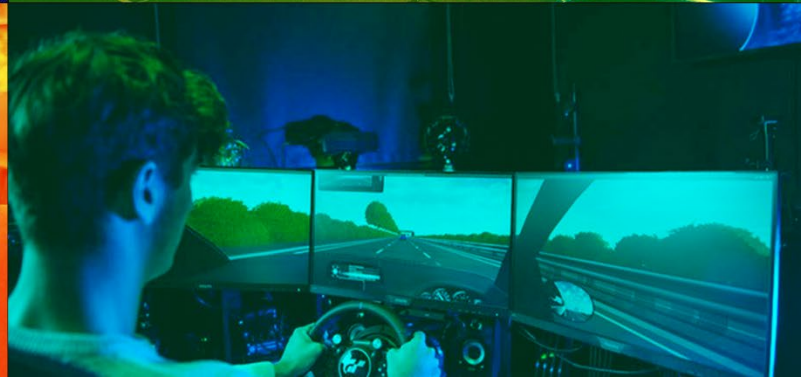# School of Computing, Engineering and Intelligent Systems
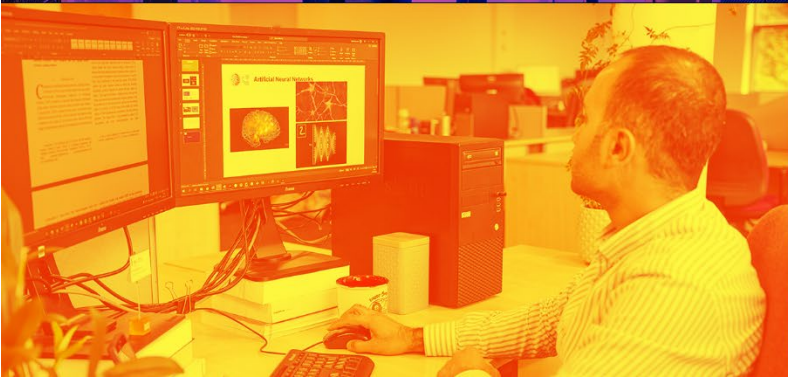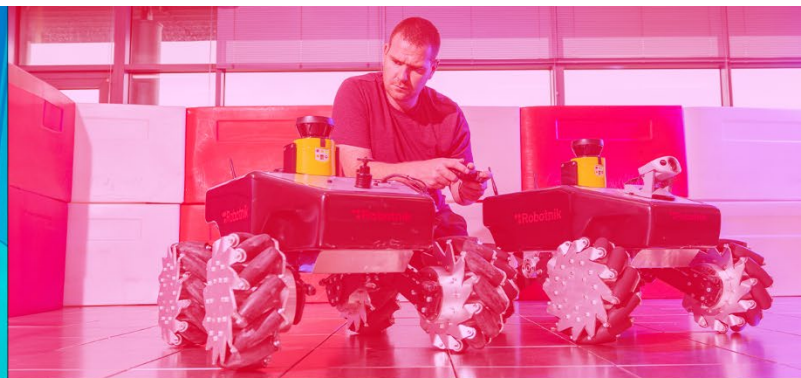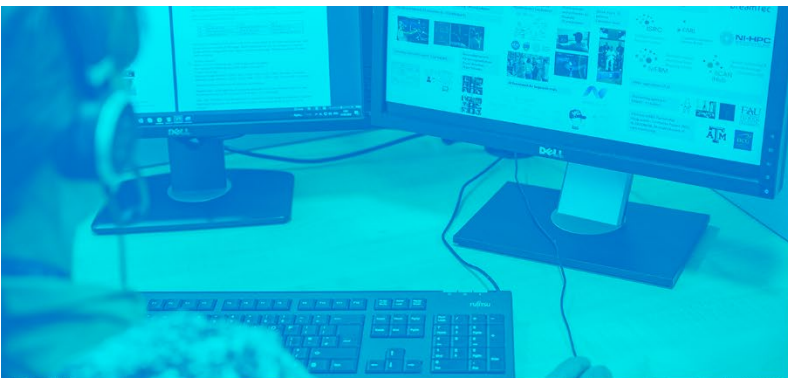
Research & Innovation Annual Report
01 August 2022 – 31 July 2023

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Contents

1 Foreword

Research Director
Prof Liam McDaid

In presenting the Annual Report for the School of Computing, Engineering, and Intelligent Systems (SCEIS) for the academic year 2022-2023, I am pleased to report that we have achieved continued success in terms of major projects funded, research outputs and potential impact case studies, and therefore the school is well positioned to maintain, or even better, our REF2021 performance in REF2028.

