

Institution: University of East Anglia

Unit of Assessment: UoA 11 (Computer Science and Informatics)

1. Unit context and structure, research and impact strategy

Overview of unit structure

The School of Computing Sciences (CMP) is one of six Schools in the Faculty of Science of the **University of East Anglia (UEA)** in Norwich. This Unit encompasses 29 permanent academic research staff, 27 from CMP and one from each of the School of Mathematics and Norwich Medical School. Research activity is grouped into five “laboratories”: **Colour and Imaging, Computational Biology, Data Science and Statistics, Interactive Graphics and Audio,** and **Smart Emerging Technologies**, although of course there is considerable interaction across the five labs.

Much of CMP’s research involves collaboration with national and international partners, ranging from academia, industry and leading Research Institutes such as **The Alan Turing Institute**. There is also close collaboration with other UEA Schools (notably the Schools of **Biological Sciences, Norwich Medical School** and **Environmental Sciences**) and the Research Institutes of the **Norwich Research Park (NRP)**, one of Europe’s largest **collaborative** research sites. With around 3,000 researchers and clinicians and an annual research spend of over £130 million, NRP provides a **thriving research environment for CMP**, including joint initiatives, seminars, projects and PhD students in areas such as Artificial Intelligence, High Performance Computing, Data Science and Bioinformatics.

Progress against REF2014 plans

Over the REF period, our 2014 strategy of strengthening our links and partnerships nationally and internationally and with industry has yielded a **diverse research output** (over 490 peer-reviewed journal/conference outputs appearing in at least 220 different journals, with over 140 co-authors from more than 27 countries listed in the UEA Digital Repository), impacting on digital critical infrastructure, health, society and the environment, as well as local/international companies such as BT, Aviva and Apple (see e.g. additional information provided for outputs). CMP has **sustained** its income stream, with more than 80 research awards and a UEA value of over £17.9M in the REF period (compared with £13.5M reported for REF2014), of which £6.2M income is reported in REF4b (£7.5M for REF2014). Research awards were from a broad range of funders, including EPSRC, BBSRC, NHS, NERC and the EU, and many of these awards **involved multiple partners** (the total award value of UKRI grants involving CMP staff was in excess of £28M).

In 2015 CMP’s research underwent a **root-and-branch review** to strategically drive forward its research led by the PVC Research & Innovation with an invited external expert reviewer. Two major aims were identified: to **broaden CMP’s research areas** and to **increase the number of early career faculty**. Over the REF period these aims have been addressed by investing in a new professor *Parr* (Telecommunications), who is currently Head of School (HoS), and lecturers *Aung* (Medical Sensors), *Buckley* (Cyber Security), *Ren* (5G), and *Zebin/Zhao* (Artificial Intelligence/IoT) to create the new **Smart Emerging Technologies** research area. In addition, the School has appointed new lecturers to **strengthen the existing research areas** of Machine Learning (*Lines*), Image and Colour (*Mackiewicz*), Digital Humans (*Taylor*), and Computational Biology (*Wu*). Further appointments, seeking a Chair in Smart Connected Environments in association with BT Adastral Park, a Senior Lecturer in Cyber Security, and a Lecturer in Robotics and Autonomous

Systems jointly with the School of Engineering are planned (appointments delayed by COVID-19 pandemic).

Research objectives over the next 5 years

CMP's vision is to **deliver international research excellence with impact** so as to address a range of priority challenges identified by UKRI and the government linked to **Sustainability, Society, Economy and the Environment**. CMP's research is scientifically underpinned, predominantly applied, and by its very nature genuinely interdisciplinary which lends vitality and puts CMP in a **strong position** to deliver on this vision. Over the next five years our strategic approach to research and impact will be driven by the following key goals:

(1) To further grow and strengthen our research excellence, including development of new areas including Cyber-risk and Smart Environments. This will be underpinned by ongoing growth in research and teaching income, and a strategic growth in research staff.

