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Institution: Brunel University London
Unit of Assessment: 11 – Computer Science and Informatics
1. Unit context and structure, research and impact strategy

i. Research structure & context, achievements in the Past REF Period

Brunel University London is a multidisciplinary research-intensive technology institution. It integrates academic rigour with the needs of governments, industry and the not-for-profit sector to deliver creative solutions to global challenges. It also brings economic, social and cultural benefit to a wide range of end users through an organisational culture of research excellence and innovation (Brunel Strategic Research Plan 2013-17; Brunel Vision 2030). The research strategy of the Department of Computer Science is aligned with this and produces significant world-class impactful Computer Science research that is both rigorous and applied within a vital, sustainable and supportive environment. Our research strategy can be found at <https://www.brunel.ac.uk/computer-science/research-and-phd-programmes>.

In 2014 we submitted to UoA 11 for the first time, achieving 63% 3*/4* research output, 90% 3*/4* environment and 50% 3*/4* impact. All our eligible staff are research active (31 FTE 2014 to 38 FTE 2020). Our ongoing performance demonstrates increasing strengths and investment around our two core, complementary themes: *Intelligent Data Analysis* and *Software and Systems*. Both are mature, groups that have existed for over a decade and are the backbone of our research strategy (all staff are members of either group). According to the NTU Performance Ranking of Scientific Papers for World Universities, we are 3rd in the UK overall in 2020 (one of only six UK Universities) and, for three years in succession, 1st in the UK for H-index and Highly Cited Papers (2018-2020).

The **Intelligent Data Analysis (IDA)** group meets the challenges of analysing, visualising and integrating a variety of high-dimensional, fast evolving, real-world noisy data by making many world-leading contributions to Artificial Intelligence and by developing innovative intelligent data analysis methods and algorithms that have found successful applications in a range of societal and industrial areas, including biology, business, computing, engineering, networks and healthcare. The group has made major advances in High-Performance Computing (HPC) architectures and Digital Infrastructures in both developed/developing countries and has had significant impact in industry. Feedback from REF 2014 noted that our contributions to Artificial Intelligence research were particularly strong. Indeed, we have published more Highly Cited Papers in Artificial Intelligence than any other university in the UK over the past 11 years (WoS). We are also 1st in the UK for H-Index in Discrete-event Simulation (Microsoft Academic). Members: Professors (4): Z. Wang, Liu, Taylor, Gilbert; Readers (2): Li, Tucker; Senior Lecturers (6): Swift, Grosan, Pandini, F. Wang, Groen, Cribbin; Lecturers (4): Anagnostou, Payne, Sassoon, Mashan; Independent researchers (3): Arabnejad, Sams, Zou. The **Software and Systems (SAS)** group (also known as the Brunel Software Engineering Lab) continues major themes in software engineering and human-centred computing. Research ranges from novel software engineering techniques aimed at eliminating costly “bad code” in large-scale codebases, through investigating cutting-edge distributed enterprise systems architectures, to advancing human-computer interaction with novel digital technologies and innovative sensorial interaction. Industrial partnerships play a key role and **SAS** continues to influence the sector through effective knowledge transfer. Members: Professors (7): Ghinea, Macredie, Shepperd, Counsell, Hone, Perry, Louvieris; Readers (2): Bell, Serrano-Rico; Senior Lecturers (5): Ali, Blackman, McGrath, Money, Sengul; Lecturers (6): Aburumman, Arzoky, Destefanis, Koulouri, Neykova, Lauria.

Notable achievements beyond significant research collaborations (Section 4). Professor Z. Wang became an elected member of Academia Europaea in 2020 and has made fundamental contributions to stochastic complex networks with incomplete information (output includes 40 IEEE Transaction papers cited more than 8,000 times (WoS)) and novel techniques such as the new state estimation H-infinity (used by many authors; around 20 instances in top journals). Cited over 24,000 times in this REF period (Google Scholar), he received the IET Control Theory & Applications

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Premium Award in 2018 and IEEE A. Sage Best Transactions Paper Award in 2020. Professor Liu has advanced IDA algorithms using a combination of techniques from Artificial Intelligence, engineering and statistics and has been consistently recognised as a Highly Cited Researcher for publishing papers among the top 1% most-cited for their subject field/year of publication (Thomas Reuters/Clarivate Analytics, 2014-2020). He has the most cited paper in the *Artificial Intelligence* journal since November 2015 and the most cited paper in *ACM Transactions on Software Engineering and Methodology* since 2016 (WoS). Taylor, Anagnostou and Groen's work on High-Performance Computing (HPC) infrastructures and Simulation resulted in over GBP 13,000,000 of increased turnover and savings for SMEs as well as guiding the development of African National Research and Education Network services provided to over 300 Universities and 4 million students annually. With Bell, their work enabled the rapid development of simulation tools to help two London-based NHS Trusts to respond to the COVID-19 pandemic. Professor Shepperd developed experimental methods to evaluate machine learners (yielded more than 20,000 experimental results and has become the definitive result in the field of defect prediction). Ghinea invented the new area of Mulsemmedia (multiple sensorial media) and has received widespread recognition (e.g., ACM Computing Reviews Notable Article in Computing).

The success of our research strategy is demonstrated by staff regularly publishing in top venues. For example, our 38 FTE published over 650 distinct journal papers since 2014 (48% increase since last REF). Of these approximately 50% were published in journals with impact factor over 4 (JCR). This includes over 190 papers in IEEE and ACM Transactions (240% increase), with 26 colleagues (140% increase) publishing one or more papers in top journals in areas such as Artificial Intelligence (IEEE Transactions (Evolutionary Computation, Cybernetics, Fuzzy Systems, Neural Networks and Learning Systems), Neural Networks, Swarm and Evolutionary Computation, Artificial Intelligence, Pattern Recognition), Software Engineering (IEEE Transactions on Software Engineering, ACM Transactions on Software Engineering and Methodology, Empirical Software Engineering), Computational Systems (IEEE Transactions (Parallel and Distributed Systems, Multimedia), Future Generation Computer Systems), Information Systems (Management Science, European Journal of Operational Research), Theoretical Computer Science (Information Sciences, Information Fusion) and domain specific areas (IEEE Transactions (Industrial Informatics, Medical Imaging), IEEE Journal of Biomedical and Health Informatics). Roughly 80% of articles in our submission pool of 93 papers were published in Q1 Computer Science journals and 50% were published in journals in the top 10% of their subcategory. Our staff have a mean H-index of 26 (up from 17) (Google Scholar); mean i10-index of 60 (GS). CWTS Leiden rankings in terms of highly-cited publications: we are ranked (globally/UK) 31st/4th (top 5%) and 14th/3rd (top 10%). CWTS recognises that many of our collaborations are international and this is reflected in our publications (14th globally/1st UK for internationally co-authored publications). THES World Ranking recognises that 95% of our publications are co-authored internationally. These show the quality and reach of our work. We are increasing our open access publishing (12th (UK) in our area for Gold open access). Overall, while these metrics are not absolute, these do show that our research is highly influential in wide areas of Computer Science.

