

Institution:

Edinburgh Napier University

Unit of Assessment:

Unit of Assessment 11 - Computer Science and Informatics

1. Unit context and structure, research and impact strategy

Computing and Informatics at Edinburgh Napier University (ENU) comprises 62 Category A staff. 41 (66.1%) are significantly responsible for research (SRR) according to our Code of Practice, and therefore included in our REF submission. 61 of these staff are members of the School of Computing (SoC).

The vision of the School is:

To deliver research and teaching in computer science that improves lives in the UK and beyond. Improvements range from technology with impact in national, economic and personal security; applying artificial intelligence to benefit the environment; bringing technology into homes and spaces to improve wellbeing; the use of information for societal development; and innovation in learning approaches to promote aspiration and inclusion.

Structure

As noted in REF5a, in 2015 a University-wide decision was made to integrate research institutes within School structures. This offered an opportunity to re-organise research within the School of Computing in a way that reflected areas of strength and critical mass.

Four clusters were formed as detailed below, each led or co-led by a senior academic who provides over-arching vision and strategic direction. Each cluster provides opportunity for cross-collaboration on a broad range of topics, while specialism subgroups within each cluster meet on a weekly basis. A School Head of Research (currently Prof. **Paechter**) provides overall strategic direction for the School's Research. The clusters are:

- Cyber Security and Cryptography (eight staff SRR)
- Internet of Things (IoT) and Smart Systems (nine staff SRR)
- Applied Artificial Intelligence (AI) & Data Science (15 staff SRR)
- Creative and Social Informatics (13 staff SRR five submitted under UoA34)

The **Cyber Security and Cryptography Cluster** (Prof **Buchanan**) focuses on citizen-centric systems such as digital health. The *Cyber Systems and Cryptography* subgroup undertakes research around the creation, analysis and investigation of information systems which respect ownership, privacy, consent and governance. There is considerable overlap with the Applied AI/DS cluster in incorporating privacy-preserving and adversarial AI methods into these domains.

The **IoT and Smart Systems Cluster** (Prof **AI-Dubai** and Prof **Liu**) focuses on the design of cognitive and integrated solutions for smart connected spaces from interdisciplinary IoT and software engineering perspectives. It comprises two interlinked groups: the *IoT and Future Networks* Group (**AI-Dubai**), focusing on IoT and networking innovation across trusted infrastructures, and the *Intelligence-Driven Software Engineering* Group (**Liu**), that develops novel intelligent approaches, models and tools for new IoT-based smart systems.

Within the **Artificial Intelligence and Data Science Cluster** (Prof **Hart** and Prof **Hussain**), there are two research groups. The *Nature-Inspired Intelligent Systems* group (**Hart**) applies methods inspired by evolutionary and social systems in optimisation and robotics domains and to build socio-technical systems. The *Data-Science group* (**Hussain**) aims to advance and integrate cross-disciplinary, problem-driven research across Data Science and AI, combining



theory and practice. Areas of particular focus are text analysis and natural language generation, and visualisation, with an emphasis on explainability.

The **Creative and Social Informatics Cluster** (Prof **Hall** and Dr **Smyth**) has two groups. The *Interaction Design Group* (**Smyth**) focuses on the design of technology to create novel products, services and experiences. The *Centre for Social Informatics* (**Hall**) provides critical perspectives on sociotechnical interactions across a range of subject areas. As this group conducts interdisciplinary work connecting technology with social-science, the majority of its staff are returned under UoA34, although many of the funded projects and PhD supervisions within the group are collaborations with staff submitted under UoA11.

Additionally, the new research **Centre for Computing Education** (Prof **Smith**) was formed during this period. This is a developing area that builds on teaching excellence in the school to focus on student placements, work-based learning, digital skills development and educational models in the context of widening participation and inclusion (one person is SRR).

A bi-weekly meeting of all Heads of Research groups, chaired by the Head of Research, ensures a collegiate atmosphere, facilitating inter-group collaborations. This is complemented by an annual School Research Conference, and an all-hands School Research meeting each January.

Weekly research-group meetings bring together PhD students, post-doctoral researchers and staff. We encourage cross-attendance of staff to promote inter-disciplinary work. The effectiveness of these meetings in fostering a sense of belonging and collaborative approach to working was clearly demonstrated during COVID-19, when meetings became virtual and provided an important focal point during the week. We firmly believe that this enabled us to continue to produce excellent research outputs and win funding throughout this period.

Strategy 2014-2020

Both the University Strategy 2020 (see REF5a) and our strategy in 2014 have set the agenda during the REF period. In 2014, we stated that we aimed to:

- increase the numbers of our PhD students
- grow our research income by working with SMEs and obtaining commercial income
- capitalise on key opportunities to grow research strengths

These aims have been achieved.

PhD students: we have successfully grown our PhD cohort. For REF 2014 we reported 20 PhD completions. **42** are returned for REF2021, i.e. a 100% increase.

Research income: external income for the previous period was £4,735,835 over five years. We have considerably exceeded this with a total income of £6,357,927 (an increase of 34.25%). We highlight significant *recent* successes in winning significant (>£100K) funding. A total of £4.5M in new project funding (including EPSRC/EU awards) has been won in 2020 and early 2021, but does not have spend in the period (3 projects had delayed starts due to COVID-19).

The **areas of research** which we identified for expansion in 2014 were *Digital Health, Urban Interaction Design, Autonomous and Adaptive Computing and Data Analytics.*

In Digital Health, the School has:

- Obtained a £3.2 million EPSRC programme grant (**Hussain**) under the Transformative Healthcare Technologies 2050 Call on cognitively-inspired 5G-IoT enabled, multi-modal Hearing Aids (COG-MHEAR, start March 2021, £1.3M).
- Led a Health Blockchain project (**Buchanan**), funded by Data Lab and Spiritus Development Limited (2017-2019, £122K). The partnership which included NHS National



Services Scotland successfully delivered trusted asset tracking using blockchain methods.

- Won a £86K DHI grant (Buchanan, 2018-21) "Next Generation Connectivity within Health and Well-being", to evaluate and demonstrate the potential of 5G connectivity within health care.
- Won a £215K DHI grant (**Buchanan**, 2018-20) to build a trust, governance and consent framework for health and social care applications, and develop new licencing models for companies to provide and consume health and social services.
- Appointed 3 ECAs (Pitropakis, McKeown, Tan).

In Urban Interaction Design, the School has:

- Led one and participated in two EU projects (UrbanIxD project (FET Open); MAZI project (EU CAPSSI); SpeculativeEDU (Erasmus+)).
- Won a Creative Informatics project (ENU, University of Edinburgh, CodeBase and Creative Edinburgh) (£7.5M total, £1.3 million to Napier) through the AHRC Creative Industries Cluster Programme.
- Appointed 2 ECAs (Sobolewska, McGowan).

This research has been supported by the creation of two new labs. The *Sensorium* focuses on biometric data for evaluation and the *E11 Studio* specialises in digital prototyping and the role of data in the creative industries.

