MedAgriTech AI eXcellence (MATX)

Ollscoil Teicneolaíochta an Atlantaigh

Atlantic Technological University

atu.ie

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HEA AN tÚDARÁS um ARD-OIDEACHAS
HIGHER EDUCATION AUTHORITY

The MedAgriTech AI eXcellence (MATX) Postgraduate Programme Description

The MATX Postgraduate Research Training Programme (PRTP) offers 12 PhD research scholarships to commence in 2024. Each project will include an enterprise placement of minimum 12 weeks duration.

Project awards will include:

- **A student stipend (usually tax-exempt) valued at €22,000 per annum**
- **Annual waivers of postgraduate tuition fee**
- **Extensive research training programme**
- **Support for travel, consumables and dissemination expenses**

The MATX PRTP proposes a cross-sectorial approach to integrate Artificial Intelligence (AI) into ICT and ICT services. This innovative program involves 12 PhD projects, each project addresses an application of AI across three distinct, yet strategically significant Smart Specialisation Strategy (S3) priority areas: Agrifood/ AgriTech, MedTech, and Advanced Manufacturing & Engineering interconnected through the innovative implementation of ICT solutions.

MATX PhD candidates will benefit from a comprehensive training program, emphasising open research, industry engagement, and cultivating specialised and transferable skills. This includes participation in training schools and symposia, completing 30 ECTS (European Credit Transfer System) structured training within the first 2 years offering in-depth knowledge in AI basics, ethical considerations, and the use of AI to shape sustainable practices within the targeted S3 priority areas.

The individual PhD projects have been developed in partnership with Ireland's Northern and Western regional enterprises in the selected S3 priority sectors, as well as national and international stakeholders. The 12 PhD projects focus on a range of research questions investigating textual, visual and tactile information for improving the quality of life (e.g., rehabilitation robotics, self-powered wearables for e-health), decision-making (e.g., medical diagnosis systems), predictive analytics (e.g., digital twins), automatic knowledge extraction and pattern recognition from data.

Postgraduate Research Training Programme

Year 1:

Induction

Doctoral Training School 1: AI / ML Fundamentals and Cases

Webinar Series 1: AI Innovations and Trends

Year 2:

Doctoral Symposium 1: Inclusive AI

Webinar Series 2: Interdisciplinary Approaches in AI

Year 3:

Doctoral Training School 2: Personal Development

Doctoral Symposium 2: Industry focus

Webinar Series 3: AI Ethics and Society

Year 4:

Symposium 3: MATX Showcase

Webinar Series 4: Career Paths in AI

Indicative Training programme and subject to change

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AI-Enhanced Self-Updating Digital Twin for Optimised Spray Drying in Dairy Manufacturing

Production of milk powders from fresh milk provides a vital mechanism for preserving nutritional value while enhancing longevity and enabling the distribution of dairy products to regions reliant on food imports. When reconstituted, this milk powder should ideally reflect the properties of fresh milk. However, the production process is complex and can result in unwanted changes in protein interactions and fat coalescence due to variations in process parameters which are difficult to monitor and control. This project investigates the potential of Artificial Intelligence (AI) and smart sensor technologies in developing a digital twin for enhanced quality control and efficiency in milk powder production. In stage one, the feasibility of using computer vision technologies combined with Deep Learning to identify relationships between e.g. powder particle size and shape and process variables will be investigated. Inline spectroscopy will be investigated, in stage two, for analysing milk protein structure and its impact on powder quality. A novel digital twin model will be developed using the experimental data obtained from sensor fusion, incorporating the significant variables identified from the analyses to self-update and enhance the spray drying process.

