Research Opportunities at the School of Engineering

There are two different schemes across Chemistry, Engineering and Maths:

1. 6 Dalian University of Technology/University of Leicester PhD scholarships funded by CSC (CSC provides stipend and UoL provides international fee waiver)
2. 7 DUT-UoL Collaborative PhD Studentships (DLI provides 20,000 RMB and University of Leicester provides international fee waiver. Only available to DLI students)

We are not considering applications for the two funding sources separately. Shortlisting for interview will be carried out purely on the basis of quality and aptitude for the PhD project for which you have applied. Only at the point of interview and appointment of successful candidates will we begin to consider funding source. If you get through to the interview, you will be asked about your funding preference (only to be considered for CSC, only to be considered for DUT, preference for CSC but also consider DUT, preference for DUT but also CSC, or no preference) and then we will allocate projects at that stage.

A formal application to the University of Leicester is essential (this can be carried out here https://le.ac.uk/study/research-degrees/funded-opportunities/cse-dut-partnership) and the **deadline for applications is: 5th January 2025**. Please choose two research projects and make it clear on your application form which is your first and which is your second choice research project. We will be holding **online interviews from 6th to 13th February 2025**, so please check your email account regularly to find out if you have been selected for an interview. You should receive an email inviting you to interview by Friday 24th January 2025.

With your application, please provide:

- CV
- Degree certificates and transcripts of study already completed and if possible transcripts to date of study currently being undertaken
- Personal statement
- Evidence of English language if available
- In the references section, please enter the contact details of two academic referees in the boxes provided or upload reference letters if already obtained
- In the funding section, please state **DUT 2025 scholarship**
- In the research proposal section, please provide the names of the **project supervisors and the project titles** you want to be considered for. You can select up to 2 projects. List both in order of preference. (a research proposal is not required)

Please take a look at the 11 different research projects which are available in the School of Engineering. The first research project is only available for the CSC funding (project 1), the next 4 research projects are available for both Schemes (projects 2 to 5), whilst the last six research projects are only available for DLI funding (projects 6 to 11).

Only available with CSC funding

1. Machine Learning Approaches for Understanding Odour Coding and Creating Novel Odours

Dr Timothy Pearce– t.c.pearce@le.ac.uk

Project Title	**Machine learning approaches for understanding odour coding and creating novel odours**	
Project Highlights:	1.	Generating novel odour molecules that can be used within chemical engineering processes
	2.	Innovating new chemical products with high user acceptance
	3.	Improved understanding of the relationships between molecular structure and smell perception
Project Overview (Maximum 350 words)		
We still don't understand how our sense of smell is linked to specific molecular features. This fascinating area is called olfactory coding that is an important outstanding problem at the intersection of chemistry and biology. By applying machine learning and AI approaches on molecules we will explore how structure is linked to olfactory perception. This relationship is hugely complex since recent studies have predicted there are likely to be billions of potentially odorous molecules that target hundreds of GPCR olfactory receptors expressed by humans. Moreover, small changes in molecular structure can lead to drastic changes in odour perception in humans and vice versa. By building upon our existing work dedicated to olfaction and machine learning on molecules we will create learnt models capable of accurately predicting whether a given molecular structure will have likely perceptual odour properties and its organoleptic profile. We will use this model to screen large computational chemistry databases such as ChemBL and Zinc for novel odour ligands that we will synthesise and assay in the laboratory. The same model will then be used to train a molecular variational autoencoder that will give us the capability to invent entirely novel odour molecules with unknown organoleptic profiles that we will then create and assay in the laboratory. Not only will this further our understanding of the relationship between chemistry and sensory neuroscience, but unlocking the olfactory code has potential for improving our well-being, not least through product development relevant to chemical engineering processes.		

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DUT/UoL CSC PhD studentships and DUT-UoL Collaborative PhD studentships

2. High-Resilience Alloys for Corrosive and High-Stress Environmental Remediation

Dr Gebril El-Fallah – gmae2@leicester.ac.uk

Project Title	**High-Resilience Alloys for Corrosive and High-Stress Environmental Remediation**	
Project Highlights:	1.	**Innovative Approach:** Using machine learning to guide alloy composition and advanced metallurgical techniques to synthesise high-performance alloys.
	2.	**Enhanced Properties:** Targeting alloys with a unique balance of high corrosion resistance, mechanical strength, and hydrogen embrittlement resistance to withstand corrosive, high-stress conditions.
	3.	**Impact on Industries:** Expected to make a significant impact across sectors like environmental remediation, chemical processing, and wastewater treatment, reducing maintenance costs and enhancing operational reliability.
	4.	**Advanced Methodologies:** Employing state-of-the-art characterisation tools, such as SEM, XRD, and Finite Element Analysis (FEA), for in-depth microstructural analysis and stress testing under simulated conditions.
	5.	**Interdisciplinary Collaboration:** Bridging the fields of materials science, environmental engineering, and computational chemistry to develop sustainable, long-lasting alloy solutions for demanding industrial applications.

