

School of Computing

Annual Report
1st August 2019 -31st July 2020



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1. Foreword:
Research Director
Prof Luke Chen

In presenting the Annual Research Report for the School of Computing (SoC) for the academic year 2019-2020, I am pleased to report a very successful year of high-quality research and impressive performance. Staff have been productive in generating research outputs in top-tier journals, conferences, and workshops, securing prestigious research grants from a wide range of funding bodies and industry, and delivering keynotes, talks and research presentations at local, national, and international events. Staff have also reached out to a wide range of communities and industries within NI and beyond, to undertake knowledge transfer and research translation as well as undertaking public engagements to raise awareness of science and technologies and impact economy and society through innovations.

This year the School has continued the trend towards excellent research translation and innovation, with growing number of KTP projects secured and 11 patents filed or under consideration being generated from the BTIIC projects. Staff continue to flourish in terms of international visibility, esteem and collaborations as evidenced by the number of keynote lectures, advisory and expert referee roles. Three members of the School received the university's Faculty and University level Distinguished Research Fellowship Awards in 2020 with two going on to receive the University Champion Award in the Early Career and Distinguished Research Fellowship categories. Ongoing research initiatives have also progressed well in the period, e.g. the Centre for Digital Healthcare Technologies (CDHT) being established under the Belfast Region City Deal has been further consolidated by the award of a £250k living lab equipment through Higher Education Research Capital (HERC) funding; and the BT Irish Innovation Centre (BTIIC) has started planning for the next phase collaboration. This excellent performance has occurred under the substantial impact of Covid-19 pandemic, demonstrating the resilience, dedication and professionalism of members of staff in the School.

In parallel, based on a collectively agreed vision for the School's future research in the backdrop of both local and national research and innovation context, and driven by the REF 2021 preparation, the School has adopted a Research Centre-based/Theme-based organisational structure in line with the University's overall strategies, i.e. two Research Centres: the Artificial Intelligence Research Centre (AIRC) and Pervasive Computing Research Centre (PCRC) each consisting of three research themes, and two Innovation Centres: Connected Health Innovation Centre (CHIC) and BTIIC. This organisation helps to sharpen each Centre's aim and mission and to create first-class independent research entities for external publicity of the research being undertaken. It also helps establish clear linkages between the Research and Innovation Centres in a manner which best serves the vision of the School and the associated research themes to achieve the School's research mission. It is believed that this new research structure will have a far-reaching impact on the School's future research performance targeting the next cycle of REF exercise.

Among a wide range of research activities undertaken in this past year, attention is drawn to two threads of endeavours, namely the School's involvement of research on Covid-19 related activities, and REF2021 preparation, particularly impact case studies. Staff have been active in both key activities to ensure that

our research and its outputs positively impact society and support the future development of the University. A brief overview from each Research and Innovation Centre in regard to research activities and key results are provided below.

Artificial Intelligence Research Centre (AIRC, headed by Prof Hui Wang)

The Artificial Intelligence Research Centre has a vision to develop AI technologies that underpin an intelligent society, empower people and support a sustainable future. Research within AIRC has three themes:

1. **Learning, Modelling and Optimisation.** This includes fundamental research in machine learning, mathematical modelling (e.g. opinion dynamics, ecological networks, pandemic modelling), and mathematical optimisation (e.g. Bayesian optimisation, multi-objective optimisation).
2. **Knowledge, Reasoning and Decision-making.** This includes fundamental research in knowledge representation, reasoning, logics (e.g. theorem proving, formal verification and Boolean satisfiability problem), ontology and decision making.
3. **Data Analytics and Systems.** This includes research that is driven by specific real-world challenges in bio/geo-informatics, multimedia, swarm systems, digital interventions, food authentication, virus detection, text/video/image analytics.

Notable research contributions include **new theories** such as lattice machine (an algebraic approach to machine learning), evidential ensemble learning (Dempster-Shafer theory of evidence based approach for combining multiple learning algorithms), subsumptive learning (an emerging approach to learning that aims to learn “part-of” relationship) and contextual probability (a structural probability formalism), and belief-rule based modelling and optimization (a data-knowledge integrated decision model under uncertainty). Research contributions also include **new algorithms** in automated reasoning, bioinformatics network analysis, similarity kernels, sensor fusion, chemometrics, explanation and abductive reasoning, Bayesian optimization, Gaussian process regression, and autonomic computing. Recent research and development activities include biomedical applications, geoinformatics application, multimedia and information retrieval, food authentication, virus detection, medical image analysis and decision support systems, text analysis, gait analysis, sentiment analysis, chemical data analysis, anomaly detection, swarm systems, digital interventions and chatbots.