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Sensor Integration for Enhanced Safety and Automation in Agricultural Applications

Agriculture is undergoing a significant transformation with the adoption of advanced technologies. Valeo, in collaboration with leading agricultural companies, is poised to play a pivotal role in this transformation. This project proposal aims to investigate the utilisation of Valeo sensors in agricultural applications, focusing on safety, compliance with the relevant standards for control systems for tractors and machinery for agriculture and forestry, and the enhancement of camera systems to meet the growing demand for autonomy in the agricultural sector. The project will deliver improved safety by utilising Valeo sensors and adhering to ISO 25119 standards to enhance the safety of agricultural operations, reducing risks and accidents. It will enhance automation through the integration of advanced camera systems that will enable autonomous functionalities, improving efficiency and productivity. It will result in market expansion as Valeo's involvement in the agricultural sector will expand its offerings and contribute to the growth of the agricultural automation market. The project will utilise cutting-edge sensor technology from the automotive industry including enhanced camera systems with advanced vision capabilities combined with data fusion algorithms for efficient decision-making.

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03

AI for Modelling Equine Reproduction

This project will use AI and mathematical modelling techniques to analyse ovarian ultrasound images and other variables (hormones, body condition score) to predict time of ovulation and the occurrence of multiple ovulations. This will help with timing of artificial insemination, allow confident booking of stallion covers and with predicting twinning. The project will lead to improved protocols for equine ultrasound scanning and improved use of ultrasound images to better estimate the reproductive health of mares and better predict the time of ovulation. This will lead to fewer missed heats, preventing late foaling and lower the costs of production of foals. It will also allow confident booking of stallion covers allowing breeders to get their top choice of genetics every time.

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Adaptive Control of Robotics for Assembly in Space Applications

Manufacturing operations for space applications face several challenges with respect to classical manufacturing and thus are often conducted at low volumes with high human input. In particular, given the size and complexity of the components and required precision in assembly, it is often difficult to program a robot to complete these tasks usually traditional methods. Classically, robotics and automation have focused on eliminating variations mechanically i.e. through jigs and fixtures in order to obtain a return on investment at high volumes. However, this paradigm is not applicable to lower volumes such as batch manufacturing due to the reprogramming and reconfiguration time. In this project, the researcher will explore novel methods to improve and accelerate system reconfiguration from one manufacturing task to another in two primary ways. First, the project aims to apply machine learning algorithms such as behavioural cloning to facilitate programming by allowing humans to demonstrate the task through CAD or through the physical setup. Secondly, the project will aim to create robot controller that matches the demonstration to the current scene using sensors such as cameras and force. In doing so, a simple demonstration by a human worker will be transformed into a robot assembly operation.

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Sustainable Precision Farming: An Explainable Self-Supervised Generative Learning Approach Leveraging the Internet of Robotics Things (IoRTS) and Digital Twin

Agriculture involves cultivating land and producing goods, playing a crucial role in economic progress. Smart/precision agriculture uses the Internet of Robotics Things (IoRTs) and predictive analytics to optimize farming practices. IoRTs monitor environmental, crop, moisture, and soil factors that are later utilized for building deep learning (DL) models for farm predictions, including crop yield. Sustainable smart agricultural practices are crucial to address challenges like population growth/climate change. These practices maximize crop yields in controlled environments while minimizing the environmental impact of deforestation, soil degradation, and carbon footprints. Current DL approaches in smart agriculture excel in supervised learning tasks but are limited by insufficient labelled data. These approaches lack real-time digital information views and explanations based on various agricultural features contributing to environmental tolls, crucial for sustainability/planning. This project proposes a self-supervised generative learning framework for sustainable farming. It aims to address insufficient labelled data through self-supervised learning facilitated by generative learning. It integrates IoRTs and Digital Twin for a real-time information view, explained with explainable AI (XAI). This integration aims to assist in interpreting decisions and understanding agricultural features and their environmental impact. It also aims to provide insights into the role of IoRTs components in predictions, aiding agriculture planning.