In REF2021 both the School of Computing (SoC) and SCEIS were accessed under subject unit of assessment UoA11 - Computer Science and Informatics: and were the only submission to this unit from Northern Ireland. In REF2021 UoA11 at Ulster was ranked 9th in the UK for overall research power with an outstanding 92% of our research outputs having been judged as being world-leading or internationally excellent. Moreover, our research impact was judged as having outstanding or very considerable impacts in terms of reach and significance.

The Outline Business Case (OBC) for the Derry City & Strabane District Council City Deal investment (~£39 million) to fund the Cognitive Analytics & Digital Robotics Innovation Centre (CADRIC) continues to be developed. CADRIC will drive multi-disciplinary innovation necessary to translate the benefits of Ulster University's leading-edge research in data driven disciplines, e.g., bio-inspired Artificial Intelligence (AI) and cognitive robotics, into economic, environmental, and social benefits for Northern Ireland. CADRIC comprises of the Cognitive Analytics Research Laboratory (CARL) and the Centre for Industrial Digitalisation and Robotics Automation (CIDRA).

CARL will build on the many years of research conducted within the Intelligent Systems Research Centre (ISRC) that has generated internationally excellent/world leading outputs in neurotechnology and bio-inspired AI research to enable technological solutions for industry. With CARL being industry agnostic, it will also seek to exploit the advances in High Performance Computing (HPC) by applying AI and Machine Learning (ML) techniques to sectors as diverse as Advanced Manufacturing, Life & Health including Personalised Medicine, Creative Industries, Law, Fintech, RegTech Agri-tech, Green-Tech, etc. CIDRA has a specific focus on manufacturing and in particular the use of AI in smart robotic systems, recognising that the five core technologies (robotics; automation, AI, industrial internet of things (IoT) and additive manufacturing) have now reached sufficient maturity that they provide huge opportunities and challenges for the manufacturing industry across a range of areas. The Outline Business Case (OBC) for CADRIC is scheduled to be finalised and submitted by Ulster to the Derry-Londonderry and Strabane Region City Deal (DCSDC) in Q4 2023 with a dedicated building scheduled to be completed and operational by 2026. It is envisaged that both CARL and CIDRA will have a shared space in which staff from industry can co-locate with researchers (PDRAs/PhD students), Centre Directors, Business/Marketing Managers, Challenge Fund Managers, Engineers, Technicians, and Administrative Support. CARL will be equipped with high performance laptops and AV/multimedia/innovation space

equipment while CIDRA will house a reconfigurable demonstrator area consisting of industrial robots, advanced machining laboratory, prototype and test analysis facility and a cyber-physical systems laboratory.

The Innovate UK funded Smart Manufacturing Data Hub (SMDH) has already bolstered the CIDRA project where it aims to support small and medium size manufacturers to capture and better utilise their data, helping them increase productivity, growth, and sustainability. SMDH currently employs 8 research associates/fellows, 2 digital innovation fund managers, 1 project co-ordinator, 1 technician, 1 executive assistant, 1 marketing coordinator and a director. SMDH has completed several projects with SMEs as well as launching various online systems including the Manufacturing Data Exchange Platform and the SMDH Community and the Virtual Manufacturing Platform. Self-Service tools for monitoring phantom load in energy and carbon reduction have also been developed by SMDH partners. SMDH also hosted the first Smart Manufacturing Summit in June 2023 in Derry~Londonderry.

The Smart Nano project is progressing very well with 6 PhDs onboarded along with 2 PDRAs appointed. An initial literature review has been undertaken by PhDs and PDRAs and the review findings has been shared with one of the partners, Seagate. Staff associated with the Smart Nano project have published a conference paper, which was subsequently invited for full submission to IEEE Transactions on Artificial Intelligence.

In the reporting period, ISRC staff have secured notable grants funded by EPSRC, HE-IFS Horizon Europe, Innovate UK, US-Ireland, Invest NI, Hartree National Centre for Digital Innovation (HNCDI) programme. Recent strategic projects include the Artificial Intelligence Collaboration Centre (AICC, ~£13M), wherein Ulster is partnering with QUB to promote the adoption of AI by industry and offer postgraduate students in AI and related subjects, and Hartree NI (~£1.5M) which aims to improve the competitiveness and growth of local industry through the adoption of digital technologies. Securing awards from these prestigious funding bodies, which will support a variety of research disciplines, is testament to the ongoing excellent interdisciplinary research within the school. Interdisciplinary research is very much the focus of research and training of our researchers and in this round the ISRC ran the Computational Neuroscience, Neurotechnology and Neuro-inspired Artificial Intelligence Autumn School (ISRC_CN3). This ran for the second time with excellent talks from staff within the school and from a range of distinguished external speakers, along with a packed schedule of activities (running alongside the world-renowned Halloween festivities). ISRC_CN3 was attended by over 100 participants from 18 countries (who attended either virtually or physically) and feedback was very positive. We are grateful to our sponsors including local industry for financially supporting the event, and to the excellent team efforts of many academic and support staff in the school.