(2) Push our regional place-based agenda through ongoing and unique opportunities in the **East of England** with regional stakeholders from ICT, Creative Industries, Health, Agritech, Manufacturing, Supply Chain and Energy. To do this we are actively engaging with several regional technology clusters named below, as well as the new Productivity East hub.

(3) Leverage collaborations with key partners both locally (e.g. the BBSRC Earlham and Quadram Institutes and Norwich and Norfolk University Hospital) and at the national and international level (e.g. BT, Aviva, IBM, Siemens, Anglian Water, Apple, Lotus Engineering, Productivity East), taking advice from industry and business (e.g. via CMP's **industrial panel**), to both raise income and leverage new impact.

(4) Develop new partnerships in PhD training, building on the new **EPSRC Centre for Doctoral Training (CDT) in Agri-Food Robotics** established in 2019 with Lincoln and Cambridge and the NRP-based **NERC, BBSRC and Leverhulme Doctoral Training Partnerships**, so as to support cutting-edge research and secure new PhD funding.

Research laboratories

We now present the five research labs and their plans (lab members listed with lead in bold). Highlights for each lab's income and additional achievements are given in Section 3.

Colour and Imaging (*Finlayson, Mackiewicz*): This lab's research is wide ranging and during the REF period it has pushed forward investigations into **perception** (how we see), **colour image processing pipelines** (display and acquisition/camera) and **physics-based computer vision**. It works with partners across the UK and beyond (e.g. through the EPSRC Network, "Vision in Image Interpretation in Humans and Machines", 2014-17, and conference/summer school organisation e.g. **British Machine Vision Association's** PGR summer school in computer vision). In addition, it fosters close relationships with industrial collaborators (see e.g. **Spectral Edge Ltd.** impact case study). This lab was the UEA lead for the "AgriForWards" **EPSRC CDT**, the world's first CDT in agri-food robotics (<https://agriforwards-cdt.blogs.lincoln.ac.uk/>). Supported in part through *Finlayson's* ongoing **EPSRC Established Career Fellowship**, the lab's growing portfolio of research interests includes the deployment of "**in the field**" **computer vision systems**, e.g. jelly-fish monitoring using deep-net based systems funded by Centre for Environment, Fisheries and Aquaculture Science (Cefas) and other industrial collaborators.

Computational Biology (*Brewer, Greenman, Hayward, Huber, Moulton, Wu*): This lab produced research spanning the biological hierarchy from genome (e.g. **protein structure modelling**) through to organism (e.g. **cancer bioinformatics**) and ecosystem (e.g. **phylogenetics and metagenomics**). A key driver continues to be the ongoing explosion in data production via **high-throughput sequencing technologies** which can deliver vast numbers (10^9) of short sequences (40–600 nucleotides) in a matter of hours, as exemplified by *Moulton's* BBSRC-funded work on

developing algorithms and open-source software for small RNA research. The lab will continue to build on its NERC- and BBSRC-facing research in bioinformatics theory and software with partners such as the Earlham Institute and the Norwich Medical School. Through involvement in initiatives such as ELIXER, this will feed into ongoing **national and international projects** (e.g. metagenomics of marine phytoplankton and phylogenetic approaches for the UK **The Darwin Tree of Life Project**).

Data Science and Statistics (*Cawley, Bagnall, De La Iglesia, Kulinskaya, Lines, Nikoloulopoulos, Wang*): The lab has developed analytical approaches that use a combination of **data science and statistical techniques to exploit big data**. As exemplars, in EPSRC-funded research, *Bagnall* and *Lines* have introduced and evaluated algorithms for time-series classification in collaboration with the **Alan Turing Institute**, and, funded by the **Institute and Faculty of Actuaries (IFoA)**, *Kulinskaya* developed a methodology for modelling longevity and morbidity risks. Going forward, the lab will continue methodology development in statistics and machine learning such as copulas, time-series classification, ensemble methods, and deep learning approaches for big data analysis. Focus applications include **health data**, seeking funding via e.g. EPSRC's Health Technologies Theme and MRC (in collaboration with e.g. Norwich Medical School and the University Hospital), **actuarial data** through ongoing collaboration with Aviva and IFoA, and **industrial applications** (e.g. ongoing collaboration with Greater Anglia/Network Rail).