Our Principal Investigators have been awarded over GBP 9,600,000 in grants in this REF period, including over GBP 4,500,000 from UKRI, GBP 3,000,000 from the EU, GBP 1,100,000 from UK central government/health authorities and GBP 400,000 from industry/public corporations. We have graduated over 120 PhD students in this period with many having taken up senior positions in industry or lectureships/postdoctoral positions at institutions such as Cambridge, Oxford, Imperial and UCL. Our staff have high visibility and include editors of major journals, members of executive committees of major organisations such as the ACM and eight members of the EPSRC College. In addition, staff have given keynotes at, or have organised, many major international conferences (see section 4 for summary).

ii. Future strategic aims over the next five years.

Our groups aim to address several adventurous challenges. **IDA**: advancement of Phase-wise and Many Objective Optimisation in complex networks across lifecycles, especially in the context of Industry 4.0; exploration of the relationship between Artificial Intelligence and Modelling & Simulation

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in terms of addressing large-scale data-rich and data-sparse environments (e.g., in the current Covid-19 Pandemic, migrations, etc.); and Artificial Intelligence explainability, especially the effect Artificial Intelligence adoption has on our national policies. **SAS**: leveraging of advances made by the IDA group to continue work in the analysis of large-scale software systems; reliability, security, performance and quality of large-scale concurrent and distributed software (e.g., Industry 4.0, microservice architectures, blockchains and future quantum computing systems); creation of even stronger relationships with the software engineering industry and apply expertise to the analysis of very large-scale problems (e.g., migration to microservice architecture and the reduction of technical debt; difficult problems that will continue to plague the IT industry); and exploration of how our world-leading expertise in rich multisensory experiences and interactions on mobile devices combined with Internet of Things/sensor-based systems enabled by the new 5G infrastructure can enhance users' Quality of Life by incorporating Artificial Intelligence techniques for hyper-personalisation. We will use our relationships with user groups to identify long-term developments to which we can contribute and we will continue to seek to ensure that our work has as strong and broad a public benefit as possible. Our Athena Swan team, Industry Advisory Board, work-placement program, annual Made in Brunel exhibitions, and involvement in industrial/user bodies all feed into our research strategy and will help us to ensure that we engage with a wide range of user/industrial interests in the above contexts. We will also continue to be focused around the two existing groups and our main application domains of healthcare and bioinformatics. In this REF period, we have also made significant advances in digital infrastructures in Africa and, again where possible, we will seek to apply our scientific advances with our partners in several African countries through equitable partnerships. Overall, we will aim increasingly to contextualize our research with respect to sustainable and green computing.

iii. Support for interdisciplinary research

The University encourages interdisciplinary research at a strategic level through four Institutes, in which we have wide participation. All staff are members of the Institute of Digital Futures. Nine staff are members of the Institute of Environment, Health and Societies. Two are members of the Institute of Energy Futures. These have facilitated new interdisciplinary collaborations in 5G and digital health (e.g., mulsemmedia, work in virtual rehabilitation (Aburumman, Grosan), new HPC applications (Groen), digital Infrastructure development in Africa (Taylor/Anagnostou), synthetic biology (e.g. drug design) (Pandini). Digital health is further supported by the Brunel Partners Academic Centre for Health Sciences (BPACHS) which works with The Hillingdon Hospitals NHS Foundation Trust and the Central and North West London NHS Foundation Trust (e.g., applying machine learning techniques to A&E performance improvement and leading 12 members of the department to develop evidence-based COVID-19 decision-making tools supporting local NHS Trusts in the current pandemic).

iv. Research and impact strategy and achievements against them.

Our Head of Research (Taylor) and the Research Group heads (Tucker and Counsell) lead the Department's Research Strategy. Our Impact Strategy is led by our Impact Champion (Shepperd). Both strategies are annually reviewed by the Department's Management Board, in conjunction with the Department's Industry Advisory Board and Athena Swan team, and reported to the College's Vice Dean (Research). We maintain a strong portfolio of impactful research with mature international collaborations, a balance of academic rigour and theoretical advancements and strong engagement with many end-user groups (see section 4). In conjunction with our Athena Swan team, we monitor the diversity and range of our end users. End users include Microsoft, Ford, Green Valley, Kew Gardens, Moorfields Eye Hospital, Tongren Eye Hospital (China), Sellafield, Three, DEFRA, Ministry of Defence, Qinetiq, several NHS Trusts, and several SMEs in digital technologies and manufacturing. Indeed, most of our projects include industrial partners. We also engage through two start-ups that came from our research in this REF period (HecoAnalytics and CloudSME UG). At the beginning of this REF period, we made the decision to continue to support REF2014 impact cases and to identify further candidates. This led to a pool of seven impact cases from which four have been selected. For example, Counsell and Swift have worked with Green Valley to create novel methods to reverse engineer software architectures from over 25 million lines of source code. Taylor

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has led high-performance simulation work with Saker Solutions/Sellafield and Ford that has developed a high performance simulation infrastructure (large scale models of nuclear waste reprocessing and engine manufacturing respectively). Taylor and Anagnostou have led digital infrastructure research in East and West Africa that has significantly enhanced digital education and student experience in African universities (over 4 million end users annually) and the delivery of new government digital policies in 11 African nations. Our research groups regularly review impact within research projects and the Department regularly runs seminars in impact-related issues. This is also one of the key elements of our mentoring program. We introduce early career researchers to industrial and NGO partners through our established networks and Institutes and support them via our University's Research Services and Development Office (RSDO) (e.g., Destefanis working with Hexxcell Ltd. to improve software testing, Anagnostou working with the Ghana Health Service to develop approaches to evidence-based decision making, Groen working with UNESCO in refugee studies, etc.). This makes possible agile responses to new research initiatives (e.g., Bell leading around a third of the department to develop COVID-19 decision support tools for local NHS Trusts in the pandemic). We also seek to support impact in Brunel's research environment. For example, within the context of the University's GCRF and ODA impact strategy, Taylor founded Brunel's Africa Group which provides focus to the University's work across that continent and supports research and collaborations in equitable partnerships; the Department was also key to the development of the Institute for Digital Futures and the Brunel Partners Academic Centre for Health Sciences (BPACHS).