In Autonomous and Adaptive computing, the School has:

- Invested in a swarm-robotics laboratory equipped with a swarm of 50 heterogeneous robots, and two research assistants to run it. This investment was fundamental in later securing a £366K 4-year EPSRC grant on robotics (**Hart**, 2019).
- Invested in 2 NAO robots, boosting our work in human-robot interaction and instrumental in an ECA (**Gkatzia**) securing a £280K EPSRC New-Investigator award.
- Won a £380K EPSRC project called "Keep Learning" in December 2020 (Hart).
- Appointed 1 ECA (Steyven).

In Data Analytics, the School has:

- Appointed two senior professors bringing expertise in privacy-preserving and explainable machine-learning, with a focus on health applications (**Hussain**, 2018) and theoretical data-science (**Liotta**, 2019).
- Appointed two ECAs; **Methven** (data-science and visualisation), and **Giuffrida** (machine learning and computer-vision).
- Won significant funding, including; £416K through the EPSRC Responsible NLP for Intelligent Interfaces Call (Gkatzia, Hussian), ranked 1/19 at panel, £232K from a Government funded project (Hussain) to develop a CovidDashboard through analysis of social-media, and Methven (partnering with Heriot-Watt) on Graphical Explainable AI (EPSRC, £49K). A further 3 KTP projects were awarded in the areas of data-analytics and visualisation with Standard Life, Zonefox (Kennedy) and Verint (Hart).

In addition, in *IoT and Smart Systems* the School has:

- Won a major EU award for a project named CAROUSEL (**Mitchell**, **Koniaris**, **Kennedy**) (start March 2021), using Augmented Reality (AR) and Artificial Intelligence (AI) technologies to improve experience and social interaction in live virtual/hybrid events.
- Won a MSCA Horizon 2020 grant (2016-2018), CAR (Liu) to develop context-active, resilient cyber-physical systems.
- Established worldwide research networks through international exchange programmes funded by the Royal Society of Edinburgh (Liu), by chairing and delivering keynotes at international conferences, and through journal editorships.



• Appointed 5 ECAs (Ahmed, Chrysoulas, Koniaris, Jaroucheh, Ghaleb).

Enabling Impact

The majority of the research undertaken in the School is in areas where the route to impact can be clearly articulated, although some of our work is at a foundational level, where impact will only be achieved in a longer timeframe. All areas of research identify potential partners in the private, public and third sectors, supported by RIE (see REF5a) through a dedicated Innovation Manager and a School appointed Enterprise lead. This includes supporting staff to:

- Use Scottish Funding Council (SFC) Innovation Vouchers to fund initial collaborations with companies (58 in total), with these providing a route to additional funding (e.g. follow up contract research with Deiseal Ltd).
- Work with the SFC Innovation Centres (DataLab; Censis, DHI) in order to collaborate on projects with local companies, ranging from SMEs to large providers (e.g. Datalab (Lothian Buses); CENSIS (Key Technologies); DHI (Glimpse Ltd)).
- Attend events such as the annual SICSA Demo-Fest/EiE in order to connect with potential partners (e.g. this led to a KTP with Verint (**Hart**)).
- Attend and run industry-focused events such as the Cyber Breakfasts hosted at ENU by the Cyber Academy, which invite leaders from industry and academia.
- Use the SFC internal GCRF funding scheme to support projects in low and middleincome countries. Examples include research on anti-phishing architectures with the Federal University of Agriculture, Abeokuta in Nigeria and a feasibility study to acquire and analyse images of plants from crops in Ethiopia with the use of machine learning algorithms (**Giuffrida**).
- Develop Knowledge Transfer Partnerships. 10 were awarded during the REF period in areas that include Data-Science, Visualisation, Cybersecurity and Interaction Design, collaborating with companies that range from multi-nationals (e.g. Standard Life/Verint) to local companies (e.g. DeltaDNA).
- Host knowledge exchange focused conferences, e.g. the International Conference for Big Data in Cybersecurity.

The effectiveness of our approach is further demonstrated by the success of the three spin-out companies that have resulted from our research in Cybersecurity (ZoneFox, Symphonic and CyanForensics), and the recent spin-out 3Finery from our research in augmented-reality. In 2018, ZoneFox was acquired by Fortinet for £28 million, and in 2020, Symphonic was acquired by Ping for \$31 million, both delivering significant return to the institution. Cyan Forensics is currently working with Police Forces across the UK in time-critical Child Sexual Exploitation and Counter Terrorism cases, and has won several awards. 3Finery, arising from research conducted via an EU project, has already attracted over £150K in investment funding.

We also continually build direct relationships with companies that can support and encourage impact from our research:

- We have provided physical space for companies to operate within the School in order to build collaborative relationships (e.g. SatisNET).
- Match-funding was provided by leading Blockchain company BlockPass to build an Advanced Blockchain Identity Lab within the School. The company also funded 2 PhD studentships.
- Datalab/Condatis have matched-funded a PhD studentship.

We currently have one Professor (**Buchanan**) and two Associate Professors (**Russell**, **Lawson**) who were promoted via the University's Enterprise pathway, recognising their contribution to working with industry and to knowledge transfer. We host a Royal Society Funded Entrepreneur in Residence (EiR) from 2021, with a remit to turn leading research and ideas into commercial impact and success. The EiR is Jamie **Graves**, who was once one of our PhD students, and for six years was CEO of the very successful ENU spinout ZoneFox.



Our success in delivering impact is recognised by considerable success in the Scottish Knowledge Exchange Awards. Our staff have twice won the Innovation of the Year award for their collaborations with external companies; in 2016 (Payfont, **Buchanan/Lawson**) and in 2019 (HAS Technology, **Buchanan/Smales/Lawson**). In 2018, **Buchanan** was awarded the Outstanding Contribution to Knowledge Exchange award for engagements that contributed greatly to growing a thriving Scottish cyber security community, drove improvements in business resilience and incident response, and led to innovations in health and social care. **Lawson** was appointed at the SICSA Director of Knowledge Exchange (2016-2019), recognising our experience in engaging with companies.

The School provides the necessary investment to ensure impact can be realised. One aspect of this is employing part-time Professors/Research Staff who hold significant posts in industry. For example, **Mitchell**, an employee at Disney and now Roblox, has been employed on a 20% FTE contract since 2013. This close collaboration has facilitated an impact case-study on pioneering breakthroughs in visual media production. **Mitchell** also played a key role in a consortium that was successful in obtaining a Marie-Curie-Sklodowska ITN (DISTRO), and a FET Proactive project CAROUSEL awarded in late 2020. The work conducted via DISTRO led to proof-of-concept funding (InnovateUK, **Mitchell** in collaboration with PhD student), resulting in a spin-out company *3Finery*, launched in 2020. This has since won significant investment and has been widely reported in the media¹. **Mival's** research, which underpins a submitted impact case-study on **Blended Spaces**, led to him obtaining employment as a consultant in the User Design industry. The School facilitated **Mival** to move to a 0.2 FTE contract in order to continue to bridge the role between our research and industry and further develop impact.