One recent highlight is the EU Horizon 2020 project “Analysis System for GAThEred Raw Data” (ASGARD) (<http://www.asgard-project.eu>). This is a 33-partner, 51-month effort coordinated by Vicomtech, led in UU by Professor Hui Wang, and worth about £607k to UU. ASGARD aims to provide law enforcement agencies (LEAs) with technological autonomy by creating a long-lasting community of LEAs and the research and development industry, focused on a set of tools and techniques, that facilitate effective collaboration in order to define, develop, share, and evolve open-source big data technological solutions that will help LEAs prevent and fight against crime. ASGARD has a total of 13 work packages, grouped into 4 pillars – Community, Data Tools and Resources, Operational Tools, and Governance. The UU team contributes to all pillars and is mainly responsible for face recognition and light enhancement on the technical side.

Pervasive Computing Research Centre (PCRC, headed by Prof Chris Nugent)

The Pervasive Computing Research Centre has been established to realise smart environment monitoring and data analytics solutions for lifelong health and wellbeing. Research within the centre has been revised during the reporting period to fall within the following 3 main thematic research areas:

1. **Human Activity Recognition.** This area has a focus on research relating to sensor-based technologies with applications in activity recognition, behaviour monitoring, assistive technologies for healthcare and independent living.

2. **Ubiquitous Intelligence.** This area undertakes research in data-driven emergent intelligence within IoT and edge computing, process analytics, knowledge-driven cognitive intelligence, privacy, security and cryptography, user-centred intelligent cyber-physical systems
3. **Human Computer Interaction.** Through the centre's Living Lab focus, this thematic area researches the human factors associated with Interactive Computing Systems, multimodal interaction and affective and wearable computing.

In addition to the impressive portfolio of externally funded Research Projects currently on-going within the centre a number of new Projects were secured during the reporting period. Funding from the ESRC has supported the Birth across the Borders: exploring contextual education as a catalyst for improved maternal health Project, which is being led by the School of Nursing and supported by PCRC. International partnerships with the South China University of Technology continue to flourish with a new Project funded by the Guangdong Provincial Science and Technology Plan Project, Adaptive Human Behaviour Recognition Framework Based on Multi-modal Sensors and Its Application in Intelligent Nursing. Furthermore, research within the centre on chatbots was developed further through new Projects funded by Interreg VB.

Planning for the future, PCRC has progressed its research efforts within the area of Living Labs through its involvement in the Belfast Region City Deal and the Centre for Digital Healthcare Technology (CDHT). The aspirations of this work are to establish the building blocks of a MedTech Innovation cluster, putting in place the necessary facilities for open innovation and creating a more efficient pathway for new ideas. The work will have industry at its core and will encourage a diverse mix of organisations to engage and interact with one another in the proposed facilities. Three of Ulster University's leading schools (Engineering, Computing and Biomolecular Sciences) will work together in Biomedical Sciences to capitalise on the significant opportunity which digital healthcare and medical technology presents. Funding secured from HERC during the reporting period will support the creation of the Integrated Diagnostics Laboratory, the first operational component of the CDHT.

Connected Health Innovation Centre (CHIC, headed by Prof Chris Nugent and Prof Jim McLaughlin (Engineering))

CHIC is an industry-led competence centre focused on collaborative research to support the connected health industry in Northern Ireland. It is hosted jointly in the School of Computing and the School of Engineering. It received its second round of funding for the period 2019-2022 providing, in total, over £8M to support industry-led research activities. During the reporting period CHIC had a member base of over 40 companies.

Areas of focus are as follows:

1. Integrated Community Care – joining together existing and new technology and process.
2. Point of Care Diagnostics – moving diagnostics closer to the patient.
3. Vital Sign Monitors – technology development to support vital sign identification, analysis and communication.

