sequence-specific DNA probes were hybridized with the total RNA extract to build DNA-RNA nanostructures. The single-molecule DNA-RNA nanostructures were detected with solid-state nanopore sensing. The nanostructures produce a characteristic positive current signature showing that the method can detect bacterial RNA at the single-molecule level in just a few hours. With further optimization, the nanopore DNA nanotechnology sensor developed in this work has the potential to speed up sepsis diagnostics to just one hour.

Understanding the Links between the Chemical and Optoelectronic Properties of Alloyed Halide Perovskites

Hayley Gilbert (right)

Lead halide perovskites have emerged as a successful material in the development of optoelectronic devices and sensor technologies such as LEDs, X-ray imaging scintillators, and optical communications. These materials can be synthesised using low temperature and inexpensive preparation techniques, aligning them with many of the UN Sustainable Development Goals. Mixed composition perovskites have been shown to be particularly successful in solar cell devices. These compositions are highly desirable for tandem devices due to the tunability of their band gaps through compositional engineering of the halides, enabling the power conversion efficiencies of these devices to go beyond 30%. However, the alloyed nature of these materials creates structural and chemical heterogeneities, which reduce device performance and long-term stability and thus creates a bottleneck in the development of perovskites into commercial devices. Additionally, increasing the bromide content (to increase the band gap and hence device efficiency) causes a process called halide segregation to occur upon light irradiation which reduces the efficiency. Currently, the mechanism behind halide segregation is not fully understood. In this talk I will discuss the aims of my PhD project: using photoluminescence and synchrotron X-ray mapping techniques to correlate the optoelectronic properties with chemical and structural heterogeneities in alloyed perovskite thin films to gain a better understanding of these heterogeneities and the mechanism of halide segregation. I will discuss the methods and experimental techniques I am using to achieve this and the current challenges of the project.

Real-time Recordings of Changes in Electrophysiological, Ionic, and Contractile Activity in Gut Tissue

Sophie Oldroyd (right)

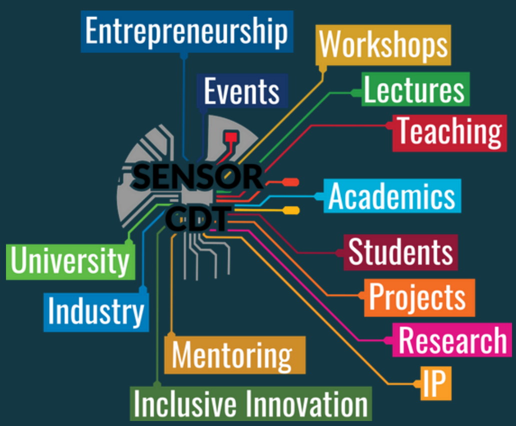
Inflammatory bowel disease (IBD) is characterised by a leaky gut barrier, which has increased permeability due to changes in localisation of tight junction proteins[1]. There is also evidence to suggest decreased gastric motility is linked with neurodegenerative diseases such as Parkinson's[2]. However, detailed understanding of these disease pathways is limited, and current methods of assessing gut tissue health are impeding progress in the field. The techniques need re-imagining in the modern era given advancements in technology. This work presents bioelectronic devices that permit real-time recordings of changes in electrophysiological, ionic, and contractile activity in gut tissue. The ability to assess gut health is important in establishing and monitoring phenotypes associated with gastrointestinal diseases.

[1] Jost WH. J Neurol Sci. (2010)
[2] Romano, S. et al. Parkinson's Disease 7, 1–13 (2021)

About the Sensors CDT

The **EPSRC Centre for Doctoral Training in Sensor Technologies for a Healthy and Sustainable Future** (Sensor CDT) delivers an interdisciplinary and research focussed training programme to students who have the aspiration as well as the academic and technical skills to become world leaders in the field of sensors.

Students are taught and supervised by academics and researchers from around 20 departments across the University of Cambridge. This allows them to sample a broad variety of research environments and gain hands-on experience in the use and capabilities of state-of-the-art research instruments and techniques. The first year of the Sensor CDT programme is an MRes course, consisting of a balanced mix of taught and research components. Lectures introduce our students to the science that underpins sensor design and applications. Research projects and a team challenge provide key skills to carry out cutting edge sensor research in experimental design, project management, data handling, dissemination of research outcomes and teamwork. This is followed by three years of PhD research during which the students continue to learn from leading experts and each other during our monthly Sensors Café workshops and seminars.



https://cdt.sensors.cam.ac.uk/

Sponsors

A special thanks to Zimmer&Peacock for sponsoring our student talk prizes!