We support impact by covering the costs of patents arising from research. These patents have contributed to the impact reported in *three* of the submitted case-studies, each of which has led to the formation of a spin-out company: (1) Enabling Sensitive Personal Data to be Shared with Trust using Novel Digital Security Methods (*CyanForensics*); (2) Protecting Employees, Children and Sensitive Data using Innovative Approaches to Cyber Security (*Symphonic*); and (3) Visual Media Production (*3Finery*). The School later enabled the spin-outs to buy back these patents in order to progress their business. The same support is being provided to a new spin-out in 2021 (*Memcrypt*) (**Buchanan**). Profits returned from spin-outs are re-invested within the School to facilitate further research (e.g. three new PhD studentships in Cyber-Security funded following the acquisition of ZoneFox).

Our impact strategy includes physical space provided free of charge at the early stages of spinout development or host investor meetings. This approach facilitated the two impact-case studies relating to trust and privacy. In relation to the **Blended Spaces** impact case-study, School funds were used to build dedicated laboratory spaces. An initial investment of £60,000 in hardware and software was provided in 2009 by the School for the creation of the ICE (Interactive Collaborative Environment), which served as a foundational bedrock for practical development work used to enable research and industry collaborations. A further investment of £30,000 by the School in 2016 enabled an upgrade to the space providing additional functionality. Joint investment from the University and School of £45,000 enabled the creation and installation of Lions' Gate Garden within the campus, which also forms part of the casestudy.

Interdisciplinary research

To further interdisciplinary collaborations within the institution the School invests in an internship programme, which enables recruitment from our undergraduate student-body to research assistant positions to work on cross-school projects. Recent examples include collaborations with:

¹ https://www.scotsman.com/business/edinburgh-napier-spin-out-makes-objects-come-life-augmented-reality-tech-3009297



- The School of Engineering and the Built Environment, using machine-learning to determine the carbon-cost of buildings, integrated into a published plug-in on Google Sketchup (Hart).
- The School of Applied Sciences, where we developed a smart-phone app to support citizen-science data-collection for crab fishing in Brazil (Hart, Wells, Urquhart), and a tool to analyse the data. This work is submitted as an impact case-study in UoA3.
- The School of Health and Social Science, taking advantage of their hospital simulation to gather real-time sensor data in health-setting, integrated with a blockchainbased infrastructure (Buchanan).

The Centre for Social Informatics is situated within our School and provides significant opportunity for cross-disciplinary work. Staff returned under UoA11 (Smith, Gkatzia) cosupervise PhDs funded by the Scottish Graduate School of Social Science, in conjunction with staff returned under UoA34. Gkatzia has secured a further award under this scheme for a studentship in 2021, co-supervised with the Business School. Hart is co-supervisor on a PhD studentship awarded in via the NERC funded SUPER Doctoral Training Programme in the School of Applied Sciences. Moradpoor jointly supervised a recently completed PhD student in the School of Engineering and the Built Environment.

We are probably the only School of Computing in the UK to employ a glassmaker (**Panneel**) as a Research Fellow as part **Smyth**'s project on Creative Informatics (focusing on creating tools to monitor carbon impact in the craft sector). This project engages with the creative sector to develop the data driven skills necessary to create the next generation of products, services and experiences. **Panneel** is also working with British Council Nepal, Kathmandu University and Applied Arts Scotland as part of the countdown to the UN Climate Change Conference (COP26).

We seek external opportunities to collaborate on interdisciplinary work, and outputs from these projects are included in our submission. **Powers (2019)** was awarded an interdisciplinary Fellowship from the Institute of Liberal Art and Sciences, Keele University to work on sociotechnical approaches to balancing energy consumption in smart energy networks. **Giuffrida** conducts interdisciplinary research with plant biologists at the University of Edinburgh and Scotland Rural College, focusing on image analysis of crops. **Hart** has an ongoing collaboration with Forestry researchers from France and Japan, and represented the Computer Science field at an international workshop on Mathematical Modelling of Wind Damage to Forests (France, 2015).

Open Research

Computer Science is a fast-moving subject and hence we recognise that Open Research is critical. All staff act in accordance with University Open Access policies described in Ref5a. In addition, we encourage:

- Open access to code through repositories such as GitHub. Staff are encouraged to publish links to repositories for outputs or make use of journal specific repositories for supplementary material.
- Publication of datasets to promote open-research. Data is stored in the University managed Data Repository with a DOI.
- Use of research-focused platforms such as ResearchGate and Kudos to share publications and data, given the fast publication of computer science papers in conferences.
- Public engagement activities to disseminate research results.

To support this, these policies are disseminated widely through School committees and research groups. All proposals are peer-reviewed to ensure that a clear open-access strategy is embedded from the outset.

We support a culture of research integrity, guided by the institution policies described in REF5a. Responsibility is devolved to the School Research Integrity Committee (supported by a cross-



school group), and provides ethical approval for all project proposals/data-collection. The role holder reports quarterly to the University Research and Innovation Committee. Research Integrity is an integral part of the bespoke PhD training that we offer to our own PhD students in addition to institutional training. A bespoke Research Integrity & Ethics website has been put in place specifically targeted at SoC staff and Research Students.

Future Strategy over next 5 years

We start the new REF period in an excellent position having recently been successful in winning a number of major grants due to start in 2021. In line with the new University Strategy launched in 2021, and in particular the formalization of research entities (REF5a), we are currently in the process of formalising our research groups into five Research Centres; Centre for AI and Data-Science, Cyber-Security & Cryptography, Social and Creative Computing, IoT and Smart Systems Centre, and Computing Education Research. These roughly correspond to existing informal clusters and to the new education group outlined above. Centre proposals are currently going through an approval process at University level. Each Centre will have agreed research objectives regarding annual research deliverables. All staff, contract researchers and PhD students will align with a Centre.

In line with the pillars described in REF5a that underpin the new strategy, our School Enterprise Lead will focus on *innovation*, working in tandem with the Innovation Hub to understand where research may lead to spin-out companies. The role-holder will work closely with the newly appointed RSE Enterprise Fellow.

With regard to the **people** pillar of the new strategy (REF5a), we will benefit from University investment in *three* areas: IoT, CyberSecurity, and Machine-learning. A Professor, ECA and two studentships will be appointed in *each* area. Similar institutional investment in Health Technologies will also benefit the Unit, building on our recently awarded Programme Grant (EPSRC Transformative Healthcare Technologies for 2050). Further School investment in a new Professor of Human-Computer-Interaction will provide new leadership in Creative and Social Informatics in the area of design.

We expect to increasingly focus on interdisciplinary research, facilitated by the new crossuniversity themes (REF5a). Across the five Centres, there is significant potential for collaborative working across all themes, exploiting our existing portfolio. We are currently investing in new infrastructure to create a **Computational Sustainability Laboratory** to act as a focal point for interdisciplinary work in **cyber-physical sustainability/ IoT** research.

COVID-19 presented an opportunity to develop a new online seminar programme in which we invited world-class researchers from a variety of disciplines to discuss their research throughout the lockdown periods (with invitations extended to researchers from across Scotland). We intend to continue to operate this scheme when we return to campus-based operations, as a way to continue to engage with global cutting-edge research, enhancing both our culture and external networks.

