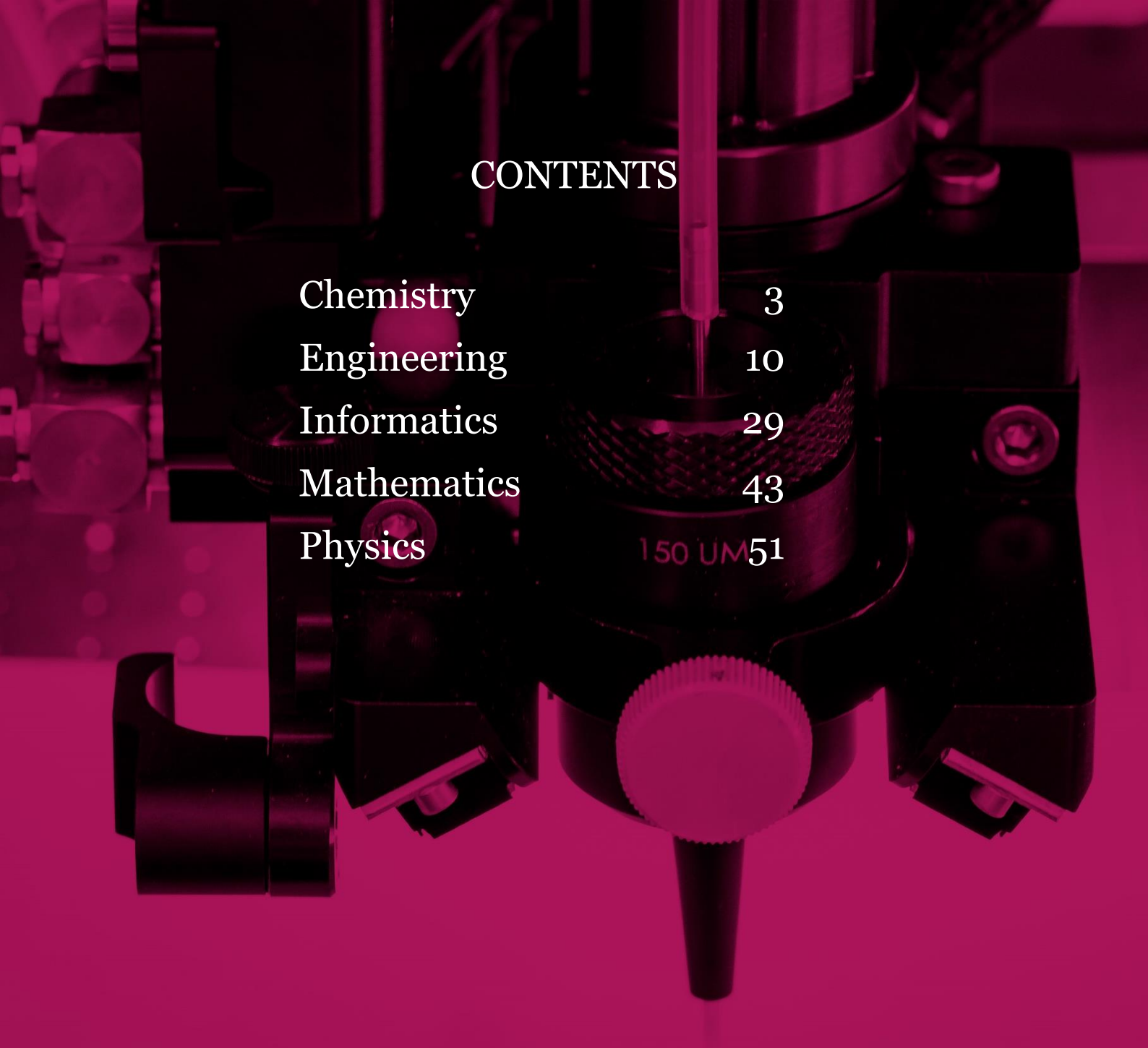
Sussex EPSRC Doctoral Landscape Projects and Themes for Autumn 2025

Engineering and Physical Sciences Research Council

UNIVERSITY OF SUSSEX



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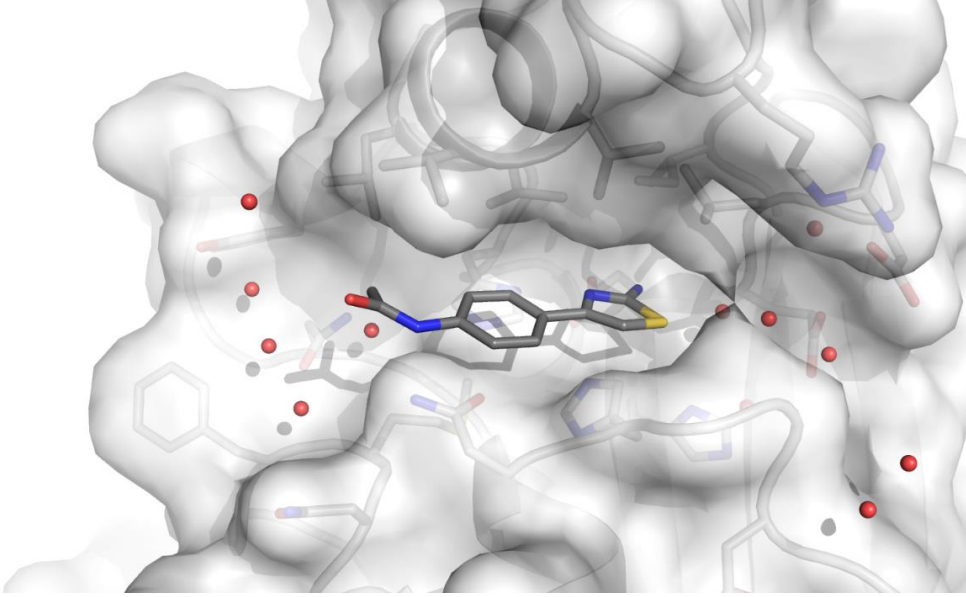
Chemistry



Theoretical and Experimental Molecular Design (EP25/1)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Alfredo Vargas

Department: Chemistry

Research outline:

We look into rationally designing stable and functional molecules under mild conditions which are amenable to synthesis, production, and stabilisation in solution and/or solid state media including functionalised surface. The underlying approach for the design and engineering lies in the use and incorporation of key features including: charge redirectional nodes/ electron and spin-density sinks, actionable structural reorganisation networks, electromagnetic and/or thermally excitable centres and usual constrainers like sterics and intra/inter molecular interactions. Building and confining properties will be carried out through computations which will be synergetically coupled to inorganic experimental synthesis, analysis and testing in a cyclic development scheme. Target systems will include high-performance switchable systems, catalysis and small molecule activation platforms and energy storage systems. Theoretical development will be driven and validated by dedicated experimental results. Electron-density and wavefunction-based approaches will be employed.

Key Publications:

Mattock JD, Vargas A. (2018). Boron centres allow design, control and systematic tuning of neutral homoaromatics for functionalization purposes. ChemPhysChem, 19, 2525-2533, 10.1002/cphc.201800453

Sampani SI, Zdorichenko V, Devonport J, Rossini G, Leech MC, Lam K, Cox B, Abdul-Sada A, Vargas A, Kostakis GE. (2021). Structural and electronic control of 1-(2-pyridyl)benzotriazole bidentate ligand in copper chemistry with application to catalysis in the A3 coupling reaction. Chemistry: A European Journal, 27, 4394-4400, 10.1002/chem.202004781

Novel imaging agents to detect and monitor disease progression (EP25/2)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Deborah Sneddon

Department: Chemistry

Research outline:

In my group we are interested in creating new imaging agents to detect and monitor disease progression, particularly focused on cancer. For this, we exploit the many properties of the f-block lanthanide elements, utilizing their paramagnetism for magnetic resonance imaging (MRI), their luminescence for the visualisation of cell biomarkers, progressing to use their radioactive isotopes for nuclear imaging. A key part of this work is synthesizing new chelators and supramolecular scaffolds, combining organic and inorganic chemistry. We have several interdisciplinary PhD projects available within the group, working between the chemistry/biology interface which can be tailored towards the students specific interest.

Key Publication: Sneddon, D. and Cornelissen. B, (2021) Emerging chelators for nuclear imaging, Current Opinion in Chemical Biology, 63, 152-162, doi: 10.1016/j.cbpa.2021.03.001

Identifying new compounds against bacteria (EP25/3)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Dr Haitham Hassan

Department: Chemistry

Research outline:

Penicillin, the first antibiotic, revolutionised bacterial infection treatment. However, bacterial resistance to antibiotics, including Penicillin, has become a significant threat. β-Lactam antibiotics are increasingly ineffective due to β-lactamase enzymes. Inhibiting these enzymes can improve treatment options for multidrug-resistant pathogens. DNA-encoded chemical libraries (DECL) are crucial for identifying new compounds against resistant bacteria. DECL involves synthesising DNA-tagged molecules for rapid screening. This project aims to mimic β-lactamase inhibitors by designing and synthesising key bicyclic lactams fragments, incorporating them into a DECL workflow, and screening the resulting compounds against resistant bacteria.

Key Publication: Hassan, H.; Marsden, S. P., Nelson, A., 2018, “Design and synthesis of a fragment set based on twisted bicyclic amides”, Bioorg. Med. Chem., 26, 3030

Phosphanyl-derived macrocycles: Toward molecular electronic components (EP25/4)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: Dr Ian Crossley

Department: Chemistry

Research outline:

We undertake fundamental synthesis and study of main-group and organometallic compounds with unusual electronic character, aligned with potential molecular electronic applications. We recently developed cyclophanes incorporating the diketophosphanyl (-C(=O)PRC(=O)-) unit, a moiety with known utility in developing molecular electronic components, but still under-explored. This project builds on our prior work, developing the core cyclophane scaffold to enhance electronic response and incorporate 'switching' functionalities. This will include adding optically/electronically active transition metal and/or main-group fragments, alongside modifying the scaffold itself. It will provide extensive experience of anaerobic synthesis/characterisation and also use electrochemical and computational methods.

Key Publication: Pearce, K.G. and Crossley, IR (2020) 'Diphosphametacyclophanes: structural and electronic influences of substituent variation within a family of bis(diketophosphanyl) macrocycles' J. Org. Chem., 85, 14697-14707 (doi: 10.1021/acs.joc.0c01950)

Redox behaviour of copper catalysis (EP25/5)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: George Kostakis

Department: Chemistry

Research outline:

This PhD project ventures into the uncharted territory of copper catalysis, seeking to master the elusive art of controlling its complex redox behaviour. Building on our innovative approach (Dalton Trans., 2023, 52, 14168) to optimize reaction pathways and unveil profound mechanistic insights, this research aims to unlock unprecedented chemical transformations. With a focus on sustainability, the project will explore diverse reactivities and molecular architectures, pushing the boundaries of what copper catalysis can achieve. This adventurous endeavour holds the promise of groundbreaking applications in pharmaceuticals, materials science, and beyond, driving forward a new era of sustainable chemical innovation.

Key Publication: Kostakis, GE. 2023. Chemical Chartographisis: a contemporary perspective in molecular design and synthesis. Dalton Trans, 2023,52, 18118-18132. (link)

New quantum methods capable of solving the many-particle Schrödinger equation for quantum chemical physics systems (EP25/6)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Hazel Cox

Department: Chemistry

Research outline:

The solution of the Schrödinger equation, without the conventional separation of electronic and nuclear motion, makes it possible to approach the non-relativistic limit arbitrarily close. However, due to the exponential growth of dimension with number of degrees of freedom, all-particle treatments are limited to few particle systems. Therefore, a key challenge is the development of more efficient computational methods. Recently we demonstrated the power of numerical tensor methods in collapsing computational costs without compromising accuracy. This project will build on these initial findings to derive new quantum methods capable of solving the many-particle Schrödinger equation for quantum chemical physics systems.

Key Publication: Brice, K.T., Melgaard, M. and Cox, H. (2024). Bound-state stability of Coulomb three-body systems using numerical tensor methods. Phys. Rev. A, 109, 062812. (link)

Laboratory astrochemistry: investigations of ice processing, by thermal, UV and electron irradiation of model ices grown on dust grain analogue surfaces (EP25/7)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: Wendy Brown

Department: Chemistry

Research outline:

My research is in the area of laboratory astrochemistry. I use surface science techniques (reflection absorption infrared spectroscopy and temperature programmed desorption) to investigate surface processes of relevance to various astrophysical environments such as the interstellar medium, comets and disk chemistry. I also undertake work at FELIX, the free electron laser at Nijmegen, The Netherlands to investigate infrared induced photo-desorption from model astrochemical ices. I am looking for a PhD student to join my research group to undertake investigations of ice processing, by thermal, UV and electron irradiation of model ices grown on dust grain analogue surfaces.

Key Publication: Minissale, M., Aikawa, Y., Bergin E., Brown, W. A. et al. (2022). Thermal desorption of interstellar ices; a review on the controlling parameters and their implications from snowlines to chemical complexity. ACS Earth and Space Chemistry, 6, 597-630. (link)

Developing the reactivity of highly reducing lanthanide organometallic compounds for small-molecule activation and using reagents for deleting atmospheric pollutant molecules (EP25/8)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: Richard Layfield

Department: Chemistry

Research outline:

In the Layfield group, we are currently developing the reactivity of highly reducing lanthanide organometallic compounds for small-molecule activation. We are particularly interested in using these reagents to find ways of deleting atmospheric pollutant molecules, including carbon monoxide, sulfur dioxide and NOx. Our preliminary results have shown that conversion of these simply-yet-harmful gases into more complex molecules is possible, notably in the case of carbon monoxide. During the proposed PhD project, we will explore the synthetic chemistry in more detail, establishing mechanisms for the transformations using a variety of analytical techniques, including NMR spectroscopy, crystallography and computational chemistry.