v. Progress towards and open research environment

We are progressing towards an open research environment through contributions to reproducibility and Open Science in research, especially with respect to empirical studies. We disseminate these across the Department and University. Taylor, in 2019 with colleagues from Southampton and Loughborough, developed the Strengthening the Reporting of Empirical Simulation Studies (STRESS) to standardise how empirical simulation studies are reported in different types of discrete simulation (Monks, et al. (2019), *Journal of Simulation*, cited 34 times). Taylor is a member of the ACM SIGSIM (Simulation and Modelling) Steering Committee and has led discussions on Open Science – one output of which is the adoption of the ACM Reproducibility Initiative by the ACM Transactions on Modeling and Simulation and the ACM SIGSIM Conference on Principles of Advanced Discrete Simulation. Shepperd is a member of the working party for Empirical Software Engineering and the Mining Software Repositories (MSR) conferences to identify protocols/results at the pre-registration stage. As part of a wider initiative, Taylor and Anagnostou co-led the development of FAIR (in the sense of Findable, Accessible, Interoperable and Re-usable) Data Infrastructures and Open Access Repositories in Africa to enable African researchers to make the outputs of their work (articles, data, results, etc.) more visible. This is currently being adopted by the West and Central Research and Education Network (WACREN) as part of the AfricaConnect3 project and has been adopted by the Ethiopian government (<https://nadreweb.ethernet.edu.et/>) as their national Open Science policy. All our staff practice Open Science to some degree, with a common baseline of green open access for all publications via the University's publications database BRAD, gold open access for publications where possible, and it is common practice for us to use access repositories to share our data/software. Around one third of our staff have produced open source software with total downloads of around 50K/year (with some being part of well-known packages).

vi. Research Integrity

Brunel has adopted the Universities UK Concordat to support research integrity. The University's Research Integrity Code of Practice provides clear policies regarding research conduct overseen by the Vice Provost (Research). Research Integrity is part of the University's commitment to the Research Councils' UK Concordat to Support the Career Development of Researchers (see section 2 – People). We also follow equitable partnership guidelines from Research England to ensure that our work with partners in developing countries is done on a fair/equal basis. Research ethics is overseen by the University Research Ethics Committee (UREC) which provides a framework for policies, processes and procedures to ensure that all research meets established

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ethical standards. For Research Data Management, we follow the University's policy (based on the 10 Principles of the Concordat for Open Research Data) and comply with all legal, ethical, funding body and organisational requirements for the collection, review, publication, storage, preservation and re-use of data (in line with the University's Data Protection Policy). Institutionally we are committed to free access to all our research outputs as part of our Code of Research Integrity (green access supported by our University's publications database (BRAD) and Institutional Repository (BURA)). The University provides a full training programme with respect to the code as well as having support staff from its Research Support and Development Office to provide advice as required.

2. People

i. Staffing Strategy and Staff Development

Brunel received the EU HR Excellence in Research for its research support environment and its alignment with the Researcher Development Concordat (first awarded in 2011, renewed every two years – most recently 2019). The University's Concordat Action Plan is at <https://www.brunel.ac.uk/about/documents/pdf/BUL-Concordat-Action-Plan-2017-19-FINAL.pdf>.

The University's Researcher Concordat Action Plan (RCAP) is managed by the Researcher Concordat Implementation Group (RCIG); the Department's Management Board follows recommendations made by the group in line with each of the Concordat's. In parallel, our Athena Swan Self-Assessment Team was set-up in 2014 (currently led by Sengul; our Bronze award was renewed in September 2020) to provide input to our staffing strategy.

Balancing/rewarding excellence in academic life is supported by the University's Academic Life Cycle (ALC) that focuses on mentoring and nurturing. It identifies clear promotion criteria across a balanced portfolio of research, teaching and learning, and leadership. All staff have an annual Professional Development Review (PDR) where feedback with respect to development and promotion is given, annual goals are set, workloads are reviewed and staff development needs are identified. Online unconscious bias training is available to all staff, and all research and academic staff must complete the University's compulsory Equality and Diversity (E&D) compliance training, refreshed every three years.

Line-managers meet with new staff to welcome them to our Department and discuss with them their responsibilities, including their teaching allocation. Line-managers are trained in effective induction, and HR checklists are used to guide the process. Probation is set at two years; realistic goals are regularly reviewed by the Head of Department and the Research Director (25% teaching load in year 1 and 50% in year 2 to support completion of the Postgraduate Certificate in Academic Practice programme). New academics can also apply for a BRIEF (Brunel Research Initiative and Enterprise Fund) award to jump-start their research. All new staff must attend University induction and compliance training sessions (including E&D). Details of the University's flexible working policy and family-friendly policies are available on the HR intranet. However, staff focus groups have highlighted that staff might not be aware of all their entitlements/Department policies and we are now providing regular briefings. On-going induction programmes introduce research support (research services, grant development, internal peer review of papers/grant proposals, a strong seminar programme, etc.) We continue to improve our induction process/support for new staff and in 2020 we introduced a new departmental mentoring scheme. We have two annual away days where all staff are given time to brainstorm new research themes. There is a strong collegiate culture in the department; research groups meet regularly and hold vibrant seminar programme.

Each Researcher within our UoA also has a PDR (**Principle 5**) and new grant holders (PI and CI) must attend PDR training for managers (including E&D). One-to-one coaching is provided by the University for Research staff to explore personal development and career aspirations. Importantly, during PDR discussions, if a Researcher expresses a desire to become a Lecturer, we recognize that many academic appointments require excellence in research and also excellence in teaching and therefore discuss opportunities with Researchers to develop teaching experience, obtain relevant qualifications (supported by the Graduate School) and encourage them to apply for Associate Lecturer (AL) positions (four Researchers have recently joined us as AL – two successfully

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promoted to Lecturer). When new grants are received, in partnership with our Researchers, we also attempt to identify continuity of employment by redeploying them to new projects (**Principles 2, 3 and 4**).

We have strategically recruited to our two research groups and will continue to do so. We are a maturing department with many staff moving from the 40-49 to the 50-59 group during the REF period – these staff contributed 47% of our research outputs. We have replaced all staff that have moved on from us (all FT with no significant gender difference; 72% cited better career prospects as their reason for leaving with the next most common reason being a career change (e.g., non-academic position along with retirement)) and have added a further 7 FTE. These form part of the balance of our staff in the 30-49 group (50%) – this group contributed 35% of our outputs. 31% of our staff are women (29% of our outputs) – most are in the 30-49 group – and we aim to raise this percentage.

We believe that we have created an atmosphere that is conducive to staff retention and promotion with almost half the staff promoted in this period, primarily through a balance of research and teaching excellence (three AL to Lecturer (L), seven to Senior Lecturer (SL) (Capiluppi, Money, Cribbin, Groen, Grosan, Pandini, Wang), four to Reader (Bell, Li, Serrano, Tucker) and four to Professor (Counsell, Hone, Perry, Taylor)). The AL posts, introduced in 2017-18, also give a career path for our Researchers (40% women – three promoted to L (one woman)) and, as all three were also PGRs, we see this as an encouraging staff development trend. Approximately 40% of AL, L and SL are women. However, this falls with increasing seniority. We are addressing this by running open discussion panels with women from the College who have been successful in their promotions/increasing research outputs, tracking staff length-of-service/promotion readiness based on PDRs and exploring gender issues in applying for promotion. All promotion/recruitment panel members are trained in topics such as E&D, unconscious bias, etc. (**Principle 1**). Since August 2018, when recruiting we have attempted to shortlist women in proportion to applications received (aspiration of 50/50) by being more flexible on research/teaching expertise without compromising criteria stated in the job description.