Interactive Graphics and Audio (*Day, Harvey, Lapeer, Laycock, Milner, Taylor*). The lab has driven forward the analysis, processing and generation of **audio and visual signals** in machine vision, computer graphics, and audio and speech processing, motivated by applications to **creative digital industries, robotics and healthcare technologies**. For example, through her ongoing **EPSRC Innovation Fellowship**, *Taylor* works on linking speech and face-and-body gesture with the New Zealand company *UneeQ*, and, in AHRC-funded work within the Virtual Past enterprise (<http://www.virtualpast.co.uk/>), *Day* collaborated with UEA's School of History on the **Magna Carta** reconstruction project (see Section 4). Moving forward, **audio work** will be largely society and industry-focused (e.g. collaboration with the *Gardline* company to develop passive acoustic monitoring systems to detect cetaceans from autonomous surface vehicles), **3D modelling of urban environments** has started to employ drones plus reconstruction software to survey historical sites, and **virtual reality** research includes development of **interactive haptic tools for drug design** and **childbirth simulation software**.

Smart Emerging Technologies (*Aung, Buckley, Liu, Mayhew, Parr, Ren, Zebin, Zhao*): This lab was established in 2017, adding new diversity to CMP's research base. Its members address technology-based research challenges in areas such as **cyber security, network resource optimisation, data management in assistive living, cloud-edge computing/network management/5G**, and **smart environments**. It has a strong **international agenda**; e.g. through *Parr* the lab is involved in a **US-Ireland-NSF Project** exploring the agility of high-bandwidth optical connections that support high-capacity cloud applications, and it is a partner in the EPSRC-funded **Internet of Food Things** network. Moving forward, the lab aims to develop more proactive, intelligent, autonomous systems that can learn, adapt and make secure decisions without the need for human control. It will grow its expertise in **smart environments** (e.g. through *Zhao's* InnovateUK-funded work to deliver smart local energy solutions) and **cyber-risk** (e.g. building on *Buckley's* EPSRC-funded work on using conversational agents in healthcare, defence and security and technology). Supporting this will be the 2019 investment in a new **Cyber Security Lab** and introduction of an **MSc in Cyber Security**, which will spin-out new research projects together with partners including BT, Siemens, Intel, IBM, Aviva, and the Norfolk Constabulary.

Enabling and facilitating impact

During the REF period, over £1.8M was brought in via consultancy, enterprise and training through over 80 awards and contracts in addition to the research awards reported above, almost doubling the £1M reported in REF2014. Much of CMP's enterprise activity **is enabled through**

SysConsulting Ltd. (SYSCo) a consulting unit trading through UEA Consulting Ltd, a wholly owned subsidiary company of UEA (<http://www.sys-consulting.co.uk/web/>).

Following our REF2014 strategy, we are engaging with a number of **Regional Technology Clusters**, most notably *Innovation Martlesham; SyncNorwich; AgriTechEast; TechEast; East of England Energy Group*; and the *New Anglian Local Enterprise Partnership*. These relationships play a vital role in raising the research profile and innovation activities in CMP with key users. It also ensures our research has opportunities to **move up the technology readiness levels** and can feed into important sectors of the regional economy (e.g. Nuisance Call Detection with *BT* through an **EPSRC iCASE award**, and Train Delay Prediction/Prevention with *Network Rail/Greater Anglia*).

Impact is also driven forward through careful support and dedicated UEA funding. Potential routes for Impact Case Studies (ICSs) and impact funding are identified and nurtured within CMP led by the **Director of Innovation (Hayward)** who regularly meets with project leads to offer guidance and signposting to resources. The range of UEA support covers financial, legal, IPR management, marketing, commercialisation. These informal interactions feed-forward into a **formal annual research review cycle** which involves in-school review, followed by Faculty-level and then PVC reviews. Feedback and quality assessment provide a **gateway to accessing UEA impact funding** which is allocated on a case-by-case basis that best aligns with CMP and UEA's impact development agenda. In the REF period, the School received 18 UEA grants totalling £158K for impact development.