Key Publication: Layfield, R. A. (2023). Targeted Synthesis of End-on Dinitrogen-bridged Lanthanide Metallocenes and their Reactivity as Divalent Synthons. J. Am. Chem. Soc. 2023, 145, 20121/doi.org/10.1021/jacs.3c07600

Development and mechanistic understanding of new organic reactions (EP25/9)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: Storm Hassell-Hart

Department: Chemistry

Research outline:

Key research areas at present: The preparation and new reactions of sulfoxonium ylides, the use of automated synthesis for reaction optimisation, and novel Pummerer methodologies (both application and mechanistic development).

Specific projects include "New palladium catalysed methods to synthesize unprecedented sulfoxonium ylides" and "The synthesis of Bleomycin analogues via sulfoxonium ylide thiazole synthesis

Key Publication: Smy, J. L., Ifill, I., Hassell-Hart*, S., Brønsted acid-mediated thiazole synthesis from sulfoxonium ylides, Chem. Commun., 60, 12401-12404.

Novel Linkerology Towards Heterobifunctional Moieties Including Protacs and Antibody Drug Conjugates (EP25/10)

Collaborative project with non-university partners

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: John Spencer and Storm Hassell-Hart in the Sussex Drug Discovery Centre

Department: Chemistry

Research outline:

Proteolysis Targeting Chimeras (PROTACs) are an exciting state-of-the-art methodology that is revolutionising how new drugs can be developed. Traditional inhibitors rely on binding to druggable pockets (binding sites) and blocking their biological activity for a limited duration. In contrast, PROTACs act by hijacking the ubiquitin system, targeting proteins for degradation via the proteasome. This mode of action is catalytic and enabling multiple turnovers and results in a longer onset of action. This project aims to address the development of new "linkerology" ie improving linker chemistry, which is crucial to many properties of protacs including solubility, selectivity, metabolism. We will develop novel chemistry to prepare a library of linkers suitable for PROTAC chemistry (and even other areas such as antibody drug conjugates (ADCs)). The most promising linkers will be elaborated into PROTACs and tested in model biological systems for protein degradation alongside our project partners.

Key Publication: Spencer, J., Dezitter, X. et al. Pharmaceutical Evaluation of Enantiomers of AZ11645373 against P2X7 Receptors. Just accepted ACS Pharm Transl. Sci. 2024. (with Reach and USBiotools).

Chemical plasma reactors and their application to small molecule reactivity (EP25/11)

Collaborative project with non-university partners

EPSRC category: Applied Research for a Better World

Lead Supervisor: John Turner and Mark Bagley in the Centre for Robotics and Sensing Technologies

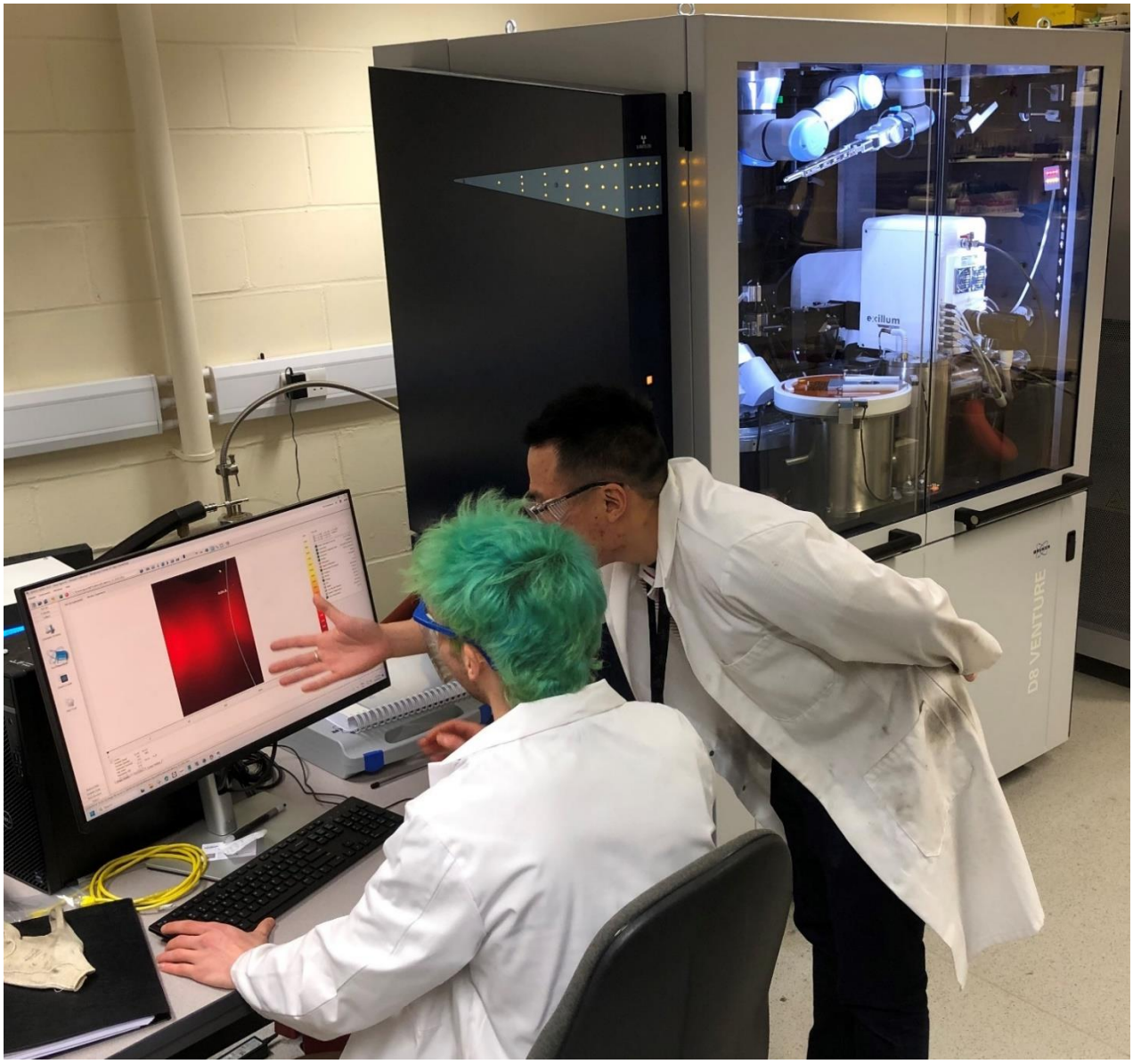
Department: Chemistry

Research outline:

The technological suite of our industrial partner, is centred on the generation of high-quality dry steam generated from a plasma struck in liquid water which captures the enthalpy of reaction of aqueous solutes to generate the excess power observed. Current applications rely on harnessing the steam and heat recovery for industrial and domestic heating applications and the current technology has highly advantageous coefficient of performance (CoP) based on the input electrical power. The chemistry within the cell is highly complex, given the physical conditions and reactive intermediates formed and observed in the plasma.

The aim of this project is to extend the scope of the current chemical plasma reactor to small molecule reactivity with precise chemical and physical control, thereby discovering new pathways to highly desirable products which can be exploited commercially by the industrial partner.

Key Publication: Morgan, R. E., Crua, C, Turner, J. F. C, Bagley, M. C. and Atkins, A. F, (2025) A novel plasma flow reactor that displays a large enthalpic coefficient of performance, in preparation for Applied Energy



Engineering

Data-driven decision-making strategies for robotics and autonomous vehicles, emphasizing control and machine learning algorithms (EP25/12)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Arash M. Dizqah in the Centre for Robotics and Sensing Technologies

Department: Engineering

Research outline:

My research focuses on data-driven decision-making strategies for robotics and autonomous vehicles, emphasizing control and machine learning algorithms. I established www.sveclab.com in 2018 to develop hardware-in-the-loop simulators and digital twins to test our developed algorithms. I propose a PhD project on an autonomous farmland monitoring system that employs a fleet of small robots with sophisticated path-planning capabilities to collect agricultural data. A cloud-based AI would then analyse this information to construct anomaly maps and predict future growth patterns. This innovative approach could significantly reduce the UK farmers' weed-related losses currently amount to £400m annually.

Key Publication: Amouzadi, M , Orisatoki, M. O. and Dizqah A. M. (2023), "Optimal Lane-Free Crossing of CAVs Through Intersections," in IEEE Transactions on Vehicular Technology, vol. 72, no. 2, pp. 1488-1500, doi: 10.1109/TVT.2022.3207054.

Cybernetic Modelling of the Evolution of Motor Control Across Species (EP25/13)

EPSRC category: Interdisciplinary Research

Lead Supervisors: Carlo Tiseo and Jimena Berni

Department: Engineering

Research outline:

Animals have evolved extremely efficient and resilient ways of interacting with the environment maximising the chance of successful encounters. This characteristic is conserved across species despite the different cognitive and motor abilities. Interestingly, during evolution, animals' nervous systems have added more complex structures built on top of the primitive nervous system of primigenial species. What role have these structures played in the preservation of new species?

It is challenging to isolate each neuronal structure in a single animal. However, approaching this research across multiple species at different levels of evolution will enable to isolate motor circuits and understand how the higher structures have developed and integrated during evolution.

Starting from the experiments with Drosophila larvae, with its simple nervous system, you will develop a dynamic simulation of a foraging experiment using a virtual artificial larva. This larval model will be developed using robotics methods to mimic biomechanics and control in a state-of-the-art simulation environment (MuJoCo). Subsequently, you will introduce evolution into the agent. You will expand the model by introducing neuro-motor using observations from more complex species. Enabling the addition of motor capabilities and neural circuits to reveal how efficiency evolves to ensure the preservation of the species.

Key Publications:

Tiseo C, et al (2021) "Exploiting spherical projections to generate human-like wrist pointing movements," 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), Mexico, 2021, pp. 6192-6197, doi:10.1109/EMBC46164.2021.9629550.

Jimena Berni (2024) Perception: How larvae feel the world around them eLife 13:e96708. (link)

Signal processing for wireless communications, focusing on novel communication paradigms (EP25/14)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Dr Menguc Oner in the Advanced Communications, Mobile Technology and IoT (ACMI)

Department: Engineering

Research outline:

My interests lie in signal processing for wireless communications, focusing on novel communication paradigms such as Molecular Communications, Visible Light Communications and novel waveforms for 6G wireless communications and beyond. While open to proposals broadly in this area, some specific research projects that I am offering are:

- Molecular communications based nanoscale sensor networks
- Channel characterisation for molecular communications
- Cyclostationary analysis of novel waveforms considered for 6G and beyond
- Waveform design for integrated satellite-terrestrial wireless networks
- Multidimensional spectrum awareness for intelligent visible light communications systems
- Joint communications and sensing for 6G wireless and beyond.

Key Publication: Solak, S., Oner, M. 2021, Sequential decision fusion for abnormality detection via diffusive molecular communications. iIEEE Communications Letters, vol. 25, no. 3, pp. 825-829, March 2021, doi: 10.1109/LCOMM.2020.3040146

Applications of Human Activity Recognition (HAR) (EP25/15)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Dr Phil Birch

Department: Engineering

Research outline:

Human Activity Recognition (HAR) has many applications from sport tracking, and healthcare, to robotics and automatous vehicles. One method is to analyse the stray reflected signals that are generated using common Wi-Fi signals. As a person walks through the EM field, these reflections can be measured. By training deep learning models, we can then infer what multiple people are actually doing and where they are going. Understanding and modelling social interaction could give better models, potentially producing more accurate results when presented with complex environments.

Key Publication: Han, X (2025) "ETTrack: enhanced temporal motion predictor for multi-object tracking" Applied Intelligence 55,33. (link)

Advanced materials, automation and AI (EP25/16)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Dr Philip D. Howes in the Energy and Materials Engineering Research Centre

Department: Engineering

Research outline:

This cutting-edge multidisciplinary project sits at the interface of advanced materials, automation and AI. You will develop/use automated systems for materials synthesis, allowing for rapid and data-rich experimentation. You will use AI to analyse gathered data and to drive experiments in search of specific research outcomes. You will discover new materials synthesis and processing approaches, and optimise these for target applications. This project is ideal for students inspired by interdisciplinary and high impact research. Candidates from a broad variety of academic backgrounds are welcome, and you will join a group where interdisciplinarity and diverse thinking are embraced.

Key Publication: Munyebvu, N; Lane, E; Grisan, E; Howes, PD. (2022). Accelerating colloidal quantum dot innovation with algorithms and automation. Materials Advances, 3, 6950-696

Optimizing Energy Efficiency in RIS-Aided ISAC with Low-Resolution Massive MIMO for 6G (EP25/17)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Dr Reza Mohammadkhani

Department: Engineering

Research outline:

This research integrates Integrated Sensing and Communications (ISAC) with Reconfigurable Intelligent Surface (RIS)-aided massive MIMO systems, focusing on energy efficiency for 5G and 6G networks. RIS technology reshapes the wireless environment, improving signal propagation and mitigating channel impairments while reducing power consumption. By employing low-resolution quantization in ADCs and DACs, the system significantly reduces hardware complexity and energy usage, enabling sustainable massive MIMO deployment. AI-driven techniques further optimize resource allocation, signal processing, and decision-making, achieving a balance between sensing accuracy, system performance, and spectral efficiency. This approach advances intelligent, energy-efficient, and high-capacity wireless networks for the future.