2. People

Since 2014 our staffing strategy has been driven by our vision to increase the quality of research, and to grow existing areas of excellence in which we have critical mass. All new staff are expected to have a PhD and are recruited through a rigorous selection process that includes a research presentation. We ensure that research interests of potential staff are aligned with existing areas of strength, believing that research cannot be conducted in isolation. Since 2014, we have recruited 24 new staff who are returned in this REF (two Professors, with the majority initially appointed at lecturer level).

95% of the 41 staff who are significantly responsible for research in UoA11 are on permanent contracts. The two staff on non-permanent contracts at the census date are now employed on



permanent contracts as ECAs. 32% of staff are ECA (lecturer, grade 6), 27% are lecturers (grade 6, non ECA at grade 7), 15% are Associate Professors, and 2% are research-staff. 24% are Professors. This represents a healthy pipeline of research-active staff to sustain future activity, particularly given that 32% of staff are ECA. Two of our staff initially appointed in the REF period as ECAs were promoted to Associate Professor in 2020.

As noted in REF5a, staff wishing to pursue a research career are typically recruited onto the Research Pathway of the University Promotions Framework and are guaranteed at least 0.2 FTE of protected research time in addition to time bought on funded projects. The School has a local policy of allocating an additional 0.1 FTE research allowance to new staff in their first year. Where external research work brings esteem and influence to the School (e.g. appointments to the SICSA research pool/UKRI activity/journal editorships) staff are given additional protected time. Where a person makes a specific request for additional research allocation to deliver beyond normal expectations (e.g., to lead a bid for a major project), up to an additional half a day a week of ENU funded research work is allocated on a temporary basis.

The vast majority of staff (83%) who are SRR align with the Research pathway in the promotion framework. Three staff (7%) align with the Enterprise pathway in recognition of the significant industry-focused slant of their research, while the remaining 9% (four staff) align with the Learning and Teaching Pathway. Annual objectives and research-related development needs are agreed through the MyContribution process outlined in REF5A.

The School is also committed to increasing the percentage of staff holding a PhD. Where appropriate staff are encouraged to undertake a PhD part-time. Two submitted staff (**Sobolewska/McGowan**) completed PhD's by this route. Support for staff undertaking PhDs is provided in line with the University Policy in this area.

All new researchers, whether postdoctoral or ECA, are allocated an experienced member of staff (often a research professor) as a mentor and are encouraged to form new internal collaborations. Mentoring in writing research proposals is provided through the mentor and the School Research Quality panel. School-funded PhD studentships are targeted to all new members of staff with directed adverts. Where possible, ECAs are appointed as additional supervisors on PhD supervision teams (9 of the 13 ECAs returned are currently members of one of more supervisory teams).

All ECAs are strongly encouraged to apply for external funding, and specifically to UKRI new investigator schemes. **Gkatzia** (now Associate Professor) achieved this when appointed as an ECA. Postdoctoral researchers are integral members of research groups and are encouraged to supervise MSc dissertations. **Methven** obtained EPSRC funding in collaboration with Heriot-Watt. ECAs and postdoctoral researchers are supported to apply for funding as research co-investigators. Two ECAS have found success as Co-I's on EU Framework Programme grants awarded in 2020; **Koniaris** (CAROUSEL, £812K) and **Chrsyoulas** (GLASS, £190K). They are also encouraged to apply for centralised funding schemes discussed in REF5a. School-specific schemes that have been set up to specifically support our researchers are weekly "*Write-Now workshops*" and a series of "*MasterClasses*" organised by PhD students, bringing in external speakers to focus on soft skills specific to Computing not covered by the University's centralised training programme.

The School supports, where possible, requests by staff (at any level or on any contract) for periods of research leave where the member of staff presents a specific proposal with tangible objectives, for example, by condensing teaching allocation into a single semester.

All overheads brought in from externally funded projects are allocated to the School budget to supplement the SFC Research Excellence Grant, to support staff research activities. We set aside funding to enable staff who have published papers in conferences but do not have external funding to attend conferences as this facilitates networking and development. These funds also enable purchasing of additional research equipment to support areas which are achieving



impact/publishing excellent research. ECRs obtaining first-grant funding are guaranteed an additional PhD student from school funds (e.g. **Gkatzia**), and where funding applications can be enhanced by additional PhD students we guarantee to provide this (e.g. three PhD students allocated to **Hussain**, Programme Grant starting 2021).

Research students

PhD students are recruited in line with existing areas of research. On average, we fully fund three new students each year, representing a significant portion of funding. 42 students have been awarded PhDs within the REF period, a significant increase on the 20 completions reported in REF2014, with 19 different staff acting as Director of Studies.

We recognise the importance to research of the student body, and in the absence of being part of any CDTs, make considerable effort to grow our student body in other ways. All research active staff have the opportunity to have at least one permanent advert on FindAPhD to attract self-funding students. Completing students were funded via a variety of sources, including University 50th Anniversary scholarships (see REF5a), studentships via internal funding from overheads, EU Marie-Curie International Training Networks, and self-funding. We have a formal relationship with King Abdulaziz University in Saudi Arabia to jointly supervise students who are awarded degrees by ENU. We allocate local supervisors in Saudi and ensure the students have the required training while fees are reduced by 50%. Three students have graduated so far via this programme. We also have a joint agreement with the Technische Hochschule Mittelhessen, Germany. One student has completed and one is in progress.

Looking forward, we have signed an agreement Hashemite University, Jordan, starting in 2020 on the same model as described with Saudi Arabia. A further agreement with China Guang Xi University of Science and Technology, China, starting in 2020, is now in place, where students spend 18 months at ENU and the rest of the period in China. Two studentships were recently funded in the area of CyberSecurity by Blockpass.

Working with industry we successfully bid for a Doctoral Training Centre with EIT Digital, which will start in April 2021 This has matched funding for up to 16 PhD studentships. Where industry provides funding towards a studentship, the School matches that funding in the same research area, e.g. we have matched funded a studentship in collaboration with the University of Oslo (CyberHunt – part of the IKTPLUSS program funded by the Research Council of Norway) around the sharing of threat hunting information within distributed ledgers, and a second via Data Labs/Condatis, relating to privacy-preserving behavioural analysis.

We encourage KTP Associates to register for a research degree, providing a fee waiver (one current PhD student, one student graduated with MRes). Recognising that a position in industry is often more lucrative than a PhD scholarship for many Computer Science graduates, we provide fee-waivers to students who wish to study part-time while working. This also attracts those who have caring or similar responsibilities. We take advantage of being co-located with researchers from the Centre for Social Informatics, which had membership of the ESRC Scottish Doctoral Training Centre (DTC) from 2011-2017, and of the new Doctoral Training Partnership (DTP) from 2018, enabling UoA11 staff to co-supervise projects. In this period, two staff (**Gkatzia, Smith**) have taken advantage of this, with a further two projects awarded to start in 2021 (**Gkatzia, Smith**, **C., Smith**, **S.**). Staff also collaborate in joint-supervision activity with other universities. **Mitchell** has co-supervised two PhD students at UCL, and one PhD and one MPhil thesis at Bath. **Hart** is currently jointly supervising a student at Imperial College London.

In order to be inclusive in our selection of students for funded studentships, we recently updated our selection processes to move away from formal interviews towards a more collaborative experience, that explores the candidates research ideas with relevant colleagues in an informal and supportive setting. This moves the emphasis toward selecting based on what the students will be required to do, rather than on their interview style, which might be influenced by culture or neurodivergence.



