Innovation in Digital Manufacturing and Design (IDMD)

Ollscoil Teicneolaíochta an Atlantaigh

Atlantic Technological University

atu.ie

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Rialtas na hÉireann
Government of Ireland

Arna chomhchistiú ag an Aontas Eorpach
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Tionól Réigiúnach Tuaiscirt & Iarthair
Northern & Western Regional Assembly

Tionól Réigiúnach an Deiscirt
Southern Regional Assembly

HEA AN tÚDARÁS um ARD-OIDEACHAS
HIGHER EDUCATION AUTHORITY

Innovation in Digital Manufacturing and Design (IDMD)

The Postgraduate Research Training Programme (PRTP) in Innovation in Digital Manufacturing and Design 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 PRTP in Innovation in Digital Manufacturing and Design brings together leading multidisciplinary academic experts and industrialists in the fields of Industry 4.0, material science, advanced manufacturing & engineering, computer science business, process design and innovation management, plus experienced researchers and academics from a range of both leading national and international collaborating institutions. Our collective vision for the PRTP in Innovation in Digital Manufacturing and Design is to deliver world class research and training excellence for our regional industrial partners and to be internationally recognised within the Industry 4.0 domain through our PhD graduates and research excellence. Many of the PhD supervisors involved in this PRTP, across the ATU campuses, are both nationally and internationally recognised as experts within their respective fields that are very relevant to advancing Ireland's position as global leaders in Industry 4.0. The overall objectives of the centre are to facilitate ATU academics and industrialists to collaborate, in the PhD training of engineers and manufacturing leaders of the future that can contribute to increasing productivity, improving sustainability, stimulating economic growth, and improving living standards for our region. The PRTP will facilitate PhD student placements with industrial collaborators and supply graduates with the necessary skills and competences to support the rapid evolution of digital manufacturing in the future.

Postgraduate Research Training Programme

Year 1:

IDMD researcher community building and induction week

Monthly forums

IDMD Symposia - Research design and planning

Year 2:

Student IDMD monthly forums Enterprise

IDMD Conferences Research

Research IDMD Symposia - Data analytics

IDMD Research Methods

Year 3:

Student IDMD monthly forums

IDMD Symposia - Publishing and presenting research

Year 4:

Student IDMD monthly forums

Enterprise IDMD Conferences Research

IDMD Symposia - Thesis preparation

Indicative Training programme and subject to change

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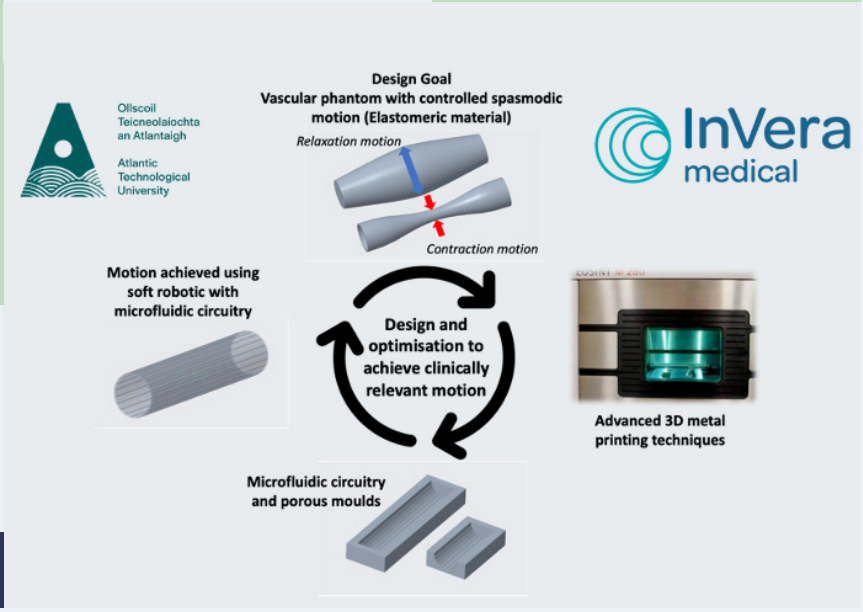

Investigation into the use of 3D Metal Printing to Develop Smart Vascular Models Able to Contract and Spasm

