



School of Computing

Annual Report for Research & Impact

August 2018 - July 2019



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1. Foreword:
Research Director
Prof Hui Wang

In presenting the Annual Research Report for the School of Computing (SoC) for the academic year 2018-2019, I am happy to report a very successful year for our research activities. Staff have been highly prolific in publishing world leading or excellent scientific papers in key journals within their discipline areas, presenting at conferences, seminars and workshops internationally as well as disseminating to local audiences in Northern Ireland. Staff have also been highly successful in securing new and prestigious research grants amounting to circa £7M, and supervising to completion 8 PhD researchers.

The research vision of SoC is to enable a connected and sustainable society by intelligent and pervasive computing systems for the benefit of citizens, businesses and civil services. The research mission is to develop cutting-edge science and technology in artificial intelligence and pervasive computing in the form of theories, algorithms and tools, and, through engagement with stakeholders and users, to create state of the art computing solutions for practical problems. The research strategy is to align with University, local, national and European initiatives in these pursuits.

Research within SoC is structured through two research groups – Artificial Intelligence and Pervasive Computing, and two externally funded research centres – Connected Health Innovation Centre and BT Ireland Innovation Centre. Research activities within SoC are reviewed briefly in this Foreword.

Artificial Intelligence Research Group (AIRG, headed by Prof Hui Wang)

The key research strengths in AIRG are knowledge engineering and reasoning, machine learning and data engineering, and mathematical modelling and optimisation.

Recent research and development activities include biomedical informatics, geoinformatics, food authentication, virus detection, and multimedia information retrieval based on spectral data analysis, medical image analysis, text analysis, gait analysis, chemical data analysis, and telematic data analysis.

One highlight is the EU Horizon 2020 project “Decision Support and Information Management System for Breast Cancer” (DESIREE) (<http://desiree-project.eu>), which is an 11-partner effort coordinated by Vicomtech, led in UU by Professor Hui Wang, and worth £384K to UU. DESIREE developed a web-based software ecosystem for the personalized, collaborative and multidisciplinary management of primary breast cancer, from diagnosis to therapy and follow-up. The system comprises a medical image analysis subsystem, a physiological predictive modelling subsystem, and a decision support subsystem consisting of three clinical decision support systems (CDSSs) – guideline-based, case-based and experience-based. The Ulster University team developed models for medical image analysis, including breast and pectoral muscle segmentation in mammography, breast density characterization, and breast and pectoral muscle segmentation in MRI. The Ulster University team also developed the case-based CDSS.

Pervasive Computing Research Group (PCRG, headed by Prof Chris Nugent)

The research focus is on developing new assistive technologies to improve aspects of healthcare, wellbeing and independence. Many of the research projects within PCRG address specific challenges of ageing or cognitive impairment along with the prevention and management of long-term health conditions.

Current and completed projects have supported the development and evaluation of assistive technologies in the following areas:

- Home based assessment of autistic children
- Self-management of stroke, COPD, CHF and chronic pain
- Promotion of independence in the elderly

One highlight is the US-Ireland project “Agile Cloud Service Delivery Using Integrated Photonics Networking”, led in UU by Professor Philip Morrow, involving DCU, UCD, TCD, the Tyndall Institute, the University of Arizona, Columbia Institute and Berkley, and worth £320,000 to UU, completed recently. The project as a whole developed new networking hardware for data centres that has the potential to improve performance and reduce power consumption. The Ulster University team developed models of realistic networks based on these technologies and developed new ways of managing those networks that was specifically tailored to the new hardware’s capabilities. Testing these combined networks and management systems with realistic datacentre workloads showed that they were indeed capable of achieving these goals. This work, therefore, has pointed the way for future data centre network system design that will enable a sustainable future with high speed networks that can be reconfigured in less than one microsecond.

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

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.

Its areas of focus are the following

- Integrated Community Care – joining together existing and new technology and process.
- Point of Care Diagnostics – moving diagnostics closer to the patient.
- Vital Sign Monitors – technology development to support vital sign identification, analysis and communication.
- Cloud Based Health – use of cloud technology for health solutions.