Our three submitted ICSs were selected from a portfolio of 16 active ICSs that exemplify CMP's wider contributions to the economy and society. The contacts and collaborations engaged developing our ICSs, and nascent impact activities, substantially enrich CMP's research environment by providing funding for staff research programmes, stimulating new lines of research, and enabling communication of our research with diverse communities. The ICS "**Spectral Edge**" illustrates our support of a spin-out company by a member of staff, "**Computer Vision for Monitoring of Animal Populations**" illustrates impact generation through engagement with EU and local partners Cefas, and "**Improved Evaluation of Longevity and Mortality Risks within the Actuarial Profession and Insurance Industry**" illustrates impact generation through a close association with a UK professional body, IFoA, and a multi-national company, Aviva plc.

Approach to interdisciplinary research

A key strength in CMP's interdisciplinary research is its **extensive involvement in the NRP** and the wide-ranging interdisciplinary collaborations and research vitality which this brings. In many cases this is via our PhD student cohort, who have supervisors from across the NRP, but require core Computer Science to solve research problems linked to areas including AI, HPC, Data Science, Bioinformatics, Health & Disease, and the Environment. Key ongoing CMP interactions are with the **BBSRC-Earlham Institute (EI)**, the **BBSRC-Quadram Institute (QI)** and the **Norfolk and Norwich University Hospital (NNUH)**. Development of NRP projects is facilitated through:

- Events such as **Birds-of-a-Feather meetings** with staff in other research institutes (e.g. EI and QI), in which we meet to present our research and brain-storm new ideas to take forward.
- **Sharing Calls for Funding with UEA Schools and NRP institutes** from UKRI and other funding bodies such as charities (e.g. UKRI and Leverhulme Fellowships).
- School membership of **Institute Steering Boards** (e.g. *Parr* sits on the QI Steering Committee).
- **Engagement with clinicians and medical practitioners** at NNUH (e.g. *De La Iglesia* collaborates with clinicians working on prostate cancer).
- **Open research forums** such as the **School annual PGR-Day**, **UEA's Vitae in Three Minutes Thesis Competition** and the **UEA Researcher Summit** where PGR students, RAs and their supervisors can share and promote their research.

Research integrity within an open environment

CMP's **ethics committee** has been in place since 2011. Its members review all ethics applications from the School taking into consideration UKRI policies for Responsible Research Innovation. Straightforward applications are reviewed by the Chair or Deputy Chair, while more complex applications are considered by the whole Committee. This ensures a flexible and proportionate review is provided for activities covered by UEA's research ethics policies (UEA is a signatory to the UUK Concordat to Support Research Integrity). CMP also actively supports an **open research environment** through making its research outputs - including publications, software and data - available to a wider audience whenever possible. This includes making publications available through the UEA Digital Repository and through Open Access Journals, in line with UEA's Institutional Open Access Policy. CMP also makes much of its **software openly available** (e.g. through GitHub), as well as making **data available for algorithm evaluation** (e.g. <http://dyndom.cmp.uea.ac.uk/dyndom/> and <http://www.timeseriesclassification.com/>).

2. People

Staffing strategy and staff development

CMP's staffing **strategy** is to create a **sustainable and thriving research environment** through recruitment of internationally excellent staff into core areas of Computing Science and careful support of existing staff. In recent years, CMP has **increased its new recruitment**, with Academic Teaching and Research (ATR) hires at the senior level (*Parr, Buckley, Lee*) and junior levels (lecturers *Aung, Mackiewicz, Lines, Ren, Taylor, Wu, Zebin, Zhao*), as well as new ATS (Academic Teaching and Scholarship) appointments (*Blair, Bostrom, Chin, Mapp*). Recruitment of a new ATR Lecturer, Senior Lecturer and Chair is planned and, as student numbers in CMP remain buoyant, strategic ATR appointments will be made across all of the School's research groups. The School has focussed on maximising the pool of female applicants and ensuring that Equality and Diversity (E&D) is embedded in the recruitment processes.

