Modelling & Computation for Health And Society (MOCHAS) Scholarships

2022
Call for Applications and Guidelines

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MOCHAS
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for Health And Society

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The Connacht Ulster Alliance invites applications for postgraduate research degrees at PhD level under its Postgraduate Research Training Program, Modelling and Computation for Health and Society (MOCHAS)

15 research scholarships are being offered across a number of disciplines to commence in 2022.

PROJECT AWARDS WILL INCLUDE:

- A student stipend (usually tax-exempt) valued at €16,000 per annum
- Annual waivers of postgraduate registration fees
- Support for travel, consumables and dissemination expenses

The Postgraduate Research Training Programme (PRTP) in Modelling and Computation for Health and Society (MOCHAS) is an exciting new interdisciplinary, cohort-based research training programme. The Connaught Ulster Alliance comprises Galway-Mayo Institute of Technology, Letterkenny Institute of Technology and Institute of Technology Sligo who are merging on 1st April 2022 to form the new Atlantic Technological University. The MOCHAS PRTP aims to produce high-level, multidisciplinary research graduates who can develop, communicate, and exploit modelling tools for the solution of real-world problems relevant to societal needs. The individual research projects have been developed in tandem with stakeholders including hospitals, local government and industry, and address problems encompassing environmental sustainability, zero-carbon transport planning, medical devices, and health technologies. The cohort of PHD scholars will share a common core training program which entails development of the technical skills but also the soft skills in communication, visualization, cost analysis and innovation processes which are key to successful exploitation and impact of modelling and computational tools. The graduates will have the ability to appraise and apply different modelling approaches to build effective models appropriate to the challenge they are designed to address.

MOCHAS Postgraduate Research Training Program

Year One	Research Project				
	Induction		Autumn School		Winter Colloquium
	Structured Modules & Seminar Series				
Year Two	Research Project				
	Placement *		Summer School		Winter Colloquium
	Structured Modules & Seminar Series				
Year Three	Research Project				
			Summer School		Winter Colloquium
	Structured Modules & Seminar Series				
Year Four	Research Project				
			Summer School		Final Conference

* Indicative - exact timing and duration will be project specific

MOCHAS
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Project Titles

1. Modelling Mobility as a Service for optimised transport provision in semi-rural Ireland

2. The use of low-cost sensors for monitoring and modelling dynamical temporal microplastic pollution in freshwater

3. Location Specific Wind Turbine Power Forecasting

4. Applying mathematical models to predict mechanical and biological properties of polymeric tissue engineered constructs

5. Human innate immune response modelling using self-supervised graph-based deep learning

6. Design, modelling and optimisation of sustainable next generation Heat Transfer devices

7. Creation of a data warehouse framework to enable organisational analytics through machine learning

8. Materials design with machine learning and soft computing

9. Graph-based extreme deep learning for uncontrolled environment monitoring

10. Design and development of advanced porous implants through topology optimization and additive manufacturing

11. Autonomous network communication models for emergency communication

12. Modelling innovation in the health technology assessment of medical devices

13. Optimising skin graft meshing techniques to improve after-burn care

14. Medical Image Analysis for breast cancer screening using Artificial Intelligence (AI)

15. Mathematical & computational modelling for 3D-printed bioresorbable orthopaedic implants

**Department of Computing,
Faculty of Engineering & Technology,
Letterkenny Institute of Technology**

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Project Title: Modelling Mobility as a Service for optimised transport provision in semi-rural Ireland
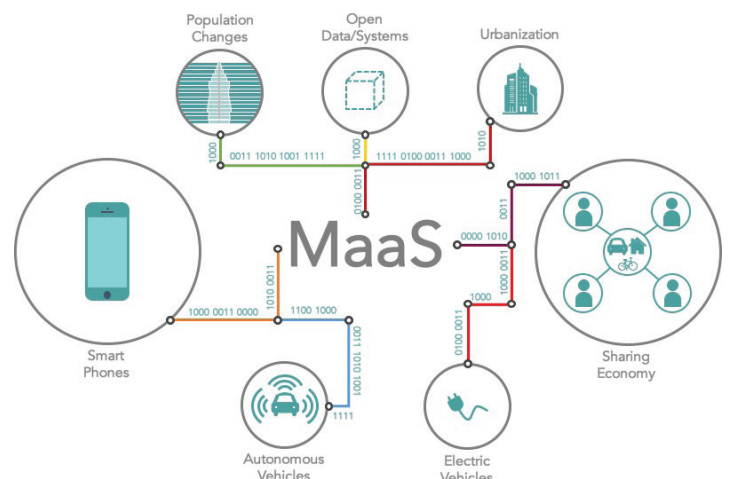
PROJECT DESCRIPTION