Of the three academic PT staff, two are women, and all have chosen to go PT (flexible retirement). We make effective use of flexible working with job-sharing for named leadership roles, which may lead to more staff working FT. Our fixed-term contracts are mostly held by Researchers but also a few AL (AL contracts are otherwise open-ended).

Brunel has invested in staff development with approximately GBP 150,000 supporting a range of schemes. Research Leave: (6) – enabled, for example, advanced algorithms for optimisation (Liu), software fault detection in large scale systems (Hierons), re-engineering the popular Chorus Twitter data harvesting tool (Cribbin). Knowledge Transfer Leave: (6): enabled industrial collaborations, for example, Grass Valley to investigate bad code elimination techniques in large code bases (Counsell), high speed simulation experimentation Ford Powertrain Operations, Sellafield PLC and Saker Solutions (Taylor). Further examples: Pandini (BRIEF award) – worked with Francis Crick Institute/Lawrence Berkeley National Lab to prepare a successful Leverhulme Trust project; Grosan (Athena Swan Research Award) explored machine learning methods for highly computational problems from biology; Tucker (seminar series award) disseminated Artificial Intelligence techniques that led to closer collaboration with UK government bodies (e.g., DEFRA); Perry (Tampere University I3 partnership) disseminated his work in digital money. We have had over 30 visitors from a range of countries including China, Germany, Italy, New Zealand, Norway, Mexico and Spain, and members of our Department have held over 20 visiting positions.

We provide financial support with: GBP 55,000 pa ring-fenced research funding for research travel; an ad hoc budget for small equipment for support research; GBP 32,000 pa for undergraduate students to work on short research projects (launched in 2018; 16 students participated; 2 went on to begin PhDs). All awards are made on the basis of successful research and impact; monitored by the Athena Swan team. The College's focus on interdisciplinary research is supported through internal funding for interdisciplinary projects with the other Colleges (with competitive bids for funding requests over GBP 10,000). Our approach to Research Integrity is described in section 1.

Research and impact are recognised and rewarded as part of the annual PDR and the promotion process of the Academic Life Cycle. The Head of Research discusses individual research plans with staff to reflect on them and to identify collaborative opportunities derived from our extensive networks. Our Impact Champion liaises with the Head of Research and the Research Group leads to regularly review impact and potential impact cases. Success is rewarded by balancing research and teaching workloads to give more time for research and impact, and to recognise working patterns (e.g., attempting to load teaching into one term, supervision of only UG or PG projects, etc.). Impact is supported in several ways. We regularly discuss impact in Research Group meetings and related seminars are run annually in conjunction with the University and we attempt to introduce early career researchers to industrial and NGO partners through our established networks. This is supported by the University's Research Services and Development Office which also identifies potential partners from the many companies that annually approach the University with an interest in collaboration. We make use of funded impact support (e.g., through the Innovation Voucher scheme – 8 staff (e.g. Destefanis and Hexxcell Ltd. to improve software testing; Li and Veritas Advisory to investigate the development of an AI-based system for automated Capital Allowance assessment, etc.)) and Innovate UK grant applications (e.g. Taylor/Anagnostou (GBP 180,000) to work with Saker Solutions and Hobsons Brewery; Bell/Serrano (GBP 80,000) to work with EnterpriSE Nation, etc.). University internal impact accelerator funding is also available through different schemes (supported Taylor/Anagnostou/Groen to develop digital evidence-based decision-making services in Ghana Health Service and the Ethiopian government/UNHCR). Impact is also supported through the University's research environment (e.g., Brunel's Africa Group, the Institutes and the Brunel Partners Academic Centre for Health Sciences (BPACHS)).

ii. Research Students

Our PhD cohort is critical to the health of our research environment. We attract doctoral students through our external profile, which has proved a successful approach that has been strengthened by our web team's maintenance of our research web pages to reflect the vital and exciting nature of the Department. Brunel provides EPSRC Doctoral Training Partnerships (DTP) studentships to support postgraduate research opportunities in our College and 19 have been awarded since the scheme started in 2016. We also have had one NERC London DTP awarded to the Department. Further, we support several research students awarded under the ESRC Grand Union DTP as second supervisors.

Overall, we have graduated 124 research students in this period. Around 35% of our cohort (and completions) are woman (above the national benchmark of 26%). Fewer women choose part-time mode (26% compared to 38%) and we are investigating if there are any barriers to PT study. The majority of our PGR students either come from other UK universities or overseas with an ethnicity split of around 45% Asian, 30% White and 25% Black. Students are split on average around 35%/65% UK/international (roughly 20% EU, 15% African, 15% Middle East, 15% Asian), with a recent shift towards UK students (50%) (reflecting impacts of BREXIT and international restrictions). A focus group also reported that information about academic careers and PhD funding is not readily available. We will do more to promote academic careers to both PGT and UG students via Q&A sessions and dissemination of research funding information. Additional financial support for doctoral researchers is available through the University's hourly-paid academics (HPAs) (Hourly-Paid Lecturers) and Graduate Teaching Assistants schemes (GTAs)). HPA roles have become more gender-balanced over the years, achieving around a 40:60 ratio of women to men. GTA roles are popular amongst PGR students, offering income and teaching experience.

Research students are supported by a supervision team consisting of two supervisors and a Research Development Advisor (RDA). Research students regularly meet with their first supervisor, with summaries of meetings being recorded on our eVision system. Having two supervisors provides input from researchers with complementary expertise and allows senior staff to share their expertise with junior colleagues. Students produce reports at 9/18 months – these are discussed in a formal meeting (student, second supervisor, RDA and an independent academic). We encourage career development and give opportunities for our research students to become GTAs, give lectures and to

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formally take roles in research projects. All research students are encouraged to publish during their studies (we support up to one EU and one non-EU conference for each student – students can also bid for the Vice Chancellor’s travel prizes of GBP 500 (12 winners since 2014). There is an annual away day for research students, which helps foster a community as well as contributing to research training. Brunel recognises excellence and encourages interdisciplinary work through its annual Research Students Poster Conference, with in the order of 150 students contributing posters each year (approximately 10 of our students annually). Three of our research students won Brunel’s Doctoral Research Prize in the period.