BT Ireland Innovation Centre (BTIIC, headed by Prof Bryan Scotney as PI, Prof Chris Nugent, Prof Sally McClean)

BTIIC, funded by Invert Northern Ireland and representing a major partnership between BT and Ulster University, is at the intersection of Artificial Intelligence, the Internet of Things and Telecommunications.

This research and engineering centre of excellence involves BT and Ulster University jointly investing in a research programme, which has created 27 new research opportunities – 15 postdoctoral researchers and 12 PhD students. During the lifetime of the project these researchers are working with BT Adastral Park Research Laboratories in Martlesham, Suffolk, UK alongside BT Belfast Global Development Centre and there also will be openings for the researchers to spend a period of time as part of a related Internship with BT. In addition to these research opportunities in Ulster University, BTIIC are also facilitating the creation of up to 50 new graduate roles in the BT Belfast Global Development Centre.

The innovative BT R&D partnership is the first in the UK outside Cambridge and brings together academic researchers, industrial researchers and industrial engineers co-located in one centre, with a focus on application of research and the power of communications to enhance our world. As such, it provides a unique opportunity for downstreaming of research results from University to Industry, providing valuable REF case studies for the University and a strong research underpinning for the BT family.

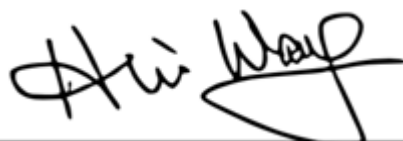
The research partnership plays to Ulster University's strengths in cloud computing, optimisation, vision systems, resilient communications, smart environments and big data analytics. This exciting and ambitious industry collaboration focuses on performing advanced Research and Development in a number of core technology areas related to future telecommunication networks and services with a particular emphasis on Future Big Data Analytics, Internet of Things (IoT), Cyber Security, Fixed and Mobile Network services and creating products for both residential and business customers.

BTIIC is highlighted in the AI Sector Deal as an example of industry action to support expanding AI clusters across the UK. "BT is collaborating with Ulster University by investing in a new £29m AI R&D cluster that aims to attract and retain industrial engineers and university researchers." London is the European capital of AI, while significant clusters exist in places such as Edinburgh, Belfast, Bristol and Cambridge.

The AI Sector Deal is part of the Government's industrial strategy, published on 26 April 2018. Under this Deal, the Government and industry have committed to spend nearly £1 billion on AI. £300 million in public funding has been allocated by EPSRC to upcoming research into data science and AI. The commitments are based on the recommendations made by Wendy Hall, Regius Professor of Computer Science at the University of Southampton, and Jérôme Pesenti, vice-president of AI at Facebook, in their review of the UK's AI industry, published in October 2017.

The above provides a short summary of some of the main achievements over the year 2018-2019, as well as research activities in computer science research within the School of Computing at Ulster University.

Further details can be found on the SoC website <https://www.ulster.ac.uk/faculties/computing-engineering-and-the-built-environment/computing> or by contacting Mrs Ursula MacDonald (Academic Excellence Executive Assistant) at Email: u.macdonald@ulster.ac.uk; Ph: [+44 28 9036 8120](tel:+442890368120).

A handwritten signature in black ink, appearing to read 'Hui Wang', written over a horizontal line.

Professor Hui Wang
Research Director - Computer Science and Informatics

2. Research Students

The following research students were registered on research degree programmes in the Institute during 2018-19.