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An AI Driven Robotic System for Physical Exercise and Personalised Sports Rehabilitation

Rehabilitation is a growing need, driven by an aging and more active population. The population over 65 in Ireland will double by 2051 (Population Projections Results, 2017) while 32% of the labour force will be over 50 by 2031. One-to-one physiotherapy, the optimum solution, is straining available resources while self-supervised use of gym equipment presents a safety risk. This project will explore the use of collaborative robots (Cobots) to address the demand for rehabilitation and the lack of data and reconfigurability associated with existing devices. The researcher will develop a control framework whereby an expert in exercise design will create motions for the system to follow. Cobots are safe to use around humans and capable of following precise force trajectories. Additionally emerging methods are allowing humans to quickly program these systems without any background in robotic programming. Thus, the project will seek to enable a physiotherapist or trainer, without programming experience, to interact and demonstrate exercises to the Cobot through kinaesthetic teaching. The subject will then grasp the system and follow the taught motion with varying force profiles. The resulting force data will be used to individualise exercise routine and provide the instructor with insights into subject's capabilities.

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Robotic Handling and Inspection of Complex Materials Using Tactile and Visual Feedback

The medical device manufacturing industry requires precise assembly and inspection tasks of complex objects typically carried out by highly trained operators. The labour shortage and competition with low-cost countries mean automating production is urgent. Yet, these operations are difficult to accomplish and even program using standard automation tools. Additionally, since many materials are deformable, task parameters vary, leading to proposed automated solutions which are inflexible and rely on complex jigs and fixtures. The resulting solutions are applicable to a narrow class of assembly tasks and reduce reconfigurability. The size of such components means that humans often rely on a sense of touch to judge the quality of the assembly, an operation extremely difficult to replicate using automated solutions. In this project, an automated cell for the handling and inspection of these objects will be designed and implemented. The project will use state-of-the-art tactile sensors developed in UCD to equip the robot with a sense of touch. A new position and force controller using these sensors will be designed for material handling. A supervised machine learning framework will be designed to replicate manual tactile inspection and then furthered to train a visual inspection feed for a novel non-contact inspection method.

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Data driven rehabilitation using AI

Development of Electrochemical Wearable Sensors for the Rehabilitation Process Using Artificial Intelligence

Wearable sensors have emerged as a tool in rehabilitation, offering a dynamic and personalised approach to therapy. By leveraging electrochemical principles, these wearable devices can detect subtle changes in biofluids such as sweat or interstitial fluid, providing real-time feedback on factors like hydration levels, muscle activity, and metabolic responses. These sensors, integrated into wearable devices such as smart gloves or motion-capture garments, play a crucial role in delivering targeted interventions for individuals undergoing arm and hand rehabilitation. By continuously monitoring and recording the precise movements of the affected limbs, wearable sensors provide real-time feedback to both therapists and patients, facilitating a more objective and data-driven rehabilitation process. This objective measurement of arm and hand movements not only enhances the accuracy of therapy but enables therapists to tailor interventions based on the individual's progress. This information allows healthcare professionals to tailor rehabilitation programs to an individual's needs and progress. Machine learning algorithms can identify patterns and correlations in data, providing valuable insights into the most effective rehabilitation strategies for specific conditions or patient profiles. Real-time monitoring further enables adjustments to the treatment plan based on the individual's response, optimizing outcomes and promoting a more personalized and efficient rehabilitation journey. The integration of wearable sensors in rehabilitation both transforms the traditional rehabilitation model and empowers individuals with a more engaging and quantifiable rehabilitation experience, ultimately leading to improved outcomes and enhanced recovery.