In 2017, led by Ali, we instigated a PhD Colloquium, encouraging students to make 10-minute presentations and to get feedback from a panel of internal and external academics. The Department is also involved in running PhD Colloquia at international conferences. For example, Sengul was co-chair of the Student Research Competition at ACM SIGCOMM (2015) and Anagnostou has been chair and committee member of the PhD Colloquium at the ACM/IEEE Winter Simulation Conference (2016-2019). Bell chaired the ACM SIGSIM Travel Grant Committee that awards travel support to around 20 students annually from across the world to attend high quality conferences. We also encourage students to take part in international competitions in which they acquire new skills (e.g., supported by NASA volunteers, the Simulation Exploration Experience (www.exploresim.org) that supports students in developing large-scale multinational simulations of a lunar settlement). Locally, we support PhD students in collaborative exercises for team building and paper writing (e.g., machine learning for robotics) (approximately GBP 1,000/year).

Developmental activities provided by the Brunel Graduate School are complemented by specialised research methods training, including a one-year-long Research Methods Course led by senior members of the department. The library also provides a training programme to help our research students develop their scholarship skills and the Language Centre provides English language training and support. Training by the Brunel Graduate School offers a comprehensive programme of personal and professional skills development in line with our Researcher Development Programme aligned with the EU HR excellence in research award. (<http://www.brunel.ac.uk/services/graduate-school/training-development-and-support/researchstudents/researcher-development-programme>). Training is also offered in GTA roles towards the Associate Fellowship of the Higher Education Academy. The University also has a dedicated research careers advisor.

Many of our research students have won awards and prizes, both internally and externally. For example, over 10 students have been awarded best paper awards in international conferences, including IEEE Congress on Evolutionary Computation (CEC-2014) and Bioimaging 2018. 8 students won the Vice Chancellor’s Prize for Doctoral Research or the Dean’s Prize for Innovation and Impact. Furthermore, Miqing Li was the winner of the Chinese Government Award for Outstanding Students Studying Abroad in 2015 (Ranked No. 1 in the Information Science field in the UK), while Bashir Dodo’s work on OCT retinal analysis was featured in the mainstream media, such as BBC World and TVC News Nigeria.

On completion, many doctoral graduates moved to lectureships or postdoctoral positions at other universities, including Oxford, Cambridge, Imperial and UCL, while others moved to positions in industry (for example, as a data analyst at The Times). Our research students authored papers in top journals, including: IEEE Transactions (Evolutionary Computation; Cybernetics), Computers & Graphics, Journal of Mobile HCI, IEEE Journal of Biomedical and Health Informatics, Optics Express, Pacific Graphics, IEEE Journal of Biomedical and Health Informatics, IEEE Access, PLOS One, AI in Medicine, Ecological Informatics, Carcinogenesis, Future Generation Computer Systems, etc.

iii. Equality and Diversity

Brunel has an E&D Office and Champion that manage E&D Policy (updated annually with concrete objectives). They also support women intending to apply for promotion – the promotion’s process is subject to an annual Equality Impact Assessment which is used to drive improvements in the equity of the process. Our department has a balanced Athena Swan Self-Assessment Team (awarded 2016, renewed 2020). The department ensures Athena SWAN principles and actions are promoted

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and enacted wherever possible, at meetings, open days, in our recruitment, decision making and through our teaching policies and practices. Institutionally, Brunel is developing guidance on the use of named researchers on grant applications, conducting focus groups with BME researchers to further explore issues raised within the local CROS 2017 survey and to better inform specific actions around intersectionality. We strive for a representative balance of gender, disability, ethnicity and age at all levels of staff, including at supervisory and managerial level. The Department has also implemented a mechanism of regular data collection and analysis by gender and race of membership of University boards and committees (e.g., College Management Boards), with data reported to the University's RCIG for monitoring (**Principle 6**).

All staff undertake compulsory E&D training as part of their compliance training. Athena Swan (AS) awareness, initiatives and actions are included in all role descriptions. We encourage all staff to engage with the implementation of previous actions through workshops. We present the results of the actions taken at meetings, and staff and student away days, motivating staff to engage more as they observe the difference their efforts are making. Additionally, we have had AS events where prominent women researchers (e.g., Prof. Ann Blandford from UCL and Ita Richardson from University of Limerick) have presented their work; AS champions from other universities have given talks on their best practice of implementing AS principles to staff and PhD students. Over 90% of our staff report they are satisfied with their awareness of diversity issues and did not feel discriminated against at work in the last 12 months. We continue to expand our dissemination activities by running further activities and events to allow our students and staff to see how AS actions are changing the culture in computing.

We have made significant progress in communicating the ability to work flexibly, with 100% staff agreeing that flexible working is supported in the Department (Brunel Voice staff survey in 2019). Our staff of all grades prefer to agree requests with their line manager (rather than through a formal HR request). This way, arrangements can be changed in an agile way (e.g., home working, hours compression, etc.) Any change to contracted hours, however, still have to be approved through a formal HR process. A potential concern with the COVID-19 pandemic is that the impact of working from home will differ for staff with different caring responsibilities (men or women). The University and the Department are very understanding of the situation and ask all staff in this position to do the best they can with support from the Department (we are already supportive of flexible working).

We implement the University Parental Leave policy and insist on the use of the optional Pre-Parental Leave Checklist for Staff to assist both the employee and the line manager to plan for the leave. All staff, including PDRAs, are offered 52-weeks parental leave: 18 weeks at current salary; 21 weeks at statutory pay; and 13 weeks unpaid. For shared parental leave (SPL), the mother must take the first two weeks, and the partner can take any of the remaining leave (SPL entitlement is 50 weeks; 16 weeks fully paid). The line manager and the employee discuss the use of Keep-in-Touch (KIT) days before the maternity leave starts. Arrangements are made for covering workload during the absence by reallocating tasks to others in the Department. During pregnancy, allowances (changes or adjustments) are made for the employee to undertake lighter duties to ensure their continued good health. We are concerned that not all staff are aware of these issues and we are ensuring better awareness of parental leave entitlements and better hand-over arrangements for staff covering others, including recruiting parental-leave cover. The University invites staff who have returned from a parental leave of longer than four months to submit applications to the University's competitive Athena SWAN Research Award grant scheme, which funds projects up to GBP 15,000 (e.g., for buying out teaching time, attending conferences, or employing research assistants). One member of staff took two periods of maternity leave and applied/was awarded through the above scheme.

Note that with the COVID-19 pandemic, following University guidance, promotion (and also appraisal) criteria give the opportunity for staff to demonstrate how they have helped the University through this challenging situation.

Overall, Brunel, as a research-intensive university, is submitting 100% of all eligible academic staff. We followed the processes set out in our Code of Practice for the fair and transparent identification

Unit-level environment template (REF5b)

of independent researchers and to ensure that the submitted outputs provide a balanced and unbiased representation of the work of our diverse academic community, their characteristics and contractual positions (age, disability, race, sex, part-time workers and fixed-term employees). Output selection was monitored through regular Equality Impact Assessments. Our Equality Impact Assessment indicates that the outputs submitted for Computer Science are a well-balanced representation of the protected characteristics and contractual positions of staff. Our submission has a high proportion of outputs selected for staff of Asian ethnicity (16% staff of Asian ethnicity contributing 22% of the outputs). The 40% staff aged 50-59 contributed 47% of the outputs indicating the maturity of the unit.

