**Title: Staring Radar**

**Supervisor: Mohammed Jahangir**

**School: Engineering**

**Description:** Placement for students interested in radar machine learning

World class radar facility at Birmingham campus

* Research transforming radar performance for difficult to spot targets
* Show casing technology for counter-drone surveillance and bird monitoring

Work will involve variety of tasks, including:

* Characterising radar hardware using bench tests
* Participation in live radar trials with drones and birds
* Processing and analysing target signatures
* Refining and validating simulation models
* Evaluating machine learning techniques for discriminating drone from non-drone targets
* Basic MATLAB experience recommended

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**Title: Computational methods for medical image analysis: Foundation models, Generative models and Multimodal Learning**

**Supervisor: Le Zhang**

**School: Engineering**

**Description:** The field of medical imaging and precision medicine has seen remarkable advancements in recent years, driven by the potential of artificial intelligence (AI) technologies, such as generative models, foundation models, multi-modal learning algorithms, and large language models. These technologies can revolutionize healthcare by enabling accurate diagnosis, personalized treatment planning, and improved patient outcomes. This project will focus on developing robust and adaptive AI models that can handle the complexities of medical imaging data as well as the domain gap and knowledge gap across different scenarios, and further adapt to individual patient needs. Depending on the profile of the student, a particular focus would be developing reliable machine learning models with Foundation models, Generative machine learning techniques and/or Multimodal Learning to enhance the reliability and applicability of AI algorithms for healthcare applications.

Candidate requirements

· Being self-motivated and enthusiastic about doing research in AI for healthcare and a commitment to supporting high quality research.

· Experiences with AI for healthcare related projects using PyTorch and/or TensorFlow libraries.

· Strong programming skills such as Python, C++, C, Java are preferred.

· Strong problem-solving abilities.

For more details about this position and application, please contact Assistant Professor Dr. Le Zhang: l.zhang.16@bham.ac.uk

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**Title: Development, Modelling, and Optimisation of Novel Waste-Plastic Recycling Systems**

**Supervisor: Christopher Windows-Yule**

**School: Chemical Engineering**

**Description:** The waste plastic crisis is one of the great global challenges facing society today, poisoning our soils and waterways, as well as contributing to the wider climate crisis as plastics which could be recycled are instead simply burned. This project is based around the development of novel technologies to create a circular economy for plastics, such that waste materials may be recycled, via pyrolysis in heated fluidised beds of quartz particles, into valuable hydrocarbon products.

The project is highly flexible, with students able to study any of several important aspects of this process, from the initial separation of different waste plastics, to the flow dynamics of plastics within the fluidised column, using experimental and/or numerical modelling methodologies as their particular interests dictate. The project will offer the opportunity to work closely with the company, DeepTech Recycling, pioneering this technology, and to utilise the University of Birmingham's positron emission particle tracking system, the only such facility in Europe. The work will also provide the opportunity to learn and apply modelling techniques such as the discrete element method (DEM), continuum fluid dynamics (CFD) and/or the multiphase particle in cell (MP-PIC) method, and apply these techniques to the important problems at hand, and also to work with the Positron Emission Particle Tracking technique, and novel data acquired therefrom.

This project has a strong track record for undergraduate students producing published work in high-quality (Q1) research journals, and as such would be ideally suited for an ambitious student with an interest in a future research or R&D career, where such publications will provide a valuable addition to their CV. Examples of past publications include:

Werner, D., H. Davison, E. Robinson, J. A. Sykes, J. P. K. Seville, A. Wellings, S. Bhattacharya, DA Sanchez Monsalve, Tz Kokalova Wheldon, and C. R. K. Windows-Yule. "Effect of system composition on mixing in binary fluidised beds." Chemical Engineering Science 271 (2023): 118562.

Windows-Yule, C. R. K., S. Gibson, D. Werner, D. J. Parker, T. Z. Kokalova, and J. P. K. Seville. "Effect of distributor design on particle distribution in a binary fluidised bed." Powder Technology 367 (2020): 1-9.

Windows-Yule, C. R. K., A. Moore, C. Wellard, D. Werner, D. J. Parker, and J. P. K. Seville. "Particle distributions in binary gas-fluidised beds: Shape matters–But not much." Chemical Engineering Science 216 (2020): 115440.