Key Publication: Azizzadeh, A., Mohammadkhani, R., Makki, S.V.A.D. and Björnson, E., (2019). BER performance analysis of coarsely quantized uplink massive MIMO. Signal Processing, 161, pp.259-267. (link)

The importance of flow-unsteadiness in fluid machinery (EP25/18)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Dr Vasudevan Kanjirakkad in the Thermo-Fluid Mechanics Research Centre (Energy, Materials and Transport)

Department: Engineering

Research outline:

It is intriguing to note that fluid flow applications that generate power are inherently unsteady (turbines, reciprocating engines, etc.), yet they are analysed (and designed in most cases) using steady flow principles. In this EPSRC funded studentship, the unsteady effects and their consequences to the design and performance of an axial compressor, an essential device on its own but also as a component within a jet propulsion system, will be the focus. Theoretical, computational and experimental tools will be used in appropriate manner to unravel the hidden physics at play.

Key Publication: Kanjirakkad, V., & Irps, T. (2021). Some observations of the behaviour of an adverse pressure gradient laminar boundary layer under wake impingement. Fluids, 6(6), 199. (link)

Optical Communication and Inter/Intera Chip Nano/Micro Communication (EP25/19)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: Dr Leila Yousefi

Department: Engineering

Research outline:

Research Interests:

Optical Communication, Inter/Intera Chip Nano/Micro Communication, Sub-Wavelength Imaging, Optical Beam Steering, Optical Metamaterials and Metasurfaces, Tuneable Metamaterials and Metasurfaces, Optical Artificial Intelligent Networks

Potential PhD Projects:

- Developing Optical AI Networks for Next-Generation High-Speed Applications
- Sub-Wavelength Imaging with Resolution beyond the Diffraction Limit using Tuneable Optical Metasurfaces
- Creating Tuneable Metasurfaces with Phase Change Materials for Advanced AI Systems
- Achieving Super-Resolution Imaging Beyond the Diffraction Limit with Quantum Dots

Key Publication: Salami, P., Yousefi, L. (2019). Far Field subwavelength imaging using phase gradient metasurfaces. IEEE Journal of Light Wave Technology, vol. 37, No. 10, pp. 2317-2323. 10.1109/JLT.2019.2902544

Developing models and methods for numerical analysis of the dynamics of critical structures and their optimisation (EP25/20)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Evgeny Petrov

Department: Engineering

Research outline:

The major research topics are developing models and methods for numerical analysis of the dynamics of critical structures and their optimisation. The models and methods are aimed at application to practical structures using large-scale finite element models and accurate modelling of contact interactions in jointed structures with friction, gap and other nonlinear interactions. The comprehensive analysis of nonlinear forced response and self-excited vibrations is performed with the assessment of stability, sensitivity and robustness of the vibration regimes. The problems of modelling aeroelastic interactions of structures with fluid and modelling the effect of heat generation by friction in high-energy rubs are considered.

Key Publication: Petrov, E. (2019) Analytical formulation of friction contact elements for frequency-domain analysis of nonlinear vibrations of structures with high-energy rubs, ASME J. Eng. Gas Turbines Power, vol. 141, pp. 121006-1-121006-12, DOI: 10.1115/1.4045183

The extension and implementation of control systems, especially for renewable energy and hydrogen systems (EP25/21)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Fan Zhang

Department: Engineering

Research outline:

Research focuses on the extension and implementation of control systems, especially for renewable energy and hydrogen systems. This includes the control and optimisation of renewable power generation and utilisation systems, especially using hydrogen as an energy carrier for storage. The research ranges from dynamic system modelling and control to ensure optimal integration of electrolytic/storage/fuel cell systems with renewable electricity supply, to hydrogen systems integration and application, such as stand-alone and grid-connected renewable hydrogen systems, renewable powered smart grid, fuel cell system applications, and use of hydrogen as alternative fuel for transportation.

Key Publication: Basnet, S., Deschinkel, K., Le Moyne, L. and Péra, M.C., 2023. A review on recent standalone and grid integrated hybrid renewable energy systems: System optimization and energy management strategies. Renewable Energy Focus, 46, pp.103-125

Biomass-based corrosion protection and surface modification strategies (EP25/22)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Fan Zhang

Department: Engineering

Research outline:

Dr Fan Zhang leads a multidisciplinary research team focusing on biomass-based corrosion protection and surface modification strategies. A key EPSRC-funded project explores transforming lignin, an underutilized forestry waste product, into high-value coatings with superior anticorrosion and anti-wear properties. The project combines Mussel Adhesive Proteins (MAPs) and lignin to overcome challenges in film formation, creating sustainable, non-toxic alternatives to fossil-based coatings. Collaborations include Prof. Yijun Shi (Luleå University) and Prof. Bin Shen (Shanghai Jiaotong University) in tribology, and Prof. Jinshan Pan (KTH) in corrosion science. Industrial partners such as SSAB, Akzo Nobel, and Becker enhance the project's industrial impact, driving renewable resource utilization in coatings.

Key Publication: Zhao, J., Wang, D., Zhang, F. et al. (2022). Self-Powered, Long-Durable, and Highly Selective Oil–Solid Triboelectric Nanogenerator for Energy Harvesting and Intelligent Monitoring, Nano-Micro Letters, Vol. 14, 150. (link)

Enhancing the prediction of locomotion transition to improve assistive technology for older people (EP25/23)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Hsien-Yung Huang

Department: Engineering

Research outline:

The stability of a human locomotion is commonly investigated in elderly population as the consequences are often significant. To provide suitable assistive technology for them, it is demanded to create a robust prediction model to separate abnormal locomotion behaviour. As shown in the key publication, a simple setup using high-density electromyography on two key muscles on the same leg allows accurate locomotion transition prediction within a range between 100-400ms using convolution neural network. The aim of the project is to leverage on existing research and identify the critical setup for better prediction accuracy and potential commercialisation.

Key Publication: Jing, S. (2024) Enhancing the prediction of locomotion transition with high-density surface electromyography. IEEE Journal of Biomedical and Health Informatics, (early access)/DOI: 10.1109/JBHI.2024.3497658

Developing and optimising low-temperature regenerable sorbents for efficient CO2 capture in indoor environments (EP25/24)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Jon Powell in the Energy and Materials Engineering Research Centre

Department: Engineering

Research outline:

This PhD project focuses on developing and optimising low-temperature regenerable sorbents for efficient CO2 capture in indoor environments. Key objectives include designing novel materials with high capacity and selectivity, evaluating performance under realistic indoor conditions, and exploring energy-efficient regeneration strategies. Advanced characterisation techniques will elucidate material properties and sorption mechanisms, including BET analysis, TGA-MS, mercury porosimetry, and FTIR spectroscopy. Breakthrough testing and humidity tolerance studies will assess real-world applicability. The research aims to deliver scalable, sustainable solutions for indoor air quality improvement by integrating experimental findings with computational modelling.

Key Publication: Powell, J. (2017). Metals (Mg, Sr and Al) modified CaO based sorbent for CO2 sorption/desorption stability in fixed bed reactor for high temperature application. Chemical Engineering Journal, 284, 1212-1223. (link)

Effective and sustainable thermal management systems (TMS) (EP25/25)

EPSRC category: Experimental approaches to Understanding

Lead Supervisors: Julian Dunne and Mark Puttock-Brown in the Energy and Materials Engineering Research Centre

Department: Engineering

Research outline:

Effective and sustainable thermal management systems (TMS) are a major requirement for all sectors using electrified power; from aerospace to automotive, to process engineering and hyperscale datacentres. Miniaturization of electrical components alongside increasing power dissipation is creating significant challenges requiring a technological step-change in TMS capability in-order to meet future demand. One promising avenue is evaporative spray cooling, which uses the latent heat of phase change alongside high momentum sprays to deliver surface heat fluxes orders of magnitude above single phase cooling technology.

We at Sussex have made considerable contributions to evaporative spray cooling, having previously received significant EPSRC funding and industrial support to develop a closed-loop evaporative spray test facility, that resulted in ten journal publications and four international conference papers. Despite this progress there are still significant challenges to optimising this technology, particularly in transport sectors where vibration, agitation and shock combine with open questions around nozzle specification, coolant type, chamber pressure, surface feature and working environment. To develop and maintain the UK as a world-leader in high-performance TMS innovation, high-quality experimental investigations [1] with detailed complex measurements (eg. [2]) are necessary in-order to answer important research questions, making this topic ideal for an EPSRC-funded Studentship.

Key Publications:

[1] A Sarmadian, J.F. Dunne, J.Thalackottore Jose, C.A. Long, J-P Pirault (2022) Temperature control of vibrating heat-generating hardware using spray evaporative cooling in the nucleate boiling region, Applied Thermal Engineering, 200 (2022) 117710.

[2] Fisher, E., and Puttock-Brown, M. R. (December 6, 2023). "Experimental Measurements of Flow-Averaged Toroidal Vortices in Buoyancy-Dominated Rotating Cavities." ASME. J. Eng. Gas Turbines Power. April 2024; 146(4): 041006. https://doi.org/10.1115/1.4063689

Developing novel cooling systems for space, quantum, fusion reactor and transport (EP25/26)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Kun Liang

Department: Engineering

Research outline:

My team are developing novel cooling systems for space, quantum, fusion reactor and transport. The UK is leading international efforts to deliver clean fusion energy to the grid but realising the fusion dream requires cryogenic innovation for superconducting magnet that needs to be kept at 4 Kelvin. In this project, we will investigate a transformative but low-TRL Helium-based Pulsating Heat pIpe (HePHI) as a heat sink that could achieve thermal conductivity two orders higher than copper. Using infra-red imaging and high-speed camera, we will fully understand the heat transfer mechanism of thermally driven oscillations of helium.

Key Publication: Liang, K.*, et al. (2019). Comparisons between heat pipe, thermoelectric system, and vapour compression refrigeration system for electronics cooling. Applied Thermal Engineering, Vol. 146, pp. 260-267. (link)

The Development of cutting-edge personalised pulsatile vascular simulator to improve decision making in pre-operative assessment of transcatheter valve implantation (TAVI) (EP25/27)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Leonardo Garcia-Garcia in the Centre for Robotics and Sensing Technologies

Department: Engineering

Research outline:

The work will be based in a proof of concept created in collaboration with Surgeons of the Sussex Cardiac Centre. The main objectives of this research will focus on develop 3D printed models of the aorta and aortic valve from patients' MRIs, development of a blood circulatory system simulator with a pumping rate recorded from patient's ECG signals. It involves working with CAD, 3D printing, FEM, ECG data acquisition and analysis, Circuit and Mechanical systems design. This Project will contribute to advancements in planning for successful surgeries and improvement in patient's speed recovery.

Key Publication: García-García, L.A., Rodríguez-Salvador, M., Moya-Bencomo, M.D. (2019). Development of a Customized Wrist Orthosis for Flexion and Extension Treatment Using Reverse Engineering and 3D Printing. In: Lhotska, L., Sukupova, L., Lacković, I., Ibbott, G. (eds) World Congress on Medical Physics and Biomedical Engineering 2018. IFMBE Proceedings, vol 68/2. Springer, Singapore. (link)

Improving gas turbine engine structures (EP25/28)

EPSRC category: Experimental approaches to Understanding

Lead Supervisors: Mark Puttock-Brown and Vasudevan Kanjirakkad in the Energy and Materials Engineering Research Centre

Department: Engineering

Research outline:

Gas turbine engines are fundamental to the modern world, from transport to power generation, and demand is set to increase. While changes from fossil to sustainable fuels and eventually hydrogen is inevitable, the engine architecture is not likely to vary significantly, meaning a continued demand for improved internal air systems. These systems supply cooling and sealing and represent direct parasitic losses, yet without them the engine could not function. This makes improvements vital to meeting stringent targets and yet significant research questions remain. The rotating cavities, formed by sequential compressor stages, represent one such challenge due the complexity of the coupled heat transfer and flow field leading to intractable simulation problems.

Sussex is home to one (of only four) experimental rotating cavity test facilities in the world, demonstrably the closest to real engine conditions [1], and has been a mainstay of gas turbine research for over 40 years. Mostly recently working with GE Aviation, we have collaborated to develop cutting edge design-models using world-leading test data. Now we are looking to initiate a step-change in the field by investigating control methods to improve engine performance, making this an exciting opportunity to deliver significant real-world impact through an EPSRC studentship.

Key Publication: [1] Puttock-Brown, M. R., and Kanjirakkad, V. (November 14, 2024). Experimental Measurements of Buoyancy-Induced Flow in Rotating Cavities Under High Reynolds Number Conditions. ASME. J. Eng. Gas Turbines Power. May 2025; 147(5): 051005. (link)

Unlocking high-efficiency geothermal power generation (EP25/29)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Martin T White

Department: Engineering

Research outline:

Geothermal energy can be extracted from underground to provide renewable, baseload electricity 24-hours, and 365 days a year that could meet 20% of global electricity needs. However, the key roadblock is high costs. The geothermal sector is moving at unprecedented speed, with significant innovation to reduce drilling costs. This project will build on groundbreaking research at Sussex that is exploring innovations in the surface-level power plant. These innovations could enable a 30% improvement in power conversion, which translates to significant cost reductions. Specific areas of interest include techno-economic optimisation of the power plant, alongside innovation in turbomachinery design.

Key Publication: White, M., 2021, Cycle and turbine optimisation for an ORC operating with two-phase expansion, Applied Thermal Engineering, 192, 116852. (link)

A robotic breast cancer palpation simulator to redefine medical training and awareness efforts (EP25/30)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Nicolas Herzig in the Compliant and Soft Robotics Lab

Department: Engineering

Research outline:

This project, in collaboration with UCL partners, will develop a robotic breast cancer palpation simulator that will redefine medical training and awareness efforts. By delivering an unparalleled touch (haptic) sensation through advanced haptic feedback, the simulator will build on our latest joint results in soft robotics to offer a cutting-edge solution. The device will replicate realistic haptic experiences and allow customization for various patient conditions. Beyond training healthcare professionals to detect abnormalities with precision and confidence, the simulator will also raise public awareness and support self-examination training. This innovation will advance both diagnosis and prevention in breast cancer care.