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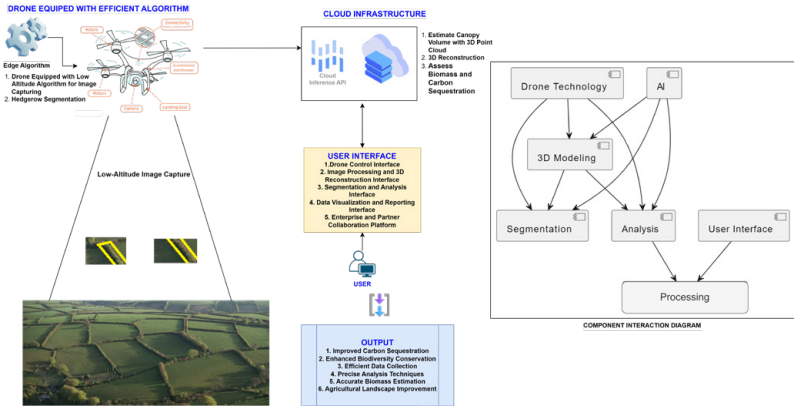

Low-Altitude Drone-based 3D Reconstructions for Precision Hedgerow Analysis and Biomass Estimation

This research is centered on hedgerows in Ireland, essential for carbon sequestration, biodiversity, and improving the agricultural landscape. Hedgerows are linear plant arrangements with various shrubs, trees, and vegetation. Hedgerows serve various purposes, including marking property boundaries, providing shelter for wildlife, and contributing to biodiversity. Current data collection often includes manual estimation, use of satellite data, or by drones flying at over 10 meters. Manual inspection is tedious and time-consuming, while satellite and high-altitude drone imagery lacks accuracy in assessing hedgerow canopy. Our project addresses this by capturing low-altitude images using structure-from-motion and multiple-view stereo techniques to create detailed hedgerow canopies. The data captured from different angles ensures 3D reconstruction from structure-from-motion for a high-quality 3D point cloud and colour information. The subsequent challenge involves accurately segmenting the hedgerow from other environmental objects. Finally, the 3D point cloud can be used to estimate the volume of the canopy or envelope of the hedgerow. This information is invaluable for assessing the biomass and carbon sequestration potential of hedgerows. It aids in formulating more accurate calculations of the ecological benefits hedgerows contribute to the environment.

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Exploiting AI to Assist Research Policy in Agritech/Medtech

Science is moving towards open science, and the arXiv (www.arxiv.org) is a growing database of 2.4 million scientific papers in the public domain. The arXiv facilitates daily announcements of scientific findings. Traditionally, the arXiv was a repository of physics and mathematics papers, but recent submissions growth is driven by computer science. The project has two phases. The first is study novel metrics to quantify the impact of research. This step will involve compressing information on the arXiv to test and develop metrics. The second phase will use AI to automate science research funding calls. More concretely, we will extract paper metadata, which is directly available from the arXiv, and funding information, which will be extracted through natural language processing (NLP) of paper acknowledgements. Given that the arXiv provides a daily update of papers, one can identify papers and authors that are generating interest, as quantified by metrics that we will develop, and use this as a basis for proposed funding allocation through AI. As a warm-up, our study will focus on Agritech/Medtech arXiv submissions, before extending the scope. The project also aligns with S3 for the North-West region through ICT and ICT services.

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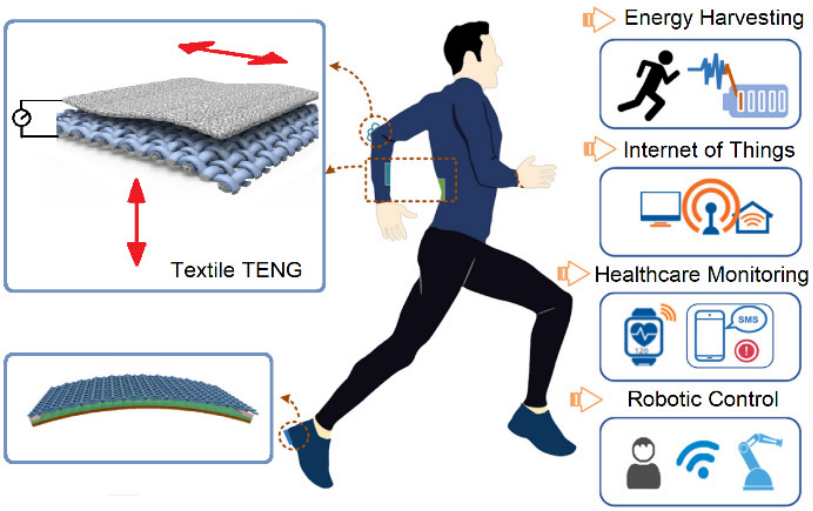

Ionogel Based Self-Powered Wearables for Energy Efficient e-health Monitoring.