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**Title: Intra-articular Injection (IAI) to treat early stage osteoarthritis**

**Supervisor: Zhenyu Zhang**

**School: Chemical Engineering**

**Description:** Intra-articular injection (IAI) is used clinically to manage and mitigate the pain associated with osteoarthritis (OA). As the intra-articular space is filled by synovial fluid, intra-articular injection of viscosupplement was developed as a physical intervention, aiming to compensate the declining rheological profile of synovial fluid, and subsequently improve the deteriorating joint lubrication. Besides viscosupplement, glucocorticoids, non-steroidal anti-inflammatory drugs, and COX-2 enzyme inhibitors have been included in IAI formulations to treat inflammation.

My team has developed a range of IAI formulations in the past five years, based on various nano- and microscopic objects such as polymeric nanoparticles, nanogel. In this summer intern project, you will be supervised by a Research Fellow to carry out laboratory tests using nanogel samples produced by our partner. The lab work involves primarily using two advanced techniques: atomic force microscopy (AFM) and quartz crystal microbalance with dissipation (QCM-D) to investigate the interfacial behaviour of nanogel on synthetic and biological substrates.

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**Title: Materials and manufacturing techniques for a 3U CubeSat platform**

**Supervisor: Leah-Nani Alconcel**

**School: Metallurgy and Materials**

**Description:** The Rotulus 3U CubeSat mission is a novel dragsail system designed to remove debris from low Earth orbit (LEO). In LEO, an object’s orbit naturally decays due to the small amount of atmospheric drag present. The decay rate depends upon the object’s mass and projected area and solar activity levels. Dragsails decrease this coefficient, causing faster rates of decay and swiftly deorbiting the object. Rotulus’ sail configuration decreases the dependency on orientation for the drag produced by the sail, as the effective surface area remains large irrespective of the angle to the atmosphere. The technique simplifies deployment compared to previous dragsail demonstrations, which use complex folding mechanisms and booms, and takes advanced of gravity gradient stabilisation to maintain its orientation. The intern on this project will conduct a materials and manufacturing methodology study for Rotulus’ platform, to complement ongoing work on the sail's design and deployment mechanism.

This project supports current EPSRC-funded research on Space Domain Awareness (SDA) and space sustainability. Applicants can read about the group's research activities here: <https://bham.ac.uk/sda>.

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**Title: 4D Printing**

**Supervisor: Gerard Cummins**

**School: Engineering (Mechanical)**

**Description:** 3D printing involves creating three-dimensional objects by adding material layer by layer, 4D printing adds an extra dimension of time by printing materials that have properties that allow them to change shape or function in response to external stimuli such as heat, light, water or other environmental factors. You can program these printed materials to behave in specific ways once triggered through the careful design of the object. 4D printing has significant applications in medical devices, enabling the creation of implantable or ingestible devices that can adapt to the body's changing needs or conditions.

In this project, you will work with a PhD student to build, test and characterise a 4D printer capable of printing a typical plastic and a hydrogel, a flexible and soft material that can absorb and hold a lot of water. Building the 4D printer will involve adapting an existing 3D printer and will require some familiarity with components such as motors, sensors, Arduino’s and basic coding. Testing the 4D printer will involve testing the reliability of material deposition and checking the accuracy of printed feature alignment, accuracy and quality. Characterising the 4D printer will involve printing simple geometrical patterns to see how design can impact the response of the printed parts when exposed to stimuli. This will involve knowledge of computer-aided design programs such as Fusion 360.

This project would suit someone from a Mechanical, Chemical, or Electrical Engineering background interested in healthcare technology, materials for health or additive manufacturing. The successful applicant will get hands-on experience in a lab, access to the School of Engineering Makerspace, and contribute to and be named in the resulting journal publication.

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**Title: Recognising Subgroups**

**Supervisor: David Hume**

**School: Mathematics**

**Description:** Given a class of groups, how wild (or not) can their subgroups be? This project will look at one of a diverse collection of new techniques to begin to answer this question in particular cases. Depending on the interests of the candidate, this could involve fractals, graph layout problems (including some closely related to computer circuitry design), electrical network theory, quantum error-correcting codes, geometry, topology, or even some algebra.