Key Publication: Abad, SA., Herzig, N., Raitt, D. et al. Bioinspired adaptable multiplanar mechano-vibrotactile haptic system. Nature Communication 15, 7631 (2024). (link)

Control methods for 'excitable' systems such as battery thermal runaway and reactions of new, zero emission fuels (EP25/31)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Peter Fussey

Department: Engineering

Research outline:

This PhD will develop control methods for 'excitable' systems such as battery thermal runaway and reactions of new, zero emission fuels being developed at Sussex. Excitable systems are characterised by a small response to small stimuli and a large response if the stimulus passes a threshold. They include a wide range of applications from chemical reactions to neuron behaviour to climate change. Excitable systems can be modelled as a 'switchlet' which this PhD will use to develop 'model-based controllers' for excitable systems, allowing them to operate in a safe and controlled manner. See https://doi.org/10.1098/rspa.2010.0485 for an introduction to excitable systems.

Key Publication: Fussey, Peter and Limebeer, David (2019) Optimal combustion control with application to engine design and development. Control Engineering Practice, 92. ISSN 0967-0661

Developing energy-efficient graphene-based programmable metasurfaces for 6G terahertz (THz) communication systems (EP25/32)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Maziar Nekovee in the Advanced Communications, Mobile Technology and IoT (ACMI)

Department: Engineering

Research outline:

Building on our previous research, this PhD focuses on developing energy-efficient graphene-based programmable metasurfaces for 6G terahertz (THz) communication systems. With the rapid evolution of wireless technologies, 6G demands ultra-high-speed data rates, low latency, and massive connectivity, all achievable through the underutilized THz spectrum. Programmable metasurfaces, engineered with graphene's exceptional electrical, optical, and tunable properties, enable dynamic wave manipulation, including beam steering and frequency filtering, crucial for 6G applications, and promise to greatly outperform in the THz range the existing structures based on PIN diodes and liquid crystals, which are more suitable for centimeter and milimterwave frequency range. This research aims to design, fabricate, and optimize energy-efficient metasurfaces while addressing challenges in power consumption, scalability, and reconfigurability. The UK government's Science and Technology Framework had identified telecommunications as one of five critical technologies. The outcomes promise transformative solutions for next-generation wireless telecommunication systems (6G), as well as having applications in next generation LEO satellite communications, fostering greener and more efficient networks. The design, testing and optimisation will be carried out at Sussex. The fabrication of graphene metasurfaces will be supported by Cambridge Graphene Centre, led by Prof. Andrea Ferrari, who will act as the external supervisor.

Key Publication: Meng, X. Nekovee, M., Wu, D. The design and analysis of electronically reconfigurable liquid crystal-based reflectarray metasurface for 6G beamforming, beamsteering, and beamsplitting, IEEE Access, 9:155564-155575, 13 November 2021

The design, modelling, fabrication, processing and evaluation of new or improved optical devices, sensors or systems using ultraviolet, visible, and infrared (IR) radiation (EP25/33)

EPSRC category: Experimental approaches to Understanding

Lead Supervisors: Rodrigo Aviles-Espinosa and Elizabeth Rendon-Morales in the Centre for Robotics and Sensing Technologies

Department: Engineering

Research outline:

Most commercially available robotic systems can achieve millimetre accuracies with very few examples of high precision instruments achieving accuracies slightly below the millimetric scale. Medical applications such as reconstructive microsurgeries, surgical anastomosis, vitreoretinal eye surgery, and neurosurgery still require achieving precision comparable to the size of human cells. The research of my group focuses on the design, modelling, fabrication, processing and evaluation of new or improved optical devices, sensors or systems using ultraviolet, visible, and infrared (IR) radiation for the development the future robotic based tools to increase their precision beyond sub-millimetre accuracies.

Key Publications:

Huang X., Rendon-Morales E., and Aviles-Espinosa R., "A Biomedical Robotic Platform Combined With an Application-Specific Laser-Based End-Effector for Achieving High Precision Neurosurgery," 2024 IEEE MeMeA, 2024, pp. 1-6, doi: 10.1109/MeMeA60663.2024.10596756.

Huang, X., Rendon-Morales E., and Aviles-Espinosa R. “ROMI: Design and Experimental Evaluation of a Linear Delta Robotic System for High-Precision Applications”. Machines 2023, 11, 1072. (link)

Research on Hybrid Model of Optimal Vehicle Control and Macroscopic Dynamic Traffic Assignment for Mixed Traffic Network Capacity Maximization (EP25/34)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Shangbo Wang

Department: Engineering

Research outline:

In this project, we will investigate the maximum capacity a mixed traffic network can achieve, by devising a hybrid model of CAVs’ optimal control strategy and macroscopic dynamic traffic assignment method, which has never been done before. The main objective of the optimal control strategy is to minimize the link average travel time and fuel consumption by adaptively adjusting CAVs’ speed and acceleration, based on which the aggregate Macroscopic Fundamental Diagram (MFD) for mixed traffic flow will be formulated for understanding the impact of the optimal control strategy on link density and flow. Based on the derived macroscopic link model and node model, we will devise a dynamic traffic assignment method to maximize the network capacity at the dynamic Wardrop equilibrium, which incorporates the spatial queuing dynamics, CAVs’ optimal control strategy and adaptive traffic signal setting. We will also propose a dynamical system, which can achieve the dynamic Wardrop equilibrium by adaptively swapping route flow and adjusting signal settings. The condition for existence and uniqueness of the dynamic Wardrop equilibrium will be derived and stability of the dynamical system will be proved by the Lyapunov stability theorem.

Key Publication: Gu, H., Wang, S.*, Ma, X., Jia, D., Mao, G., Lim, E., Wong, C., (2024). Large-Scale Traffic Signal Control Using Constrained Network Partition and Adaptive Deep Reinforcement Learning. IEEE Transactions on Intelligent Transportation Systems, pp. 7619-7632, July 2024. doi: 10.1109/TITS.2024.3352446.

Energy network resilience and reliability and the impact of climate change (EP25/35)

EPSRC category: Interdisciplinary Research

Lead Supervisor(s): Spyros Skarvelis-Kazakos in the Energy and Materials Engineering Research Centre

Department: Engineering

Research outline:

Our research interests include energy network resilience and reliability, the impact of climate change and pandemics on energy networks, adaptation and mitigation of those impacts, critical infrastructure interdependencies, intelligent control / aggregation of Distributed Energy Resources, multiple energy carriers / integrated energy systems, complex network dynamics, micro-grids, Virtual Power Plants, energy storage, multi-agent systems, electric vehicles. Potential PhD project topics include: “Network Theory Resilience Metrics for interdependent multilayer critical infrastructure networks”; “Climate adaptation of critical infrastructure networks”; “Preventing electrical network blackouts with epidemic control techniques”; “Forest fires, climate change, pandemics and critical infrastructure resilience”

Key Publication: Skarvelis-Kazakos, S., Van Harte, M. et al. (2022). Resilience of electric utilities during the COVID-19 pandemic in the framework of the CIGRE definition of Power System Resilience, International Journal of Electrical Power & Energy Systems, Vol. 136, 107703

Fluid-dynamics and its applications, particularly, to turbomachines (EP25/36)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Dr Vasudevan Kanjirakkad in the Thermo-Fluid Mechanics Research Centre (Energy, Materials and Transport)

Department: Engineering

Research outline:

Have you ever wondered what is common to vehicle tunnel safety and aircraft propulsion? The Thermo-Fluids research group at Sussex has been at the forefront of cutting-edge research in collaboration with jet-engine manufacturers. In this EPSRC-funded studentship, however, we use our knowledge to design a tunnel ventilation ‘jet-fan’ component that will reduce the risk of pollutant or incident-related tunnel contamination 'quietly' and 'efficiently'. The work will utilise computational and experimental methodologies akin to aero-engine research. It is an ideal opportunity for candidates intrigued by fluid-dynamics and its applications, particularly, to turbomachines and for those interested to work in collaboration with relevant industry.

Key Publication: Mustaffa, A. F., and Kanjirakkad, V. (2021). Stall margin improvement in a low-speed axial compressor rotor using a blockage-optimised single circumferential casing groove. Journal of the Global Power and Propulsion Society, 5, pp.79-89. (link)

Developing a robotic system for ultrasound scan for diagnosis of rheumatoid arthritis (EP25/37)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Yanan Li

Department: Engineering

Research outline:

This project will develop a robotic system for ultrasound scan for diagnosis of rheumatoid arthritis (RA). This system will function in two modes: i) an autonomous mode that scans hand joints to capture clear and accurate joint information and detect potential early signs of RA; ii) a teleoperation mode, where, after the initial autonomous scan, clinicians can intuitively manipulate the robotic probe to assess specific joints of concern. This dual-mode system will save clinicians' time and effort, improve the reproducibility of ultrasound procedures, and provide a more standardized approach, facilitating its adoption as a routine method for early RA diagnosis.

Key Publication: Li, Y et al. (2018). Force, Impedance, and Trajectory Learning for Contact Tooling and Haptic Identification. IEEE Transactions on Robotics, vol. 34, no. 5, pp. 1170-1182

Developing AI- and model-based shared control modes for human-robot collaborative surgery (EP25/38)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Yanpei Huang

Department: Engineering

Research outline:

Traditional control of surgical robots relies on direct teleoperation, which can lead to errors from surgeon fatigue or limited experience. Shared control between human and robot can reduce workload and enhance performance by assisting with routine operations while the surgeon retains control of complex tasks. We will use game theory to develop AI- and model-based shared control modes for human-robot collaborative surgery. Robot will learn from expert human using machine learning approaches. Control authority will dynamically shift between the surgeon and robot, allowing the robot to autonomously manage certain tools with real-time sensory data and adapt based on recent performance.

Key Publication: Hu, Z. J., Wang, Z., Huang, Y., Sena, A., Rodriguez y Baena, F. and Burdet E. (2023), Towards human-robot collaborative surgery: trajectory and strategy learning in bimanual peg transfer, IEEE Robotics and Automation Letters, 8(8):4553-60, doi: 10.1109/LRA.2023.3285478.

Exploiting the potential of V2X communications, edge computing and intelligent traffic control for revolutionizing future transport networks (EP25/39)

EPSRC category: Experimental approaches to Understanding

Lead Supervisors: Zhengguo Sheng, Naercio Magaia and Shangbo Wang in Intelligent communications, computing and control (I3C) for future vehicle and transportation networks

Department: Engineering

Research outline:

Over the past few years, we have witnessed an increasing research interest and efforts in the development of connected and intelligent vehicles. There have been significant advancements in vehicle-to-everything (V2X) communications and edge computing to enable intelligent transportation systems (ITS). Our research aim is to fully exploit the potentials of V2X communications, edge computing and intelligent traffic control for revolutionizing the future transport networks. By developing intelligent communications, computing and control capabilities, the combination of vehicles and infrastructure have the potential to address a wide range of open questions from sustainability to Net Zero.

Key Publications:

Cui, M. et al. Secure Data Sharing for Consortium BlockchainEnabled Vehicular Social Networks. in IEEE Transactions on Vehicular Technology, doi: 10.1109/TVT.2024.3448207

Gu, H. et al. Large-Scale Traffic Signal Control Using Constrained Network Partition and Adaptive Deep Reinforcement Learning. IEEE Transactions on Intelligent Transportation Systems, vol. 25, no. 7, pp. 7619-7632, July 2024, doi: 10.1109/TITS.2024.3352446

Carlos Silva, Naercio Magaia, and António Grilo. 2023. Task Offloading Optimization in Mobile Edge Computing based on Deep Reinforcement Learning. In Proceedings of the Int'l ACM MSWiM '23. (link)

Innovations in high-performance high-lift heat pumps (EP25/40)

Collaborative project with non-university partners

EPSRC category: Applied Research for a Better World

Lead Supervisors: Martin T White and Kun Liang in the Thermo-Fluid Mechanics Research Centre

Department: Engineering

Research outline:

Heat decarbonisation is a significant challenge that requires urgent action to meet net-zero targets. A particular challenge lies in the industrial sector, where heat demand is significant and can range enormously in terms of the amount and temperature of heat required. High temperature industrial heat pumps are expected to play a major role, but existing systems are limited in terms of the achievable temperature lift and heat-sink temperature, and new solutions need to be identified.

This PhD studentship will focus on conducting state-of-the-art research to develop the tools and knowledge to enable the design of high-performance heat pumps that can meet the challenging needs of industrial applications.

Key Publication: White, M., 2024, pocketTHERM: A web-based tool for teaching non-ideal thermodynamic cycles, SoftwareX, 27, 101806. (link)

Digital Twin Empowered Integrated Sensing and Communications (DT-ISAC) for Smart Transportation (EP25/41)

Collaborative project with non-university partners

EPSRC category: Experimental approaches to Understanding

Lead Supervisors: Zhengguo Sheng and Shangbo Wang in the Advanced Communications, Mobile Technology and IoT (ACMI)

Department: Engineering

Research outline:

Addressing traffic safety is the foremost priority in current smart transportation research, as it serves as the foundational basis for other core requirements, such as traffic capacity, energy efficiency, time delay and so on. Meanwhile, vehicular communications and sensing are crucial for achieving universality, flexibility and integrated solutions within 6G network scenarios, and is key to connect with the broader infrastructure to optimize traffic flows and to achieve intelligent transportation. Inspired by the recent advancement in integrated sensing and communication (ISAC), this project will investigate new opportunities to explore the ISAC capacity for traffic and pedestrian safety. Essentially, the proposed solution should reuse Ultra-wideband such as 5G mmWave or optical wireless communications (OWC) to construct communication/sensing channels for achieving concurrent message exchange and status awareness between vehicles and pedestrian at urban crossings.