Project Overview (Maximum 350 words)

Environmental remediation systems, such as wastewater and chemical waste treatment facilities, endure highly corrosive environments that quickly degrade traditional materials, resulting in increased maintenance costs and frequent equipment failures. This project seeks to address these challenges by developing novel high-performance alloys optimised for corrosion resistance, mechanical durability, and environmental compatibility. Current materials, like standard stainless steels and some industrial alloys, lack the robustness required for long-term operation under such extreme conditions.

The primary objective of this research is to design and optimise alloys that can withstand a wide array of corrosive substances and mechanical stresses typical in remediation environments.

Research Plan

Year 1: Literature Review, Alloy Design, and Synthesis

- **W1.1:** Conduct a comprehensive literature review on current alloys used in environmental remediation, highlighting their limitations in corrosion resistance, mechanical stability, and susceptibility to hydrogen embrittlement.
- **W1.2:** Identify gaps in the performance of these alloys and prioritise potential alloy compositions, leveraging machine learning to predict favourable characteristics.

- **W1.3:** Synthesise preliminary alloy samples using advanced metallurgical techniques tailored to withstand harsh environmental conditions.
- **W1.4:** Begin initial alloy characterisation with high-resolution microscopy and spectroscopy, assessing composition and microstructure.
- **W1.5:** Initiate baseline FEA simulations to predict stress-strain behaviours and evaluate performance across remediation conditions.

Year 2: Mechanical Testing, Microstructural Analysis, and FEA Optimization

- **W2.1:** Perform rigorous mechanical testing under various operational conditions to measure tensile strength, ductility, and creep resistance.
- **W2.2:** Conduct detailed microstructural analysis using SEM and XRD to understand the influence of alloying elements and processing on performance.
- **W2.3:** Implement hydrogen charging techniques to assess embrittlement resistance in corrosive environments.
- **W2.4:** Use experimental data to refine FEA models, simulating stress distribution, crack propagation, and fatigue resistance, which will inform alloy composition adjustments.

Year 3: Hydrogen Embrittlement Assessment, Optimisation, and Final Validation

- **W3.1:** Conduct comprehensive testing to evaluate hydrogen embrittlement resistance using innovative methods to assess alloy durability under real-world environmental conditions.
- **W3.2:** Finalise the optimised alloy synthesis and validate its properties with extensive mechanical and corrosion-resistant testing. Utilise FEA for final simulations, confirming long-term performance in simulated remediation conditions and predicting real-world durability.

Significance:

The development of these high-performance alloys aims to extend the lifespan of equipment in harsh remediation environments, reducing operational downtime and maintenance costs. The outcomes are expected to contribute to more sustainable practices in environmental engineering, directly supporting the UK's 2025 targets for reducing industrial emissions and advancing net-zero commitments. By enabling longer-lasting, environmentally resilient materials, this project creates a pathway for innovative solutions essential to the transition towards a more sustainable and climate-conscious future in demanding industrial applications.

3. Multiscale Testing and Modelling of Hydrogen Embrittlement in Engineering Alloys

Dr. Elsiddig Elmukashfi – elsiddig.elmukashfi@le.ac.uk

Project Title		**Multiscale Testing and Modelling of Hydrogen Embrittlement in Engineering Alloys**
Project Highlights:	1.	**Scientific Advancement**: Developing advanced multiphysics and multiscale modelling tools and full-field experimentations of hydrogen in metals will benefit the materials science community.
	2.	**Innovation**: Developing advance materials for green energy applications.
	3.	**World-wide Impact**: Support the transition to net-zero and hydrogen economy by improving and developing the next generation of systems and materials for hydrogen energy systems.