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**Title: Modelling biomagnetic field gradients for use in Orthopaedic medical device design**

**Supervisor: Alicia El Haj**

**School: Chemical Engineering**

**Description:** This industry and clinical collaborative project with MICA Biosystems (a spin out from the El Haj group) and the Royal Orthopaedic Hospital will be investigating the use of external dynamic magnetic fields to control magnetic nanoparticle delivery and biomodulation during spinal repair. The research will involve computational modelling alongside experimental validation studies investigating bone production in response to controlled stimuli. In addition, the student will provide data for the design of an external magnetic bandage for use in post operative care of spinal fusion patients. The bandage will be part of a medical device design and testing for regulatory approvals with the MHRA. The student will gain experience in computational modelling and experimental lab techniques in biomedical engineering. The student will be introduced to commercial activity in the healthcare industry through a start up in this sector alongside potential avenues for progressing further research in Chemical engineering. The project will involve working within multidisciplinary teams in the Healthcare Technology Institute.

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**Title: Predicting the environmental impact of aviation emissions**

**Supervisor: Simon Blakey**

**School: Engineering**

**Description:** A summer project to contribute to a team developing flexible models to assess the impact that changes in fuel chemistry can have on aircraft engine emissions performance. The emissions from aircraft are challenging to directly measure due to the speed and altitude of the aircraft. The industry uses emissions models to estimate the environmental impact of flying. The successful internship would work as part of a team of research staff to convert available performance data into a series of thermodynamic engine models based on the Brayton cycle. The output will be used to predict combustor inlet temperatures and pressures using state of the art modelling software. We would then go on to use these models to calculate the emissions from the combustion process using Python Cantera and novel combustion models.

The successful intern must have an interest in thermodynamics and coding.

Relationship to EPSRC themes and priorities

This project relates to Energy and Decarbonisation and the utilisation of synthetic energy carriers in aviation.

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**Title: Neuromorphic Vision for Robot Navigation**

**Supervisor: Beth Jelfs and Christopher Gilliam**

**School: Engineering**

**Description:** Unlike standard cameras neuromorphic cameras do not produce a traditional image but instead operate asynchronously. Each pixel operates independently and produces a spiking event when a change above a specified threshold occurs – similar to how the human retina behaves. These cameras have the ability to operate at very fast update rates with high dynamic range making them ideally suited to robotic applications. The goal of this project is to use two neuromorphic cameras to produce stereo vision for a robot. The student will investigate using the cameras to obtain information about the 3D position of objects in the robot’s field of view and incorporating this information into the robot navigation. There is scope to extend this project to other scenarios and incorporate other sensors.

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**Title: Training and capacity building in batch reverse osmosis technology**

**Supervisor: Philip Davies**

**School: Engineering**

**Description:** Batch reverse osmosis (RO) technology is an innovative water treatment technology with exceptionally low energy consumption and high recovery. The technology has been under development in Birmingham for over 10 years. Several prototypes and pilots have been built − addressing applications including groundwater desalination, phosphate remediation, and metal plating wastewater treatment. The University of Birmingham has secured several research projects on batch RO technology, filed two patents, and created a spin out company, Salinity Solutions, to commercialise the technology.

Nonetheless, despite this large research effort and significant technical and economic progress, the technology remains challenging for other individuals and organizations to replicate. The chronological development of the research literature in the field has not necessarily led to readily accessible learning resources. To help address this, this project sets out to develop training resources that will make batch RO more widely accessible.

The specific objectives are to:

1. Build and test a training batch RO-system at benchtop scale with a minimum of complexity, using a budget of less than £1000.

2. Develop a simple controller for this system (e.g. using a microcontroller, programmable logic controller, or discrete electromechanical components).

3. Develop training resources to support learning about the batch RO technology with the help of the training system.

4. Identify a suitable digital repository for publication of these resources on a Creative Commons basis.

5. Evaluate and improve the resources through peer review and reflection.

Regarding the scope of the project:

· In line with Sustainable Development Goal 6 on Clean Water and Sanitation, the emphasis of the project will be for applications to provide drinking water in Low-Middle Income Countries (LMIC) where capacities to implement such technology may be limited.

· The learning resources should be pitched at engineering students of any discipline (i.e., civil, mechanical, or electrical) at 1st year level.