3D metal printing is increasingly used in the medical field for various applications. Metal 3D printing is adopted to complete the customised printing of medical implants, allowing for personalised and highly complex designs. Furthermore, the use of 3D metal printing for microfluidic applications holds promise for advancing research and development in various fields, including biomedicine, soft robotics, tissue engineering, and wearable technology. The 3D printing process can be used to create moulds with high resolution and accuracy for soft robotic application using microfluidic circuitries. Micro milling is an option for fabricating microfluidic devices, and CNC micro machining centres can mill moulds made from brass, aluminium, and stainless steel. However, there are some disadvantages associated with CNC micromachining for micro soft robotics applications. Micro soft robotic actuation requires the machining of complex geometries which may be challenging to fabricate.

This research project will focus on the development of smart vascular models capable of displaying vessel contraction and spasm. The development of such models is required to facilitate the development of medical devices and minimise animal testing. The team is proposing to investigate the use of 3D metal printing to fabricate the micro moulds necessary to create the complex vascular micro actuation.

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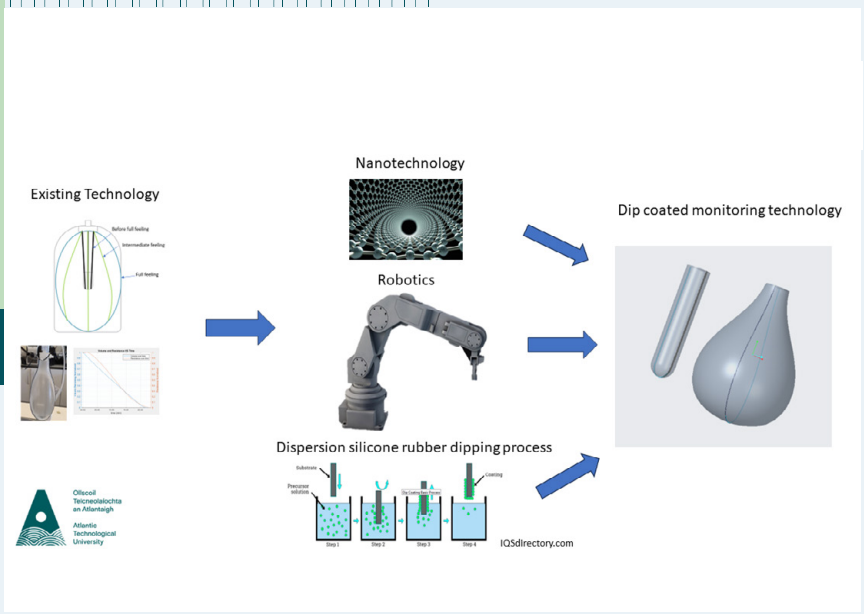

Development of a Dip Coated Stretch Sensor to Monitor an Innovative Feed Delivery System

Rockfield Medical is a developer of innovative feed delivery systems which can transform the quality of life of those on tube feeding. The smart feeding system includes a powerless mechanical pumping system and an integrated stretch sensor for real-time monitoring. The large deformation stretch sensor has been developed by the MET centre with the support of Enterprise Ireland DTIF funding. Dispersion based silicone rubber dipping process allows for the manufacture of complex shapes and shell geometries, such as balloons with small openings, thin walls with tight tolerances, “undercut” and coatings. The team propose to review the design and manufacturing of the monitoring system to facilitate its fabrication. Presently the mechanical pump and the stretch sensor are manufactured separately and are bonded to allow monitoring through the data acquisition system.

We are proposing to coat the stretch sensor directly on the mechanical pump by dipping. This will require to update the materials used for the stretch sensor and develop a new manufacturing process. We intend to use a collaborative robot to coat the sensor material safely and accurately at the surface of the pump. The dipping process will have to be optimised to obtain the specific electric properties for the sensor.