Project Overview (Maximum 350 words)

Improving the planet's health relies on fighting climate change, protecting nature, and preserving resources for future generations. Greenhouse gas (GHG) emissions are responsible for climate change, global warming, acid rain, pollution, etc. As an alternative fuel and energy carrier, hydrogen is a low-carbon energy solution supporting decarbonisation and providing greener, flexible energy across power, heat, and transport. This research project aims to support the transition to net-zero and hydrogen economy by improving and developing the next generation of systems and materials for hydrogen energy systems.

In metallic materials systems, hydrogen embrittlement and accelerated fatigue failure remain the biggest threats to their operability in the presence of hydrogen. These detrimental effects are reported to reduce ductility, strength, toughness, and fatigue life, leading to premature catastrophic failures. Hence, the effect of hydrogen on the mechanical properties needs to be determined, understood, and, if necessary, mitigated. The objectives are to employ comprehensive experimental and modelling approaches to enhance our comprehension of the metals' overall behaviour in the presence of hydrogen.

The experimental part starts with the development of advanced hydrogen charging equipment. It will be used to charge metallic materials and mechanical experiments will be performed to study the hydrogen impact on the different mechanical properties. The second step is to incorporate micromechanical testing and characterisation testing. The aim is to investigate the different effects of hydrogen on the deformation and failure mechanisms. Our overarching objective is to discern the distinct influences of hydrogen on the various microstructural features.

The modelling contribution includes devising micromechanical and diffusion models for hydrogen diffusion through the materials in the mesoscale. Such models provide information about how hydrogen diffuses through the bulk material and accumulates within different microstructural features. Additionally, it incorporates the effect of hydrogen on the plastic and decohesion processes and then the materials response.

4. Safety-critical control-based decision-making framework for smart engineering: Integrating optimization and machine learning

Dr Xuefang Wang - xw259@leicester.ac.uk

Project Title	**Safety-critical control-based decision-making framework for smart engineering: Integrating optimization and machine learning**	
Project Highlights:	1.	Development of safety-critical control algorithms in smart engineering to allow systems to adapt to external changes and internal fluctuations, enhancing robustness and stability.
	2.	Integration of intelligent technologies to monitor and assess potential risks in real-time, supporting safety-related decisions.
	3.	Establishing a networked human-machine collaboration control system that interconnects various components to facilitate a more flexible, scalable, manageable, and safe operation environment.

Project Overview (Maximum 350 words)

The integration of optimization and machine learning within a safety-critical control-based decision-making framework is indispensable for the advancement of smart engineering. This fusion empowers the system to dynamically optimize processes while leveraging machine learning for real-time risk assessment and decision-making. The significance lies in its potential to enhance operational safety, streamline efficiency, and adapt to evolving conditions. However, challenges arise in balancing the trade-off between computational complexity and the need for rapid decision-making, ensuring the reliability of machine learning models in dynamic environments (e.g., dynamic chemical processes), and addressing cybersecurity concerns associated with interconnected threats. Overcoming these challenges is fundamental to unleashing the full potential of smart chemical engineering, ushering in a new era of safer, more efficient, and intelligent chemical processes.

This project aims to explore the development of advanced safety-critical control strategies and its implementation in smart engineering such as chemical processes, robotics, and autonomous vehicles. Advance intelligent tools towards design, integration, and evaluation of optimization-based and learning-based architectures for smart engineering. The research activities for this position include:

- Development of artificial intelligence (AI) and machine learning technologies for handling real-time large-scale data to improve safety-critical decision-making framework. For example, in smart chemical engineering, employ intelligent technologies for adaptive and real-time process optimization.
- Developing intelligent algorithms make the system recognize patterns and trends that may lead to unsafe conditions, enabling proactive risk mitigation strategies. Especially, in smart chemical engineering, the developed intelligent technologies can be used to predict analytics, use historical and real-time data to forecast potential safety risks throughout the chemical processes.

• Establishing a networked human-machine collaboration decision system by providing real-time insights into safety-related risks. Human-machine collaboration ensures that operators have access to comprehensive information, allowing them to make informed decisions swiftly and effectively in response to potential safety concerns.
• Techno-economic-environmental assessment of novel optimization and learning technologies, improving operation efficiency, reduce costs, and ensure safe and stable operation environment for smart engineering system.

The applicants should have interests in advanced safety-critical control strategies design for smart engineering based on optimization and machine learning methods, and sufficient knowledge of programming in Matlab, C/C++, etc.