During the reporting period the impacts produced from CHIC have been documented as Impact Case Studies for consideration of inclusion within the forthcoming Unit of Assessment 11 (Computer Science & Informatics) REF2021 submission. PCRC's research in the area of reminding technologies to support both people with dementia and medication management have underpinned the development of a new enterprise for the managing the logging and dispensing of medication. In addition, PCRC's research in the area of wearable computing and self-management have underpinned the development of a new postural walking aid for children with cerebral palsy which is now being sold in 22 countries.

BT Ireland Innovation Centre (BTIIC, headed by Prof Bryan Scotney)

In its third year of operation, BTIIC continued to explore interesting research topics at the intersection of Artificial Intelligence, the Internet of Things and Telecommunications. The 20 postdoctoral researchers and 12 PhD students are working in close collaboration with BT Adastral Park Research Laboratories in Martlesham, Suffolk, UK alongside BT's Belfast Global Development Centre to underpin leading edge engineering work in BT's operations in Belfast and more widely.

The research partnership has consolidated in the past year to deliver excellent academic outputs, and impactful industry engagement. The maturation of the previous years' work in areas related to future telecommunication networks and services including Future Big Data Analytics, Internet of Things (IoT), Cyber Security, Fixed and Mobile Network services and creating products for both residential and business customers.

In the past academic year, BTIIC published 16 peer reviewed papers in high impact venues, gave 5 keynote talks at conferences, filed 11 patents with their colleagues in BT, won one best paper award, won one IEEE outstanding service award and hosted 10 visiting research fellows and academics from around the world.

As one of BT's flagship innovation centres, the engagement is strongly aligned with the needs of the various engineering teams operating out of BT's Belfast offices. Specifically, BTIIC have delivered advanced process analytics techniques that BT use in their smart software engineering processes and automated software test teams. They are also developing proof of concept demonstrators for cyber security technology for deployment in future fixed and mobile networks. Other key engagement is to develop proof of concept systems based on novel architectures that embed BTIIC technologies which will allow BT to offer secure and scalable value-added services in the IoT domain.

A team of BTIIC researchers and BT colleagues also engaged with the leading global industry body in the IoT space - the Telecoms Management Forum (TMF) - and were invited to participate in a large scale project with a number of global companies to develop a robust prototype system to demonstrate the impact of IoT in an industrial context. That project won the award for '*Catalyst Award for Business Impact*'. The team also won the '*Digital Innovation of the Year*' award at the Digital DNA awards and the '*Emerging Technology of the Year*' category at the UK IT Industry Awards.

The information above provides a summary of research activities within the School of Computing at Ulster University, and highlights significant achievements, and accomplished and ongoing research development over the year 2019-2020.

Further details can be found on the SoC website [School of Computing - Ulster University Departments](#) or by contacting Mrs Ursula MacDonald (Academic Excellence Executive Assistant) at Email: u.macdonald@ulster.ac.uk; Ph: [+44 28 9036 8120](tel:+442890368120).



Professor Luke Chen
Research Director - Computer Science and Informatics

2. Research Students

The following research students were registered on research degree programmes during 2019-20.