The high levels of ownership and usage of private cars must be tackled in order to dramatically reduce the environmental impact of transport in Ireland. This is of particular concern in semi-rural areas where public transport is insufficient to meet the daily transport needs of citizens. The growth of the sharing economy, in which people exchange goods and services, has the potential to yield an innovative transport strategy that enables users to gain short-term access to transport modes on an 'as-needed basis'. The concept of 'Mobility as- a-Service' (MaaS) describes the use of digital technologies that integrate various forms of transport services into a single mobility service accessible on demand. This project will involve the development of models to explore the impact of Connected and Autonomous MaaS solutions to enhance the uptake of public transport and improve transport equity in semi-rural areas. The model will include analysis of transport carbon emissions, traffic flow, infrastructure cost and accessibility of several different future shared and autonomous mobility scenarios with a view to minimizing emissions without depriving rural citizens of access to transport.

RELEVANT QUALIFICATION DISCIPLINES

Computer Science, Physics, Mathematics or Engineering

LEAD SUPERVISOR

**Dr. Eoghan Furey
Email: eoghan.furey@lyit.ie**

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Department of Environmental Science
Faculty of Science
Institute of Technology Sligo

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Project Title: The use of low-cost sensors for monitoring and modelling dynamical temporal microplastic pollution in freshwater

PROJECT DESCRIPTION

Surface and subsurface water contamination is the leading cause of many diseases, death, and human disasters. Microplastic pollution in water bodies is an alarming problem that requires and urgent attention mainly because of the direct impact on human health. Tracking freshwater vulnerability to microplastic pollution in fine temporal scale resolution is one of the main challenges in conceptualising the what-if scenarios modelling framework to control microplastic pollution.

The proposed project aims to advance the use of the integration of low-cost sensors, remote sensing, GIS and statistical methods to assess freshwater vulnerability temporally by explicitly introducing the time dimension, remotely sensed soil moisture data and land use data in the analysis.

This project will develop an innovative integrated framework to map freshwater vulnerability applying GIS and remote sensing on a fine temporal scale. This project will use integrated datasets of observed freshwater microplastic concentration data and satellite images from NASA's SMAP project for soil moisture and several statistical downscaling techniques.

RELEVANT QUALIFICATION DISCIPLINES

Environmental or civil engineering, environmental science, hydrology or a related discipline with a strong component of GIS and hydrological modelling.

LEAD SUPERVISOR

Dr. Salem Gharbia
Email: **gharbia.salem@itsligo.ie**

The use of low-cost sensors for monitoring and modelling dynamical temporal microplastic pollution in freshwater

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Department of Computer Science and Applied Physics
School of Science and Computing
Galway-Mayo Institute of Technology

MOCHAS
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Project Title: Location Specific Wind Turbine Power Forecasting

PROJECT DESCRIPTION

Wind turbines generate electricity from the wind, an unpredictable source of energy. For turbines to be economically viable, accurate models for forecasting wind speeds and wind turbine power output are needed.

In this project, you will create reliable and efficient models to forecast the power output of a wind turbine given a location on the island of Ireland. The location will not only consider the longitude and the latitude of the wind turbine, but also the altitude – a key consideration for turbine operators.

You will combine open and freely available data from three sources: Met Eireann, the Single Energy Market Operator, and turbine manufacturers. The data will be used to develop models for estimating the commercial value of placing a given model of turbine at a given location.