PhD supervision arrangements follow those outlined in the REF5a. 89% of students reported they are happy with supervisor contact (PRES.) We ensure that the individual student experience is an excellent one, monitored through panel chairs, student representatives, and our action plan in response to PRES. 89% reported in PRES that they have developed the ability to communicate to diverse audiences, 89% report they have established contacts and networks outside of the university, and 94% report that they have increased their confidence in their abilities to innovate and be creative.

All students undertake a core programme of training offered centrally by the University. In addition, a series of Departmental Masterclasses with external speakers provides subject-specific training. During the period, we ran a series of fully funded three-day residential retreats with student organised activities, which we intend to reintroduce post-COVID-19. Two student-representatives take part in the School Research and Innovation Committee, ensuring a smooth working relationship between staff and students.

Students take on developmental roles, such as Seminar Coordinator. Our students have been selected to participate in the organising committee of the annual SICSA PhD conference, providing valuable skills in team-working and conference organisation. Students also have the opportunity to undertake limited teaching duties for their own career development as graduate teaching assistants, and all PhD students are offered a specifically designed Associate Lecturer (PhD Student Experience) contract to facilitate this. Our students are also able to take advantage of the SICSA PhD Peer Support Network, a network of Support Volunteers across all Scottish Institutions, run by PhD students for PhD students, and supporting mental health.

An annual School PhD conference is organised by the students themselves to showcase student work across all levels. The School has put in place mentoring and career support for students in their final year to ensure that all avenues for continuing the research have been explored, for example contributing to a funding application naming the student as the preferred researcher.

The strength of our training and support is reflected in students winning awards at major conferences. Since 2014, our students have produced five Patents and received eight best paper awards at leading international IEEE/ACM Conferences, including IEEE IUCC 2015, IEEE SmartloT 2019, IEEE FedCSIS and ACM MOMM 2014 and ACM GECCO 2019. Two of our students working on routing protocols contributed to the International standardisation in Internet of Things protocols (**Ghaleb**, **Qasem**) via the Internet Engineering Task Force (IETF). Our PhD students work has directly contributed to the spin-out of companies (CyanForensics, 3Finery, Memcrypt). They have also gone on to gain post-doctoral/academic positions in leading research institutions such as the University of St Andrews, University of Exeter and Heriot-Watt. Other students have gained employment with prestigious companies such as IBM, Dell Secure Works and China Mobile.

Equality and diversity

The School obtained Athena Swan Bronze award in 2017 and will apply to renew this. The School Inclusion Monitoring Committee (see REF5a) is responsible for monitoring E&D data, ensuring processes are followed and reasonable adjustments are put in place.

In terms of gender profile of our submission, 15% of our total return (41 staff) is female which is consistent with typical profiles for this subject. This represents 43% of the eligible pool, compared to 73% of the eligible male pool being returned. This figure is slightly higher than the 42% of eligible female staff returned at institution level, as reported in REF5a.

67% of the six eligible staff identifying as Asian are returned, 100% (one person) of those identifying as Mixed, and 100% (5 people) of those identifying as Other. No Category A staff identify as Black. 100% of Category A staff who identify as bisexual/gay/lesbian are returned. Three out of four Category A staff who have declared a disability are included in the submission (75%). 78% of those identifying as Christian are returned; 82% of those with no-belief and 83%



of those with other beliefs. 68% of Category A staff that are married are returned, with 80% of single.

The age-profile of researchers within the School is as follows, reported as % of submitted staff. Age range 25-35 (12%), 35-45 (32%), 45-55 (39%), 55-65 (17%). This reflects the new emphasis on recruiting research-active staff in the earlier parts of the career over the period, while recognising the overall shape of the School is still influenced at the older end by a more teaching-centric focus prior to REF 2014. Close monitoring of diversity takes place at the Inclusion Monitoring Group which gives confidence that we reflect our stated E&D values. The data provides robust evidence that there is no discrimination against staff with protected characteristics being deemed SRR.

SoC adopts the University maternity/paternity leave policies, and encourages flexible working patterns, particularly for those with caring responsibilities. Three staff have taken maternity leave during the REF Period, all returned as SRR. We support research staff returning to work after leave, and they are offered the opportunity to attend a conference on return to work (without a publication) to facilitate transition back to academic life. We offer child-care to support staff and PhD students attending residential events. Meetings are organised between the hours of 10-4 to facilitate those with caring responsibilities. Following agreement with a line-manager, staff are supported to work flexibly and at home where required. E&D considerations are taken into account during promotion panels and staff are supported by line-managers during annual reviews to ensure additional support needs are met where possible and to accommodate flexible working requests. Our female staff have a 50% success rate in promotion, comparable to the success rate for male staff of 55%.

Our Code of Practice outlines the procedure for *identification* of staff who are SRR. It further outlines the policy for output-selection for these staff which is based only on quality. In UoA11, when considering outputs of *equal quality*, our selection process aimed to equalise the number of output authorships per staff member as far as possible.

The School maintains an "Inclusion Station" within a social area. Inclusion stations make a visible commitment to creating an inclusive environment. The Inclusion Station is a place to celebrate achievements, promote events and share ideas. A range of texts on inclusion are available to freely borrow.

3. Income, infrastructure and facilities

Our income overall has grown substantially since our 2014 submission. External income for the previous period was averaged at £0.95M per year over 5 years. This has grown to £1.27M per year over this REF, an increase of £1.6M in total. COVID-19 has had some impact on income in the final months of the REF period in that it has delayed the start date of three awarded EPSRC grants until late 2020/early 2021.

The biggest sources of contribution are EU (27%), UK Government & Authorities (25%), UK industry and commerce (21%), Research councils (17%). We have seen a significant rise in **EPSRC** funding with four major new grants awarded or starting in late 2020 and early 2021 totalling £2.45 million pounds (1. **Gkatzia**, 2. **Gkatzia** (with **Hussain**), 3. **Hussain** (with **Hart, Al-Dubai, Buchanan**), 4. **Hart**) and two new **EU** funded projects totalling £1.08 million (Carousel £898,000 (**Mitchell**, **Kennedy**, **Koniaris**), Glass £190K, (**Buchanan**, **Chrysoulas**)). These successes reflect our collaborative and inclusive approach to funding.

External funding is directly linked to many of high-quality outputs submitted. For example, the EPSRC funded life-long learning project generated a number of articles in leading optimisation journals, and DISTRO (EU) led to high-quality publications in leading graphics journals and a spin-out. Work in the IoT/Smart Systems funded through EU or other international funding has generated outputs that have underpinned recently won funding, e.g. the COG-MHEAR programme grant.

Our focus has been on developing and sustaining research areas which have attracted external income, or have high potential to do so, while recognising the need to be bold in supporting new ideas and researchers at an early stage in their careers. We specifically encourage partnership with industry, reflected in **ten KTP** projects being awarded this period. The impact our research has is reflected in £200K in Proof-of-Concept funding from Scottish Enterprise/Innovate UK and in 64 collaborations with local companies via SFC funded Innovation Vouchers. The recent successes reflect the increased emphasis placed on providing training for researchers through the centralised RIE support (REF5a), combined with mentoring and support within the School.