Surname	Thesis title
Adams, Dawn	Wearable technologies for self-management of diabetes in pregnancy
Ahmad, Bilal	Resource optimisation for cloud-based digital gaming
Ahmad, Salman	BTIIC-02: Novel data analytics to automatically detect patterns in diverse customer data
Ajayi, Oluwashina	BTIIC-09: Securing Self-Organising IOT Ecosystems
Ampomah, Isaac	Automatic feature extraction for graph data mining with deep learning
Asharindavida, Fayas	A New Approach to Spectral Data Analysis for Food Quality Control
Black, Brendan	A meshed synchronous internet of medical things
Blair, Stuart	Sentiment mining from social media using topic model ensembles
Booth, Frederick	Analysis and Visualisation of Geo-Referenced Health Big Data
Brisk, Rob	Intelligent systems to improve decision making in cardiovascular emergencies
Burns, Matthew	Fusing sensor, video and depth data for analysis of ADLs and multiple occupancy tracking in a smart environment
Chen, Xianjiang	Development of computational and statistical models for prediction of nitrogen and energy utilisation efficiencies and methane emissions in cattle
Chen, Zhi	Big Data TV Analytics for service and customer improvement
Christodoulou, Vyron	Detecting anomalies from satellite and terrestrial electromagnetic data sources by big data analytics
Clare, Conor	Bayesian optimization using Student-t processes with gradient information
Cruciani, Federico	Personalisation of Machine Learning Models for Human Activity Recognition
Currie, Jonathan	Computer-based simulations for medical training
Davies, Richard	Gait and limb analysis for post stroke rehabilitation
Doran, Martin	Developing a Generic Architecture for Autonomic Fault Handling in Mobile Robots
Ekerete, Idongesit	Non-obtrusive sensing to assist post-stroke sufferers in home-based settings
Etumusei, Jonathan	Detecting Anomalies from Satellite and Terrestrial Data Sources by Data Analytics
Fusco, Terence	Predicting likelihood of schistosomiasis epidemic disease using remote sensing data and machine learning approaches
Gama, Clement	SATURN: Swarms, Autonomic Technolugues, Ubiquitous Robotics & Nanotech software paradigms for future space exploration
Gebresilassie, Samson Kahsay	BTIIC-10: Managing Identities and risk in an Internet of Insecure devices
Haider, Abbas	Contextual Probability based Approach to Reinforcement Learning
Hamill, Luke	Situation reasoning and task planning in human robot systems to support independent living
Hand, Rebecca	ThermAct: The use of thermal sensing technology to quantify wellbeing
Hernandez-Cruz, Netzahualcoyotl	Data Fusion of hererogenous sensing technologies within IoT platforms
Hussain, Tazar	BTIIC-07: An IoT management framework for decision making in instances of unreliability
Iftikhar, Aleeha	Mobile technology bases solutions for improving the interpretation of the 12-lead electrocardiogram and clinical decision making in cardiology
Irvine, Naomi	Human Activity Recognition with deep learning in Neural Networks
Jack, Deaglan	Enhancing Wearable Technologies through Artificial Intelligence

Jasinska-Piadlo, Alicja	Heart failure data analytics
Marshall, Fiona	Video analysis of abnormal behaviours within smart environments (VAAB)
McCalmont, Graham	Wearable Technologies to Support the Assessment of Physical Activity Functions for Stroke Rehabilitation
McGuigan, Liam	MAARRS: Multi-Agent Autonomic Robot/Rover Swarms
McHugh, Orla	Decision Analytic with Combined Data Driven Models and Domain Knowledge for Sustainable Land Management
Milliken, Michael	Intrusion detection from networks by using data mining and pattern recognition
Muhammad Tariq, Zeeshan	BTIIC-05: Process Analytics for predictive and self-correcting processes
Moore, Samuel	BTIIC-06: Quantification of information reliability within IoT deployments
Orr, Claire	A multi-agent based approach to activity recognition within smart environments
Pavlovic, Maja	Anomaly Detection in MBES, SWARM and SENTINEL-3 Data using Data Analytics
Potts, Courtney	Advanced analytics and machine learning of real-world
Quigley, Bronagh	Computational monitoring and interpretation of social and communicative behaviours in autism
Rabbani, Kashif	BTIIC-11: Information SLAs for IoT Systems
Ramezani, Anousheh	BTIIC-04: Novel adaptive machine learning, for response to changes over time
Rjooob, Khaled	Investigating how humans make decisions in cardiology and developing intelligent algorithms to improve decision making
Saedi, Mohammad	BTIIC-12: Secure real-time communications over 5G- Using Big Date Analytics, Fuzzy Set Techniques and Fuzzy Roles to evaluate and optimize network's parameter in 5G
Saunders, Catherine	Spaces: self-properties autonomic computing for exploring spaces
Shanavas, Niloofer	Efficient Structure-Based Approach to Text Classification
Shewell, Colin	Context aware reminder delivery with Google glasses
Torney, Hannah	Usability engineering methods for assessing and enhancing the human-machine interaction of automated external defribillators
Turkington, Robin	Machine learning of big data to discover mental health behaviour patterns
Ullah, Hanif	Bridging and real-time swarm collision avoidance protocols in UAV deployment scenarios
Vincent, Jordan	Spectral Pattern Recognition
Wan, Huan	Facial recognition from videos
Wang, Mengyuan	Development of an integrated metagenomic analysis system using the microbial community, their genes and biological mechanisms to predict cattle phenotypes
Wassan, Jyotsna Talreja	Big data analytics
Wei, Xin	Face Recognition Using Feature Fusion and Deep Learning
Xu, Chunlin	Multimodal Search
Yang, Lingkai	BTIIC-01: Autonomous abnormality detection for informed data-driven decision making
Zi, Bingxin	AI Assistant Robots for Supporting Independent Living
Zia, Syed Muhammad Unsub	BTIIC-08: Novel cryptographic solutions for IoT