Responsibility for staffing strategy rests with the HoS and the School's Executive Team (including six senior staff members, including the Directors for Research (*Moulton*), Innovation (*Hayward*), Teaching and E&D (*Kulinskaya*). New ATR appointments are aligned with the School's research priorities, as determined by the School's **Research Committee** (comprised of lab leaders and Research, Innovation, PGR, E&D Directors). CMP's Research and Innovation Directors sit on the relevant Faculty of Science committees, facilitating the **flow of information** between CMP and the University, as well as ensuring that the School's overall strategy is informed and contributes to the Faculty and University as a whole. CMP also strategically hires a small number of non-research ATS faculty (currently roughly 20% of academic computing staff) who focus on teaching, freeing up research time for ATR faculty.

CMP has a **workload model** which ensures faculty engaged in research activities (e.g. leading grants, participating in national/international committees, chairing conferences, and Journal Editorial membership) have lower teaching and administrative duties. All ATR staff have a **base research allowance of 30%**. Additional credit can be given for innovation and engagement activities such as developing technology, establishing spin-out companies and consultancy with the agreement of the HoS and Research Director. **New ATR staff members** in their first lecturing post receive an extra 15% reduction in their workload for each of their first two years. They also receive a Faculty **start-up package** of £7.5K per year for the first two years and are assigned a **mentor** who is generally a senior member of their research lab (all staff can request a mentor at any career stage). The Faculty also ensures that every new member of staff is **given priority in the Faculty's annual allocation of PhD** studentships (e.g. *Lines, Ren* and *Taylor* received studentships through faculty-wide competition).

All research staff have a formal annual **research activity planning meeting**. The aim is to encourage **self-reflection** and **strategic planning** by individuals on their research activities, as well as providing a sounding-board for future plans. Recently, after consultation with staff, CMP has moved to holding this planning meeting jointly with an annual appraisal involving the HoS, Research Director and Teaching Director. This provides a greater overview in planning of activities for the following year. The overall approach is **supportive**: achievements and readiness for career advancement are **identified and celebrated**, and opportunities for advice, further mentoring support and training are identified. Data on outputs, grant activity, PhD supervision and research impact activity for the last few years is provided centrally, and the individual describes their plans on a simple form. We have found that these meetings encourage staff **to plan more strategically** (e.g. deciding which UKRI funding calls to target) and provides knowledgeable feedback on future aims and aspirations. An overview of the planning meetings, along with relevant data, informs the **School's annual research review**, which is led by the Director of Research and HoS, and overseen by the Associate Dean for Research in Science and the Pro Vice Chancellor for Research. This enhances and supports the strategic planning of the School's research within the University as a whole, and with government and industrial partners.

The **School Promotion Committee** considers all staff each year (whether or not they have applied for promotion) to see whether they would be eligible for early confirmation in post or promotion, and the HoS makes a recommendation to the Faculty Promotions Committee. CMP has implemented a number of actions to encourage promotion applications (e.g. a prompt to discuss promotion in the Appraiser checklist which all staff receive, and a workshop on "Demystifying promotion"). During the REF period four staff were promoted to Senior Lecturer, one to Reader and one to Professor. Faculty can apply for six months of **study leave** after every three years, with applications assessed on their scientific merit and research ambitions. **CMP facilitates research and industrial collaborations** by working with faculty to rearrange their teaching or other duties around study leave or other lengthy events/visits. These periods are important as they permit extended visits to globally leading universities, institutes and corporate research labs of world-renown (e.g. *Finlayson*, *Apple*, *Moulton*, Isaac Newton Institute).

Contract research staff

The **School's Research Staff Co-ordinator** (*Moulton*) is an important point-of-contact for Research Associates (RAs) and early career researchers. They provide information and a two-way dialogue between RAs and CMP's executive team, as well as information and advice regarding the support available to them (e.g. via the Researchers' Working Group or UEA-wide Researchers' Fora). Research staff also have a representative on the School Board.