There have been major contributions from individual staff and PhD researchers across the school in securing and managing the projects outlined above and in undertaking new and exciting research activities. Key outcomes of note are the publication of 139 research papers in high impact journals, books and conferences. This along with the funding secured in the past year has placed the school in an excellent position. Congratulations and thanks to everyone for the collective effort in achieving these successes. As we publish this report, we look forward to another exciting year that will capitalise on the recent funding secured and our strong REF2021 performance to build new high quality research capacity within the school that can positively impact both regionally, internationally, and globally.

Further details of our research, facilities, staff profiles and research expertise can be found at Intelligent Systems Research Centre - Ulster University

Or by contacting Louise Gallagher (Academic Excellence Executive Assistant) at Email: l.gallagher@ulster.ac.uk; Ph: +44 28 7167 5148.

Professor Liam McDaid
Research Director, School of Computing, Engineering and Intelligent Systems.

Unit of Assessment 11. Computer Science and Informatics

REF2021 Research Excellence Framework

11. Computer Science and Informatics (ulster.ac.uk)

"Computer Science and Informatics at Ulster, the only Computer Science and Informatics unit in Northern Ireland, goes from strength to strength.

We are the 6th largest Computer Science and Informatics unit in the UK having 100% of our research impact assessed as outstanding or very considerable, 100% of our research environment rated world-leading or internationally excellent, and ranking 7th in the UK out of 90 for the level of world-leading or internationally excellent research and impact for the number of staff returned."

Professor Liam McDaid & Professor Luke Chen

2 Research Students

Name	Project Title
Ahmed, Salman	Natural Language Processing for Speech Tagging, Sentiment analysis and Predictive analytics
Ansari, Nishath	Robotics and AI Technologies for Heart Health Screening
Chavan, Sayali	Computer vision for advertising analytics
Devlin, Sophia	Robotics and AI Technologies for Heart Health Screening
Doherty, John	Autonomous Object Recognition for Robots
Fotouhi, Ramin	Image Labeling in Computer Vision
Gambale, Antonio	Cobots for Smart Manufacturing
Gillespie, James	Learning of bio-inspired movement in highly noisy environments.
Gorman, Mark	Utlising multivariate high frequency time series datasets for real-time decision-making applications
Hamilton, Natasha	Exploiting Brain Inspired Information Processing in Hardware to Develop Highly Reliable, Always-on Smart Sensor Systems.
Harkin, David	AI-based Algorithms for Medical Image Processing
Henderson, Benn	Automated Classification of Autism Spectrum Disorder in Children using Gait Analysis
Ijaz, Yasir	Computer Vision for Cobotics and Smart Manufacturing
Javed, Aqib	Intelligent hot-spot prediction in networks-on-chip (NoC)
Jha, Ravi	Quantum Enhanced Brain-Inspired Mathematical and Computational Models of Spiking Neural Networks for Deep Learning of Spatio-Temporal Data
Khodadadzadeh, Massoud	Intelligent data analytics.
Lenfesty, Brendan	Computational Modelling and Machine Learning in Decision Neuroscience
Liu, Shuo	Intelligent Data Analytics - novelty detection in critical systems
Madden, Kyle	Secure Networks-on-Chip (NoC) for cyber-physical systems.
McBrearty, Shaun	Result ranking for searchable symmetric encryption
McCready, Kevin	Adaptive Robotics for Smart Manufacturing Environments
McKinney, Joseph	VR/AR Upper Arm Rehabilation: Personalised Upper Arm Rehabilitation within Virtual and Augmented Reality.
McShane, Niall	Augmented Reality Brain-computer Interface
Melaugh, Melissa	Machine Learning and Environmental DNA Metagenomics for Advanced Forest Health Surveillance
Millar, Christopher	Kinaesthetic learning for robotic object manipulation.
Murray, Cathal	Creating opportunities for growth within the circular economy - predicting and minimising food waste
Poshtkohi, Alireza	Computational Modelling of Plasma Membrane Electrophysiology and Calcium Dynamics in Microglia
Qiu, Senhui	EyeSee: A Fast and energy-efficient deep learning model for semantic segmentation in self-driving cars
Rasheed, Muhammad	Machine Vision for Anomaly Detection
Robinson, Tony	FPGA Computational Acceleration in Genomics – bringing personalised medicine closer to clinical practice for healthy communities
Saha, Sanjoy Kumar	SmartNanoAI - AI in Smart Manufacturing: Integrating AI for key performance input and output variable (KPIV) analytics