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
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	The use of connected health solutions to promote physical activity
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	Assessing distribution of epidemic disease vectors by remote sensing and earth observation data mining
Gama, Clement	SATURN: Swarms, Autonomic Technologues, 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
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.
Lees, Stephanie	Assessing and optimising human-machine symbiosis through neural signals for big 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
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
Moore, Samuel	BTIIC-06: Quantification of information reliability within IoT deployments
Muhammad Tariq, Zeeshan	BTIIC-05: Process Analytics for predictive and self-correcting processes
Orr, Claire	a multi-agent based approach to activity recognition within smart environments
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, Niloofar	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 defibrillators
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
Zia, Syed Muhammad Unsub	BTIIC-08: Novel cryptographic solutions for IoT

Graduated December 2018

Student Name	Thesis Title
McAllister, Patrick	Deep learning-based food image classification and crowdsourcing-based calorie estimation approach to support dietary management
Abernethy, Gavin	Computational approaches to predator-prey and food web modelling

Graduated July 2019

Student Name	Thesis Title
Joshi, Monika	Semantification of text through summarisation
Hampton, Peter	Neural & hybrid architectures for entity classification
Song, Weiran	Spectral pattern recognition and application
Price, Edward	Digital in-situ assessment of cognitive fatigue using smartphones
Samara, Anas	Affective and cognitive state modelling within human-computer interaction
Morrow, Philip	Software sizing for cost/schedule estimation

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

Abernethy, G, McCartney, M & Glass, DH 2019, 'The Robustness, Link-species Relationship and Network Properties of Model Food Webs', *Communications in Nonlinear Science and Numerical Simulation*, vol. 70, pp. 20-47.

Abernethy, G, McCartney, M & Glass, DH 2019, 'The Role of Migration in a Spatial Extension of the Webworld Eco-evolutionary Model', *Ecological Modelling*, vol. 397, pp. 122-140.

Abu-Tair, M, Perry, P, Morrow, PJ, McClean, SI, Scotney, B, Parr, G & Biswas, I 2019, 'Optical Space Switches in Data Centers: Issues With Transport Protocols', *Photonics*, vol. 6, no. 1, 16, pp. 1-13.

Ahmad, B, McClean, SI, Charles, DK & Parr, G 2018, 'Energy Saving Techniques Comparison for Green Computing in Cloud Server', *International Journal On Advances in Intelligent Systems*, pp. 192.

Ahmad, M, Khan, A, Khan, AM, Mazzara, M, Distefano, S, Sohaib, A & Nibouche, O 2019, 'Spatial Prior Fuzziness Pool-based Interactive Classification of Hyperspectral Images', *MDPI Remote Sensing*, vol. 11, no. 9, 1136, pp. 1-19.

Al-Azawi, S, Nibouche, O, Boussakta, S & Lightbody, G 2018, 'New Fast and Area-Efficient Pipeline 3-D DCT Architectures', *Digital Signal Processing*.

Ali, Z, Imran, M, McClean, SI, Khan, N & Shoaib, M 2019, 'Protection of Records and Data Authentication based on Secret Shares and Watermarking', *Future Generation Computer Systems*, pp. 1-14.

Blair, S, Bi, Y & Mulvenna, M 2019, 'Aggregated Topic Models for Increasing Social Media Topic Coherence', *Applied Intelligence*.

Bond, RR & Mulvenna, M 2019, 'Popular topics in HCI: Special Issue of Selected Extended Papers from the 32nd International BCS Human Computer Interaction Conference', *Interacting with Computers*, vol. 31, no. 2, pp. 113-115.

Bond, RR, Novotny, T, Andrsova, I, Koc, L, Sisakova, M, Finlay, D, Guldenring, D, McLaughlin, J, Peace, A, McGilligan, VE, Leslie, S, Wang, H & Malik, M 2018, 'Automation Bias in Medicine: The Influence of Automated Diagnoses on Interpreter Accuracy and Uncertainty when Reading Electrocardiograms', *Journal of Electrocardiology*, pp. 1-12.

Boyd, K, Bond, RR, Vertesi, A, Dogan, H & Magee, J 2019, 'How people judge the usability of a desktop graphic user interface at different time points: Is there evidence for memory decay, recall bias or temporal bias?', *Interacting with Computers*.

Burns, M, Morrow, PJ, Nugent, CD & McClean, SI 2019, 'Fusing Thermopile Infrared Sensor Data for Single Component Activity Recognition within a Smart Environment', *Journal of Sensor and Actuator Networks*, vol. 8, no. 1, 10, pp. 1-16.