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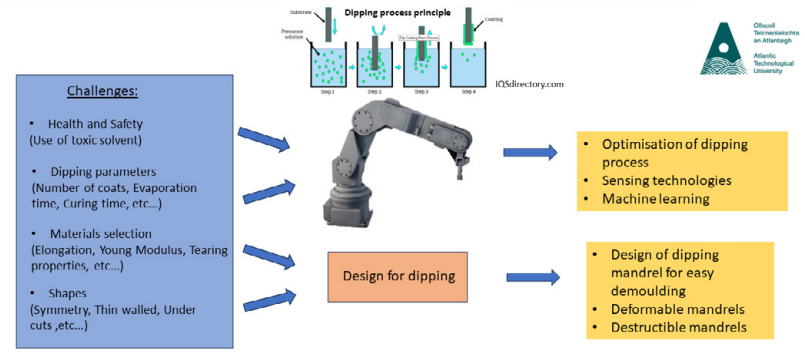

Optimisation of the Silicone Rubber Dipping Process Using Robotic

Dispersion based silicone rubber dipping process allows for the manufacture of complex shapes and shell geometries, such as balloons with small openings, thin walls with tight tolerances, and “undercut” and other geometries not achievable by traditional moulding. Collaborative robots are designed to work safely alongside humans, without the need for safety barriers or cages. In the silicone rubber dipping process, augmented with advanced sensors and machine, cobots can be used to perform various tasks such as dipping the mandrel into the silicone solution, controlling the dipping time and speed, and handling the evaporation and curing process. By automating these tasks, cobots can reduce cycle time, eliminate human errors, and improve productivity.

There is a need to optimise the dipping process based on design specifications. To achieve this, we propose in-process monitoring and closed loop controller that will alter the robot’s behavior during dipping. Additionally, we will explore the automated generation of motion from design parameters using machine learning techniques to facilitating adoption by non-expert users. Furthermore, the demoulding process is particularly challenging if the casted shapes include small openings and “undercut”. While maintaining quality, the development of deformable and destructible mandrels will also be a key objective of this project.

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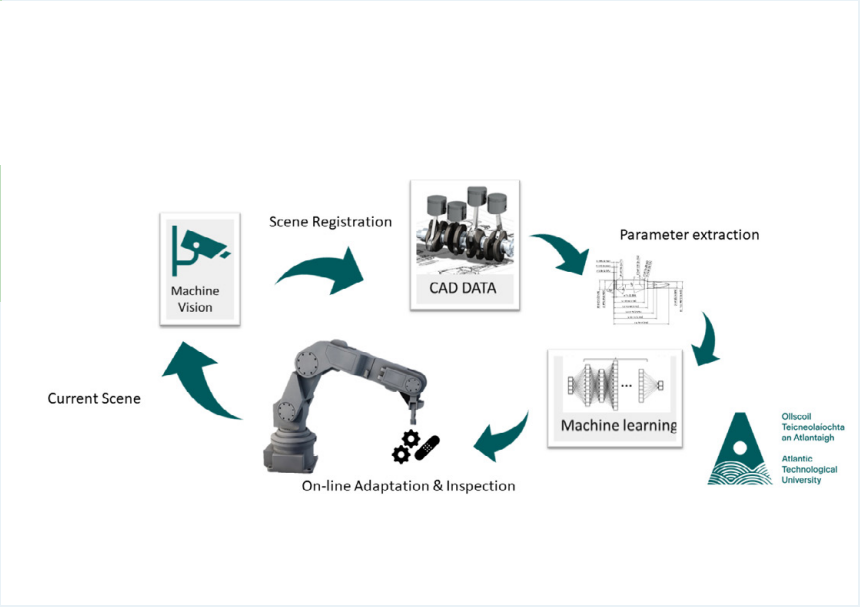

Automated Re-Configuration for Material Handling and Inspection in Advanced Manufacturing

The medical device manufacturing industry requires precise assembly and inspection tasks of complex objects. Compared to classical manufacturing, volumes are low, meaning robotics and automation is difficult to justify. In particular, in batch manufacturing, product changeover is frequent meaning that any solution must cope with different families of parts. Additionally, while sampling-based inspection is used in continuous manufacturing, many components in batch must have 100% visual inspection. In this project, we propose leveraging existing data to create a reconfigurable material handling and visual inspection system. The overarching object is to exploit current digital CAD data, available for system designers, to update the system's behaviors, for example by optimizing field of view inspecting critical dimensions and defining grasp poses. Secondly, machine vision is highly sensitive to ambient conditions, lighting type, intensity, and systems shadows etc., therefore as part of the project, we will investigate if such environmental setup can be generated automatically based on required precision and part definition. The project will exploit machine learning techniques to learn behaviors and constraints based on the digital data and photorealistic simulators. The project will comprise simulations and proof-of-concept demonstration in ATU's facility with a potential for online testing in the manufacturing environment.