3. Income, infrastructure and facilities

Given our commitment to carry out world-leading applied research with commensurate impact, we see external funding and engagement as crucial and aim to grow both further. We strongly encourage colleagues to apply for external funding to support high-quality research and maintain a world-class research culture. In the current REF period, we were awarded in excess of GBP 9,600,000 in grants, including over GBP 4,500,000 from UKRI, GBP 3,000,000 from the EU, GBP 1,100,000 from UK central government/health authorities and GBP 400,000 from industry/public corporations. From the total grant value, GBP 3,000,000 can be classed as capacity strengthening with countries including Nigeria, Malawi, Tanzania, Ethiopia, Ghana, India and Malaysia. Our industrial/commercial sponsors included: Hutchison 3G UK Ltd; GlaxoSmithKline; Level Business Ltd; Sharp Laboratories of Europe Ltd; Fujitsu Laboratories of Europe Ltd; Microsoft Research Limited; and Ford Power Train Operations. Our researchers frequently collaborate with user groups and attracted a significant amount of consultancy (over GBP 110,000) and this helps develop the impact of our work. We also were awarded GBP 40,000 of industrial innovation vouchers. This consultancy was with a mixture of industrial and not-for-profit organisations including Ipsos MORI, Merck Serono, Veritas Advisory, DSTL, Thales, Quantel, Sellafield and the Medicine and Health Regulatory Authority. Our Department was also recognized as part of the UKRI World Class Lab programme and we received GBP 150,000 investment to bring together Artificial Intelligence and Health in the new Brunel Artificial Intelligence Lab.

Our strategy to attract funding is based on strong research collaborations supported by numerous mechanisms for finding and developing new industrial and academic collaboration. These include our Department's Industrial Advisory Board and work placements schemes, the University's Institutes and the University's Research Services and Development Office (RSDO). We support new members of staff by identifying opportunities for grant development through discussions with senior members of staff and colleagues in research group meetings, internal peer-review and workshops, and through mentoring discussions. We promote large projects that involve members of both groups and will continue to organise focused workshops around themes that involve both groups and to provide internal funds to support the development of interdisciplinary proposals. This will be supported by Brunel's Research Development Fund (for researchers working on major grant applications) and its panel, chaired by the Vice Provost (Research), which provides additional peer review for large funding applications. We introduce new staff to our existing industrial and academic networks and help them to develop mature collaborations of their own through initial involvement as Co-investigators, and support them as Principal Investigators with collaborations through existing academic and industrial partners. We also recognise and reward successful proposals in the annual PDR, workload allocation and promotion processes, and monitor equality and diversity issues to ensure that grants are pursued equitably across our Department. The University's Institutes were introduced in this period and the Department play a major role in the Institute of Digital Futures, the Institute of Environment, Health and Societies and the Institute of Energy Futures. The Department is also part of Brunel Partners Academic Centre for Health Sciences (BPACHS), which works with NHS Trusts and the University's Africa group, helping to develop collaborations in that region. These structures have proved invaluable in generating successful research proposals.

In addition to the elements of Brunel's strong research infrastructure noted above, the University's library provides electronic access to a large selection of journals, conference proceedings and

Unit-level environment template (REF5b)

facilities such as Web of Science. It also has an institutional archive (BURA), an open access repository (Figshare), an Open Access Mandate, and an Open Access Publishing Fund. Our physical environment has received significant investment in recent years – in 2016 we moved to a newly refurbished building (GBP 12,500,000) which has a dedicated STEM centre on the ground floor and three floors for Computer Science. The building has shared offices (organised by sub-groups/projects), a large research student office, ample meeting rooms and lab spaces.

Our two groups have associated specialist hardware facilities that support their research. This includes investment of GBP 10,000 in updating a PC-based Grid infrastructure used by Modelling and Simulation researchers to mimic secure industrial settings (e.g., high performance simulation impact at Saker Solutions and Sellafield (Taylor/Anagnostou) and GBP 60,000 for six rack mountable server base units with dual CPUs and two GPU cards (10K cores) with 10 TB of storage to support the analysis of large data sets (e.g., to support research at Green Valley (Swift/Counsell)). Additionally, both groups make use of a further GBP 60,000 computing facility consisting of a 32-core computer system (e.g., used for advancements in protein modelling (Pandini)). We also make use of national HPC centres (e.g., Edinburgh Parallel Computing Centre Archer and the London-based Materials and Molecular Modelling (MMM) Hub that both provide significant HPC resources) and, through European collaborations, we have significant access to European HPC facilities (Leibniz, Stuttgart, Poznan, etc.) This investment has led to joint papers, funding proposals and research projects.

While we have had much success in obtaining funding from the Research Councils, we recognise that in future we will have to obtain more funds from other sources including the EU. Our groups will continue to support the development of large funding proposals through, for example, mentoring, internal peer review and the provision of internal funds for activities that facilitate the development of high-quality proposals. We will develop large funding applications and through this look to further develop our presence in Industry 4.0, which is an area we will grow. We expect most large projects to involve members of both groups and so will continue to organise focused workshops around themes that span the groups and provide internal funds to support the development of interdisciplinary proposals. This will be supported by Brunel's Research Development Fund (for researchers working on major grant applications) and its panel, chaired by the Vice Provost (Research), that provides additional peer review for large funding applications.

4. Collaboration and contribution to the research base, economy and society
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On the REF 2021 census date there were zero Category C staff.

Our approach to support effective research collaborations, networks and partnerships is enabled by numerous mechanisms for finding and developing new industrial and academic collaboration including our Industrial Advisory Board and work placements schemes, University's Institutes and the Research Services and Development Office. We support new members of staff by introducing them to our existing industrial and academic networks. We help them to develop mature collaborations of their own through initial involvement as Co-investigators and/or joint authors in high quality publishing. For example, this strategy enabled Anagnostou (joined 2018) to be awarded GBP 370,000 as part of the H2020 STAMINA European pandemic crisis prediction project, Groen (joined 2017) to win two H2020 projects worth GBP 900,000 in exascale computing (VECMA) and HPC (HILDALGO), and Destefanis (joined 2018) to obtain an innovation voucher with Hexxcell Ltd to assess, design and implement improved testing processes.