Burns, N, Bi, Y, Wang, H & Anderson, T 2018, 'Enhanced TWOFOLD-LSA Model for Aspect discovery and Sentiment Classification', *International Journal of Knowledge-Based Organizations*.

- Catherwood, P, Black, B, Mohamed, EB, Cheema, AA, Rafferty, J & McLaughlin, J 2019, 'Radio Channel Characterization of Mid-band 5G Service Delivery for Ultra-Low Altitude Aerial Base Stations', *IEEE Access*, vol. 7, 8606910, pp. 8283-8299.
- Chen, L, Chen, D & Wang, H 2018, 'Fuzzy kernel alignment with application to attribute reduction of heterogeneous data', *IEEE Transactions on Fuzzy Systems*, vol. 27, no. 7, pp. 1469-1478.
- Chen, L, Guo, G & Wang, H 2019, 'An ordered sparse subspace clustering algorithm based on p-Norm', *Expert Systems*, vol. 2019;e12368, e12368.
- Christodoulou, V, Bi, Y & Wilkie, FG 2018, 'A Fuzzy Shape-Based Anomaly Detection and its Application to Electromagnetic Data', *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 11, no. 9, pp. 3366-3379.
- Crangle, C, Bradley, C, Carlin, P, Esterhay, P, Harper, R, Kearney, P, McCarthy, V, Mc Tear, M, Savage, E, Wallace, JG & Tuttle, M 2018, 'Exploring Patient Information Needs in Type 2 Diabetes: A Cross Sectional Study of Questions', *PLoS ONE*.
- Currie, J, Bond, RR, McCullagh, P, Black, P, Finlay, D, Gallagher, S, Kearney, P, Peace, A, Stoyanov, D, Bicknell, CD, Leslie, S & Gallagher, AG 2019, 'Wearable technology-based metrics for predicting operator performance during cardiac catheterisation', *International Journal of Computer Assisted Radiology and Surgery*, vol. 14, no. 4, pp. 645–657.
- Ferry, FR, Ryan, A, McCauley, C-O, Laird, LEA, Gibson, A, Mulvenna, M, Bond, RR, Bunting, B & Curran, K 2018, 'Economic Costs and Health-Related Quality of Life Associated with Individual Specific Reminiscence: Results from the InspireD Feasibility Study', *Dementia: The International Journal of Social Research and Practice*, pp. 1-18.
- Glass, DH 2018, 'An evaluation of probabilistic approaches to inference to the best explanation', *International Journal of Approximate Reasoning*, vol. 103, pp. 184-194.
- Glass, DH 2018, 'Coherence, Explanation, and Hypothesis Selection', *British Journal for the Philosophy of Science*.
- Glass, DH 2019, 'Competing hypotheses and abductive inference', *Annals of Mathematics and Artificial Intelligence*, pp. 1-18.
- Higgins, S, Mulvenna, M, Bond, RR, McCartan, A, Gallagher, S & Quinn, D 2018, 'Multivariate Testing Confirms the Effect of Age and Gender Congruence on Click-Through Rates from Online Social Network Digital Advertisements', *Cyberpsychology, Behavior, and Social Networking*, vol. 21, no. 10, pp. 646-654.
- Holmes, S, Moorhead, A, Coates, V, Bond, RR & Zheng, H 2018, 'Impact of digital technologies for communicating messages on weight loss maintenance: a systematic literature review: Impact of digital technologies for communicating messages on weight loss maintenance', *European Journal of Public Health*.
- Kong, X, Bi, Y & Glass, DH 2018, 'Detecting Anomalies in Sequential Data Augmented with New Features', *Artificial Intelligence Review*.
- Laird, LEA, Ryan, A, Mc Cauley, C, Bond, RR, Mulvenna, M, Curran, K, Bunting, B, Ferry, FR & Gibson, A 2018, 'Using mobile technology to provide personalised reminiscence for people living with dementia and their carers: An appraisal of outcomes from a quasi-experimental study', *JMIR Mental Health*, vol. 5, no. 3, e57.
- Liu, J, Zhang, J, Luo, Y, Yang, S, Wang, J & Fu, Q 2019, 'Mass spectral substance detections using long short-term memory networks', *IEEE Access*, vol. 7, 8606092, pp. 10734-10744.