Samanta, Kaniska	A Transferable Brain-Computer Interfacing based Status Monitoring System to Augment Motor Imagery based Neurorehabilitation
Saranirad, Vahid	George Moore PhD scholarship in Intelligent Data Analytics: Enhancing biological plausability of deep learning for computer vision
Simpson, David	Brain-inspired Autonomous Learning for Resilient Electronic Systems
Sweeney, Terence	Machine vision for automated inspection of hard drive components CAST.
Tahernezhadjavazm, Farajollah	Evolutionary strategies for optimising signal and text classification
Venezia, Samuel	SPRINT: Smart Sports Video Analytics

Graduated December 2022

Name	Thesis Title
Sharma, Pratikshya	Spontaneous Facial Micro Expression Recognition and Analysis using Varying Resolutions

Graduated July 2023

Name	Thesis Title
Dhakan, Paresh	Open-Ended Continuous Reinforcement Learning For Mobile Robots
McHugh, Catherine	Algorithmic Approaches to Energy Market Price Prediction
Roy, Sujit	Advancing MEG- and EEG-Based Decoding of Motor Imagery for Practical Brain-Computer Interfaces for Neuro-Rehabilitation

3 Publications

Details of all Publications by the School of Computing, Engineering and Intelligent Systems are on the Ulster University's Institutional Repository- PURE https://pure.ulster.ac.uk/. This section reports those outputs published over the period of this report and classified as either journal articles, books/chapters in books and published conference papers.

3.1 Journal Articles

Abdullayev, K, Chico, TJA, Manktelow, M, Buckley, O, Condell, J, Van Arkel, R, Diaz, V & Matcham, F 2023, 'Stakeholder-led understanding of the implementation of digital technologies within heart disease diagnosis: a qualitative study protocol', BMJ Open, vol. 13, no. 6, e072952, pp. 1-4. https://doi.org/10.1136/bmjopen-2023-072952

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Bucholc, M, Bradley, D, Bennett, D, Patterson, L, Spiers, R, Gibson, D, Van Woerden, H & Bjourson, AJ 2022, 'Identifying pre-existing conditions and multimorbidity patterns associated with in-hospital mortality in patients with COVID-19',

Scientific Reports, vol. 12, no. 1, 17313. https://doi.org/10.1038/s41598-022-20176-w

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Universities and knowledge institutions globally have a critical role to play in the achievement of the United Nations Sustainable Development Goals (SDGs).

Here is a breakdown of the research outputs and their SDG's.
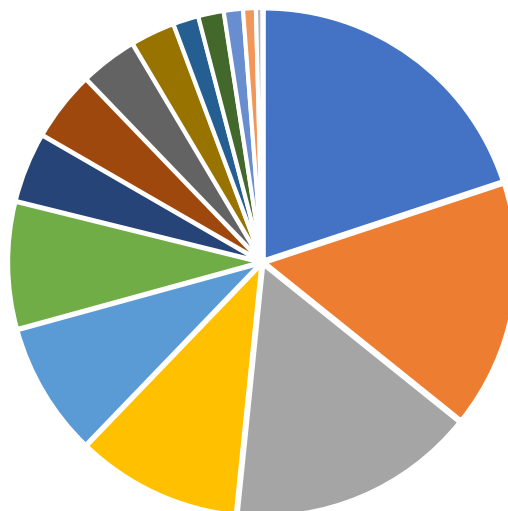
- SDG 9 - Industry, Innovation, and Infrastructure
- SDG 7 - Affordable and Clean Energy
- SDG 11 - Sustainable Cities and Communities
- SDG 13 - Climate Action
- SDG 12 - Responsible Consumption and Production
- SDG 3 - Good Health and Well-being
- SDG 8 - Decent Work and Economic Growth
- SDG 10 - Reduced Inequalities
- SDG 17 - Partnerships for the Goals
- SDG 16 - Peace, Justice and Strong Institutions
- SDG 15 - Life on Land
- SDG 14 - Life Below Water
- SDG 4 - Quality Education
- SDG 6 - Clean Water and Sanitation
- SDG 1 - No Poverty