· The project does not set out to develop a high-performance system; instead to enhance learning and capacity building so that learners can go on to build more advanced systems at a later stage.

Relationship to EPSRC themes and priorities

Batch RO technology is a clean technology that aligns with EPSRC priorities of ‘Circular Economy’ and ‘Decarbonisation’. The EPSRC has recently supported the development of this technology through its award ‘Batch Reverse Osmosis (RO): Desalination with minimum wastage of energy and water’ (ref EP/T025867/1). The proposed internship will contribute to dissemination and achieving impacts from this award.

**Title: Custom laser pulsing system for advanced biomedical ultrasound imaging**

**Supervisor: James Guggenheim**

**School: Engineering**

**Description:** A number of emerging advanced biomedical imaging systems detect ultrasound using optical ultrasound sensors (e.g. https://doi.org/10.1038/s41566-017-0027-x). An optical ultrasound sensor is essentially a small optical element that detects ultrasound waves when illuminated by a laser beam. Higher laser power leads to higher sensitivity. However, the sensors become thermally unstable if the power gets too high. One way to avoid this is reducing the power by using pulsed (rather than continuous) lasers. Such pulsing can be provided by fast (e.g. MEMs based) optical switches. However, this proves challenging because existing optical switches are poorly optimized for this application. To address this challenge, this project will investigate custom developing a laser pulsing system based on a MEMs mirror and selected free-space optics (e.g. mirrors, lenses). By increasing the power thresholds of optical ultrasound sensors, this could enable increasing the sensitivity of advanced ultrasonic imaging systems. The project will provide a student with experience of practical engineering research within an interdisciplinary lab focussed on medical imaging technology. Skills gained will include optical design and alignment, software control of electronic devices, electronic triggering and timing, and experimentation with lasers, optical ultrasound sensors, and piezoelectric ultrasound sources.

Selected research areas:

Imaging & diagnostics, Healthcare Technology

**Title: Sensitivity characterization of ultrasound detectors for photoacoustic imaging**

**Supervisor: James Guggenheim**

**School: Engineering**

**Description:** Photoacoustic imaging is an emerging biomedical imaging technique in which light excites ultrasound waves in living tissues. The penetration depth of the technique is limited by detector sensitivity. As such, we are developing highly sensitive detectors and wish to compare them to the existing state-of-the-art. Unfortunately, because detection sensitivity is less important in conventional ultrasound imaging, sensitivity benchmarks are often missing in the literature. To address this limitation, this project will involve characterizing the sensitivity of a range of existing ultrasound detectors to provide the required benchmarks. The project will provide a student with experience of research within an interdisciplinary lab focussed on medical imaging technology. Skills gained will include scientific literature review, experimentation with different ultrasound detectors, and ultrasonic data acquisition and analysis.

Selected research areas:

Imaging & diagnostics, Healthcare Technology

**Title: Shock absorption liquids**

**Supervisor: Yueting Sun**

**School: Engineering**

**Description:** A shock absorption liquid has been developed which makes use of the liquid flow inside nanopores to absorb mechanical energy (<https://www.iom3.org/resource/shock-and-impact-protection-advanced-with-zifs.html>). Its behaviour can be controlled by electric field, and it can also potentially generate electricity through shock absorption. This project aims to understand the mechanisms of such phenomena through experimentation.

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**Title: Shape changing hydrogels**

**Supervisor: Yueting Sun**

**School: Engineering**

**Description:** The hydration and dehydration of hydrogels can lead to substantial volume change of the material. Such phenomenon can be controlled by externally applied mechanical pressures, and with appropriate design one can obtain significant shape change that is useful for practical applications. This project aims to demonstrate such mechanism by material and structure design and testing.

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**Title: Highly compressible liquids**

**Supervisor: Yueting Sun**

**School: Engineering**

**Description:** Liquid is usually poorly compressible, but by introducing molecules or crystals of certain structures, much greater compressibility can be obtained (<https://doi.org/10.1002/adma.202306521>). Such liquids can have interesting mechanical, thermal, acoustic, and optical properties that are useful for practical applications. This project aims to experimentally investigate the fundamental physical properties of such compressible liquids, which may involve experimental design, material preparation, and testing.

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