Leorin, C, Stella, E, Nugent, CD, Cleland, I & Paggetti, C 2019, 'The Value of Including People with Dementia in the Co-Design of Personalized eHealth Technologies', *Dementia and Geriatric Cognitive Disorders*, vol. 47, no. 3, pp. 164-175.

Ma, L, Wang, R, Chen, S, Wang, X, Cheng, C, Lin, Z & Shi, Y 2019, 'A Novel Many-objective Evolutionary Algorithm Based on Transfer Matrix with Kriging model', *Information Sciences*.

McCartney, M & Bradley, E 2018, 'Four hundred years of the fractal coastline of Scotland', *The Mathematical Gazette*, vol. 103, no. 558, pp. 1-4.

McCartney, M 2019, 'A man who has infinite capacity for making things go': Sir Edmund Taylor Whittaker (1873–1956)', *British Journal for the History of Mathematics*, vol. 34, no. 3, pp. 179-193.

McChesney, I & Bond, RR 2018, 'Eye tracking analysis of computer program comprehension in programmers with dyslexia', *Empirical Software Engineering*.

Medina-Quero, J, Zhang, S, Nugent, CD & Espinilla, M 2018, 'Ensemble classifier of long short-term memory with fuzzy temporal windows on binary sensors for activity recognition', *Expert Systems with Applications*, vol. 114, pp. 441-453.

Mendoza-Palechor, F, Menezes, ML, Sant'Anna, A, Ortiz-Barrios, M, Samara, A & Galway, L 2018, 'Affective recognition from EEG signals: an integrated data-mining approach', *Journal Ambient Intelligence and Humanized Computing*, pp. 1-20.

Munoz Esquivel, K, Nevala, E, Alamäki, A, Condell, J, Kelly, D, Davies, RJ, Heaney, D, Nordström, A, Åkerlund Larsson, M, Nilsson, D, Barton, J & Tedesco, S 2018, 'Remote Rehabilitation: A solution to Overloaded & Scarce Health Care Systems', *Trends in Telemedicine & E-health*, vol. 1, no. 1, pp. 1-19.

Nevala, E, Alamäki, A, Jalovaara, J, Munoz Esquivel, K, Condell, J, Heaney, D, Barton, J, Tedesco, S, Kelly, D, Davies, RJ, Nordström, A & Åkerlund Larsson, M 2018, 'SENDoc – to implement wearable sensors in rehabilitation practice for the elderly', *Age Now! - Online Journal of Ageing*, vol. 2, no. 2019.

Ni, Q, Cleland, I, Nugent, CD, García Hernando, AB & Pau de la Cruz, I 2019, 'Design and assessment of the data analysis process for a wrist-worn smart object to detect atomic activities in the smart home', *Pervasive and Mobile Computing*, vol. 56, pp. 57-70.

Oakes, L, Magee, B, McIlhagger, AT & McCartney, M 2019, 'Strength prediction and mix design procedures for geopolymers and alkali-activated cement mortars comprising a wide range of environmentally responsible binder systems', *Journal of Structural Integrity and Maintenance*, vol. 4, no. 3, pp. 135-143.

Ortiz-Barrios, M, Nugent, CD, Cleland, I, Donnelly, MP & Verikas, A 2019, 'Selecting the most suitable classification algorithm for supporting assistive technology adoption for people with dementia: A multicriteria framework', *Journal of Multi-Criteria Decision Analysis*, pp. 1-19.

Rababah, A, Finlay, D, Bear, L, Bond, RR, Rjoob, K & McLaughlin, J 2019, 'Interpolating Low Amplitude ECG Signals Combined with Filtering According to International Standards Improves Inverse Reconstruction of Cardiac Electrical Activity', *Lecture Notes in Computer Science*, pp. 112-120.