RELEVANT QUALIFICATION DISCIPLINES

Computer Science, Mathematics, Applied Mathematics, Data Science, Computational Science or a related discipline

LEAD SUPERVISOR

Dr. Ian McLoughlin, GMIT
Email: ian.mcloughlin@gmit.ie

**Department of Mechanical
and Industrial Engineering,
School of Engineering,
Galway-Mayo Institute of Technology**

MOCHAS
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Project Title: Applying mathematical models to predict mechanical and biological properties of polymeric tissue engineered constructs

PROJECT DESCRIPTION

Stem cells can be used to build new tissues and organs and hold the potential to cure many diseases. The in vitro microenvironment controls self-renewal and differentiation of stem cells into different lineages. Particularly, very recently, mechanical properties emerged as key determinants of stem cell differentiation. Systems to fine-tune the mechanical properties of biomaterials and ultimately the behaviour of seeded cells are thereby of extreme interest for tissue engineering applications. Nevertheless, a high number of involved variables in scaffold fabrication and the complexity of biological signalling networks limit the development of predictive and robust engineered systems, ultimately limiting clinical translation of tissue engineered constructs. Recently, theoretical modelling has been proposed to aid the design and optimisation of biomaterials. However, research in this direction is limited. We propose to develop novel mathematical tools to precisely tailor scaffold mechanical and biological properties, by only adjusting their fabrication parameters. A range of biopolymers (collagen, fibrin) and synthetic polymer analogues (bio-inspired L-DOPA-derived poly(ester amide)s) will be studied for hydrogel formation and used as tissue engineered scaffolds. Mechanical and dynamic properties of hydrogels prepared using polymers of different molecular weight and crosslinker ratios will be experimentally measured. Their capability to activate signalling transduction pathways, involved in the differentiation into the stem cell lineages (adipogenic, chondrogenic and osteogenic) will be assessed and the behaviour described by mathematical models. This work will tailor tissue-engineered biomaterial constructs for triggering stem cell differentiation. It will ultimately increase our ability to engineer tissues and whole organs.

RELEVANT QUALIFICATION DISCIPLINES

Biology, Biomedical Science, Mechanical Engineering, Biomedical Engineering or a related discipline.

LEAD SUPERVISOR

Dr Liam Morris
Email: liam.morris@gmit.ie

**Department of Computing,
Faculty of Engineering & Technology,
Letterkenny Institute of Technology**

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Project Title: Human innate immune response modelling using self-supervised graph-based deep learning
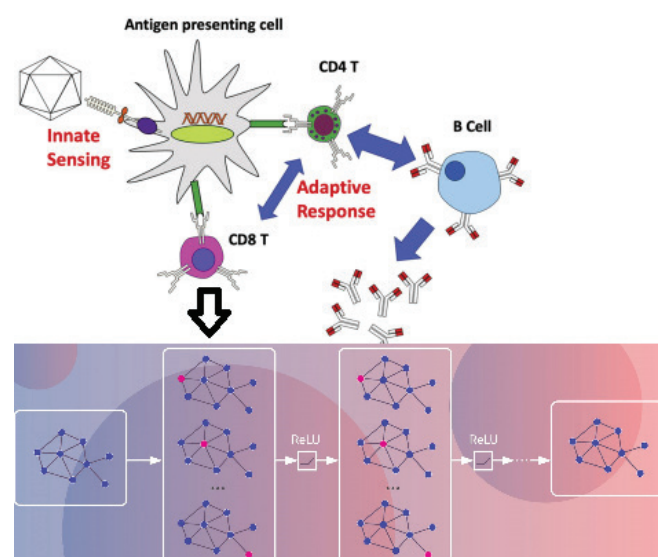
PROJECT DESCRIPTION

The immune response of severe acute respiratory syndrome coronavirus (SARS-CoV) infection is a complicated process and plays a critical role in the progression of the disease. The immune response is based on various pattern recognition receptors (PRRs) to react to viral pathogens using pathogen-associated molecular patterns (PAMPs), an essential component of immune system response. The recognition of PAMPs triggers a cascaded signalling process that activates microbicidal/pro-inflammatory responses for an adaptive immune response. Several investigations report critical implications of PRRs for immunomodulator design and cancer immunotherapy, etc. This project aims to use graph-based deep learning to model the cascaded activation process of PRRs in response to SARS-CoV strains to determine an understanding and reaction of the immune response. Further, the project seeks to harness self-supervised learning to handle large-scale unlabelled molecular graphs data with better generalization capabilities.