Graduated December 2019

Student name	Thesis title
Fusco, Terence	Predicting likelihood of schistosomiasis epidemic disease using remote sensing data and machine learning approaches

Graduated July 2020

Student name	Thesis title
Doran, Martin	Developing a generic architecture for autonomic fault handling in mobile robots
Wassan, Jyotsna Talreja	Integrative data analysis for the prediction of metagenomic functions
Wei, Xin	Face recognition using feature fusion and deep learning

3. Publications

Details of all Publications by the School of Computing 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, research reports and published conference papers.

3.1 Journal Articles

Ahmad, B., Maroof, Z., McClean, S., Charles, D., Parr, G., 2020, Economic impact of energy saving techniques in cloud server, *Cluster Computing*, vol. 23, 2, pp. 611-621.

Bai, L., Ciravegna, F., Bond, R., Mulvenna, M., 2020, A Low Cost Indoor Positioning System Using Bluetooth Low Energy, *IEEE Access*, vol. 8, pp. 136858 - 136871.

Bai, L., Pepper, M. G., Yan, Y., Phillips, M., Sakel, M., 2020, Low Cost Inertial Sensors for the Motion Tracking and Orientation Estimation of Human Upper Limbs in Neurological Rehabilitation, *IEEE Access*, vol. 8, pp. 54254 - 54268.

Bin Rampun, A., Morrow, P., Scotney, B., Wang, H., 2020, Breast density classification in mammograms: An investigation of encoding techniques in binary-based local patterns, *Computers in Biology and Medicine*, vol. 122.

Blair, S., Bi, Y., Mulvenna, M., 2020, Aggregated Topic Models for Increasing Social Media Topic Coherence, *Applied Intelligence*, vol. 50, 1, pp. 138-156.

Bond, R., Moorhead, A., Mulvenna, M., O'Neill, S., Potts, C., Murphy, N., 2019, Exploring temporal behaviour of app users completing ecological momentary assessments using mental health scales and mood logs, *Behaviour and Information Technology*, vol. 38, 10, pp. 1016-1027.

Bond, R., Rjoob, K., Finlay, D., McGilligan, V. E., Leslie, S. J., Knoery, C., Iftikhar, A., McShane, A., Tache, I. A., Biglarbeigi, P., Manktelow, M., Peace, A., 2020, Near future artificial intelligence in interventional cardiology: new opportunities and challenges to improve the care of STEMI patients, *Journal of ESC Digital Health*.

Brisk, R., Bond, R., Banks, E., Piadlo, A., Finlay, D., McLaughlin, J., David, M., 2019, Deep Learning to Automatically Interpret Images of the Electrocardiogram: Do We Need the Raw Samples?, *Journal of Electrocardiology*, vol. 57, S65-S69.

Bucholc, M., Ding, X., Wang, H. / H., Glass, D. H., Wang, H., Prasad, G., Maguire, L., Bjourson, A., McClean, P., Todd, S., Finn, D., Wong-Lin, K., 2019, A practical computerized decision support system for predicting the severity of Alzheimer's disease of an individual, *Expert Systems with Applications*, vol. 130, pp. 157-171.

Cao, F., Xu, Y., Liu, J., Chen, S., Ning, X., 2019, CSE_E 1.0: An integrated automated theorem prover for first-order logic, *Symmetry*, vol. 11, 9, pp. 1.

Chen, H., Guo, B., Yu, Z., Chen, L., 2019, A location-constrained crowdsensing task allocation method for improving user satisfaction, *International Journal of Distributed Sensor Networks*, vol. 15, 10.

Chen, L., Farha, F., Ning, H., Liu, H., Yang, L. T., 2019, Physical unclonable functions based secret keys scheme for securing big data infrastructure communication, *Information Sciences*, vol. 503, pp. 307-318.