Rampun, A, Scotney, B, Morrow, PJ, Wang, H & Winder, J 2018, 'Segmentation of Breast MR Images using a Generalised 2D Mathematical Model with Inflation and Deflation Forces of Active Contours', *Artificial Intelligence in Medicine*.

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- Sekar, B, Lamy, J-B, Larburu, N, Seroussi, B, Guézennec, G, Bouaud, J, Muro, N, Wang, H & Liu, J 2018, 'Case-based decision support system for breast cancer management', *International Journal of Computational Intelligence Systems*.
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- Ullah, H, Gopalakrishnan Nair, N, Adrian, M, Nugent, CD, Muschamp, P & Cuevas, M 2019, '5G Communication: An Overview of Vehicle-to-Everything, Drones, and Healthcare Use-cases', *IEEE Access*, vol. 7, 6287639, pp. 37251-37268.
- Vincent, J, Wang, H, Nibouche, O & Maguire, P 2018, 'Differentiation of Apple Varieties and Investigation of Organic Status Using Portable Visible Range Reflectance Spectroscopy', *Sensors*, vol. 18, no. 6, pp. 1708.
- Wang, T, Qiao, M, Lin, Z, Li, C, Snoussi, H, Liu, Z & Choi, C 2018, 'Generative Neural Networks for Anomaly Detection in Crowded Scenes', *IEEE Transactions on Information Forensics and Security*, vol. 0, no. 0, 1, pp. 1-10.
- Wassan, JT, Wang, HHY, Fiona, B & Zheng, H 2019, 'Phy-PMRFI : Phylogeny-aware Prediction of Metagenomic Functions using Random Forest Feature Importance', *IEEE Transactions on Nanobioscience*.
- Wei, X, Wang, H, Scotney, B & Wan, H 2019, 'Selective multi-descriptor fusion for face identification', *International Journal of Machine Learning and Cybernetics*.
- Xu, Y, Liu, J, Chen, S, Zhong, X & He, X 2018, 'Contradiction separation based dynamic multi-clause synergized automated deduction', *Information Sciences*, vol. 462, pp. 93-113.
- Yang, L, Liu, J, Wang, Y & Martinez, L 2018, 'A Micro-Extended Belief Rule-Based System for Big Data Multi-Class Classification Problems', *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, pp. 1-21.
- Yang, L, Liu, J, Wang, Y & Martinez, L 2018, 'Extended Belief-Rule-Based System with New Activation Rule Determination and Weight Calculation for Classification Problems', *Applied Soft Computing*, vol. 72, pp. 261-272.
- Zhang, S, Ng, WY, Zhang, J, Nugent, CD, Irvine, N & Wang, T 2019, 'Evaluation of Radial Basis Function Neural Network minimizing L-GEM for Sensor-based Activity Recognition', *Journal of Ambient Intelligence and Humanized Computing*, pp. 1-11.
- Zheng, H, Wang, HHY, Dewhurst, R & Roehle, R 2018, 'Improving the Inference of Co-occurrence Networks in the Bovine Rumen Microbiome', *IEEE/ACM Transactions on Computational Biology and Bioinformatics*.

3.2 Books/Chapters in Books

Boger, J, Jutai, J, Moorhead, A, Mulvenna, M & Bond, RR 2019, Ethical Issues in Technology for Dementia. in A Astell, S Smith & P Jodrell (eds), *Using Technology in Dementia Care: A Guide to Technology Solutions for Everyday Living*. 1 edn, Jessica Kingsley Publishers, pp. 43-66.

Gibson, A, McCauley, C-O, Mulvenna, M, Ryan, A, Laird, L, Curran, K, Bunting, B, Ferry, FR & Bond, RR 2019, How Usable Are Usability Tests? Examining the Suitability of Standard Usability Testing Methods for the Assessment of Apps for People Living with Dementia. in HM Fardoun, AAM Hassan & ME de la Guía (eds), *New Technologies to Improve Patient Rehabilitation: 4th Workshop, REHAB 2016, Revised Selected Papers. Communications in Computer and Information Science*, vol. 1002, Springer, pp. 126-143, REHAB 2016, Lisbon, Portugal, 13/10/16.