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AI-Based Testing of Automotive ECU and Camera Hardware

The automotive industry is rapidly evolving with the integration of advanced technologies such as Electronic Control Units (ECUs) and camera systems. This project proposal aims to harness the power of AI to improve the testing and validation processes of automotive ECUs and camera hardware. This project will focus on hardware access and test methodology to ensure the accuracy, efficiency, and effectiveness of the testing process. The project's scope includes developing methods to access and interface with automotive ECUs and camera systems for testing purposes. This may involve hardware interfaces, protocols, and communication standards. Mechanisms will be designed to collect real-time data from ECUs and camera hardware during various operational scenarios. AI models will be created to analyse and interpret the collected data to detect anomalies, identify defects, and ensure the functionality of ECUs and camera systems. Comprehensive test scenarios and methodologies will be defined to utilise AI models for automated testing and validation, which can significantly reduce testing time and human intervention. Ensuring the reliability of ECUs and camera hardware is crucial for vehicle safety, making AI-driven testing a critical component of the automotive industry.

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A Digital Twin for enhancing Sustainability and Quality in Biopharmaceutical Manufacturing

Lyophilization, also known as freeze-drying, is an important and well-established process to improve the long-term stability of labile drugs, especially therapeutic proteins. About 50% of the currently marketed biopharmaceuticals are lyophilized, representing the most common formulation strategy. However, despite the high cost and critical importance of the raw materials, optimisation and control of the process is extremely difficult and highly variable. The process is also highly energy intensive.

A major problem for process operators is the lack of available sensor data for process monitoring, hence process faults and product quality issues can not be detected until post production. The integration of sensors into the process has historically been hampered by the extreme process environment and space restrictions. Due to developments in sensor technologies and wireless communication, novel Process Analytical Technologies are now feasible for process integration. This project will examine the use of novel wireless sensing devices for monitoring of morphology, pH, moisture level and other factors during freeze drying. This real-time sensor data will be integrated with computational process models to develop a digital twin which will provide detailed insight into the product formation during the process, highlight potential issues, and recommend optimal processing strategies.

- Review the state of the art of modelling and monitoring of the lyophilisation process across first-principles, computational and data-based approaches.
- Develop advanced skills in the latest physics-informed machine learning and data driven approaches for dynamical process modelling and monitoring.
- Develop a computational intelligence approach to utilize sensor data with computational process models for real-time 3D visualization of product formation throughout each step of the process (Digital Shadow).
- Develop AI-based recommender system for minimization of energy and resources in achieving desired product quality metrics.

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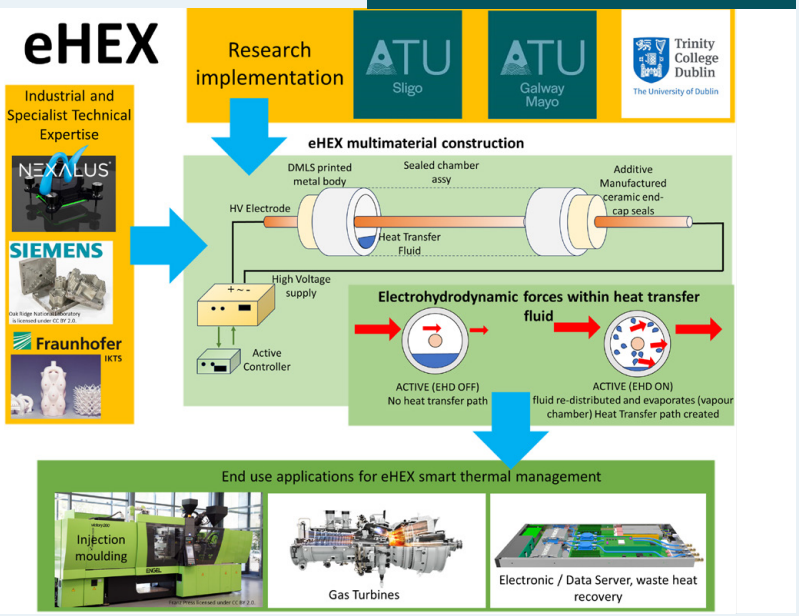