Our reach is demonstrated by almost all of our papers having one or more international authors (95% THES) and by the downloads of our open source/freeware software (around 20 available with downloads totaling around 50K/year). We have many examples of successful collaborations noted below and with the Chinese Academy of Sciences, EPFL, Google, GSK, Loiretech, MRC, Philips, Royal Free Hospital, Zoological Society of London and Royal Botanical Gardens at Kew, and with Duisburg (Germany), Hong Kong, Pavia, Sheffield, Swinburne (Australia), Tsinghua (China) and UCL universities. Examples of significant research collaborations by area include:

Commerce

Z. Wang, Liu and Lauria in the H2020 INTERGRADDE project (2018-2022) are applying advances in Phase-Wise Many-Objective Optimisation across the Additive Manufacturing lifecycle. This is with several prominent end users in the area including Loiretech (France), Hogskolan (Sweden), GKN Aerospace (Sweden), Arcelormittal (Spain), DGH Robotica (Spain), and the Atomic Energy Commission (France), and involves Imperial College, University of Sheffield and the Jules Verne Institute of Research Technology (France). Similarly, Liu and Z. Wang are applying similar techniques in the H2020 Z-BRE4K predictive maintenance project with the Spanish Metallurgical Association, Atlantis Engineering (Greece), Fraunhofer-Gesellschaft (Germany) and Philips (Netherlands). Counsell, Hall, Hierons and Swift [EPSRC projects Using Fault Characteristics to Improve Software Fault Prediction (2014-2017), AQUATIC: Assessing the Quality of Test Suites in Industrial Code (2015-2018) and Exploiting Defect Prediction for Automatic Software Repair (FIXIE) (2019-2021), and the EPSRC network FIAR-NET: Faults in industry and academic research (2015-2019)] have made major contributions to understanding how faults can be found and fixed in software through machine learning. This work has included Green Valley, Sky Broadband, Bloomberg, Microsoft USA, BAE Systems, Quantel Ltd, FlossLab Srl, TESM Ltd and Cagliari (Italy), Stuttgart (Germany), Queen Mary and Lancaster Universities, and the Polytechnic of Montreal. The research builds on a highly-cited review by Hall et al. on software defect prediction and has delivered many industrial benefits as well as publications in IEEE Software. In this context, Destefanis and Counsell have also investigated the impact of developer team composition in the development process through data collection from large open source software repositories (e.g., GitHub).

Ali designed and developed an architecture recovery tool with Lero, The Irish Software Engineering Research Centre, which has been adopted to support software maintenance in four companies (including Fineos and Fidelity) and has influenced the practice of 17 practitioners. Work continued, through an InnovateUK project (2014-2016), with the extension of the techniques to support the migration of legacy systems to a more structured and service oriented architecture (Travel Places (SME UK), and has been subsequently extended to support the migration of microservice systems with in-kind support from several companies, including: EMERGEIQ; WESTPAC; CONNECTPME; ACURIS; and WOOD. Taylor and Anagnostou co-designed the CloudSME Simulation Platform, with the University of Westminster, the Institute for Computer Science and Control (SZTAKI) (Hungary), CloudBroker (Switzerland), Inycom (Spain) [FP7 Cloud-based Simulation Platform for Manufacturing and Engineering (CloudSME) project (2013-2015)]. CloudSME is being used to develop cloud-based systems for high-speed simulation experimentation by many European companies (e.g., Saker Solutions (UK), DH CAE Tools (Germany), PODACTIVA (Spain), etc.) and a spin-off company CloudSME UG (Germany). Subsequent research [H2020 Cloud Orchestration at the Level of Application (COLA) (2017-19)] developed the MICADO-Scale auto-scaling cloud system. This is being used by several companies (e.g., Outlandish, The Audience Agency, Sellafield PLC (UK)) to develop scalable cloud services. The InnovateUK CraftBrew Whole Brewery Management System project (2015-2018) applied some of these innovations to the UK brewing industry. Perry and Louvieris [EPSRC project Smart Money: Precision Data Management for Distributed Ledger-enabled Central Bank Issued Digital Currencies (2017-19), EPSRC project Digital Personhood (2013-2016) and Royal Society project Chinese 'Money Work': Studies of Use and Interaction Design for Digital Money] have worked with the Bank of England, Office of National Statistics, Ministry of Justice and GCHQ in collaboration with City University and the Chinese University of Hong Kong to explore how users access and use digital banking and payment services. They contributed to UK government policy (e.g., the Technology (POST) Report on Alternative Currencies).

Healthcare/Bioinformatics

Z. Wang and Liu [Royal Society travel grant (UK-China Industry Academia Partnership Programme)] have worked with the Fujian Key Laboratory of Medical Instrumentation and Pharmaceutical Technology at Fuzhou University (China) to develop a series of algorithms for quantitative evaluation of gold immunochromatographic assay (GICA). This has helped to develop/improve specific medical devices used to test for Downs syndrome and Acute Myocardial Infarction (AMI); the devices have been trialled in China with 468 patients having used them in two city hospitals and in five other county hospitals with approximately 1000 patients for each hospital per year and a saving of GBP 10 per

Unit-level environment template (REF5b)

patient per test. Grosan [InnovateUK Intelligent medical system with customised exercises for personalized home telerehabilitation (IntelliRehab) project (2016-2019)], with MIGHT Malaysia, developed gesture correctness algorithms used in the quality assessment of rehabilitation sessions through machine learning. This is being used by Mira Rehab (UK SME) and ProvenPac (Malaysian), and several UK-based Hospital trusts are adopting these technologies (Manchester University NHS Foundation Trust, Royal National Orthopaedic Hospital NHS Trust, Guy's and St. Thomas' NHS Foundation Trust, St. Helier Hospital and Great Ormond Street Hospital). Money developed 'Falls Sensei', a first-person 3D exploration game that aims to educate older adults about extrinsic risk factors associated with falls within the home environment for older adults in the UK [supported by a Royal Society grant]. He continues to work with Disabled Living Foundation (London), Staffordshire and Stoke-on-Trent Partnership NHS Trust, Homerton University Hospital NHS Foundation Trust, Stoke-on-Trent Mobility and Independent Living Centre and The Shaw Trust (London). Li worked with Moorfields (UK) and Tongren (CHINA) Eye Hospitals on medical imaging with respect to segmentations of retina layers and diseased regions in the eye to support diagnosis. He developed automation techniques to help improve the effectiveness of their work and to develop new protocols in clinics. This has provided domain expert knowledge and data and has advanced the research base in terms of level set method and graph cut in retinal analysis.