Mulvenna, M & Bond, RR 2019, *Proceedings of the 31st European Conference on Cognitive Ergonomics*. Association for Computing Machinery, New York, NY, USA.

Roy, S & Hinchey, M 2018, Apoptotic Computing: Programmed Death by Default for Software Technologies. in M Hinchey (ed.), *Software Technology: 10 Years of Innovation in IEEE Computer*. First edn, 10.1002/9781119174240.ch5, John Wiley & Sons, Inc., pp. 93-106.

Wang, HHY, Wassan, JT & Zheng, H 2018, Measurements of Accuracy in Biostatistics. in S Ranganathan, M Gribskov, K Nakai & C Schönbach (eds), *Encyclopedia of Bioinformatics and Computational Biology*. vol. 1, Elsevier, pp. 685-690.

Wassan, JT, Wang, HHY & Zheng, H 2018, Machine Learning in Bioinformatics. in S Ranganathan, M Gribskov, K Nakai & C Schönbach (eds), *Encyclopedia of Bioinformatics and Computational Biology*. vol. 1, Elsevier, pp. 300-308.

Zheng, H, Hu, X, Callejas, Z, Schmidt, H, Griol, D, Baumbach, J, Wang, HHY, Dickerson, J & Zhang, L (eds) 2018, *Proceedings of 2018 IEEE International Conference on Bioinformatics and Biomedicine (BIBM)*. IEEE.

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 JAD McLaughlin Prof CD Nugent	Connected Health Innovation Centre (CHIC)	Invest NI	£624,600.00
Prof SI McClean Prof B Scotney Dr AA Moore Dr D Charles Dr S Zhang Dr Z Lin Mr J Rafferty Prof CD Nugent Prof GP Parr Prof Philip Morrow Mr W Revels, BT Prof N Azarmi, BT	BT-Ireland Innovation Centre (BTIIC). An International Centre of Excellence for Industrial Research and Engineering	British Telecom	£6,193,427.00
Prof JAD McLaughlin Prof D Finlay Dr I Cleland Dr PJ McCullagh Prof CD Nugent Dr J Synnott Dr N Soin	Connected Health Innovation Centre (CHIC) Phase 2	Invest NI	£441,640.00

Portfolio of Research Grants awarded during period 1 August 2018 - 31 July 2019

Unit of Assessment Member	Title of Award	Funding Body	Value
Prof P Moore Alan Hook Prof F Lyons Tom Maguire Justin Magee Prof Karen Fleming Dr E Magennis Prof K Hutchinson Dr D Charles Dr C Fitzpatrick Alvarez-Casado Dr D Keeney, QUB Dr F Schroeder, QUB Dr K Rafferty, QUB Dr M Doherty, RTE Dr P Hanna, QUB	Future Screens NI	AHRC	£5,625,772.00

Mr Donal Phillips, Northern Ireland Screen Mr G Patterson, QUB Prof D MacSithigh, QUB Prof M Alcorn, QUB Prof R Deazley, QUB			
Prof CD Nugent Dr I Cleland	Opportunity Led Scheme	HSC R&D, PHA (Dfe match funding)	£164,000.00
Dr DH Glass Dr M McCartney	Conjunctive Explanations: how science and religion can work together	The Templeton Foundation	£381,685.00
Dr R Bond Prof SM O'Neill Prof H Zheng Prof MD Mulvenna Prof MF McTear Dr G Chollet, Intelligent Voice Ltd Gavin McConvey, Action Mental Health Matthias Hemmje, Globit Globale Prof A Esposito, Universita Degli Studi Prof M Ines, Universidad de Pais Vasco Prof Titular de, Universidad de Granad Wolfgang Minker, Universitaet ULM	MENHIR: Mental Health Monitoring Through Interactive Conversation	CEC-H2020-MSCA-RISE	£71,971.00
Prof H Zheng Dr A Moorhead Dr HY Wang Dr R Bond Prof MF McTear Andreas Hundsorfer. Incontec GMBH Andreas Hundsorfer. Incontec GMBH Orazio Miglino, Universita Degli Studi D Prof D Heutelbeck, FTK Forschungsinstit Prof M Hemmje, Globit-Globale Prof P Bouquet, OKKAM SRL	Stop: Stop Obesity Platform	CEC-H2020-MSCA-RISE	£61,715.00