Key Publication: Y. Song, R. Mo, P. Zhang, C. Wang, Z. Sheng and Y. Bing, “VehicleTalk: Lightweight V2V Network Enabled by Optical Wireless Communication and Sensing”, Proc. of IEEE Vehicular Technology Conference (VTC) 2024, Singapore. 10.1109/VTC2024-Spring62846.2024.10683127

High precision robotics and sensing in manufacturing (EP25/42)

Collaborative project with non-university partners

EPSRC category: Applied Research for a Better World

Lead Supervisors: Elizabeth Rendon-Morales and Rodrigo Aviles-Espinosa in the Centre for Robotics and Sensing Technologies

Department: Engineering

Research outline:

Hydrogen can be used to generate energy with ultra-low carbon emissions for applications in distributed power systems aimed at decarbonising cities, factories, data centres and electric vehicle charging. The UK Hydrogen Strategy comprises a group of companies from which our partner is one of the three key players working at the forefront of hydrogen fuel cells technology development. Their technology, a solid oxide fuel cell developed for low carbon power generation has been patented and is already contributing with the UK to achieve net zero by 2050 as well as the Sixth Carbon Budget target by 2035. This research project with an industry partner aims to overcome the current challenges faced in quality inspection to make it as efficient, simple, reliable and cost-effective as possible and will set up the foundations for the development of a machine vision system combined with deep learning capability to improve the quality, safety and speed in the post-test analysis (PTA) of hydrogen fuel cells technology.

Key Publication: X. Huang, E. Rendon-Morales, and R. Aviles-Espinosa. A Biomedical Robotic Platform Combined with an Application-Specific Laser-Based End-Effector for Achieving High Precision Neurosurgery. 2024 IEEE International Symposium on Medical Measurements and Applications (MeMeA), Eindhoven, Netherlands, 2024, pp. 1-6, doi: 10.1109/MeMeA60663.2024.10596756. (link)

Hybrid Air/Land Robot Navigation in Unstructured Farming Environments (EP25/43)

Collaborative project with non-university partners

EPSRC category: Applied Research for a Better World

Lead Supervisors: Dr Bao Kha Nguyen

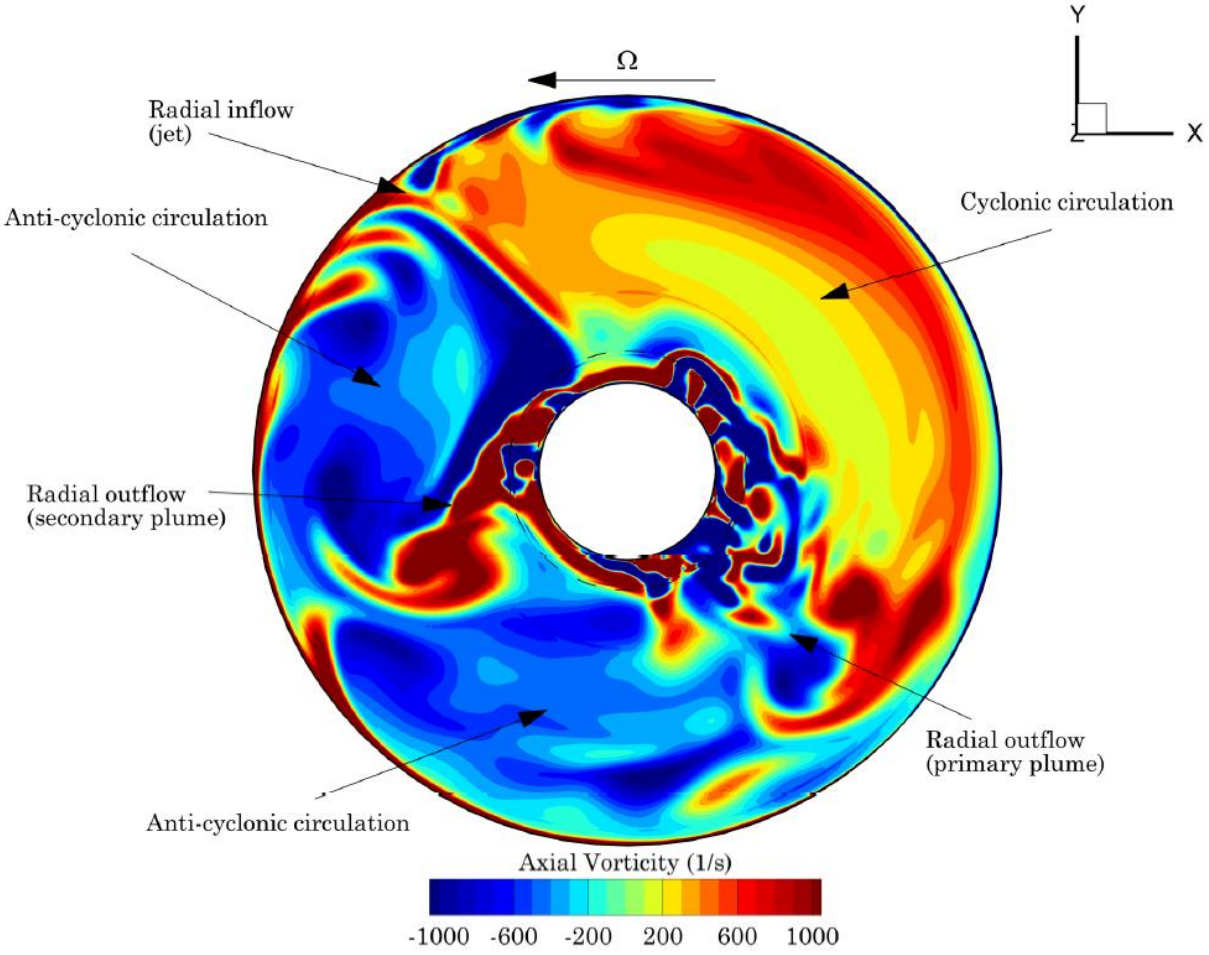
Department: Engineering

Research outline:

Mobile robots have played a significant role in many agricultural applications as they reduce human labour and enhance the operation safety. Pasture - based farms with variations of terrains and vegetations lack of well-defined features, making robot navigation more challenging. This project will develop multi-sensor fusion strategies for a hybrid land/air robot including a wheeled robot and a drone that is capable of navigating its way around different terrains including hedgerows and other features of a typical UK pasture-based farm landscape. The proposed strategies will enable the robot

to estimate its location, distinguish obstacles, ditches or other obstructions including moving objects on unstructured pasture-based farms and perform a traversability analysis to identify the safest and most effective method for autonomous navigation through various terrains, not within a fixed path but anywhere on the farm.

Key Publication: Liu, C.; Nguyen, B.K., 2024. Low-Cost Real-Time Localisation for Agricultural Robots in Unstructured Farm Environments. Machines, Volume 12, 612.



Informatics

Active visual learning (EP25/44)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Andrew Philippides

Department: Informatics

Research outline:

Perception is not passive. Animals actively explore their environments to acquire the information they need to guide future behaviour and evolution has shaped the animal movements to shape incoming information to make it easier to learn/recall. This is seen across animals from choreographed learning flights of bees to eye movements of humans. However, precisely how active vision is co-evolved with task, environment and visual system is not well understood. This project will explore this question either experimentally, theoretically or both with details guided by the student with applications ranging from insects to humans, and AI to robots.

Key Publication: Philippides, A., de Ibarra, N. H., Riabinina, O., & Collett, T. S. (2013). Bumblebee calligraphy: the design and control of flight motifs in the learning and return flights of Bombus terrestris. Journal of Experimental Biology, 216(6), 1093-1104.

Computational and biological perspectives on how neural systems can self-organise to produce robust, adaptive and intelligent behaviour (EP25/45)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Benjamin Evans

Department: Informatics

Research outline:

Broadly I am most interested in how neural systems can self-organise to produce robust, adaptive and intelligent behaviour, which I study from both a biological and a computational perspective

through modelling. I seek to enhance artificial neural networks by drawing inspiration from their biological counterparts and reverse-engineering the solutions discovered through evolution. In particular, I am interested in how the unusual properties of information processing with spikes (action potentials) may be crucial to achieving such impressive perceptual and cognitive abilities from varied, noisy and unreliable neurons.

In particular, I would welcome projects on biologically inspired models of vision for example with adaptive convolutional kernels mimicking the behaviourally modified response properties found in early visual processing areas such as the Superior Colliculus of mice. This could be an interdisciplinary project co-supervised by my collaborator Dr Sylvia Schroeder in Life Sciences.

Key Publication: Evans, B.D.; Malhotra, G; Bowers, J.S. (2022). Biological convolutions improve DNN robustness to noise and generalisation. Neural Networks, 148, p96-110. 10.1016/j.neunet.2021.12.005

Bayesian Intelligence in Animals and Machines (EP25/46)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Christopher L Buckley

Department: Informatics

Research outline:

The idea that the brain operates as a Bayesian inference engine has gained substantial traction across the brain sciences. Active inference is a recent advance in theoretical neurobiology that offers a unified framework for understanding action, perception, and learning through the lens of variational Bayes. This paradigm contrasts with traditional machine learning (ML) approaches by prioritizing probabilistic reasoning and employing distributed message-passing algorithms rather than relying exclusively on backpropagation. We encourage projects that sit at the intersection of Bayesian models of intelligence and ML, both to further develop theory in neurobiology and to design novel techniques for next-generation AI architectures.

Key Publication: CL Buckley et. al., The free energy principle for action and perception: A mathematical review. Journal of mathematical psychology 81, 55-79

Modelling post-growth economics (EP25/47)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Dr Adam Barrett in the Sussex Centre for Consciousness Science

Department: Informatics

Research outline:

Most economic models assume endless growth, but in this era of climate change, exploration is beginning on what happens if economic growth comes to an end. This PhD will apply complexity

science, agent-based modelling and machine learning tools to understand the dynamics of post-growth macroeconomics. The goal will be to investigate how a sustained period with little or no GDP/productivity growth might impact the frequency and severity of recessions, bankruptcies, financial dynamics, and/or inequality. The PhD will take place in an inter-disciplinary environment encompassing the Sussex AI research centre and the Science Policy Research Unit.

Key Publication: Barrett, A.B. (2018). Stability of zero-growth economics analysed with a Minskyan model. Ecol. Econ. 146: 228-239.

Sussex Centre for Consciousness Science (EP25/48)

EPSRC category: Interdisciplinary Research

Lead Supervisors: Adam Barrett, Anil Seth and Christopher L Buckley in the Sussex Centre for Consciousness Science

Department: Informatics

Research outline:

Adam Barrett can supervise projects on: (i) computational neuroscience of consciousness, e.g., understanding diverse states of consciousness and their contents via complexity theory, measures of emergence and information theory; (ii) the fundamental physical substrate of consciousness, e.g., re-formulating integrated information theory in terms of axioms and operationalisations, potentially better linking it to fundamental physics; (iii) applications of neuroscience of consciousness and machine learning to mental health, e.g., neuroscience of mechanisms of psychedelic-assisted therapy. He is open to any proposal applying mathematical, computational and/or data science tools to the study of consciousness.

Anil Seth is keen to supervise projects in the area of 'computational neurophenomenology' - broadly, the use of computational and machine learning models to bridge between properties of neural mechanisms and properties of perceptual experience. One particular project involves using variants of predictive processing to model visual illusions, exploring conditions under which predictive networks 'perceive' the world in ways like us. He is also interested in projects relating to measuring emergence in complex systems; the relationship between consciousness, AI, and biology; computational models of stroboscopic hallucinations, and other topics at the interface of computational neuroscience, AI, and philosophy.

Christopher Buckley: The idea that the brain operates as a Bayesian inference engine has gained substantial traction across the brain sciences. Active inference is a recent advance in theoretical neurobiology that offers a unified framework for understanding action, perception, and learning through the lens of variational Bayes. This paradigm contrasts with traditional machine learning (ML) approaches by prioritizing probabilistic reasoning and employing distributed message-passing algorithms rather than relying exclusively on backpropagation. We encourage projects that sit at the intersection of Bayesian models of intelligence and ML, both to further develop theory in neurobiology and to design novel techniques for next-generation AI architectures.

Key Publications:

Adam Barrett: Mediano, P.A.M., Rosas, F.E., Bor, D., Seth, A.K., & Barrett, A.B. (2022). The strength of weak integrated information theory. Trends Cogn Sci. 26(8) 646-655.

Anil Seth: Seth, A.K. and Bayne, T. (2022). Theories of consciousness. Nature Reviews Neuroscience. 23: 439-452.

Christopher Buckley: Buckley, C.L., Kim, C.S., McGregor, S., Seth, A.K. (2017) The free energy principle for action and perception: A mathematical review Journal of mathematical psychology 81, 55-79.

Leveraging machine learning (ML) to address verification and synthesis challenges in timed logics (EP25/49)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Hsi-Ming Ho

Department: Informatics

Research outline:

This project explores leveraging machine learning (ML) to address verification and synthesis challenges in timed logics, which model systems with temporal constraints. It aims to enhance scalability and efficiency in verifying system behaviours, generating counterexamples, and providing explanations. Key steps include developing data representations, feature engineering, training ML models, and integrating them with existing tools. The research promises novel ML methodologies tailored to formal verification, improved verification performance, and automated synthesis capabilities. Over three years, the project will progress from data collection and experimentation to methodology development, integration, and evaluation, contributing insights to both formal methods and ML.

Key Publication: Brihaye, T., Geeraerts, G., Ho, H. M., & Monmege, B. (2017, July). MightyL: A compositional translation from MITL to timed automata. In International Conference on Computer Aided Verification (pp. 421-440).