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5. Zero Emission Aviation: hydrogen-fuelled propulsion system design and operation

Dr Jinning Zhang – jz388@leicester.ac.uk

Project Title	Zero Emission Aviation: hydrogen-fuelled propulsion system design and operation	
Project Highlights:	1.	Develop detailed complex chemistry turbulent-chemistry interaction models for hydrogen micromix combustion
	2.	Implement surrogate model approach for propulsion system design space exploration
	3.	Evaluate aircraft mission-level life cycle emissions and economic viability

Project Overview (Maximum 350 words)

To reduce their environmental impact and achieve net-zero emissions in the aviation sector by 2050, there is a shift towards adopting hydrogen fuel in gas turbine engines, which would eliminate exhaust CO2 emissions. However, this transition presents technological challenges, the zero-emission hydrogen-fuelled propulsion systems should be developed to achieve ultra-low NOx emissions while also satisfying other performance and operability requirements, such as combustion efficiency, pressure loss, durability, stability.

This project aims to investigate the design, performance evaluation, and integration approaches and assess the emissions characteristics of a novel carbon-free ultra-low NOx emissions hydrogen-fuelled propulsion system, by developing multi-fidelity tools for the computational modelling and numerical simulation of chemical processes, ranging from reduced order models to high-fidelity numerical simulation models.

The objectives of this project are as follows:
WP1. Develop detailed complex chemistry turbulent-chemistry interaction models for hydrogen micromix combustion with high-fidelity large eddy simulations, to investigate the flame characteristics, including flame thickness, length, position temperature and emissions.

WP2. Implement surrogate model approach for propulsion system design space exploration and optimisation. A Reduced Order Model (ROM), such as the Flamelet Generated Manifold, will be developed to utilize pre-tabulated combustion chemistry, offering lower computational cost than detailed chemical mechanisms. Results from detailed complex chemistry model will calibrate the ROMs, thereby enhancing their accuracy. Following that, the impact of micromix injector design parameters on hydrogen/air mixing, flame characteristics, and NOx formation will be investigated through design space exploration.

WP3. Hydrogen-fuelled propulsion system integration with advanced airframe configurations, such as blended wing body, boundary Layer Ingestion, etc., and further achieve aircraft mission-level assessments including trajectory and engine cycle optimisation, as well as evaluations of life cycle emissions and economic viability.

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This work is well positioned within **the subject theme of 'Power Engineering and Engineering Thermophysics'**, representing interdisciplinary research of chemical engineering, environmental engineering, and mathematics. The research outcomes are expected to guide the design, operation, and control of future hydrogen gas turbine engines. This has the potential to significantly impact decarbonisation of the UK civil aviation sector and facilitate a cost-effective transition to a sustainable and resilient future in aviation by 2050.

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Only available with DLI funding

6. Optimised high performance ultra-light structures for telescopes and satellites

Dr. Mohammed Abdul Azeem – mohammed.azeem@leicester.ac.uk

Project Title	**Optimised high performance ultra-light structures for telescopes and satellites**	
Project Highlights:	1.	**Structures for novel applications**: The parametric tool-box and strategies developed in this project could be used for performing benchmarking in development of all satellite and telescope structural components.
	2.	**Advanced characterization and kirigami techniques**: Potential students will use advanced real and reciprocal imaging tools in-house at University of Leicester and at national and international facilities in Europe and worldwide
	3.	**World-wide collaborations**: The potential students will collaborate with researchers and students from across UK and worldwide.

Project Overview (Maximum 350 words)

Space exploration demands increasingly lightweight and robust bus (main body of a satellite or telescope) structures to endure harsh operating conditions. These buses are manufactured by machining large plates of light alloys after conventional rolling and age hardening treatments. However, residual stresses introduced during these processes often results in warping of the bus, affecting critical functions like optics and tightly electronics. Thus, leading to partial or complete loss of functionality. The current strategy to mitigate these problems is to re-heat and apply counter stress in incremental steps to eliminate warping.