Delivering research excellence depends on attracting, developing and retaining high-achieving research staff. CMP's aim is to **support the development of all research staff and to nurture our early career researchers**. Prompted by the 2015 School research review, **CMP has increased its focus on attracting research fellows** and encourages Fellowship applications via mentoring by experienced research leaders and proposal support from academic, professional and technical staff. Opportunities, call deadlines and the comprehensive support that we can provide are advertised via UEA's Science Fellowships webpages. During the REF period we have **mentored fellowship applications** to a variety of schemes, including those funded by EPSRC, Leverhulme and UKRI, as exemplified by *Taylor's* EPSRC UKRI Innovation Fellowship awarded in 2018 and *Finlayson's* EPSRC Established Career Fellowship in 2019. Fellowship schemes that require a significant financial contribution, such as the UKRI's Future Leaders Fellowships, undergo an internal sift process organised by the Faculty, which helps direct applicants to the most appropriate scheme.

CMP implements UEA's **Code of Practice** for the Management of Research Staff which provides guidance to research staff and research managers and is informed by the **UK Concordat to Support the Career Development of Researchers**. The School uses indicative research job descriptions to ensure that RA jobs are costed at the correct level on grant applications and that appointments are made on an appropriate salary grade. From April 2019 the University introduced

relocation assistance for research staff, while from summer 2020 it introduced a **merit-based promotions process for RA staff** which accords with expectations under the revised Concordat for the Career Development of Research Staff. The Faculty funds any shortfall in funding for merit-based promotions and salary progression awards, and also has a new **bridging fund** to cover short-term funding gaps of up to three months' employment.

Research students

Overseen by the School's Postgraduate Research Director (*Huber*), research students play a **vital and underpinning role in our research**. During the REF period the School awarded 74 doctoral degrees (see REF4a), which is an increase from REF2014 (10.6 vs 9.2 degrees p.a.). This reflects **the School's strategy in the 2015 review to increase PhD student numbers** by diversifying its income sources for studentships. In particular, students have been funded from sources such as the Agriforwards EPSRC CDT; the BBSRC NRP DTP; NERC NEXUSS CDT and NERC ARIES DTP (CMP was a partner applicant for the BBSRC and NERC DTPs); EPSRC iCASE-studentships (e.g. BT, Scottish Whisky Research Institute); UEA Science Faculty scholarships; overseas government scholarships; fully/partly industry/institute funded studentships/internships (e.g. Apple, Google, nVidia Research, Turing Institute and IFoA), and self-funding. CMP is also involved in a co-supervision agreement with Southern University of Science and Technology, China. A **commended feature of the EPSRC CDT** project was the comprehensive approach to equality and diversity.

CMP runs a **rigorous post-graduate student (PGR) recruitment process**, with potential students identified initially by application to advertised projects or by scrutinising projects proposed by students, followed by an interview. Interview panel members are independent of the supervisor and in the case of CDT studentships are from across NRP. The student's academic ability is paramount. **PGR studentship funding provided by the Science Faculty** is used strategically by CMP to (a) encourage research students into areas outside the CDT and DTP domains, (b) to support early career faculty, and (c) to address specific initiatives (e.g. dictated by our industrial strategy). The Faculty funded 21 CMP studentships in the REF period, representing a **significant strategic investment** into the School.

All PGR supervisors are required to undertake training in '**Best Practice in Research Supervision**' every three years, as outlined in the UEA Code of Practice for Research Degrees. This course is designed and run by the Associate Dean for Postgraduate Research (Science), PGR service and PGR Skills co-ordinators. The course covers best practice in supervision and PhD regulation, but also focuses strongly on the staff-student relationship and **student wellbeing**. This provides opportunity for all staff to reflect on the role as a supervisor, and a forum to exchange best practice.