Electronically Controlled Adaptive AM Heat Exchanger (eHEX)

Electronic devices such as laptops, phones, batteries produce heat which is often managed via two phase heat transfer devices such as vapour chambers or heat pipes. However, these passive devices face operating limits depending on numerous parameters. Electrohydrodynamics (electric fields acting on the fluid) have been identified as one method to overcome such limitations. An electronically controllable two phase heat exchange device (eHEX) will be designed and built from Additive Manufacturing techniques. The eHEX will comprise a hermetically sealed metallic chamber (such as vapour chamber or heat pipe) charged with a dielectric thermal fluid, with an internal insulated high voltage electrode. A high voltage in the electrode creates electrohydrodynamic forces within the fluid which will control and re-distribute it internally. This redistributed fluid will allow thermal energy transfer to continue via renewed fluid circulation for vaporisation and condensation. The behaviour of the fluid in the eHEX will correspond to the input voltage characteristics, and thus thermal performance of the eHEX can be controlled electronically, regulating the passage of heat as required. The project is a multi-disciplinary combination of thermal management, multimaterial additive manufacturing (metal, ceramic), and electronic control collaborating between ATU, and leading manufacturers and research institutes.

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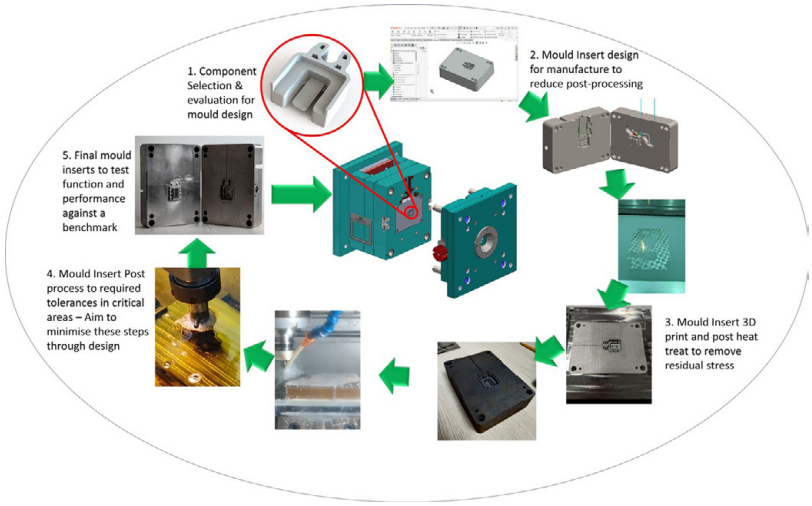

Injection Mould Tooling, Efficiency Enhancement Through Design Optimisation and Advanced Post-Processing Methods for Metal 3D-Printed Tooling

Injection moulding is a high-volume manufacturing process that accounts for the production of the vast majority of plastic components we use in everyday life. The advent of metal 3D printing, with vast improvements in the printing technology since its first introduction, has accumulated opportunities to improve the performance of injection mould tooling further. Technologies such as conformal cooling and advanced sensorisation are now easier to achieve and yield vast process improvements in the injection mould cycle times, part quality, and overall process control and setup, which can be made easier by digitalising the manufacturing process.

This research will explore the digitalisation of manufacturing through the principles of design for additive manufacturing with respect to injection mould tooling. The work will entail developing an understanding of a range of metallic materials suitable for metal 3D printing and for the end-use case of injection mould tooling. Successful candidates will set out with the objective to develop a design methodology that reduces the need for post-processing, after the printing process, to produce functional tooling with the high levels of precision and tight tolerances demanded of injection mould tooling. Also within the scope of this work will be the formulation, development and optimisation of existing and/or novel post-processing strategies to align with the design principles and further optimise the manufacture of advanced injection mould tooling for industrial applications. There may be further scope to investigate tooling lifecycles and longevity for injection mould tools produced by metal 3D printing.