RELEVANT QUALIFICATION DISCIPLINES

Mathematics, Engineering, Telecommunications or Computer Science

LEAD SUPERVISOR

Dr. Shagufta Henna
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Department of Mechanical and Manufacturing Engineering, Faculty of Engineering & Design, Institute of Technology Sligo

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Project Title: Design, modelling and optimisation of sustainable next generation Heat Transfer devices
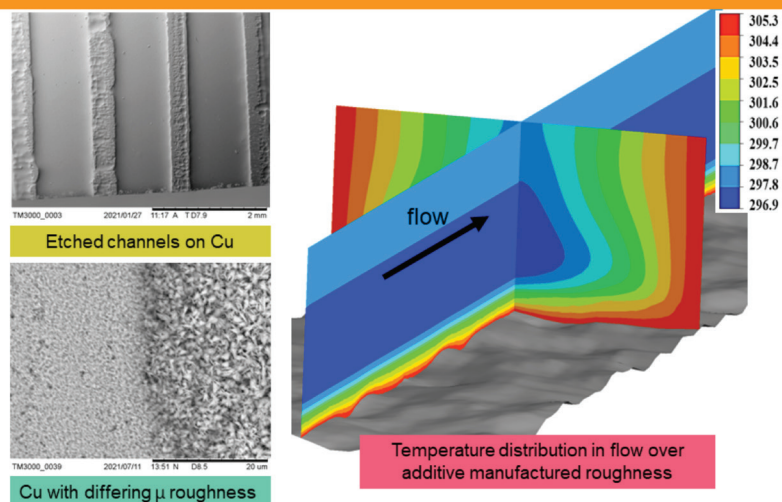
PROJECT DESCRIPTION

Many devices today generate heat which is often lost to the atmosphere and recovery of this energy is a major sustainability opportunity. Two-phase heat transfer processes permit high heat power to be handled with minimal temperature drops and are widely utilised for thermal management of electric vehicles, batteries, commercial electronics, and data servers. They are identified as a key technology for energy recovery and redeployment of waste heat and energy management. This project will focus on simulation and modelling of Heat Transfer during the complex processes of "phase change" (boiling and condensation of liquids) leading to development of improved two-phase cooling modelling and prediction solutions. While modelling of heat transfer in single phase is well understood, the multiple inter-related phenomena during phase change processes including vapour generation, displacement of liquid, surface characteristics, working fluid type, buoyancy effects and the contribution of gravity confer a vast array of complexity leading to difficulty in reliable prediction. This project will continue the work from current research projects on convective flow and condensation heat transfer and will further develop and refine the models to incorporate the more complex parameters needed for phase change processes. Subsequently these will be applied to the analysis of thermal management and heat recovery devices.

RELEVANT QUALIFICATION DISCIPLINES

Mechanical Engineering, Chemical Engineering, Materials Engineering, Manufacturing Engineering or related.

LEAD SUPERVISOR

Dr. Gerard McGranaghan
Email: **mcgranaghan.gerard@itsligo.ie**

Etched channels on Cu

TM3000_0003   2021/01/27 11:17 A T D7.9   2 mm

Cu with differing μ roughness

TM3000_0039   2021/07/11 13:51 N D8.5   20 um

flow

305.3
304.4
303.5
302.5
301.6
300.6
299.7
298.7
297.8
296.9

Temperature distribution in flow over additive manufactured roughness

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Department of Analytical, Biopharmaceutical and Medical Sciences, School of Science and Computing, Galway-Mayo Institute of Technology

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Project Title: Creation of a data warehouse framework to enable organisational analytics through machine learning

PROJECT DESCRIPTION

This project aims to establish an adaptative framework and intuitive user interface which will enable compliant extraction and evaluation of data from infrastructural, environmental and online sources. This will offer new insights and opportunities in resource management for efficiency, user wellbeing and data driven decision making. Data silos are pervasive, presenting challenges where researchers wish to securely extract, store, cleanse, encrypt, mine and analyse data while remaining compliant with ethical and regulatory frameworks. Collaborating with Microsoft Ireland, the project will explore the aggregation, cleansing and analysis of CUA partners' data using cloud-based data lake/warehouse approaches. Machine learning algorithms will assess the relationships between disparate data sources, creating a data pipeline and interface enabling future research. Automating feature engineering optimises the process of deploying accurate machine learning models by handling necessary but tedious tasks. This enables researchers to automate data health checks to understand and cleanse their data before developing robust, optimised models. This live, dynamic data pipeline will open vast opportunities for investigation of the current state of real time resource usage to inform and support decision-making. The development of a CUA campus data warehouse and user interface will mitigate common hurdles that occur around data optimisation, analysis and GDPR compliance.