Since REF2014, the School has made significant investment in research facilities in line with our core areas of research that have been key to winning funding and supporting impact. The School has invested in:

- **A Swarm Robotics** laboratory, facilitating research on Evolutionary Robotics (including investment of £183,000 from the University Capital Fund), providing state-of-the-art camera monitoring, and 50 robots from multiple manufacturers. This underpinned a successful multi-institution EPSRC application (**Hart**, 2018-2022) which continues to deliver high quality research, and was pivotal in an RSE International Exchange award.
- The **Sensorium:** (£30K new equipment). A state-of-the-art laboratory that facilitates User Experience studies and research. The laboratory is equipped with sensors that measure physical, psychological, and neurological real-time responses to interaction with systems and services. These biometric data-streams are synchronised with audio and video data to produce visualisations that inform user-centred design and underpins some of the work reported in the Blended Spaces case-study.
- The **E11 Studio** (£120K in-kind contribution by the School to the AHRC Creative Informatics project) specialises in digital prototyping and the role of data in the creative industries and provides a space for researchers from the creative arts and informatics to work together. Provision of this support from the School was a key element of the submitted proposal that led to this funding.
- A Security Operation Centre (vSOC) (£50K). This enables research and training on scenarios such as ransomware, Denial of Service and data loss, all within a safe environment. This is a collaborative venture including leading companies involved in Cyber Security analytics such as CheckPoint, RSA, HPE, IBM and F5. A key part of the building this has been a partnership with an external company Satisnet, who build and run security operation centres. This infrastructure has facilitated a number of research projects, including an EU funded project on cyber-crime training (DFET, 2014-16).
- An **Advanced Blockchain Identity Lab** co-funded over a three-year period by leading Blockchain company BlockPass, which focuses on the rights of the citizen to privacy, while enabling new methods to provide citizen-focused systems, using blockchain and advanced cryptography methods. This led to securing a major EU funded project GLASS (2021-23).

The School also invested:

- £72,000 in a state-of-the-art high-performance cluster to support research within optimisation and data-science (2016) to support networking research.
- £10,500 on components and equipment for the Internet of Things lab.
- £9,000 on new equipment for the Auralisation research suite.

Companies who have provided the School with in kind investment to support our infrastructure include:

- £8,000 of GPU Equipment provided by Nvidia to support Games research.
- \$100,000 of CISCO Networking Equipment provided for the Internet of Things lab



4. Collaboration and contribution to the research base, economy and society

We work *collaboratively* with a large number of institutions both nationally and internationally. For example, joint UK-based research projects with other HEIs with spend reported in this REF include: EPSRC funded ARE (Hart: U. of York, UWE), Rigorous Graphical Explainable AI for Higher-Risk Applications (Methven: Heriot-Watt), and AHRC funded Creative-Informatics (Smyth: University of Edinburgh). Additional collaborative projects awarded but without spend during the period are COG-MHEAR (EPSRC; Glasgow, Manchester, Edinburgh), and Keep-Learning (EPSRC; St Andrews).

We have participated in collaborative projects with multiple European partners funded via the EU framework programs, e.g., DISTRO (**Mitchell**), MAZI (**Smyth**), CAR (**Liu**), FOCAS (**Hart**), Speculative Design (**Smyth**), and Clustering Creativity (**Morrisson**). We have won two Royal Society International Exchange Awards that fund international collaborations (**Hart** – South Africa, **Liu** -China). The success of our collaborative approach is reflected in our submitted outputs which include collaborators from across the globe, including UK, Europe, Middle East, China, and Australia.

We also place considerable emphasis on collaboration with industry. We have worked on **10 KTP** projects and won **64 SFC funded innovation vouchers** which fund short projects with Scottish industry. We have undertaken contract research with **8 companies** (e.g. HAS Technology, Payfont, BAE systems).

We further support collaboration through the appointment of Visiting Research Professors (currently two; **Pitt**, Imperial College London, and **Guckert**, Technische Hochenschule Mittelhessen). We hosted two visitors as part of the **HPC-Europa3 Transnational Access programme**, which facilitates scientific collaboration with visiting researchers from Europe (two further visits were postponed due to COVID-19). These have also resulted in joint publications.

At a national level, the School benefits from its membership of SICSA (the Scottish Informatics and Computer Science Alliance), a government funded pooling initiative of Computer Science departments across all Scottish Universities. Our staff play a significant role within SICSA. **Hart** co-chaired the Artificial Intelligence theme from 2016 to 2020, and **Gkatzia** was appointed as new co-lead in 2021. **Lawson** was the SISCA Director for Knowledge Exchange (2016-18). **Buchanan** is heavily involved in the SICSA Cyber Nexus, linking academia, business, government, the public sector and the third sector in the area of Cyber Security. Our staff are regular exhibitors at the annual SISCA Demofest which provides a forum for industry to engage with Scottish academics. A current KTP project (**Hart**) arose directly from a contact made at Demofest. **Gkatzia** was awarded a SICSA *Postdoctoral and Early Career Researcher Exchanges* (PECE) bursary to undertake a research visit to Germany (Bielefeld University). We have collaborated on two SICSA *Distinguished Visiting Fellow* (DVF) applications, hosting seminars from DVFs from the U.S and New Zealand.

Our involvement in the ORCA hub (part of the government's £93m R&D funding on "Robotics and AI for Extreme Environments" through the Industry Strategic Challenge Fund (ISCF)) led to a project (**Methven**) with Heriot-Watt on Rigorous Graphical Explainable AI for Higher-Risk Applications. Our involvement with the Scottish Innovation Centres has funded a number of research projects in collaboration with Scottish companies, including *Datalab* (5 projects), *Digital Health Institute* (6 projects) and *CENSIS* (1 project).

Engagement with diverse communities

We place considerable emphasis on Public Engagement, setting aside £20K plus staff time to support this annually. Our staff have published 51 articles in The Conversation about their research during the REF period, totalling 679,000 reads. This demonstrates a broad reach of our research to the wider public.

We take an active part in Edinburgh International Science Festival, ranging from running robotics



workshops (**Davison**) to appearing on panels in public discussions (**Hart**). We exhibited our robotics work at the Scottish Parliament (**Steyven**). **Smyth** coordinated the City | Data | Future exhibition created as part of the UrbanIxD project, exhibited in Venice, Aarhus, Pula, Split & Ljubljana, and now a permanent piece at the Museum of Contemporary Art, Zagreb, Croatia. **Buchanan** was co-creator and regular contributor to the Cyber Christmas Lectures, held every year across 6 Scottish cities. **Hart** has taken part in the UK initiative Pint of Science, delivered classes at the Canberra AI Summer School (open to the general public, undergraduates and researchers) and was recently a panellist at Holyrood Magazine's AI and Automation Conference, the premier gathering of senior AI and Automation professionals from across the Scottish public sector.