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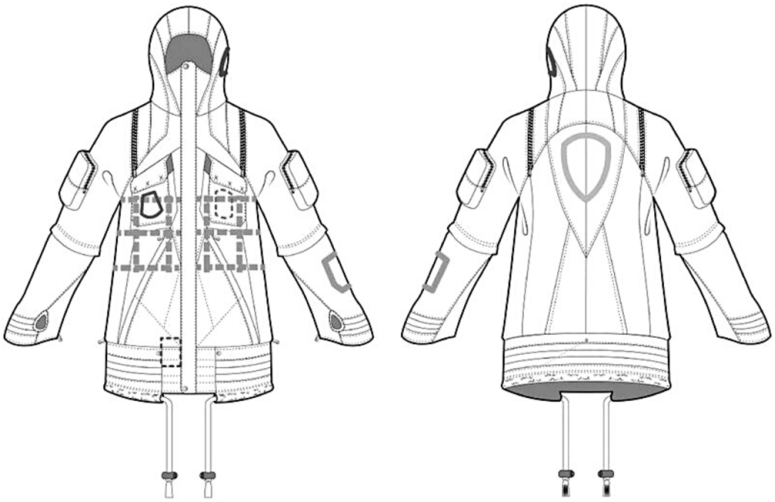

Integration of Body-Worn Sensors and 5G/6G in Human Interfacing with Industry 4.0/5.0 Actuator Systems and Control

While industry automation increases there is still a need for high-level interaction by skilled operators. Standard interfaces are not available in all contexts, particularly in hazardous environments. In these situations, operators may need to wear specialised clothing which could be designed to incorporate wireless user interface systems.

Safety and security may also necessitate tracking of individuals. Key topics: on-body communications, off-body communications, sensor-actuator integration, flexible antennae.

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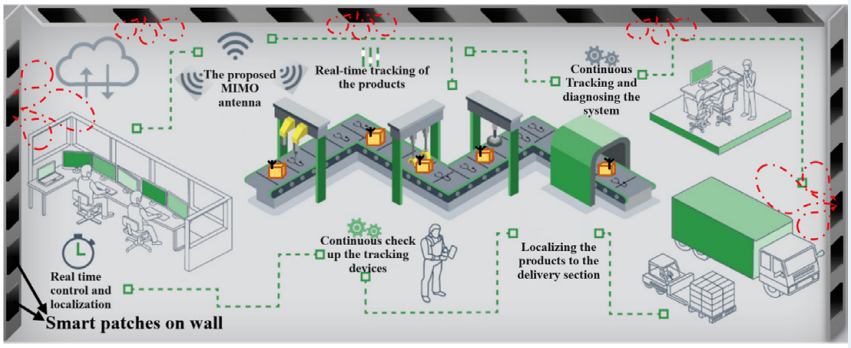

5G Indoor Positioning Utilizing Self-Morphing Wallpatch and Circular Polarization MIMO Transceivers for Smart Factories

The smart factory epitomizes the pinnacle of digitization in manufacturing, featuring a highly digitized shop floor where data is continuously collected and shared among interconnected machines, devices, and production systems. This data is harnessed to optimize operations, improve production processes, boost productivity, and enhance responsiveness, aligning with the principles of Industry 4.0. Various IoT-related technologies, including telecommunication and transceiver systems like Bluetooth beacons and RFID readers, have been employed for decades in factories worldwide. These technologies assist localize manufacturing staff and products using wristbands, cards, pockets, cardholders, and safety helmets. However, they also have some drawbacks and challenges such as accuracy and reliability, real-time tracking, integration with automation systems, variability in product sizes and shapes, and collision avoidance, and environmental Conditions. Therefore, a robust communication system employing a lower 5G frequency band, special antennas, and self-morphing wall patches is required to address these challenges. The following objectives and expected outcomes from this proposed project will align perfectly with the National Smart Specialisation Strategy for Innovation (S3) in North-West region, strengthening the advanced manufacturing and engineering sector to link national and regional enterprise and innovation policy, improve research and innovation capacity, encourage more regionally dispersed RD&I, and improve industry-academic collaboration.