Creating multimodal machine learning models that unify the information from disparate measurements including audio, camera traps, vegetation, and soil surveys (EP25/50)

EPSRC category: Interdisciplinary Research

Lead Supervisors: Ivor Simpson, Alice Eldridge and Chris Sandom

Department: Informatics

Research outline:

Ecosystems involve a complex web of interactions across a vast range of temporal and spatial scales. Accordingly, data from any set of sensors offers a limited perspective of the underlying ecological processes. This complicates accumulating evidence for nature recovery programmes, and there is a real need for more comprehensive metrics to assess ecological health and integrity.
The focus of this project will be creating multimodal machine learning models that unify the information from disparate measurements including audio, camera traps, vegetation, and soil surveys etc. to build a holistic picture of an ecosystem, and describe how it changes over time and across space. This will build on ongoing machine learning research within the lab, which has focused on learning spatiotemporal models of ecoacoustic data to date.

This project will be supervised in collaboration with Chris Sandom and Alice Eldridge, who each offer rich domain-specific expertise in ecological monitoring and ecoacoustics analysis respectively. Data will be sourced from ongoing collaborations and projects.

Key Publications:

Gibb, K.A., Eldridge, A., Sandom, C.J. and Simpson, I.J., 2024. Towards interpretable learned representations for Ecoacoustics using variational auto-encoding. Ecological Informatics, 80, p.102449. https://doi.org/10.1016/j.ecoinf.2023.102449.

Balfour, N.J., Durrant, R., Ely, A., Sandom, C.J., 2021. People, nature and large herbivores in a shared landscape: A mixed-method study of the ecological and social outcomes from agriculture and conservation. People and Nature 3, 418–430. https://doi.org/10.1002/pan3.10182

Bradfer-Lawrence, T., Desjonqueres, C., Eldridge, A., Johnston, A. and Metcalf, O., 2023. Using acoustic indices in ecology: Guidance on study design, analyses and interpretation. Methods in Ecology and Evolution, 14(9), pp.2192-2204. https://doi.org/10.1111/2041-210X.14194

Magnetic resonance (MR) imaging as a powerful and flexible method for understanding the human brain (EP25/51)

EPSRC category: Interdisciplinary Research

Lead Supervisors: Ivor Simpson, Nicholas Dowell and Itamar Ronen

Department: Informatics

Research outline:

Magnetic resonance (MR) imaging offers a powerful and flexible method to understand the human brain, and how it can be perturbed by disease. A vast range of quantitative measurements of structure, microstructure and tissue composition are possible and would enable the development of sensitive biomarkers.

Dr Simpson is a computer scientist with extensive experience in developing probabilistic machine learning and statistical modelling approaches for inference in inverse-problems. In particular, he focuses on methods that enable principled uncertainty-aware inference of latent biomarkers from brain MR data. Working in collaboration with Professor Ronen and Dr Dowell at CISC, we would encourage proposals from students interested in the development of novel analysis solutions.

Professor Ronen is an MRI physicist with more than 20 years experience in designing MR acquisition methods, with strong focus on advanced methods in magnetic resonance spectroscopy (MRS). In particular, Prof. Ronen developed a range of diffusion weighted MRS (DW-MRS) methods, aimed at exploring cellular morphology in health and disease. Specific projects under his supervision will include developing robust and clinically-applicable acquisition schemes for diffusion-weighted magnetic resonance spectroscopic imaging, and sequences sensitised to intercompartmental exchange of brain metabolites with applications to brain metabolism.
Dr Dowell is a Senior Lecturer in Imaging Physics with extensive experience in developing MRI techniques for generating sensitive biomarkers of physiology and pathophysiology, particularly in the brain. This has involved using MR pulse sequence programming and the development of software to acquire the data and compute the final biomarker maps. Projects under his supervision would involve the development and optimization (of both the acquisition and analysis) of quantitative imaging approaches both at high field (3T) at ultra low magnetic field (50mT). Areas of interest include myelin quantification using magnetization transfer methods, and blood-brain barrier permeability measures with dynamic-contrast-enhanced MRI.

Key Publications:

Duff, M.A., Simpson, I.J., Ehrhardt, M.J. and Campbell, N.D., 2023. VAEs with structured image covariance applied to compressed sensing MRI. Physics in Medicine & Biology, 68(16), p.165008. 10.1088/1361-6560/ace49a

De Marco, R., Ronen, I., Branzoli, F., Amato, M.L., Asllani, I., Colasanti, A., Harrison, N.A. and Cercignani, M., 2022. Diffusion-weighted MR spectroscopy (DW-MRS) is sensitive to LPS-induced changes in human glial morphometry: a preliminary study. Brain, Behavior, and Immunity, 99, pp.256-265. https://doi.org/10.1016/j.bbi.2021.10.005

Alruwais, N.M., Rusted, J.M., Tabet, N. and Dowell, N.G., 2022. Evidence of emerging BBB changes in mid-age apolipoprotein E epsilon-4 carriers. Brain and Behavior, 12(12), p.e2806. doi: 10.1002/brb3.2806

Investigating the neural algorithms implemented in animal brains and their integration into modern AI (EP25/52)

EPSRC category: Interdisciplinary Research

Lead Supervisor: James Bennett

Department: Informatics

Research outline:

The Bennett lab works at the intersection of biology and AI. We investigate the neural algorithms implemented in animal brains and their integration into modern AI. Ongoing projects in the lab encompass: i) Control theoretic approaches to reinforcement learning and forgetting in changing environments, and their implementation in the brain's dopamine system; ii) Efficient coding in continual learning paradigms, investigating neural networks with separate excitatory and inhibitory neurons that fulfil complementary objectives through distinct learning rules; iii) Hierarchical reinforcement learning over multiple time-scales to facilitate risk-sensitive and adaptive decision-making; iv) identifying stereotypical behaviours in animal movements using self-supervised deep learning.

Key Publication: Bennett JEM, Philippides A, Nowotny T. (2021). Learning with reinforcement prediction errors in a model of the Drosophila mushroom body. Nature Communications 12:2569, DOI: 10.1038/s41467-021-22592-4

Event-based machine learning and neuromorphic computing (EP25/53)

EPSRC category: Interdisciplinary Research

Lead Supervisors: James Knight and Thomas Nowotny

Department: Informatics

Research outline:

Event-based Spiking Neural Networks (SNNs) are inspired by the efficiency of biological neurons and with recent advances such as Eventprop (Wunderlich & Pehle (2021), Nowotny et al. (2024)) we can train them using supervised learning. However, there are technical difficulties and the methods have thus far only been applied to a few benchmark problems. Equally important, like in ML more generally, lack of labelled data is becoming a problem. Self-supervised approaches are an exciting and competitive alternative (Chen et al. (2020), Illinger et al. (2020), Halvagal & Zenke (2023)).

We are looking for PhD students interested in working on these challenges using our GPU-accelerated SNN simulation framework (Knight et al. (2021), Knight & Nowotny (2023) to:

- further improve methods for gradient descent in SNNs
- extend gradient descent methods towards real-world problems
- combine SNNs and self-supervised learning to solve real-world tasks
- train SNNs for deployment on neuromorphic hardware like Loihi 2

Key Publications:

Nowotny T, Turner, JP, Knight, JC (2024). Loss shaping enhances exact gradient learning with EventProp in spiking neural networks, arXiv. (link)

Knight, JC & Nowotny, T (2023). Easy and efficient spike-based machine learning with mlGeNN. Neuro-Inspired Computational Elements Conference, 115–120. (link)

Human-computer interaction, with a focus on technologies for learning and education (EP25/54)

EPSRC category: Applied Research for a Better World

Lead Supervisors: Kate Howland and Sam Berens

Department: Informatics

Research outline:

Kate Howland: My research is in human-computer interaction, with a focus on technologies for learning and education. I design and evaluate educational interfaces based on empirical evidence about how we learn, particularly systems that take account of the embodied, enactive and situated nature of learning. My recent work has investigated a concreteness fading approach to designing interfaces for computing education, enhancement of social-motor synchrony through multisensory full-body interaction and the use of gestures and gestural interaction in both programming education and language learning.

Sam Berens: My research aims to understand the cognitive and neural mechanisms that enable us to learn general knowledge and solve problems. I am particularly interested in how we learn concepts that help us make sense of the world. To do this, I investigate the neural representations and computations involved in combining information across different events, identifying commonalities/differences, and extracting generalisable patterns. My work uses a combination of bespoke cognitive tasks and model-based analyses of behavioural and functional MRI data.

Proposed joint project: The design, development and evaluation of an adaptive learning environment that builds on neuroscientific evidence about learning and generalisation to support personalised representations that match learners' needs based on their current performance on learning tasks.

Key Publications:

Trory, A., Howland, K., Good, J. and du Boulay, B. (2024). From Pirate Islands to Routing Tables: Investigating Intermediate Representations in Concreteness Fading through AR Learning. In Proceedings ACM Interaction Design and Children Conference (IDC '24). Association for Computing Machinery, New York, NY, USA, 469–479. (link)

Berens, S. C., & Bird, C. M. (2022). Hippocampal and medial prefrontal cortices encode structural task representations following progressive and interleaved training schedules. PLOS Computational Biology, 18(10), e1010566. (link)

New approaches to the monitoring and management of large scale distributed systems (EP25/55)

EPSRC category: Interdisciplinary Research

Lead Supervisors: Luc Berthouze and George Parisis

Department: Informatics

Research outline:

Currently funded by an EPSRC New Horizon grant, and in close collaboration with industrial partners, we are developing new approaches to the monitoring and management of large scale distributed systems. We adopt a strongly interdisciplinary approach, combining methods from complexity and network science, neuroscience, and machine learning. We are particularly interested in supervising research aimed to leverage the potential of temporal networks and graph learning methods to improve key tasks such as anomaly detection and load prediction in microservice architectures. The successful applicant will be embedded in a very active group.

Key Publications:

Messager A, Parisis G, Kiss IZ, Harper R, Tee P and Berthouze L. (2019). Inferring functional connectivity from time-series of events in large scale network deployments. IEEE Transactions on Network and Service Management, 16(3):857-870. doi: 10.1109/TNSM.2019.2932896.

Winchester G, Parisis G, and Berthouze L. (2023). On the temporal behaviour of a large-scale microservice architecture. NOMS 2023-2023 IEEE/IFIP Network Operations and Management Symposium, pp. 1-6. doi: 10.1109/NOMS56928.2023.10154427.

Integrating Explainable Artificial Intelligence into Intrusion Detection Systems to offer more transparent, trustworthy, and effective detection of cyberattacks (EP25/56)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: Naercio Magaia

Department: Informatics

Research outline:

Intrusion Detection Systems (IDS) are critical for securing modern networks against cyber threats. While machine learning (ML) techniques have enhanced IDS capabilities, many of these models function as "black boxes," providing little insight into their decision-making processes. This lack of transparency can limit trust, especially when security systems have high stakes. Explainable Artificial Intelligence (XAI) offers a solution by making ML models more interpretable, providing users with insights into how decisions are made. Applying XAI to intrusion detection could enhance system security, accountability, and compliance by explaining detection decisions to cybersecurity professionals. Our research aims to explore how XAI can be integrated into IDS to offer more transparent, trustworthy, and effective detection of cyberattacks.

Key Publication: Sousa, B.; Magaia, N.; Silva, S. An Intelligent Intrusion Detection System for 5G-Enabled Internet of Vehicles. Electronics 2023, 12, 1757. (link)

Develop innovative and statistically principled machine learning approaches for incorporating multi-modal medical imaging data into models of disease progression (EP25/57)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Peter Wijeratne and Ivor Simpson

Department: Informatics

Research outline:

Dr Wijeratne's EPSRC research area is artificial intelligence (AI) in healthcare and neuroscience, with a particular focus on data- and computationally-efficient probabilistic modelling of disease progression with a strong theoretical foundation. Along with Dr Simpson, who has expertise in developing machine learning approaches for inverse problems with spatiotemporal data, we are looking to supervise PhD projects that develop innovative and statistically principled machine learning approaches for incorporating multi-modal medical imaging data into models of disease progression. This will build on Dr Wijeratne's recent optimal transport (OT) model of disease progression and utilise structured data likelihoods (from Dr Simpson's work) to robustly incorporate different sources of evidence. This project has multiple research directions, including the development of OT theory to power the next generation of image-driven disease progression models. Multi-disciplinary applications include early diagnosis and prediction of dementia.

Key Publications:

Wijeratne, PA, Alexander, DC. (2024). Unscrambling disease progression at scale: fast inference of event permutations with optimal transport. Advances in Neural Information Processing Systems (NeurIPS). doi: 10.48550/arXiv.2410.14388

Simpson, IJA, Vicente, S, Campbell, NDF. (2022). Learning structured Gaussians to approximate deep ensembles. Computer Vision and Pattern Recognition (CVPR). doi: 10.48550/arXiv.2203.15485

Theoretical or applied Natural Language Processing - with applications to misinformation and disinformation, propaganda detection, mental health support, biodiversity and conservation, and climate change (EP25/58)

EPSRC category: Experimental approaches to Understanding

Lead Supervisor: Julie Weeds

Department: Informatics

Research outline:

I am looking to supervise projects in the area of theoretical or applied Natural Language Processing. I am interested in projects developing or applying methods for textual similarity, paraphrase detection,

partial paraphrase detection, natural language inference, contradiction and entailment recognition. With recent advances in large language modelling, I am especially interested in hallucination detection and the distinction between factuality and plausibility. Applications of interest include misinformation and disinformation, propaganda detection, mental health support, biodiversity and conservation, and climate change.