Self-powered wearables represent a groundbreaking advancement in the realm of energy-efficient e-health monitoring, seamlessly blending cutting-edge technologies to enhance user experience. These innovative devices harness a multifaceted approach, integrating materials science and advanced sensing technologies. Ionogels and their composites serve as efficient energy storage components, leveraging ionic conductivity to harvest and store energy from the wearer's movements. This not only ensures a continuous power supply but also reduces reliance on external charging sources. The incorporation of highly sensitive sensing technologies further enhances the accuracy and depth of health monitoring, providing real-time insights into various physiological parameters. The synergy of these elements not only propels the evolution of self-powered wearables but also sets the stage for a more sustainable and effective approach to e-health monitoring.

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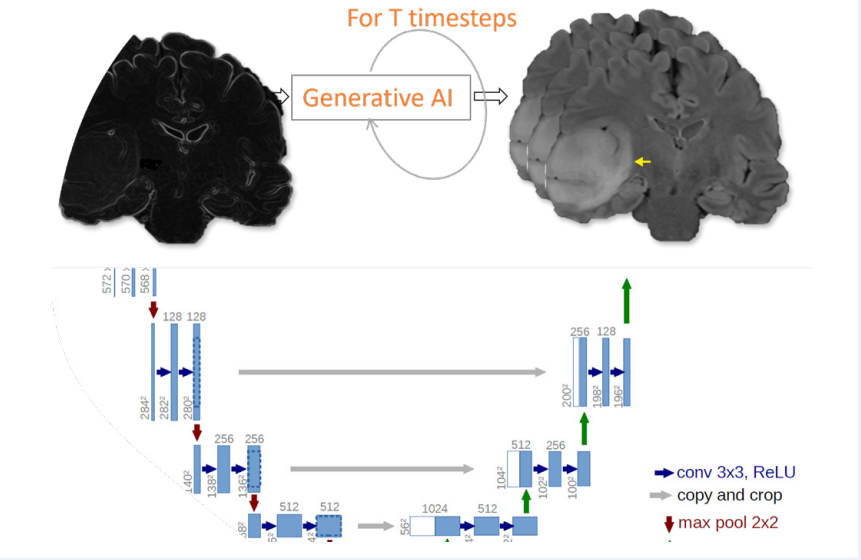

Generative AI for Non-invasive MRI Enhancement in Brain Tumour Diagnosis

Diagnosing cancer today involves using chemical “contrast agents” to improve the accuracy of medical imaging processes such as X-rays as well as computed tomography (CT) and magnetic resonance imaging (MRI) scans. MRI has revolutionised medical diagnostics. However, the efficacy of MRI is often inhibited by the low contrast of specific tissues or pathological conditions. Therefore, it necessitates the use of contrast agents. These agents can be expensive, take more time to use and pose potential health concerns. This project aims to develop a virtual contrast enhancement tool using generative artificial intelligence algorithms, which will reduce the inherent noise and generate a contrast-enhanced image for brain tumour diagnosis while acting as a non-invasive approach for early cancer diagnosis replacing the current invasive contrast enhancement methods.

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Requirements/Qualifications

A minimum of 2.1 honours degree (Level 8) in a relevant discipline.

Project Duration:
48 months (PhD)

All projects will be available on a full-time study basis only.

Applications:
Application Form / Terms and Conditions can be obtained on the website: www.atu.ie/TU-Rise

The closing date for receipt of applications is 5pm, (GMT) Monday 29th April, 2024.

Only selected applicants will be called for an online interview (shortlisting may apply).

Funding Statement
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