Our collaborations with sculpture park Jupiter Artland have both communicated and produced new research. As a response to **Flint** and **Turner**'s work on appropriation, a Minecraft facsimile of the park was constructed and used to explore remote engagement with the sculpture park leading to; an online Easter Egg Hunt and Sculpture Competition during COVID-19, a bespoke mixed-reality game release on the Android platform, and activities using the game at Edinburgh International Science Festival 2016 & 2017. Our work with the Whale Arts Agency on digimapping involved working with local children in an area of social deprivation to produce interactive maps of their area and led to a conference publication.

Impact of research not captured in impact case studies

Collaborative research during the REF period at the IoT and Smart Systems Cluster and the Applied AI and Data Science Cluster has pioneered innovations in partnership with industry, standardisation bodies, policy makers, clinicians and academics, from across the UK, EU, Australia, Canada, China, Middle East and the USA. Novel IoT communication protocols (AI-Dubai, Romdhani) and multi-modal Deep Learning (DL) algorithms (Hussain) were developed as part of interdisciplinary projects funded by industry and national and international funders (including the UKRI, EPSRC, Innovate UK, King Abdulaziz City for Science and Technology and NNSFC China). The work has directly informed development of international standards and commercialisation of innovative smart city transportation and healthcare applications. End-users include Neusoft, Nokia-Bell Labs, Phonak, Liaoning-Ruixiang General Aviation, ni2o, Nanjing Pudao and the Scottish Government (SG) COVID-19 Advisory Group. Al-Dubai and Romdhani have been instrumental in developing key protocol standards that addressed major limitations in current IoT communication standards in terms of load balancing, mobility and energy efficiency. Global impact on standards was realised by building prototypes and leading active participation of team members in two international technical standards bodies for communications, specifically the Internet-Engineering Task Force (IETF), the main international technical standards body governing the Internet, and The Institute of Electrical and Electronics Engineers (IEEE). Commercial impact was realised through adoption of our IoT and AI-based approaches in smart city applications. This includes drone-based transportation (Al-Dubai), effective and efficient spectrum management for ITS (AI-Dubai and Hussain) and optimised power management for IoT-enabled electric vehicles (Liu).

Work combining machine-learning and optimisation (**Sim, Hart**) in predicting wind-damage in Forestry was awarded an international Bronze "Humies" award at the International Conference of Genetic and Evolutionary Computing, for achieving human-competitive results on a significant problem. We continue to actively engage with the cyber business community in Scotland through our spinouts (Symphonic, ZoneFox, CyanForensics), and with Scottish Companies through engagement with Datalab funded projects (**Hart, Lawson, Urquhart, Sim, Buchanan**). Our state-of-the-art Blockchain work in collaboration with has led to EU-funded collaboration re privacy-preserving Internet searches.

We are agile in our response to funding opportunities and creating impact from our research. **Hussain** won £135,104 to work on an Artificial Intelligence-powered dashboard for tracking COVID-19-related public sentiment and opinion, mining in social media platforms from the Scottish Government Rapid Research programme, with University of Edinburgh. This aids policymakers, public health and clinical practitioners in understanding and mitigating the impacts



of the COVID-19 pandemic. The findings will support decision-makers, informing the development of appropriate interventions and aiding development of exit strategies from current or future lockdowns. The delivered framework is currently being evaluated by the Scottish Government to inform its vaccination policy.

Urquhart developed a free piece of software that scheduled food deliveries using his research on optimisation and was made freely available to local companies during the first lockdown. Example users included Untitled Oats, Edinburgh Community Food, Leaf & Bean Cafe (Edinburgh), Breadshare Community Bakery (Edinburgh), and Edinburgh Food Social.

Contribution to discipline sustainability

Our staff play a role in contributing to the sustainability of the discipline in the UK and internationally. **Smith** chaired the Council of Professors and Heads of Computing (2014-2016). **Hart** is a member of the Research Committee of the UK Operation Research Society (with a remit to grow the discipline and focus on interdisciplinary connections) and is a panel member for UoA11 REF2021. **Hussain** was a member of UKCRC from September 2020. Membership of IEEE/ACM Technical Committees is listed below. Buchanan was named by the UK Government in Top UK Influencers in Blockchain, 2018.

Collectively we contribute to the discipline through acting as external examiners for PhD students. **13 staff** have examined PhDs at **37 institutions** in the UK during this period, while seven staff have examined **15** PhDs at international institutions across the globe, in Europe, in Hong Kong, New Zealand, South Africa, Malaysia and the Middle East. Our contributions to the discipline are further evidenced by our participation as Editors of journals, journal and conference reviewing, roles as General Chairs/Programme Chairs and on organisational committees of conferences, participating in grant awarding committees and in reviewing proposals both nationally and internationally as listed below.

• Membership of national policy committees

- Hart: Invited member of government Steering Group to oversee development of Scottish Government AI Strategy (2020)
- Smith, S: Shadbolt Review (2016)
- Buchanan: Invited member of INTERPOL CYBER Experts Group
- **Hussain**: Invited Member, National Centre of Big Data & Cloud Computing (NCBC), Higher Education Commission, Pakistan Government
- Hussain: Member, UK Computing Research Committee (CRC)

Membership of international committees

- Hussain: Vice-Chair, IEEE Computational Intelligence Society (CIS) Emergent Technologies Technical Committee (2017-); Vice-Chair, IEEE CIS Task Force on Intelligence Systems for Health, 2017-)
- Buchanan: IEEE Technical Committee Co-chair for Blockchain (2018-)
- **AI-Dubai** Member IEEE Technical Committee on Internet of Things (2015-); member EEE Technical Committee on Smart Cities (2015-)
- Hart: Member IEEE Evolutionary Developmental Systems and Robotics Task Force (2021-); Member ACM Special Interest Group on Evolutionary Computation (SIGEVO) (2015-).

• Journal editorship

- Three staff currently hold Editor in Chief positions of well-regarded journals: Hart (Evolutionary Computing, MIT Press); Hussain (Cognitive Computation, Springer Nature; Big Data Analytics, Bio-Med Central/Springer Nature); Buchanan (Journal for Cyber Security Technology, Taylor & Francis, Journal of Blockchain in Health).
- Four members of staff also hold Editor positions of book series: Hussain (Book Series on Socio-Affective Computing, Springer, Book Series on Cognitive Computation Trends,



Springer); **Al-Dubai**, Book Series on Internet of Things, Springer) **Liu** (Handbook on Green Computing, IGI Global); **Liotta**; (Springer book series Internet of Things)

 9 staff hold Associate Editor positions on 14 journals (including 4x IEEE Transactions, 1 ACM journal, 1 Elsevier, 2 x Springer. 6 staff have acted as guest editor on over 20 Special Issues in a wide range of journals).

• Participation on grant awarding committees

- Kennedy participated on 5 BBSRC funding panels
- Hart: Carnegie Funding panel; Royal Society International Networks panel
- Al-Dubai: Omani Research Council funding panel.