- Chen, L., Ning, H., Nugent, C., Yu, Z., 2020, Hybrid Human-Artificial Intelligence, *IEEE Computer*, vol. 53, 8, pp. 14-17.
- Chen, S., Glass, D. H., McCartney, M., 2019, Two-dimensional opinion dynamics in social networks with conflicting beliefs, *AI and Society*, vol. 34, 4, pp. 695-704.
- Chen, X., Finney, G., Zheng, H., Wang, H., Gordon, A. W., Ferris, C. P., Magowan, E., Yan, T., 2020, Modern Holstein-origin dairy cows within grassland-based systems partition more feed nitrogen into milk and excrete less in manure, *Science of the Total Environment*, vol. 727.
- Cleland, I., Neira-Rodado, D., Nugent, C., Velasquez, J., Vilorio, A., 2020, Evaluating the Impact of a Two-Stage Multivariate Data Cleansing Approach to Improve the Performance of Machine Learning Classifiers: A Case Study in Human Activity Recognition, *Sensors*, vol. 20, 7, pp. 44927.
- Cleland, I., Razzaq, M. A., Nugent, C., Lee, S., 2020, SemInput: Bridging Semantic Imputation with Deep Learning for Complex Human Activity Recognition, *Sensors*, vol. 20, 10.
- Cruciani, F., Vafeiadis, A., Nugent, C., Cleland, I., McCullagh, P., Votis, K., Giakoumis, D., Tzovaras, D., Chen, L., Hamzaoui, R., 2020, Feature learning for Human Activity Recognition using Convolutional Neural Networks, *CCF Transactions on Pervasive Computing and Interaction*, vol. 2, pp. 18-32.
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- Fu, H., Chen, S., Xu, Y., Liu, J., 2020, Improving WalkSAT for Random 3-SAT Problems, *Journal of Universal Computer Science*, vol. 26, 2, pp. 220-243.
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- Liu, Y., Liu, J., Qin, Y., 2019, Pythagorean fuzzy linguistic Muirhead mean operators and their applications to multi-attribute decision-making, *International Journal of Intelligent Systems*, vol. 35, 2, pp. 300.
- Liu, Y., Qin, Y., Xu, L., Liu, H., Liu, J., 2019, Multiattribute group decision-making approach with linguistic Pythagorean fuzzy information, *IEEE Access*, vol. 7, 143412.
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- Mc Cauley, C., Bond, R., Ryan, A., Mulvenna, M., Laird, L., Gibson, A., Bunting, B., Ferry, F. R., Curran, K., 2019, Evaluating User Engagement with a Reminiscence App Using Cross Comparative Analysis of User Event Logs and Qualitative Data, *Cyberpsychology, Behavior, and Social Networking*, vol. 22, 8, pp. 543-551.
- McChesney, I., Hernandez-Cruz, N., Lundstrom, J., Favela, J., Arrnrich, B., 2020, Literature Review on Transfer Learning for Human Activity Recognition Using Mobile and Wearable Devices with Environmental Technology, *SN Computer Science*, vol. 1, 2.

Mulvenna, M., Bond, R., 2019, Editorial, Behaviour and Information Technology, vol. 38, 10, pp. 1003-1003.

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O'Neill, S., Bond, R., Grigorash, A., Ramsey, C., Armour, C., Mulvenna, M., 2019, Data analytics of call log data to identify caller behaviour patterns from a mental health and wellbeing helpline, Health Informatics Journal, vol. 25, 4, pp. 1722-1738.

Ortiz_barrios, M., Cleland, I., Nugent, C., Pancardo, P., Jarpe, E., Synnott, J., 2020, Simulated data to estimate real sensor events: A Poisson-regression-based modelling, MDPI Remote Sensing, vol. 12, 5, 4pp. 3466.

Ortiz-Barrios, M., Nugent, C., Cleland, I., Donnelly, M., Verikas, A., 2020, Selecting the most suitable classification algorithm for supporting assistive technology adoption for people with dementia: A multicriteria framework, Journal of Multi-Criteria Decision Analysis, vol. 27, 43862, pp. 20-38.