The primary objective of this project is to establish a parametric exploratory toolbox for estimation and minimisation of residual stresses observed in Al-base wrought high strength alloys.
The prospective student will systematically address these challenges by:

- Multiscale characterization, mapping and modelling of the development of residual stresses in large thick Aluminium age hardenable alloy plates.
- Developing effective stress-relieving strategies such as by performing functionally graded heat treatments and by selectively machining out patterns inspired by kirigami strategies.
- Developing a parametric exploratory **tool-box** which can be directly used in space, automotive and precision engineering sectors for improving functional resolution of innumerable instruments that employ high strength wrought Al-alloys and thus would be instrumental in improving their efficiency

Methodology: The prospective student will using multi-physics modelling tools such as COMSOL, in-house imaging and strain measurement tools at University of Leicester and they will be working in collaboration with several national and international residual strain measurement facilities* such as Diamond Light Source (DLS), European Synchrotron Radiation Facility (ESRF), ISIS Neutron and

Muon Source etc to first map strains in existing buses. Wide angle small angle scattering will be used to obtain morphology, distribution and quantities of strengthening phase. Neutron X-diffraction will be used to map residual strains in as rolled and machined plates produced using conventional routes.

*Subject to approval of research proposals, often open for application biannually.

7. Transition to turbulence in Couette flow for supercritical fluids

Dr Benjamin Bugeat - bb283@le.ac.uk

Project Title	**Transition to turbulence in Couette flow for supercritical fluids**	
Project Highlights:	1.	Develop and use a simple CFD model of the problem.
	2.	Perform a modal decomposition of the data (such as FFT) to analyse the results
	3.	Obtain new insights into the linear and non-linear growths of perturbations leading to turbulence

Project Overview (Maximum 350 words)

Above certain conditions of temperature and pressure, fluids reach a supercritical state in which the distinction between liquid and gas states no longer exists. This state of matter is ubiquitous in nature, forming, for example, the atmosphere of some planets (e.g., Venus). Growing interest in supercritical fluids is also observed in industrial applications, such as energy production, rocket engines, or chemical processes.

The nature of the flow regime – laminar or turbulent, is a central element in the design of fluid systems by engineers: turbulence promotes high heat transfer, which increases efficiency in energy applications. Despite recent advancements, transition to turbulence remains a largely unexplored phenomenon in supercritical fluids. Ren et al. (JFM 2019) discovered a new linear instability specific to supercritical fluids, which may occur at much lower Reynolds numbers than in conventional fluids. Bugeat et al. (JFM 2024) showed that this instability was caused by large gradients of density and viscosity. What happens to small perturbations once they grow beyond the linear regime is still unknown. This project aims to address that question.

The PhD candidate will develop a Computational Fluid Dynamics (CFD) model of a simple problem involving supercritical fluids. It will be built upon an existing in-house 1D solver programmed by the supervisor. A plane Couette flow with heat transfer will be considered, and small disturbances will be introduced. These disturbances will grow due to the newly discovered linear instability. Their growth will be tracked using Fourier analysis and compared with a validated in-house linear stability tool. This will provide new insights into the validity of the linear regime and the effects of weak non-linearities. Furthermore, the breakdown to turbulence will be analysed and a novel model representing this new route to turbulence will be developed.

Overall, this project has the potential to positively impact the design of more efficient energy systems in supercritical fluids by identifying the key features involved in transition to turbulence, which engineers can use to trigger turbulent heat transfer.

8. Integrated Downhole Drilling Motor Drives for Oil and Gas Extraction

Dr Bing Ji – bing.ji@leicester.ac.uk

Project Title	Integrated **D**ownhole **D**rilling Motor **D**rives for **O**il and **G**as Extraction (IDDDog)	
Project Highlights:	1.	To reliably maximise the full potential of SiC-based motor drives in the heavy-duty downhole drilling platform.
	2.	To address fault and ageing challenges of SiC power modules in hostile operational and environmental conditions for the crude oil extraction.
	3.	By contributing to the digitalization of motor drive systems, the project will provide new tools and insights for system integrators to improve both the cognitive capabilities and reliability of VSDs in the oil extraction sector.

Project Overview (Maximum 350 words)

Context: This PhD project aims to address the challenges in oil extraction, where reliable, efficient, and intelligent variable-speed drives (VSDs) are essential in extreme downhole oil and gas exploration conditions. These VSDs must operate in harsh thermal and mechanical environments, requiring high precision and robustness. Silicon Carbide (SiC) and Gallium Oxide (Ga_2O_3) power semiconductors, known for their superior switching speed, high-temperature tolerance, and power density, have emerged as potential candidates to replace silicon-based components, improving the efficiency and reliability of downhole drilling VSDs.