RELEVANT QUALIFICATION DISCIPLINES

Computing; Mathematics; Statistics, or a related discipline.

LEAD SUPERVISOR

Dr Etain Kiely
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Department of Computer Science and Applied Physics,
School of Science and Computing,
Galway-Mayo Institute of Technology

MOCHAS
Modelling & Computation
for Health And Society

Project Title: Materials design with machine learning and soft computing

PROJECT DESCRIPTION

The problems of ever-rising global energy consumption, rapidly decreasing availability of fossil fuels, increasing levels of pollution and global warming all require solutions that are sustainable, clean and renewable. The breadth and complexity of these problems necessitates a multidisciplinary response involving expertise in areas as diverse as Physics, Chemistry, Computer Science, Environmental Science and Nanotechnology. Over recent decades, each of these disciplines have developed significant data repositories that contain a wealth of information that can potentially be mined, combined, orchestrated and exploited to yield knowledge and insights. The objective of this project is to exploit advances in machine learning and soft computing to analyse, mine and extract information from material and life science databases and then apply this knowledge to create practical solutions to problems.

RELEVANT QUALIFICATION DISCIPLINES

Computing, Mathematics, Applied Mathematics, Statistics, Data Science, Computational Science or a related discipline

LEAD SUPERVISOR

Dr. John Healy
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Department of Computing,
Faculty of Engineering & Technology,
Letterkenny Institute of Technology

MOCHAS
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Project Title: Graph-based extreme deep learning for uncontrolled environment monitoring
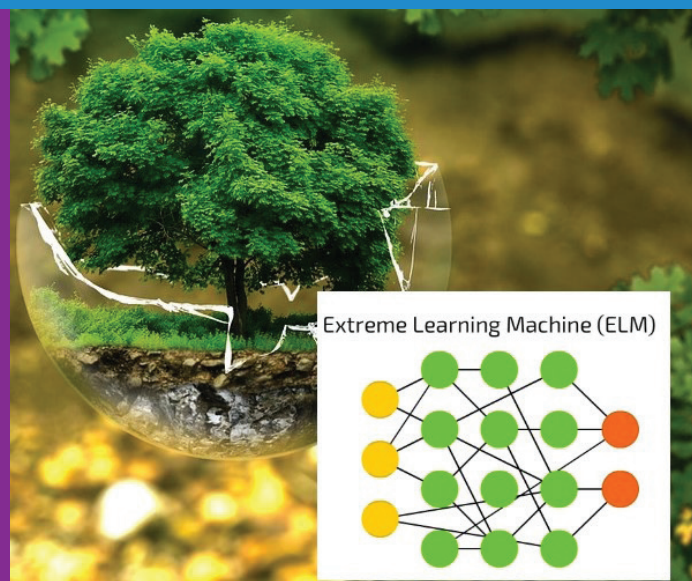
PROJECT DESCRIPTION

Recent advancements in sensor technology have encouraged an inexpensive deployment of large-scale wireless sensor networks (WSNs). Recalibration of sensors in large-scale WSNs is a major challenge and affects the quality of monitoring. Various applications requiring blind calibration include environmental monitoring, building structure health monitoring, and precision agriculture. This project aims to propose a self-calibration framework using incremental deep learning for sensor measurements. The project will also consider the development of a graph-based extreme deep learning framework to improve the accuracy of calibration under noisy and uncontrolled environments.

RELEVANT QUALIFICATION DISCIPLINES

Mathematics, Engineering, Telecommunications or Computer Science.

LEAD SUPERVISOR

Dr. Shagufta Henna
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Extreme Learning Machine (ELM)

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Department of Mechanical and Manufacturing Engineering, Faculty of Engineering & Design, Institute of Technology Sligo

MOCHAS
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Project Title: Design and development of advanced porous implants through topology optimization and additive manufacturing

PROJECT DESCRIPTION

A porous implant can mimic natural bone more reliably and satisfies the biomechanics requirement. The main objective of this research will be to replace the solid titanium biomedical implant with a porous structure for enhanced performance and biocompatible characteristics. The research involves theoretical study, FEA computations, topology optimization (TO), additive manufacturing (AM), material characterization, and mechanical testing. TO algorithms will be employed to explore porous configurations with improved weight-to-stiffness ratios. The study will undertake the requirements of international standards for biomedical implants. Mechanical testing and material characterization of AM porous titanium implant will provide a good benchmark for evaluating the microstructure, tribological parameters, thermo-mechanical characteristics, and biocompatible characteristics.