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- Siddique, N., Alam, K. M. R., Adeli, H., 2020, A dynamic ensemble learning algorithm for neural networks, *Neural Computing and Applications*, vol. 32, 12, pp. 8675-8690.
- Song, W., Jiang, N., Wang, H., Guo, G., 2020, Evaluation of machine learning methods for organic apple authentication based on diffraction grating and image processing, *Journal of Food Composition and Analysis*, vol. 88.
- Song, W., Jiang, N., Wang, H., Vincent, J., 2020, Use of smartphone videos and pattern recognition for food authentication, *Sensors and Actuators B: Chemical*, vol. 304.
- Sterritt, R., Wilkie, G., Saunders, C., Doran, M., Gama, C., Hawe, G., McGuigan, L., 2020, Inspiration for Space 2.0 from Autonomous NanoTechnology Swarms Concept missions towards Autonomic Robotic Craft, *Journal of the British Interplanetary Society*, vol. 73, 11.
- Synnott, J., Ortiz_barrios, M., Lundstrom, J., Jarpe, E., Sant'Anna, A., 2020, Complementing real datasets with simulated data: a regression-based approach, *Multimedia Tools and Applications*.
- Tian, X., Zhou, X., Ng, W., Li, J., Wang, H., 2020, Bootstrap dual complementary hashing with semi-supervised re-ranking for image retrieval, *Neurocomputing*, vol. 379, pp. 103-116.
- Uhomoibhi, J., Azevedo, A. I. R. L., Azevedo, J. M. M. L., Ossiannilsson, E., 2019, Learning analytics in theory and practice: Guest editorial, *International Journal of Information and Learning Technology*, vol. 36, 4, pp. 286-287.
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3.3 Published Conference Papers

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4. Research Funding

Ongoing and Active Research Projects, notably:

Unit of Assessment Member	Title of Award	Funding Body	Value
Prof B Scotney Prof CD Nugent Prof SI McClean Prof Luke Chen Dr Shuai Zhang Dr Jorge Martinez Dr Darryl Charles Dr Joe Rafferty Dr AA Moore Dr Philip Perry	BT-Ireland Innovation Centre (BTIIC). An International Centre of Excellence for Industrial Research and Engineering	British Telecom	£6,193,427.00
Prof JAD McLaughlin Dr N Soin Prof D Finlay Dr I Cleland Dr PJ McCullagh Prof CD Nugent Dr J Synnott	CHIC Phase 2 Research - Connected Health Innovation Centre	Invest NI	£2,917,596.00
Dr M Huang Prof N Hewitt Dr Y Bi A Joyce, Laboratorio Nacional de Energia B Fox, LF Fasthouse C Walsh, Energy Co-Operatives Ireland E Strazzer, Uni Degli Studi Di Cagliari E Torralba Callega, Acondicion Tarrasens K Moosdorf, Assoc Portuguesa Das Empresa M Bottarelli, Uni Degli Studi Di Ferrara P Duff, Power Capital Renewable Energy P Lavin, APK Architects & Engineering P McHale, Mayo County Council Prof S Vranes, Institut Mihajlo Pupin S McCormack, Trinity College Dublin Z Ure, Phase Change Material Products	IDEAS	CEC-H2020-LC-SC3-RES-4-2018	£510,330.00

Portfolio of Research Grants awarded during period 1 August 2019 - 31 July 2020

Unit of Assessment Member	Title of Award	Funding Body	Value
Tanya McCance Dr D Brown CD Nugent	Co-producing a person-centred cancer nursing implementation project (continuation)	HSC R&D Public Health Agency	£28,119
Dr R Price Prof MD Mulvenna Dr C Hughes Dr R Bond Dr F Duffy, NHSCT	Dementia Data Analytics Project: Understanding the Outcome of Memory Service Assessments and the Impact of CLEAR Dementia Care	HSC R&D Public Health Agency	£28,418
Dr M Black Prof AJ Moore Dr CIR Gill Dr D Rankin Prof HM McNulty Prof JG Wallace	NHSCT (HSC)	DARUG	£99,904.81
Dr J Liu Dr G Hawe Prof H Zheng Prof H Wang Dr J Uhoimoibhi	KTP Programme between University of Ulster and Sandvik Limited	Innovate UK/INI and Sandvik Limited	£177,614.00
Dr MS Gallagher Dr Samuel Ginja Prof M Keenan Dr R Bond Prof MD Mulvenna	Addressing behavior change in the context of technology-based interventions	Department for the Economy-GCRF	£45,000.00
Dr V Simms Dr R Bond Dr C Jimenez, Autonomous Uni Dr M I Susperreguy, Pontifia Universidad Dr N Estevez, Cuban Centre for Neuroscience	HELM: Home Environments supporting Learning Mathematics: Understanding the impact of the home environment on early mathematical development in a global context	The British Academy - GCRF	£251,976.00