Objective: The project seeks to unlock the full potential of SiC-based VSDs in downhole oil extraction. It aims to implement in-situ status-awareness and optimal control strategies for SiC devices to extend operational lifespan, improve fault detection, and enhance VSD reliability under extreme conditions.

Approach:

1. Standardized Power Switching Framework:
   - Develop a standardized framework for testing and monitoring SiC-based power switching units, tailored for downhole conditions.
   - Key features include enhanced status-awareness through smart sensing, active gate control algorithms for high-pressure environments, and robust protection mechanisms.
2. Innovative SiC Embedded Power (ISEP) Technology:
   - Design a 10 kW SiC-based high power-density inverter for AC motors used in downhole drilling, incorporating ISEP technology.
   - Key features include real-time adaptive control, optimized energy use, and cognitive capabilities for self-adjustment based on real-time drilling data.
3. Advanced Status-Awareness and Health Monitoring:
   - Implement multi-dimensional feature extraction for in-situ health monitoring of SiC-based VSDs.
   - Use multivariate machine learning for early fault detection, hybrid diagnostic algorithms, and aging-sensitive electrical parameters to ensure accurate fault detection with reduced hardware costs.

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Expected Outcomes:

- A robust, reliable SiC-based VSD system optimized for downhole operations.
- Improved real-time fault detection and status-awareness to reduce downtime.
- Contribution to the digitalization of power electronics in oil extraction, providing tools to enhance system performance and reliability.

9. Predicting Neonatal Outcomes and Maternal Health Risks Using Machine Learning: A Focus on Obesity, Ethnicity, and Reproductive Complications

Dr Xin Li – Xin.li@leicester.ac.uk

Project Title	Predicting Neonatal Outcomes and Maternal Health Risks Using Machine Learning: A Focus on Obesity, Ethnicity, and Reproductive Complications	
Project Highlights:	1.	Database from national BHF NIHR centres (Prof Bee Kang Tan being associated with the BRC NIHR network for pregnancy research)
	2.	Interdisciplinary supervision board
	3.	Project focusing on Obesity as an NHS Priority

Project Overview (Maximum 350 words)

Obesity during pregnancy increases the risk of complications such as preeclampsia, gestational diabetes (GDM), fetal growth restriction, and preterm birth, with long-term impacts on maternal and child health. These risks vary by ethnicity, requiring predictive models that consider such variations. This project aims to develop machine learning models to predict maternal-fetal outcomes using multimodal data from NIHR and BHF centers across the UK, focusing on obesity, reproductive complications, and the impact of interventions like aspirin.

The project proposal includes three stages:

Data Integration and Preprocessing
We will prepare and integrate diverse data sources from NIHR and BHF centers. Missing data will be managed using advanced imputation techniques, such as multiple imputation by chained equations (MICE) and generative models. To address data imbalances in outcomes like preeclampsia, we will use SMOTE and cost-sensitive learning, improving model robustness.

Predictive Modeling and Dynamic Analysis
This stage involves building predictive models using ensemble methods (random forests, gradient boosting) and deep learning to capture non-linear relationships in clinical, demographic, and biometric data. Time-series models, including recurrent neural networks (RNNs) and long short-term memory (LSTM) networks, will enable dynamic tracking of maternal health metrics, allowing real-time risk assessment throughout pregnancy.

Model Interpretability and Intervention Analysis
We will use Shapley values and feature importance analysis to identify key predictors related to obesity and ethnicity, enhancing model transparency. Causal inference techniques will assess the impact of interventions, such as aspirin, on obesity-related risks and complications, ensuring applicability across diverse ethnic groups and supporting personalized clinical interventions.

Our models will integrate maternal health indicators (e.g., BMI, blood pressure, glucose levels) with demographic factors to predict outcomes like birth weight, fetal growth restriction, and GDM. The large-scale, diverse dataset from NIHR and BHF centers will ensure model accuracy and

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generalizability, enabling early risk assessment and personalized intervention strategies in clinical settings.