RELEVANT QUALIFICATION DISCIPLINES

Biomedical Engineering; Mechanical Engineering; or related fields.

LEAD SUPERVISOR

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MOCHAS
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Project Title: Autonomous network communication models for emergency communication

PROJECT DESCRIPTION

Disasters are events that can occur at any time and can cause a severe loss of life and damage existing infrastructure. In these events, the victim needs to communicate, and first responders need to coordinate their efforts to provide an efficient and timely response, which may include data, voice, and video transmission. The existing wireless technology has been proposed widely to be used in case of emergencies, like GSM, LTE, Satellite, Internet-of-Things, etc. To be useful, these technologies must fulfil the requirements for an emergency response network, which includes, rapid deployment, interoperability, quality of service, coverage, mobility, agility, and self-organization. Most importantly, autonomous communication models are required for these situations to avoid the need for manual configuration and management. For example, LTE-based mobile small cells can be used in case an existing base station is damaged. However, the antenna direction and alignment, the placement of the cells, frequency usage planning, congestion avoidance, and resource management are some of the challenges, which need to be addressed. To address these challenges for an emergency network, autonomous network models are required to support the self-organization, configuration, and management of different network operations.

RELEVANT QUALIFICATION DISCIPLINES

Mathematics, Engineering,
Telecommunications
or Computer Science.

LEAD SUPERVISOR

Dr. Saim Ghafoor
Email: **saim.ghafoor@lyit.ie**

MOCHAS
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Project Title: Modelling innovation in the health technology assessment of medical devices
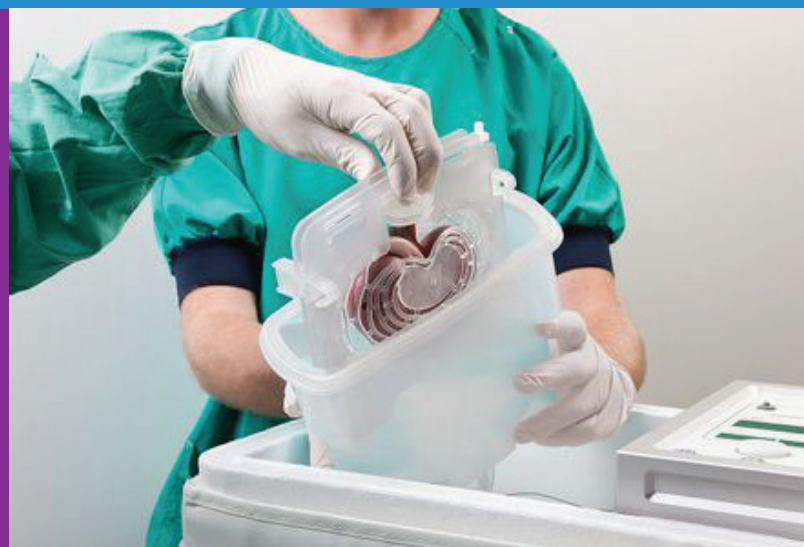
PROJECT DESCRIPTION

The aim of this project is to provide a robust and adaptive computational framework for highlighting the multifaceted impact of medical device innovations in the delivery of healthcare. The proposed research will review existing evaluation techniques in the health technology assessment of medical devices field, classifying strengths, weaknesses and functionality of these computational modelling techniques across a range of clinical areas. An innovative modelling tool, consistent with best practice, will be developed that addresses the needs of health technology assessment agencies with personalised features ensuring clinically and economic plausibility but also adaptive functionality for bespoke clinical areas. Transplant technology is an emerging area where medical innovation is being applied to maximise the health benefits associated with transplantation. Cost implications however limit the feasibility of these innovations, mainly due to limitations on the modelling capacity of health technology appraisal techniques. Therefore, innovation in transplantation will be the main case study assessed in conjunction with the Oxford Transplant Centre and the Nuffield Department of Surgical Sciences, University of Oxford. The modelling tool will incorporate data collected by the Oxford Transplant Centre and the EU COPE consortium in the area of innovation in organ perfusion to validate functionality and predictive ability.