Prof H Zheng Dr HY Wang	Co-funded PhD Studentship: Development of an integrated metagenomics analysis system using the microbial community, their community, their genes and biological mechanisms to predict cattle phenotypes	SRUC	£39,556.00
Prof SM McDonough Dr D Charles Francesco Barbabella, Tech4Care (IT) Giovanni Lamura, INCRA IT Norma Barbini, INCRA IT Rytis Maskeliunas, Kaunas Uni of Tech	Training ergonomics, self-managemtn and health behaviour strategies to mature workers suffering from chronic low-back pain (MY-RELIEF)	C.E.C. Erasmus+	£39,842.00
Dr R Bond Prof SM O'Neill Dr S Loane Prof E Ramsey Prof MD Mulvenna Prof MF McTear Anna Karjalainen, Kuopio Crisis Centre Annika Nordstrand, Region Norrbotten Catrine Kostenius, Norrbottens Kommuner Gavin McConvey, Action Mental Health Hannele Turnen, University of Eastern Finland Lena Abrahamsson, Lulea Uni Of Tech	Conversational Interfaces Supporting Mental Health and Wellbeing of People in Sparsely Populated Areas - VoicePal	Interreg NPA Prep	£25,895.00
Prof H Zheng Dr HY Wang Prof SI McClean	eZiGait	Invest NI	£107,036.00
Dr R Bond Prof CBT Moore Prof D Finlay Prof JAD McLaughlin	Smart Theatre Data Science and Object Tracking for Image Guided Therapies	EPSRC via IGT	£39,641.00

Dr M Ketola Dr M Braniff Dr SP McDowell Dr J Liu Dr R Bond Prof MD Mulvenna Dang Nguyen Anh, Vietnamese Acad Dr R Velazquez Leyer, Universidad Iber Frauke Urban, Royal Inst of Tech Johan Nordensvard, Uni of Stockholm	Understanding remote and resilient communities: environmental management, sustainable development and conflict	Department for the Economy-GCRF	£19,395.00
Dr MF Garcia-Constantino Dr I Cleland Dr J Synnott Mr J Rafferty Prof CD Nugent Mr A Ennis Prof J Beltran, CITEDI Prof J Favela, CICESE	Low-cost monitoring to assist people with dementia and their caregivers using smart microphones	Department for the Economy-GCRF	£18,635.00
Prof JG Wallace Michaela Black Prof MF McTear	KTP Programme between University of Ulster and Kraydel Limited	Innovate UK/INI and Kraydel Limited	£242,280.00
Prof H Zheng Dr F Browne	KTP Programme between University of Ulster and Datactics Limited	Innovate UK/INI and Datactics Limited	£143,288.00
Prof SM O'Neill Dr E Ennis Dr R Bond Hui Wang Prof MD Mulvenna	Evaluation of interventions on bridges on suicidal behaviour - a secondary data analysis	Samaritans Enterprises Limited	£7,500.00
Prof JAD McLaughlin Prof D Finlay Dr R Bond Mrs A Blair	Southern Health & Soical Care Trust PhD student costs for ECME Project	INTERREG VA	£258,865.00

Dr C Hughes Dr R Price 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	£39,965.00
Dr HY Wang Prof H Zheng	Development of a novel database and evaluation tool for nutritive values of white clover herbage	AFBI	£74,361.00
Tanya McCance Dr D Brown Prof CD Nugent	Co-producing a person-centred cancer nursing implementation project (continuation)	HSC R&D Public Health Agency	£28,119.00