Not-for-profit Organisations

Taylor and Anagnostou in the H2020 Sci-Gala and TANDEM projects led improvements and strategy in digital infrastructures in National Research and Education Networks (NRENs) across Africa. This work has benefitted over four million students and three hundred universities (with stakeholders including WACREN (Ghana), UBUNTUNET (Malawi), Eko-Connect (Nigeria) NRENs in Ethiopia, Kenya, Malawi, Tanzania and Zambia). This has also led to the adoption of Open Science by the Ethiopian government. Groen [H2020 HPC and Big Data Technologies for Global Systems (HILDAGO) project (2018-2021)] is developing large-scale HPC simulations with partners including ATOS SE (Spain), the High Performance Computing Centre Stuttgart (Germany), Poznan Supercomputing Centre (Poland), University of Salzburg (Austria), National Technical University of Athens (Greece), European Centre for Medium-Range Weather Forecasts (UK) and the Hungarian Public Road network (Hungary)). Groen leads the technological development and also refugee migration simulation (FLEE). The FLEE modelling code is being trialled by several agencies (e.g., the German Foreign Office and the UNHCR innovation service) and has led to the adoption of agent-based simulation as a research priority in the UNHCR Innovation Fund. Ali [The Royal Academy of Engineering Newton – An Autonomic Software Architecture for Knowledge Management in Medical Diagnosis, and The Royal Society – An Autonomic Architectural Approach for Health Care Systems (2015-2017)], in partnership with Universidad Autonoma de Mexico, led the application of self-adaptive techniques in the Instituto Nacional de Rehabilitacion (a Mexican Hospital Centre) to reduce the maintenance of their systems and aid doctors in the diagnosis of patients through ontologies. The hospital adopted the ontologies and over 20 GP doctors and 500+ patients have benefited from early diagnosis. Ghinea [The Royal Academy of Engineering Newton-Bhabha Industry Academia Partnership Programme – Making Deep Learning and Artificial Intelligence Skills Mainstream in India (2018-2020)] worked with Bennett University (India) to train over 6000 Trainers in Artificial Intelligence resulting in 69 Indian Institutions adding AI-related courses in their UG Curriculum. This has received widespread attention in India with 100+ news items in mainstream media. Ghinea has led and applied innovations in Mulsemmedia (multiple sensorial media); in the H2020 NEWTON (Networked Labs for Training in Sciences and Technologies for Information and Communication) project (2016-2019), with ATOS (Spain/Slovakia), SMEs (Aperian Ltd (Ireland), Kybertec (Czech Republic), etc.) and Dublin City, Fundacion (Spain), Slovakia Technical, and Bucharest (Romania) Universities, Mulsemmedia was used to increase learner quality of experience and outcomes in novel state-of-the art teaching labs and this created a pan-European learning network platform. Hone worked with QinetiQ in the Defence Human Capability Science and Technology Laboratory to investigate the role of the processing of social signals in interventions for skills training for the Ministry of Defence as part of the EMPATIC project funded by DSTL Commercial Services. This has resulted in new training capabilities for QinetiQ.

Unit-level environment template (REF5b)

Note that work on open research environments and reproducibility are described in Section 1.

Indicators of the Department's wider influence include:

Advisory board membership: Taylor, ACM SIGSIM Steering Committee/International Computer Simulation Archive; Bell, ACM SIGSIM Education Chair; Groen Flemish Tier-1 Allocation Board and PRACE User Forum Steering Committee; Sengul, ACM-Women Europe Communications Chair and Secretary; Liu, Springer Natural Computing Book Series Advisory Board, British Classification Society Steering Committee, and IEEE Computational Intelligence Society Task Force on Many-Objective Optimization; Perry, ACM SIGCHI Executive Committee Member; Z. Wang, Member of the IEEE Press Editorial Board (2015-present).

External leadership roles: Bell, NHS Data Governance; Grosan advised Government Digital Services Academy on the Emerging Technologies Programme (Artificial Intelligence topic); Liu, Member of the international panel to assess the quality of computer science research in the Netherlands; IDA Founder and Honorary Member of the Council; Louvieris, Confederation of British Industry (CBI) AI Working Group, CBI Data Protection Working Group, Co-Director, Trusted Open Models Institute, Hartree Centre, STFC; Perry, contributor and reviewer on Parliamentary Briefing paper on 'Alternative Currencies' (UK Parliamentary Office of Science and Technology, 2014); Sengul, standards: IETF ACE Workgroup: ACE MQTT-TLS Profile, Kantara UMA; Shepperd, Chair of international quinquennial review of universities Gothenburg and Chalmers; Taylor chaired DSTL Numerical Simulation and Analysis Group formal audit, model reviewer for Ministry of Defence and Sellafeld, member of SISO- STD-009-2017 Simulation Reference Markup Language delivery team; Tucker, Medicine and Health Regulatory Authority.

Research Councils: EPSRC College: Ali, Gilbert, Hone, Liu, Perry, Shepperd, Taylor, Wang. Reviewer: Ali, Science and Technology Facilities Council, Dutch Research Council; Young, European Research Universities Network (YERUN) Research Mobility Awards 2019-2020, UK National Commission for UNESCO Newton Prize 2020; Anagnostou, EC Innovation and Networks Executive Agency (INEA), National Science Centre (NCN), Poland; Ghinea, EU H2020 programme, national research councils of Greece, Portugal, Kazakhstan, and Oman; Grosan, Royal Society International Exchanges Committee, Newton Fund (the British Council) panel member; Liu, Member of EPSRC Grant/Fellowship/Research-Hub Panels (ICT, Engineering, Healthcare), ESF College of Expert Reviewers, Assessor for the Turing Institute Senior AI Fellowship Programme; Louvieris, EPSRC Directed Assembly Network (Steering Committee), EPSRC Digital Personhood Network (Steering Committee), STFC Trusted Open Models Institute (Steering Committee); Perry, IKTPLUSS programme Panel Member (Research Council of Norway), NordForsk programme Panel Member (Nordic research advisory body), EPSRC ICT Panel; Member of international award panels (Science Academy of Finland, KK Foundation (Sweden) and NSERC (Canada)); Taylor, H2020 reviewer.

Journal Editors: Counsell: IEEE Software; Macredie: Virtual Reality (Springer); Taylor: Journal of Simulation (Taylor & Francis); Z. Wang: Neurocomputing (Elsevier), International Journal of Systems Science (Taylor & Francis), Systems Science & Control Engineering (Taylor & Francis). Associate Editors: over 40.

Fellowships: Ghinea, Royal Academy of Engineering Newton Katip-Celebi Distinguished Visiting Fellowship; Koulouri, Parliamentary Fellowship, House of Commons Library; Lauria, DUO-India Fellowship; Perry, Royal Society Kan Tong Po International Fellowship; Aburumman, CMI Fellowship at the Institute for Research in Computer Science of Toulouse (IRIT).

Keynotes: over 40, including: 2nd IEEE/ACM Second International Workshop on Emerging Trends in Software Engineering for Blockchain (Destefanis); 11th IEEE International Conference on Ubi-Media Computing (Ghinea); 13th International Conference on Computational Intelligence methods for Bioinformatics and Biostatistics, 21st IberoAmerican Congress on Pattern Recognition (Liu); IEEE/ACM Workshop on Distributed Simulation and Real Time Applications (Taylor); 13th International Conference on Natural Computation, Fuzzy Systems and Knowledge Discovery (Z. Wang)

Learned Societies: Elected member of Academia Europaea, IEEE Fellow (Z. Wang); FBCS (Shepperd, Counsell, Li, Liu, Macredie); IEEE Senior Member (Li).

Conferences: more than 70 instances of organisation committee membership (56 IEEE/ACM); more than 400 instances of International Programme Committees membership (300 IEEE/ACM); 17 best papers awards (15 ACM/IEEE conferences).