RELEVANT QUALIFICATION DISCIPLINES

Economics, Mathematics, Pharmaceutical Science, Public Health, Applied Health Sciences or a related discipline

LEAD SUPERVISOR

Dr. Richéal Burns
Email: **burns.richeal@itsligo.ie**

MOCHAS
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Project Title: Optimising skin graft meshing techniques to improve after-burn care

PROJECT DESCRIPTION

Burns are among the most common type of trauma occurring in society. For example, burn injuries affect 250,000 people annually in the United Kingdom. Burns pose a threat to life when not treated properly. For deep partial thickness and full thickness burns, skin grafts are necessary for treatment. Usually, the skin from the donor site is stretched to cover the injured site. To increase the expansion, the donor skin is meshed by cutting slits using a skin mesher. Skin meshers on the market are rated according to the expansion they achieve. The manufacturers usually overrate the expansion of the mesher. In addition, there is a relative dearth of analysis of the skin meshing, in particular, the mechanics of cutting. This project aims to fill the gap in the knowledge around skin mesher design. Specifically, it will analyse current skin meshers and determine the optimum arrangement and geometry of cutters on the device that will maximise the quality of cutting and expansion of donor skin. The influence of the mechanical properties of skin on the expansion will be analysed. This research will result in better skin mesher designs and thus improve the quality of life of patients requiring skin grafts.

RELEVANT QUALIFICATION DISCIPLINES

Mechanical, biomedical engineering or other related discipline.

LEAD SUPERVISOR

Dr. Cormac Flynn
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MOCHAS
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Project Title: Medical Image Analysis for breast cancer screening using Artificial Intelligence (AI)
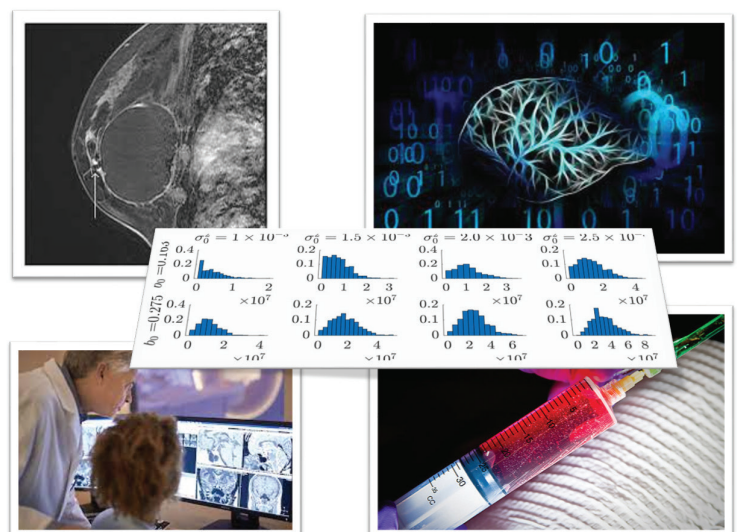
PROJECT DESCRIPTION

This project focuses on developing a novel technique, using radiomics and AI, to aid breast cancer screening. In current radiological practice, evaluation of tumors is largely qualitative and subjective. Radiomics, which is the extraction of tumour specific characteristics from radiographic images, has demonstrated promising potential in the early diagnosis of cancers, such as brain tumours, compared to conventional screening methods practised in hospitals. However, radiomics approaches in breast cancer screening are still not widely available in clinical practice due to several reasons such as lack of knowledge about this approach among radiologists, absence of efficient radiomic techniques and limited data sharing. In addition, the majority of radiomics studies are mostly preliminary with a retrospective design. In this study, we are proposing an explainable AI approach for the feature extraction and AI-based screening of breast cancer. Advanced imaging modalities will be explored for the extraction of the tumor biomarkers, which will be used to train Machine learning algorithms along with other relevant clinical and histopathological data to predict the malignancy of the tumour. Early diagnosis of malignancy reduces mortality and facilitates less aggressive treatment. The feature reproducibility and clinical utility of the developed model will be evaluated via prospective analysis.