References:

1. Bodnar LM et al., *Obesity Reviews* (2021)
2. Chawla NV et al., *Journal of Artificial Intelligence Research* (2002)
3. Van Buuren S et al., *Journal of Statistical Software* (2019)

10. AI Applications in Bearingless Permanent Magnet Motor Design and Vibration Reduction

Dr Yuan Gao – yg213@leicester.ac.uk

Project Title	**AI Applications in Bearingless Permanent Magnet Motor Design and Vibration Reduction**	
Project Highlights:	1.	Utilize AI to speed up the BPMM optimization considering torque and magnetic suspension performance for vibration in BPMM
	2.	Apply AI techniques to real time-identification of the current harmonics which can reduce the radial force acting on the stator
	3.	Develop AI models for real-time vibration monitoring and predictive maintenance to prevent failures
Project Overview (Maximum 350 words)		

Bearingless Permanent Magnet Motors (BPMMs) offer several advantages over traditional motors with bearings; For example, high speed and efficiency due to no bearing friction, reduced failure points with fewer mechanical components. In addition, BPMMs can operate in harsh environments where traditional bearings might fail, such as in high temperatures or corrosive environments. However, BPMMs present unique challenges, particularly regarding vibration. Both motor vibration and acoustic noise are excited by torque ripple acting on the rotor and radial force acting on the stator, and are dominantly caused by the radial force. To reduce them, this project aims to use artificial intelligence (AI) techniques during the BPMM design and control phases.

The reduction methods of vibration and acoustic noise can be classified into: (1) structural design including rotor/stator-skew, during the motor design phase; (2) injection of harmonic currents eliminating the problematic-radial force, a part of motor control. Method (1) is effective to the reduction of the vibration and acoustic noise, however, cannot be applied to existing PM motors as well as addition of manufacturing process. Method (2) can be applied to existing PM motors but, it takes a lot of time to find the harmonic currents reducing the radial force in the Finite Element Analysis or experiment. Taking their advantages, AI technique will be integrated with both methods, which can fast search for the optimal structural design, and effectively identify the harmonic currents for the radial force reduction when driving the motor.

To build the AI models, data should be collected from existing BPMM designs, operational logs, and vibration sensors. Then, the data need to be cleaned up and pre-processed to remove noise and irrelevant information. After multi-round training and validation, the trained AI models can identify key features influencing BPMM performance and vibration characteristics in real-time.

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11. Gas Turbine Blade Cooling: High-Fidelity Simulations and Bayesian Uncertainty Quantification of Low-Fidelity CFD Models

Dr Ali Haghiri – ah794@leicester.ac.uk

Project Title	**Gas Turbine Blade Cooling: High-Fidelity Simulations and Bayesian Uncertainty Quantification of Low-Fidelity CFD Models**	
Project Highlights:	1.	Gaining fundamental insights into the complex mixing phenomena (turbulence and heat transfer) in gas turbine blade cooling using Direct Numerical Simulation (DNS).
	2.	Enhancing the reliability of predictions by quantifying uncertainties in low-fidelity models (RANS/LES) through Bayesian inference for turbine blade cooling.
	3.	Resulting in optimised cooling designs that enhance turbine efficiency and extend component lifespan.

Project Overview (Maximum 350 words)

This research project focuses on the critical examination of gas turbine blade cooling, specifically targeting the trailing edge, where cooling air is expelled to mitigate thermal stress and improve performance. Gas turbines are pivotal in aviation and energy generation, and optimising their efficiency is essential for reducing operational costs and emissions. The trailing edge of turbine blades plays a vital role in this context, as effective cooling strategies can significantly enhance the durability and performance of these components.

To achieve this, the project employs Direct Numerical Simulation (DNS), a high-fidelity computational fluid dynamics technique that allows for the detailed analysis of turbulent flow and heat transfer phenomena occurring at the trailing edge. DNS captures intricate flow structures and mixing behaviours that are critical for understanding the cooling processes, providing fundamental insights that traditional methods may overlook. By employing DNS, the research aims to develop a comprehensive understanding of the mechanisms that govern the cooling performance of turbine blades.

Moreover, the project addresses the uncertainties associated with low-fidelity models, such as Reynolds-Averaged Navier-Stokes (RANS) and Large Eddy Simulation (LES). These models are often used in preliminary design phases but can introduce significant errors in predictions. To improve the reliability of these models, Bayesian inference techniques will be employed to quantify and reduce uncertainties, leading to enhanced predictive capabilities for turbine blade performance.

Ultimately, the findings of this research aim to inform the development of optimised cooling designs that not only improve turbine efficiency but also extend the lifespan of turbine components. This work will have direct implications for the aviation and energy sectors, contributing to more sustainable and efficient gas turbine operations. By bridging the gap between high-fidelity simulations and practical design considerations, this project seeks to advance the state of knowledge in gas turbine blade cooling technologies.