• Fellowships

- Senior Fellow IEEE (Al-Dubai, Mitchell, Liu, Ahmad, Hussain)
- Senior Member ACM (Hart)
- Fellow of BCS (Smith, Flint, Kennedy, Buchanan, Paechter):
- Liotta: Shanghai Thousand Talents Distinguished Professorship in Al
- Mitchell: BAFTA member; Pioneer Member ACM SIGRAPH
- Research Fellowships:
 - o Industry Fellowship for Taku Komura (Royal Society) [Mitchell]
 - Leverhulme Fellowship [Hart]
 - Keele Institute of Liberal Arts and Sciences Fellow [Powers]

• Honours

- Kennedy: inducted into IEEE Vis Academy 2020
- o Buchanan: OBE, 2018 for services to Cyber-Security

• Awards

- **Buchanan/Lawson**: Winner, Innovation of the Year, Scottish Knowledge Exchange Awards (2016,2019).
- **Buchanan**; Outstanding Contribution to Knowledge Exchange, Scottish Knowledge Exchange Awards, 2018
- Buchanan: Cyber Evangelist of the Year, Scottish Cyber Awards, 2016.
- **Buchanan**: Winner, Cyber Security Innovation of the Year, Scottish Cyber Awards, 2016.
- Buchanan: Winner, Best Collaboration with Police Scotland, Scottish Cyber Awards, 2016.
- o Al Dubai: Outstanding Service Award, IEEE Computer Society, 2016
- **Smyth**: Recognition of Service Award from the Association of Computing Machinery, ACM, 2017
- o Tan: Outstanding Service Award, IEEE Computer Society, 2017
- Tan: The National Research Award 2017 The Research Council of the Sultanate of Oman
- **Moradpoor** Winner of Outstanding Woman in Cyber (Scottish Cyber Awards 2017)

• Prizes

- **Hussain**: co-Leader of the Winning Team (jointly with Tsinghua University) at the 2nd World Intelligent Driving Challenge (WIDC), held in Tianjin, China, 15-17 May 2018.
- Hussain: Best Performing Approach Award for 'Semantic Parsing' Task at the jointindustry & academic-led 'Concept-Level Sentiment Analysis Challenge', organized as part of the 11th Extended Semantic Web Conference 2014
- Sim/Hart: Humies Bronze Award \$1000, ACM GECCO 2018

• Reviewing Awards

- Liu: Springer's IJAC Outstanding Reviewers Award
- **Tan**: Outstanding Contribution in Reviewing 2018 Computers, Environment and Urban Systems, ISSN: 0198-9715



Tan: Outstanding Contribution in Reviewing 2017 - Future Generation Computer Systems, ISSN: 0167-739X Tan: Outstanding Contribution in Reviewing 2016 - Journal of Network and Computer 0 Applications. • **Gkatzia**: Outstanding reviewer (ACL 2018, ACL 2020) Ahmad: Outstanding Contribution in Reviewing 2018 – Journal of King Saud University – Computer and Information Science, ISSN: 1319-1578 Ahmad: Outstanding Contribution in Reviewing 2018 – Signal Processing, ISSN: 0165-1684 Ahmad: Outstanding Contribution in Reviewing 2018 – Journal of Information Security and Applications, ISSN: 2214-2126 **Reviewing of Funding Proposals** • Five staff are EPSRC College members(Al-Dubai, Hart, Liu, Hussain, Kennedy); staff have also reviewed for EPSRC (Chapman, Tan); NERC(Liu), MRC (Gkatzia, Hussain, Tan);PhenomUK (Giuffrida) Reviewing for Scottish Informatics and Computer Science Alliance (SICSA); PECE (Early Career Exchanges) applications [Moradpoor; Hart; Lawson]; Distinguished Visiting Fellows Applications [Hart] Internationally our staff provided support for the discipline by being part of the evaluation process for proposals for: • EU H2020 (Liu, Romdhani, Paechter, Hussain); Croatian Science Foundation (Hart); Canada Research Council [Hussain]; Omani Research Council (Al-Dubai); Research Council of Cyprus [Al-Dubai]; Natural Research Foundation of South Africa Liu]: Polish national Science Centre (Wells); Netherlands Organisation for Scientific Research (NWO) [Tan, Wells] **Invited keynotes at International Conferences** Al-Dubai: 5th International Symposium on Modelling and Implementation of Complex \circ Systems, 2018 Algeria; Reliable Intelligent Transportation Systems for Smart Cities, 2nd international Conference and Business Expo on Wireless & Telecommunication, 2016.Dubai. UAE. Buchanan: 5th International Conference on Information Systems, Security and Privacy, 0 Prague, 2019 Hart: 28th European Conference on Operations Research (EURO) 2016, Poland; IEEE Congress on Evolutionary Computing (CEC) 2019, New Zealand; 20TH Latin-Iberio Conference on Operations Research: Euro Distinguished Lecturer, 2020; 9th International Conference on Computational Intelligence, Maderia, 2018: • **Paechter**: 10th International Conference on Practice and Theory in Automated Timetabling, 2014 Liu : International Conference on Information Science and Systems (ICISS) 2020; 3rd 0 International Conference on Algorithms, Computing and Artificial Intelligence (ACAI) 2020, Edinburgh; 7th International Conference on Geo-Spatial Knowledge and Intelligence (2019), China Smyth: ACM CHITALY19, Padova, Italy, September 2019 0 International Conference General Chair: Hussain: General Chair IEEE WCCI 2020: IEEE SSCI CICARE 201 • Hart & Paechter: General Chairs, PPSN 2016 o Al-Dubai: General Chair IEEE IUCC 2019, IUCC 2020, CPSCom-2017 • Gkatzia: INLG 2016 Chapman: Diagrams 2018, ICCS 2018 0 Smith, S: Horizons in STEM Education 2017 0 **International Conference Programme Chair:** • AI-Dubai: IEEE SutainCom 2020, PDCAT 2014 • Hart: IEEE SASO 2016



- Hussain: IEEE DSS 2018, IEEE SmartData-2017
- Chapman: Diagrams 2020
- Liu: ACAI 2020, ICAISE 2020, ICISS 2020, CNIOT 2020, ITIOT 2020, CENET 2020, CENET 2019, SETA 2016
- o Flint BCS HCI 2017
- **Smyth, M**. Technical Programme Chair, ACM Designing Interactive Systems (DIS), Edinburgh, 2017.
- o Tan: iSCI 2020, DependSys 2019, CloudComp 2019, BD:TA 2018
- Sim . EvoApplications Programme Chair 2018
- Moradpoor, SIN 2018

• Peer-Review Activities:

Staff have reviewed for over 120 different journals, including over 30 IEEE/ACM Transactions, for example:

- **ACM Transactions**: including Transactions on: Graphics; Evolutionary Learning and Optimization, Networking, and Internet Technology
- IEEE Transactions: including Neural Computing; Evolutionary Computing; Mobile Computing; Cloud Computing; Visualisation and Computer Graphics; Information Forensics & Security; Parallel and Distributed Systems
- **Springer**: includes Cognitive Computing; Neural Computing and Applications
- Elsevier: includes Neurocomputing; Information Fusion; Computer & Graphics; European Journal on Operations Research; Computer Networks; Pattern Recognition Letters; Computers & Security
- **Royal Society:** including Proceedings of the Royal Society B: Biological Sciences, Interface, Philosophical Transactions of the Royal Society B

• International Programme Committees

 Staff have been on programme committees for over 50 different international conferences, including A-ranked conferences such as AAAI; AAMAS; GECCO;CHI; SIGGRAPH