RELEVANT QUALIFICATION DISCIPLINES

Computer Science, Computing with Machine Learning & Computer Vision, or related Engineering discipline

LEAD SUPERVISOR

Dr. Saritha Unnikrishnan
Email: **unnikrishnan.saritha@itsligo.ie**

Department of Mechatronic Engineering,
Faculty of Engineering & Design,
Institute of Technology Sligo

MOCHAS
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Project Title: Mathematical & computational modelling for 3D-printed bioresorbable orthopaedic implants

PROJECT DESCRIPTION

3D printing is revolutionizing the production of orthopaedic implants by the customization of an implant specific to the patient, which can be rapidly fabricated onsite where and when it is needed. Bioresorbable implants provide temporary mechanical support in areas of damaged tissue but are gradually resorbed by the human body as the patient's tissue heals. The implant design should be tailored to match the degradation of the implant with the healing process.
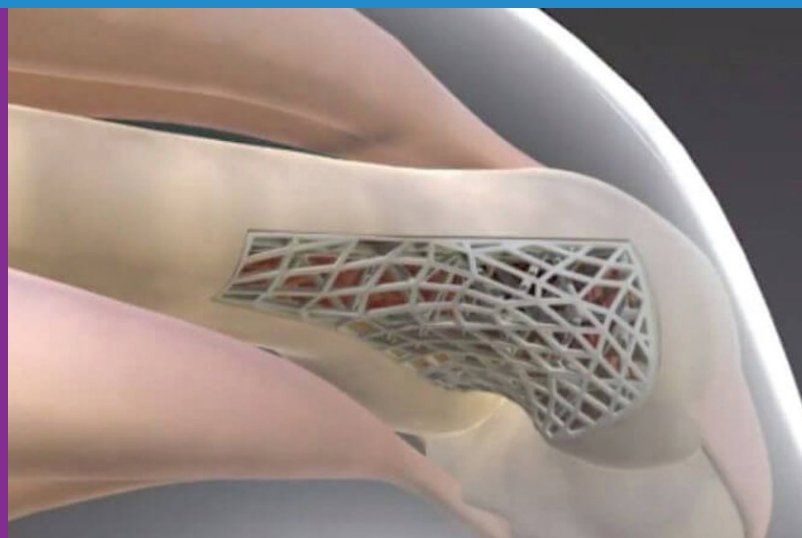
Biocompatible composites made of bioresorbable polymers filled with magnesium (Mg) particles are promising candidates for orthopaedic applications due to ease of low-temperature 3D printing, high mechanical properties, enhanced osseointegration and reduced inflammatory response compared to polymer-only implants. Mg is the second most abundant element in human tissues and plays important roles in neuromuscular activity and supporting a healthy immune system. However, the influence of the shape, composition and dispersion of Mg particles on the polymer degradation, bioresorption and transport processes and resulting mechanical properties and implant degradation profile is not well understood. In this project a mathematical model (using e.g. a cellular automata approach) will be developed to explore the effect of different filler loadings and attributes on the degradation and rate of loss of mechanical properties of biopolymer/magnesium composite tissue scaffolds. The model will be validated against experimental data on 3D printed tissue scaffolds.
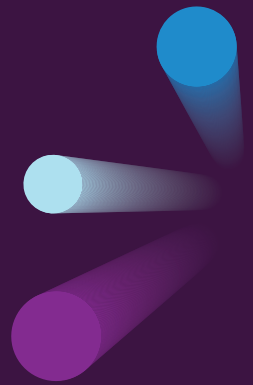
RELEVANT QUALIFICATION DISCIPLINES

Mathematics, Engineering or Computer Science

LEAD SUPERVISOR

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MOCHAS

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REQUIREMENTS / QUALIFICATIONS:

An Honours Degree (minimum 2.2, but 2.1 or higher is desirable)
in the relevant disciplines listed beneath each project description.

PROJECT DURATION:

48 months (PhD)

APPLICATIONS

to **cawley.veronica@itsligo.ie** only using the application form.

Application Form / Terms of Conditions can be obtained on the website:

https://www.itsligo.ie/mochas/

The closing date for receipt of applications is 5pm, (GMT) 21st February 2022.

An initiative of the Connacht Ulster Alliance which will become the Atlantic Technological University (ATU) on 1st April 2022.

PLEASE NOTE:

Candidates from outside the EU are eligible to apply but may be expected to provide evidence of sources of additional funds to cover non-EU fees and living expenses for the first month in Ireland.

If either English or Irish is not the applicant's first language, evidence of English language proficiency is required for registration.