4 Research Funding

Portfolio of Research Grants awarded during period 1 August 2022 - 31 July 2023

Unit of Assessment Member	Title of Award	Funding Body	Value	Date
Mr D Holmes Dr D Charles	RA Eng Enterprise Fellowship.	Royal Academy of Eng Enterprise Fellow	£60,000.00	01/07/21
Prof Joan Condell Prof Jim Harkin William McElholm	Heat and Energy Education and Empowerment for Rural Areas.	Interreg NPA 2021-2027 Programme	£19414.19	04/08/22
Dr Darryl Charles Dr Deborah Rankin	Magic Glass: Virtual Reality Upper Arm Stroke Rehabilitation.	INI Invest Northern Ireland	£122500.37	26/08/22
Prof Damien Coyle Dr Saugat Bhattacharyya	AI-EPOCMON	US Ireland - DfE, Invest NI	£299,999.00	02/09/22
Prof Joan Condell	NI Healthy Ageing scaling social ventures.	Innovate UK	£49,897.95	26/01/23
Dr Deborah Rankin Prof Michaela Black Dr Adrian Moore Prof Jonathan Wallace	Lung Cancer-related risk factors and their impact assessment.	HE-IFS Horizon Europe – Innovate UK Guarantee via IFS	£469,521.00	02/02/23
Dr Dermot Kerr Prof Sonya Coleman Dr Justin Quinn	Standardised Architecture for Trusted Research Environments.	MRC Medical Research Council	£55,332.00	07/02/23
Dr Magda Bucholc	Excess mortality in Northern Ireland.	HSC R&D Health & Social Care R&D Division Public Health Agency	£11,170.00	15/02/23
Prof Eugene McNamee Prof KJ Curran	Machine learning for more efficient data extraction in legal documents.	Allen and Overy Foundation	£832,853.18	01/03/23
Dr Justin Quinn Dr Dermot Kerr Prof Sonya Coleman Peter Devine	Hartree Northern Ireland (Hartree NÍ).	STFC Science and Technologies Facilities Council	£1,219,845.00	01/03/23

Prof Jim Harkin Prof Neil Hewitt William McElholm	Modelling and Optimising on-farm Renewable Energy Generation and Consumption using Artificial Intelligence.	Agri Search-NI Agricultural Research and Development Council	£120,000.00	18/04/23
Prof Joan Condell Prof Gerard Leavey Dr Ruth Price	Longitude Prize for Dementia.	Challenge Works	£80,000.00	07/06/23

Note from the Associate Dean

It is my pleasure to endorse the Research & Innovation Annual Report from the School of Computing Engineering and Intelligent Systems (SCEIS) for the 2022-23 Academic Year. The report provides a concise account of the core research activities undertaken and the outputs achieved in the period.

The research and innovation activities reported here build on the excellent outcomes that colleagues in the School achieved in the 2021 Research Excellence Framework (REF 2021) and contribute to our ambition for an even better performance in the next REF exercise.

The achievements reported here are fully aligned with the Ulster University Strategy, People, Place & Partnerships: Delivering Sustainable Futures for All (Strategy - People, Place and Partnership (ulster.ac.uk)) and the Ulster University Research Strategy 2023-28 (Ulster University Research Strategy 2023-2028). As such, they contribute significantly to the Faculty of Computing, Engineering & the Built Environment Operational Plan in respect to the delivery our collective goal of research excellence, inclusion, and impact.

Prof Brian Meenan
Research & Innovation
Faculty of Computing, Engineering & the Built Environment

Research Centres and Groups

Computational Neuroscience and Neuromorphic Engineering (CNET)   Team members:
Dr. Cain O Donnell (Lead), Dr. John Wade, Dr. Bronac Flanagan, Dr. Marinus Toman, Dr.
Aqib Javed, Mr Malachy McElholm, Prof. Jim Harkin and Prof. Liam McDaid

Cognitive Neuroscience and Neurotechnology (CNN)   Team members: Dr, Wong Lin
Kongfatt (Lead), Prof Girijesh Prasad and Dr. Saugat Bhattacharyya.

Cognitive Robotics (CR)   Team members: Dr. Dermot Kerr (Lead), Prof Sonya Coleman, Dr.
Philip Vance, Dr, Nazmul Siddique.

Intelligent Data Analytics (IDA)   Team members: Dr. Bryan Gardner (Lead),Dr. Karl
McCreadie, Dr. Muskaan Singh, Dr. James Connolly, Dr. Xuemei Ding

Human Centred Computing (HCC)   Team members: Prof. Joan Condell (Lead), Prof
Michaela Black, Dr. Debbie Rankin, Dr. Priyanka Chaurasia, Dr. Pratheepan Yogarajah, Mr.
Michael Callaghan, Prof. Kevin Curran