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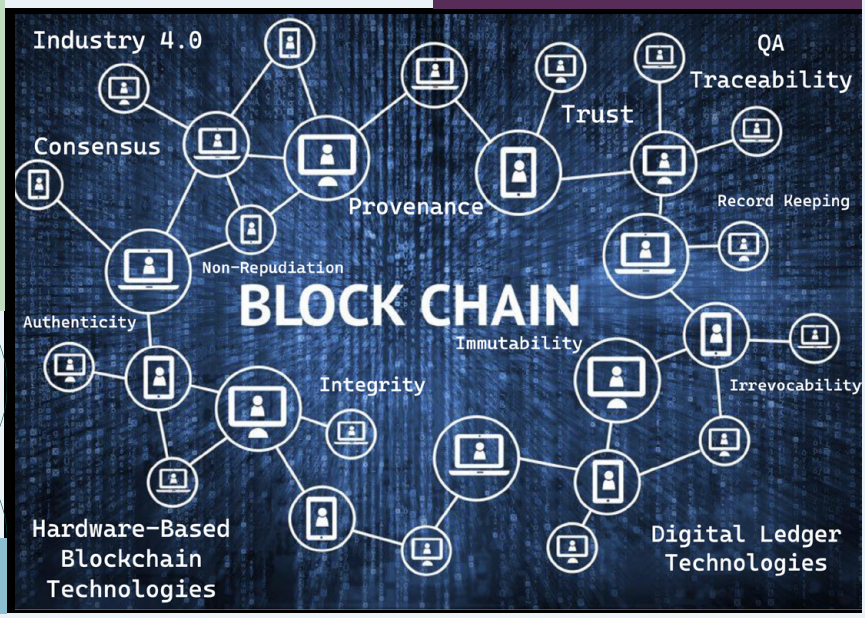

Assuring Manufacturing Quality Assurance Records, Using the Consensus, Immutability, Provenance and Finality Characteristics of Blockchain Technology

Industry 4.0 has created a significant shift in the way we produce products, with smart autonomous systems fueled by Big Data, Machine Learning (ML) and Artificial Intelligence (AI) techniques. Quality Assurance (QA) and QA processes have not escaped this transition. Record keeping is a fundamental component of a QA system. Timestamped records of product quality metrics not only give a snapshot of the acceptability of a specific manufactured item, they can also be viewed as a continuum, to measure the effectiveness of process improvement initiatives.

Storage of these records on conventional databases or in paper format, render them exposed to a number of potential vulnerabilities. Blockchain is a technology that is just over ten years old, yet the underlying technologies that make it possible, stretch back decades. It is based on simple principles, that is a subset of Distributed Ledger Technology (DLT). It has evolved from its initial use underpinning cryptocurrencies to become a highly disruptive technology with many uses and many configurations. Blockchain characteristics of consensus, immutability, provenance and finality are shown to be integral components in the delivery of trust. This study will examine the beneficial potential of blockchain technology when used to manage Manufacturing QA records.

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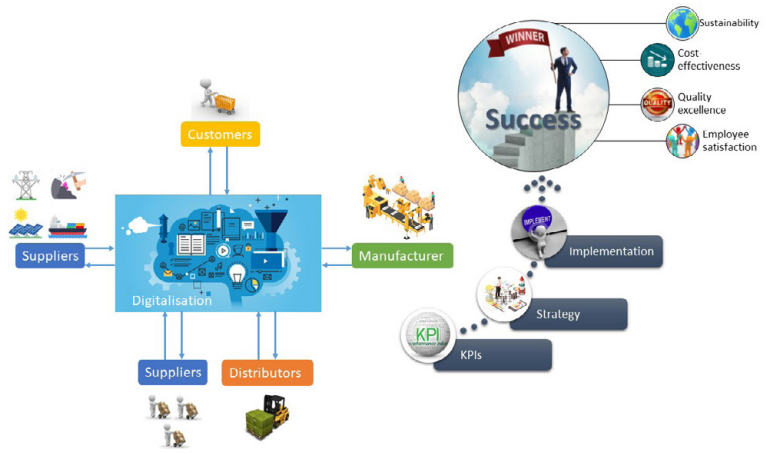

Digital Transformation for Sustainable Growth: a Small and Medium-Sized Enterprises (SMEs) Perspective

The proposed research aims to investigate the impact of digitalisation on sustainability within the context of Small and Medium-sized Enterprises (SMEs). As businesses increasingly embrace digital technologies, understanding the interplay between digital transformation and sustainability is crucial for the long-term viability of SMEs. This research seeks to uncover the mechanisms through which digitalisation practices can contribute to sustainable business operations, resource efficiency, and overall environmental and social responsibility. This study anticipates providing valuable insights into the synergetic relationship between digitalisation and sustainability for SMEs, offering practical recommendations for businesses, policymakers, and researchers.

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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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