Key Publication: Peng, Q., Weir, D. and Weeds, J. (2023). Testing Paraphrase Models on Recognising Sentence Pairs at Different Degrees of Semantic Overlap. Proceedings of the 12th Joint Conference on Lexical and Computational Semtics (*sem 2023). pgs 259-269. DOI: 10.18653/v1/2023.starsem-1.24

Understanding the dynamics of land use change and supporting the co-creation of pathways towards sustainable land use (EP25/59)

EPSRC category: Interdisciplinary Research

Lead Supervisors: Novi Quadrianto and Fiona Marshall

Department: Informatics

Research outline:

This transdisciplinary project is concerned with understanding the dynamics of land use change and supporting the co-creation of pathways towards sustainable land use that address biodiversity, climate change, food security and poverty concerns. The focus is on opportunities for sustainable food estate programmes in Indonesia, in the context of major concerns about their adverse environmental and social impacts. We work with farming communities, NGOs, conservation agencies and government agencies; drawing together quantitative and qualitative data (and formal and informal knowledges) to visualize and assess the multiple values of landscapes and impacts of food estate interventions at sites with a variety of monocrop and agroforestry systems. We seek to support productive, evidence-based dialogue through the development and use of an open access mapping and modelling tool; developing land use scenarios that integrate climate resilience and biodiversity conservation into initiatives that support sustainable livelihoods of farming communities and wider food security concerns. Through participatory action research and capacity building activities with key stakeholders, we identify land use planning and policy process opportunities and practical intervention points.

Key Publication: Dolley, J., Marshall, F., Butcher, B. Butcher, Reffin, J., Robinson, J.A., Eray, B., Quadrianto, N. Analysing trade-offs and synergies between SDGs for urban development, food security and poverty alleviation in rapidly changing peri-urban areas: a tool to support inclusive urban planning. Sustainability Science, 10.1007/s11625-020-00802-0.

Develop new models and data sets to address current technical challenges in the recognition of sign language (EP25/60)

EPSRC category: Applied Research for a Better World

Lead Supervisors: Ronald Grau and John Walker

Department: Informatics

Research outline:

British Sign Language is the primary means of communication for many deaf and hearing-impaired people in the UK. There is a clear need to promote sign language proficiency within this group, as this has been declining over recent years, especially among younger people. However, learning sign language requires the acquisition of psychomotor skills, and these are not easily obtained without practice and feedback. AI-supported learning tools would not only help address this problem but also make sign language more accessible to the general population and so, help improve inclusion for deaf and hearing-impaired people in society.

Previous research has shown the potential of computer vision algorithms and convolutional neural networks for transforming image data of signs into actionable insights and providing feedback in real time - a major improvement over passive approaches such as instructional videos. The PhD project will build on previous developments of BSL training prototypes, the latest of which won the Sussex University JRA competition in 2024. The project will develop new models and data sets to address current technical challenges in the recognition of signs but also contribute towards ongoing work for developing and evaluating methods to integrate AI-supported techniques into established sign language pedagogy.

Key Publications:

Aldahir, R., Grau, R. (2024). Using convolutional neural networks for visual sign language recognition. Towards a system that provides instant feedback to learners of sign language. 21st International Web for All Conference (W4A '24), 70-74 / DOI: 10.1145/3677846.3677848

O'Brien D, Hodge G, Gulamani S, Rowley K, Adam R, Emery S, Walker J (2023). Deaf professionals' perceptions of 'trust' in relationships with signed language interpreters. The International Journal of Translation and Interpreting Research, 15(2), 25-42 / DOI: 10.12807/ti.115202.2023.a02

Continuous monitoring of movement difficulties for people with Parkinson's disease (EP25/61)

EPSRC category: Applied Research for a Better World

Lead Supervisor: Temitayo Olugbade

Department: Informatics

Research outline:

Continuous monitoring of movement difficulties, related worry, and pain can be helpful for people with Parkinson's disease for managing their wellbeing and discussing needs with healthcare professionals. The proposed PhD project will contribute to the limited research in this area. The project will involve investigation of distribution shifts and spurious features in automatic detection of these variables, based on existing and new body movement and physiological datasets. Strong experience in machine learning, interest in the application area, and critical analysis skills will be needed.

Key Publication: Olugbade, T., Buono, R. A., Potapov, K., et al. (2024). The EmoPain@Home dataset: Capturing pain level and activity recognition for people with chronic pain in their homes. IEEE Transactions on Affective Computing (Early Access). pp. 1-14. https://doi.org/10.1109/TAFFC.2024.3390837

Natural Language Processing for Improving Support for Young People's Mental Health (EP25/62)

Collaborative project with non-university partners

EPSRC category: Applied Research for a Better World

Lead Supervisor: Julie Weeds

Department: Informatics

Research outline:

This project will be in collaboration with an organisation specialising in providing digital mental health support for young people. Their app provides a safe space for young people to talk about their experiences; pre-moderated, anonymous peer support; pre-emptive counsellor intervention and access to a directory of specialist resources. Previous collaborations have focussed on using NLP to support the moderation process as well as finding and recommending resources within the directory based on user posts. Now the partner would like to investigate using NLP technology for directly answering user questions given certain constraints: user data (including posts) is highly sensitive making certain cloud services off-limits, building and running large language models locally is prohibitively expensive, users are vulnerable and may be at high risk if given incorrect information. Given these constraints, how much can NLP and other AI technology be used to speed up response times in a scalable way?

Key Publication: Rummer-Downing, T. and Weeds, J. (2023). Leveraging Out-of-the-Box Retrieval Models to Improve Mental Health Support. In Proceedings of the 16th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2023) - HEALTHINF; ISBN 978-989-758-631-6; ISSN 2184-4305, SciTePress, pages 64-73. DOI: 10.5220/0011634300003414

Advancing mechanistic understanding of atrial fibrillation through analytical and physics-based machine learning (EP25/63)

Collaborative project with non-university partners

EPSRC category: Interdisciplinary Research

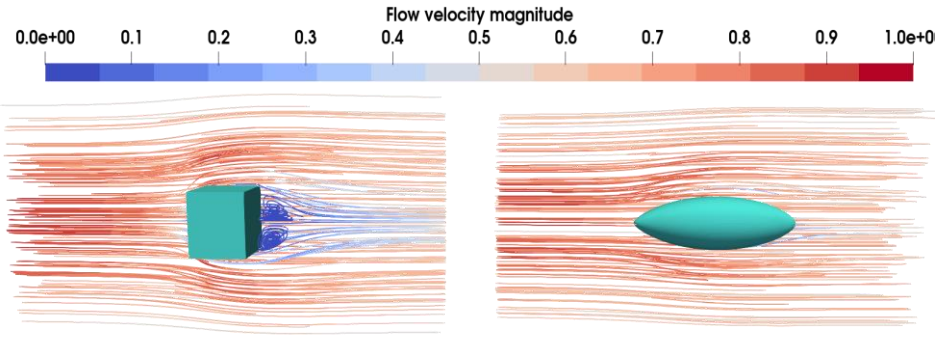
Lead Supervisor: Luc Berthouze

Department: Informatics

Research outline:

Atrial fibrillation (AF) is the most common heart rhythm disorder, but understanding its causes is challenging due to its complexity. It involves triggers like abnormal electrical signals (focal triggers) and swirling patterns of electrical activity (re-entrant rotors), which interact across the heart's inner and outer layers. Because most studies to date focus on just one layer, understanding what keeps AF going is challenging. This PhD project aims to bridge that gap by combining advanced machine learning tools with a new experimental protocol developed by University Hospital Sussex in collaboration with their industrial partner, and which makes it possible to collect data from both layers of the heart at the same time.

Key Publication: Caprioglio E, Berthouze L. (2024). Emergence of metastability in frustrated oscillatory networks: the key role of hierarchical modularity. Frontiers Network Physiology. 4. (link)



Mathematics

Developing a model of the cytoskeletal circuits for cancer research (EP25/64)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Chandrasekhar Venkataraman

Department: Mathematics

Research outline:

In this project, an interdisciplinary team will unravel some open problems in cancer research such as how persistence is controlled during migration in non-transformed cells and how this is altered in cancer cells. We hypothesise that cytoskeletal circuits control membrane protrusion, cell migration persistence and the directed migration of cells. The student will develop a model of the cytoskeletal circuits (using experimental work of the group) which regulate polymerisation and backward flow of the actin network thereby controlling lamellipodia protrusion and cell migration as well as a numerical method for the approximation of the model and tools for parameter estimation.

Key Publication: Ptashnyk, M, Venkataraman, C. (2020). Multiscale analysis and simulation of a signaling process with surface diffusion. Multiscale Modeling & Simulation 18 (2), 851-886

Developing a flexible framework based on harmonic analysis with applications to equidistribution theory (EP25/65)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Dr Bence Borda

Department: Mathematics

Research outline:

Equidistribution theory studies the problem of placing finitely many points in the unit cube or a manifold so that the points are as evenly distributed as possible. Harmonic analysis provides powerful tools in equidistribution theory, such as the Erdos-Turan inequality and its various generalizations. The aim of the PhD project is to develop a flexible framework based on harmonic analysis with applications to equidistribution theory. Potential applications include number theoretic point configurations as well as determinantal point processes and random walks on groups. Students with an interest in harmonic analysis or probabilistic number theory are encouraged to apply.

Key Publication: Borda, B. (2023). Empirical measures and random walks on compact spaces in the quadratic Wasserstein metric. Ann. Inst. Henri Poincare Probab. Stat. 59, 2017-2035 / doi: 10.1214/22-AIHP1322

Epidemic processes in highly heterogeneous populations (EP25/66)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisors: Dr Chris Hadjichrysanthou, Kieran Sharkey (University of Liverpool) and Dr Demetris Avraam (University of Copenhagen) in the Mathematics Applied to Biology research group

Department: Mathematics

Research outline:

Epidemic dynamics has been traditionally studied in homogeneously mixed and infinitely large populations. However, real populations are finite and highly heterogeneous. We aim to develop individual-based mathematical models to describe epidemic processes in populations that are characterised by high heterogeneity in the characteristics of individuals and complex interactions among them. The focus will be on the identification of the properties of the contact network structure that could predict the impact of the epidemics in different real-world scenarios.

Key Publication: Hadjichrysanthou, C., Sharkey, K.J. (2015). Epidemic Control Analysis: designing targeted intervention strategies against epidemics propagated on contact networks. Journal of Theoretical Biology, 365, 84-95 / DOI: 10.1016/j.jtbi.2014.10.006.

Probability and statistics: random matrix theory and its interactions with other fields of mathematics and physics (EP25/67)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor(s): Dr Nicholas Simm

Department: Mathematics

Research outline:

I am offering PhD projects in probability and statistics, specifically on topics related to random matrix theory and its interactions with other fields of mathematics and physics. One of the projects is to understand the relationship between random matrix theory and the Riemann zeta function, the latter being of central importance in number theory. The main focus of the project will be about statistical properties of characteristic polynomials of random matrices. The aim will be to use these properties to make precise number theoretical predictions about the behaviour of the Riemann zeta function close to the critical line.

Key Publication: Najnudel, J. and Paquette, E. and Simm, N. (2023). Secular coefficients and the holomorphic multiplicative chaos. Annals of Probability, Vol 51, No. 4, 1193-1248. (link)

Applied and numerical analysis for nonlinear partial differential equations with applications to cell biology (EP25/68)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor(s): Konstantinos Koumatos and Chandrasekhar Venkataraman

Department: Mathematics

Research outline:

This is a project in applied and numerical analysis for nonlinear partial differential equations with applications to cell biology.

Force generation by biological cells underpins all cellular functions. Accurate measurement of cellular forces is challenging and direct experimental measurements are infeasible. Traction force microscopy (TFM) attempts to sidestep this challenge by estimating forces indirectly from deformations of the medium upon which the cells exert force. The medium is approximated by a linearly elastic law, however, nonlinear constitutive laws arise in most practical settings. Also, in the in vitro setting, when the forces exerted are large, cells cause wrinkling in their vicinity which can only be captured by nonlinear models.

This project seeks to develop a framework for the formulation of well-posed inverse problems related to traction force microscopy (TFM). We will focus on nonlinear models for the mechanics of the medium for which the forward problem is well-posed but allow for enough generality to be applicable. We will develop, analyse and implement numerical methods for the approximation of the inverse problem. The project would be suitable for a student interested in the analysis of PDEs, continuum modelling, finite element methods, numerical analysis or mathematical biology.

Key Publications:

Ryder, LS, et al. (2019). A sensor kinase controls turgor-driven plant infection by the rice blast fungus, Nature, 574, 423-427. (link)

Koumatos, K and Spirito, S. (2019). Quasiconvex elastodynamics: weak-strong uniqueness for measure-valued solutions. Communications on Pure and Applied Mathematics, 72(6), 1288-1320. (link)

Optimal transport maps for modelling physical phenomena (EP25/69)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Lukas Koch

Department: Mathematics

Research outline:

Optimal transport has been a very active area of research in the recent past driven by applications in machine learning and theoretical advances. In particular, a number of variants have been explored which contain additional penalty terms. These variants have been introduced in order to facilitate numerical computation of optimal transport maps, as well as to better model physical phenomena such as congestion. I am interested in studying regularity properties of these models, possibly with numerical applications depending on applicant's interest.

Key Publication: Koch, L. (2024). Geometric linearisation for optimal transport with strongly p-convex cost, 63. (link)

Mathematical modelling to explore the intricate dynamics of microbial interactions and diversity in the soil microbiome (EP25/70)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Marianna Cerasuolo in the Mathematics Applied to Biology research group

Department: Mathematics

Research outline:

The soil microbiome is essential for soil health and ecosystem sustainability. The PhD project will integrate statistics and mathematical modelling to explore the intricate dynamics of microbial interactions and diversity. By developing network-based approaches and stochastic dynamical systems, we aim to construct assembly maps that uncover pathways of microbiome development. State-of-the-art Bayesian inference methods will be extended to analyse sparsely sampled datasets and infer ecosystem-level dynamics. These models will provide insights into how ecological dependencies shape microbial community assembly, stability, and resilience, with applications to environmental challenges such as agricultural interventions and climate change impacts.