Dr R Bond Dr E Ennis Prof SM O'Neill Dr K Boyd Dr S Loane Prof E Ramsey Prof MD Mulvenna Annika Nordstrand, Region Norrbotten Brian Cahill, Cork Institute of Technolog Catrine Kostenius, Norrbotten Ass of Loc Kirsi Bykachev Uni of Eastern Finland Lena Abrahamsson, Luleå Uni Technology Martin Malcolm, NHS Western Isles McConvey, Action Mental Health	ChatPal	Interreg VB	£173,112.00
Dr D Charles Prof SM McDonough	VR-RELIEF PCP - Phase 3	CEC-H2020 VIA RELIEF PCP (GIP RESAH)	£11,554.00
Dr R Bond Dr A Jasinska Piadlo, Royal Victoria Hospital Dr D McEneaney, Craigavon Area Hospital Patricia Campbell, Craigavon Area Hospital	A data mining approach to understanding heart failure: Retrospective and real time analysis of Northern Ireland heart failure databases to enhance patient outcomes	HSC R&D Public Health Agency Doct Fell	£222,340.00
Prof AA Ryan Dr C McCauley Dr EA Laird Mrs D Goode Dr K Boyd Dr R Bond Prof MD Mulvenna	Developing and testing the Inspired reminiscence app as a stand-alone support for people living with dementia and their families	HSC R&D Public Health Agency	£85,883.00
Prof D Finlay Dr S Davey Prof JAD McLaughlin Dr MP Donnelly Dr R Bond	SHAPES - Smart and Healthy Ageing Promoting Empowering Systems	CEC-H2020-DT TDS-01-2019	£352,706.00

<p>Dr JG Harkin Mr M McElholm</p>	<p>iTEMID - Intelligent Total Management in Dairying</p>	<p>NI Agricultural R&D Council – AgriSearch</p>	<p>£59,339.00</p>
<p>Prof SM O'Neill Dr C Campbell Dr E Ennis Dr K Kirby Ms B Friel Prof D Heenan Dr R Bond Prof MD Mulvenna Dr A Allen, Action Mental Health Dr J O'Loughline, Playboard NI Dr L Thompson, Donegal Youth Service Mr A Quinn, Co-operation Ireland Mr M McMullan, Youth Action NI Pr P Burke, Youth Work Ireland</p>	<p>Our Generation</p>	<p>CEC - Peace IV</p>	<p>£590,394.00</p>
<p>Dr E Ennis Prof SM O'Neill Dr R Bond Prof MD Mulvenna</p>	<p>Analysis & Dashboard Development of Samaritans Ireland Call Data</p>	<p>Samaritans Ireland</p>	<p>£29,166.00</p>
<p>Prof WG Kernohan Dr P Slater Prof M Sinclair Prof A Smith Prof CD Nugent Dr L Dornan Prof J McCoy Dr M MacDonald, QUB Mrs N Chaloumuk, Chiang Mai Uni Ms P Prasitwattanaseree, Chiang Mai</p>	<p>UKRI GCRF Birth across the Borders: exploring contextual education as a catalyst for improved maternal health</p>	<p>UKRI GCRF via ESRC (Education as a drive</p>	<p>£1,761,027.00</p>

Prof SM O'Neill Dr E Ennis Mrs M McLafferty Dr E Murray Prof CP Walsh Dr R Bond Prof MD Mulvenna Prof G Davidson, QUB	Future Minds NI	MRC	£100,782.00
Dr R Price Dr C Hughes Dr R Bond Prof MD Mulvenna Dr F Duffy, NHSCT Dr P Zvolsky, NHSCT Mr M Harvey, NHSCT Mrs M Serplus, NHSCT	Dementia Data Analytics Project: Understanding the Outcome of Memory Service Assessments and the Impact of CLEAR Dementia Care	HSC R&D Public Health Agency	£7,774.00
Dr D Rankin Dr M Black Dr R Bond Mr J Lubinda Prof JG Wallace Prof MD Mulvenna	MIDAS Symposium 2020	HSC R&D Workshop and Conference Scheme	£2,500.00