Key Publication: K Begum, R Zornoza, R Farina, R Lemola, J Álvaro-Fuentes, M Cerasuolo (2022) Modeling soil carbon under diverse cropping systems and farming management in contrasting climatic regions in Europe. Frontiers in Environmental Science 10, 819162.

Bayesian approach to inverse problems involving diffusion processes (EP25/71)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Masoumeh Dashti

Department: Mathematics

Research outline:

Many dynamical processes involving noise are modelled by stochastic differential equations (SDEs). Often in applications all or part of the coefficients of the model are unknown but we have access to some data generated by the process itself. This project studies some problems related to the estimation of diffusion and drift coefficients of an SDE using discrete measurements of its solution. A Bayesian approach will be employed and some aspects of well-posedness and approximations of the solution to this approach will be investigated. The project has both theoretical and computational components and uses techniques from the analysis of SDEs, parabolic partial differential equations, applied probability and sampling methods.

Key Publication: Dashti, M., Stuart, A. M. (2017). The Bayesian approach to inverse problems, In Handbook of Uncertainty Quantification, pages 311--428.

Mathematical and computational methods for Schrödinger type Partial Differential Equations (EP25/72)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Michael Melgaard

Department: Mathematics

Research outline:

Potential Projects include:

- New numerical tensor methods and tensor-structured neural networks in quantum physics.
- Nonlinear PDEs (in astrophysics, electronic structure models etc).
- Spectral and scattering properties of quantum systems.

Group articles:

- Bound-state stability of Coulomb three-body systems using numerical tensor methods. Phys. Rev. A 109 (2024), 062812.
- Spectral approximation scheme for a hybrid, spin-density Kohn-Sham Density-Functional Theory in an external (nonuniform) magnetic field ..., J. Math. Chem. 62 (2024), 711-760.

Poisson wave trace formula for Dirac resonances at spectrum edges..., Asian J. Math. 25 (2021), no. 2, 243-276.

Key Publication: Melgaard, M. et al (2024), Bound-state stability of Coulomb three-body systems using numerical tensor methods. Phys. Rev. A 109, 062812. DOI (link)

Numerical Analysis of Partial Differential Equations (EP25/73)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Omar Lakkis in the Numerical Analysis and Scientific Computing research group

Department: Mathematics

Research outline:

I am interested in working with a PhD student on a project that is focussed on Machine-learning based self-adaptive numerical methods for hyperbolic equations and related inverse problems.

Key Publication: Grote, M.J., Lakkis, O. and Santos, C. (2024). A posteriori error estimates for the wave equation with mesh change in the leapfrog method. *arXiv preprint arXiv:2411.16933*. (link)

Numerical methods for delay differential equations, in particular to compute Razumikhin- and Krasovskii-Lyapunov functions (EP25/74)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Peter Giesl

Department: Mathematics

Research outline:

Peter Giesl's research is in numerical methods for Dynamical Systems. In particular, he works in the numerical computation of (complete) Lyapunov functions as well as contraction metrics to determine the basin of attraction and stability of attractors. He mainly studies dynamical systems given by ODEs, but has also considered switched systems, iterations of maps and stochastic differential equations. As numerical methods, he uses meshfree collocation or formulates the construction as an optimization problem. A potential PhD project (together with Prof. Yuliya Kyrychko) would be numerical methods for delay differential equations, in particular to compute Razumikhin- and Krasovskii-Lyapunov functions.

Key Publication: Giesl, P., Hafstein, S., Suhr, S., Wendland, H.: Minimization with differential inequality and equality constraints applied to complete Lyapunov functions. Discrete Contin. Dyn. Syst. Ser. B 30 No. 2 (2025), 449-473.

Building on functional analysis, PDE-theory, and numerical methods to develop novel mathematical concepts and scientific software to assess and improve the performance of numerical shape optimisation (EP25/75)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor: Philip Herbert

Department: Mathematics

Research outline:

Optimal design is key to many industrial applications, ranging from hydro and wind energy harvesting to space travel and telecommunication. Finding optimal designs is notoriously challenging, especially when this requires determining optimal component shapes (e.g., of wind turbine blades). Numerical methods to solve shape optimisation problems are available, but their approximation qualities (and hence reliability) are not well understood. This project aims to address this issue by building on functional analysis, PDE-theory, and numerical methods to develop novel mathematical concepts and scientific software to assess and improve the performance of numerical shape optimisation.

Key Publication: Herbert, P.J. (2022). A novel W1,∞ approach to shape optimisation with Lipschitz domains. ESAIM: Control, Optimisation and Calculus of Variations, 28, 2. (link)

Analysis and Partial Differential Equations (EP25/76)

EPSRC category: Interdisciplinary Research

Lead Supervisor: Ali Taheri in the Analysis and Partial Differential Equations research group

Department: Mathematics

Research outline:

Geometric Analysis, Calculus of Variations, PDEs and Harmonic Analysis, Optimisation and Dynamics on Infinite Dimensional Spaces, Applications to Continuum Mechanics, Kinetic Theory, Graph Theory and Machine Learning, Geometric Deep Learning and AI.

Key Publication: Taheri, A., (2024) Differential Harnack estimates for a weighted nonlinear parabolic equation under a super Perelman–Ricci flow and implications, Proc Roy. Soc. Edinb. A, Mathematics, DOI:10.1017/prm.2023.103

Geometric properties of a typical random convex hull (EP25/77)

EPSRC category: Mathematics and Theoretical Foundations

Lead Supervisor(s): Vladislav Vysotsky in the Probability and Statistics research group

Department: Mathematics

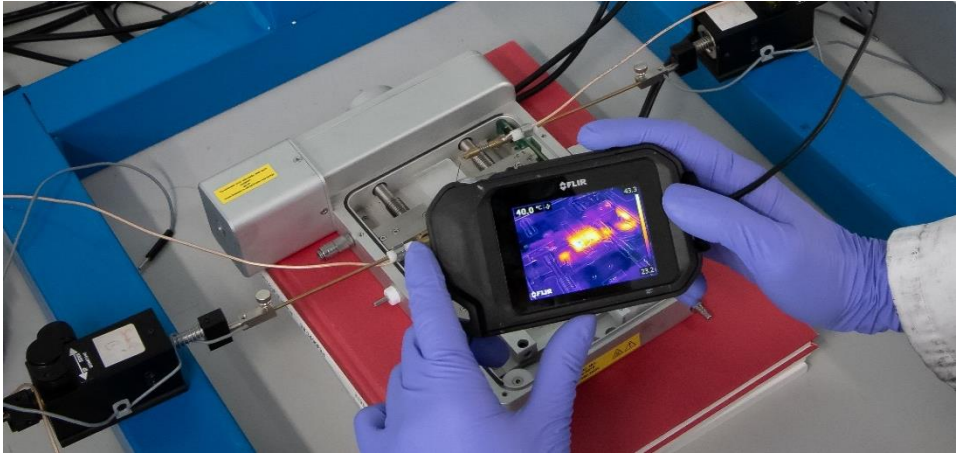
Research outline:

Convex hulls provide a tractable yet reasonably accurate approximation for sets of more complicated structure. Selecting the sets at random, for example taking a finite number of points in the space according to some probability distribution, produces a random convex hull. The most popular models assume that these points are sampled independently or represent the steps of a random walk. This PhD project aims to study geometric properties of a typical random convex hull of such type when the

number of points is large. The project is suitable for a student with a strong interest in theoretical probability.

Key Publication: Z. Kabluchko, V. Vysotsky, D. Zaporozhets (2017) Convex hulls of random walks, hyperplane arrangements, and Weyl chambers. Geometric and Functional Analysis, v. 27, pp. 880-918, DOI:10.1007/s00039-017-0415-x

Physics



Nanomaterials including graphene and 2D materials, for a diverse range of nanotechnologies and device applications (EP25/78)

EPSRC category: Applied Research for a Better World

Lead Supervisor(s): Alice King, Alan Dalton and Sean Ogilvie in the Materials Physics Group

Department: Physics

Research outline:

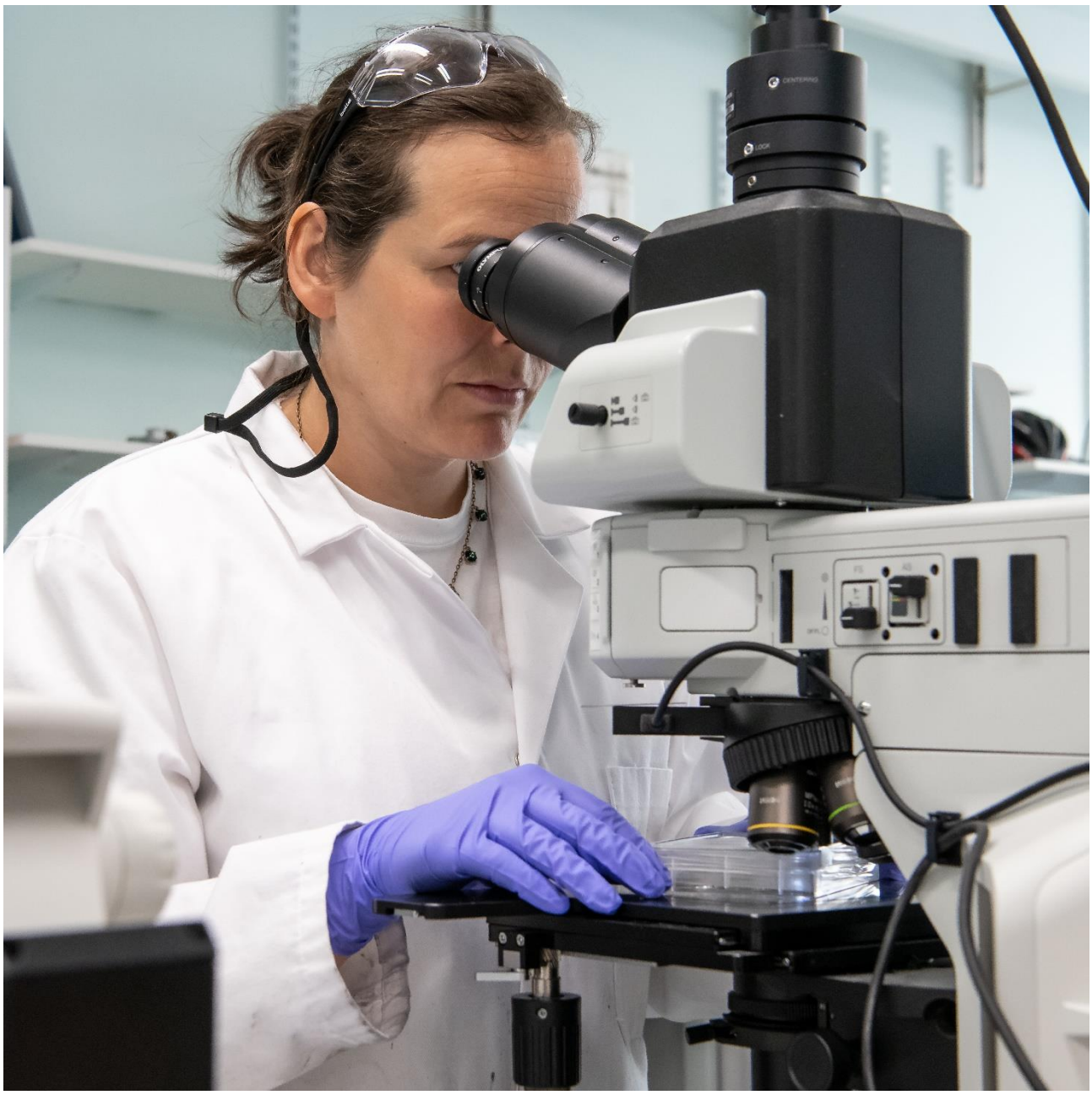
In Materials Physics, we process and study nanomaterials with emergent functional properties, including graphene and 2D materials, which have the potential to enable a diverse range of nanotechnologies and device applications. We work primarily with scalable solution processing techniques, allowing us to develop functional inks, coatings, composites, and free-standing hierarchical structures. Our work ranges from nanoscale characterisation of optoelectronic and nanomechanical properties of materials for quantum technologies to the assembly of nanomaterials into macroscopic structures and devices. Our current research streams include the understanding and enhancement of electrical transport in nanomaterial networks, which has supported the development of conductive inks for radiofrequency applications such as printed RFID tags and absorbing panels for NASA's Europa Clipper mission. We are also investigating nanomaterial-based electromechanical sensors for strain monitoring, including applications in electric vehicle batteries and, in collaboration with clinicians at St Thomas' Hospital London, wearable devices for health monitoring. Additionally, we explore the use of nanostructures for tissue engineering to understand cellular interactions, and we are developing nanomaterial functionalities for energy devices such as electrochemical energy storage, solar infrared smart windows, and thermoelectric heat capture. Our team is a diverse and dynamic group of interdisciplinary researchers with backgrounds across physics, chemistry, engineering, and materials science, and we have a wide network of external and industrial partners. Contact us to discuss how your experience and research interests align with ours to develop an exciting new project in one of these areas.

Key Publication:

King, A.A.K. (2022) Tuneable synthetic reduced graphene oxide scaffolds elicit high levels of three-dimensional glioblastoma interconnectivity in vitro. Journal Materials Chemistry B, doi:10.1039/D1TB01266E

Dalton. A.B. (2023) Explosive percolation yields highly-conductive polymer nanocomposites. Nature Communications, doi:10.1038/s41467-022-34631-9

Ogilvie S.P. (2024) Emergent high conductivity in size-selected graphene networks. Carbon, doi:10.1016/j.carbon.2023.118642



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