All students are assigned a **Training Pathway (TP)** when they start their PhD (CDT/DTP's have specialised pathways; other students take the Science Faculty pathway). The TP has mandatory training requirements as well as suggested **professional and personal development** which can be tailored to the needs of individual students. Within eight weeks of starting, students complete a **training needs analysis**. The student can select from a variety of courses, from specialist advanced skills training (e.g. HPC and R), to broader academic and professional/life skills (e.g. academic oral and poster presentation preparation, project management, viva/thesis preparation, leadership skills and employability). The UEA Code of Practice for Research Degrees ensures a commitment to the provision of skills and employability training in the TP for all research degree candidates, bearing in mind national standards including **Roberts' 'SET for Success' report**, the **Vitae Researcher Development Framework** and the expectations of Research Councils.

As well as frequent informal meetings, students meet formally with their supervisory team eight times per year, including an annual review meeting to update and plan TP targets. In addition, after six-eight months they have a formal probationary review to allow progression. As part of the annual review students are required to upload a "**living thesis**" to a purpose-built CMP database to help ensure that they are on track for submitting their thesis on time. Outcomes of formal

meetings are recorded by the School and are evaluated by the PGR Director with follow-up actions if necessary.

All of CMP's PhD-students are required by the School to participate in **CMP's Annual Postgraduate Research Day**. This is a **lively forum** which showcases their research via poster presentations, and includes an external invited speaker who is involved in judging posters for the best poster prizes. Feedback from students and past invited speakers has been very positive. CMP also runs a **research seminar series** to which the PhD-students are invited either to speak (e.g. to practice for their viva) or to be a member of the audience. In addition, students can intercalate to undertake internships **working in industry and institutes** (e.g. placements include: Google Washaw, 2015, Nvidia Research Helsinki, 2018, Google Research Amsterdam, 2019, Alan Turing Institute, 2019).

Equality and diversity

CMP received the Bronze Athena SWAN (AS) Award in 2015 which was reconfirmed in 2019, indicating our continued commitment to E&D and to acting inclusively and flexibly wherever possible. We have **embedded AS principles** within our processes: The HoS is a member of E&D Committee and the E&D Director (*Kulinskaya*) is a member of the School ET and Promotions Committee. A Deputy E&D Director role was also established in 2017, recognising the breadth of work to be undertaken. **Awareness of E&D** has been raised through, e.g.:

- Bimonthly E&D committee meetings with rotating annual membership, regular updates given at the School Executive Team and School Meetings. The committee has representation of gender/BAME and early career researchers as well as technicians.
- Online **'Diversity in the Workplace'** training, which is compulsory for all staff, renewed every two years (100% compliant).
- **Celebrating female role models** through 'Women in Computing' posters, online female staff and alumni case studies, and marking International Women's Day through School celebration events, pledge selfies and posters.
- **Networking opportunities**, including daily coffee and lunch breaks in the D'Arcy Thompson communal area are open to everyone in the School including RAs and PGR students (for now moved online).
- A commitment to E&D together with a positive action statement in job adverts, and completion of UEA's 'Recruitment and Selection training' for staff involved in recruitment, which includes a component on **unconscious bias**.

The number of female academics in the School has increased to eight (22%) of ATR/ATS staff, compared to three (10%) in 2009 and five (16%) in 2015. In particular, the **gender gap in the staff pipeline has narrowed** at Senior Lecturer and Professor level since 2009 with the promotion of two female Lecturers to Senior Lecturer in 2012 and the recruitment of a female Professor in 2010. Recently, it has also narrowed at the Lecturer level with the recent recruitment of three female Lecturers (*Taylor, Chin (ATS), and Zebin*). CMP robustly analyses recruitment data, and our commitment to fostering an inclusive culture is evidenced by the number of BAME staff working in the School.

All staff have access to **ResNet**, a UEA-supported network promoting equality and fairness across the NRP. The School **promotes wellbeing** through highlighting University-provided support such as the staff counselling service, Mental Health First Aiders, the Employee Assistance Programme, the 'Report and Support' online tool and the on-campus medical centre. Flexible working, defined core-working hours, and care leave policies are in place to support a healthy work-life balance and family friendly working. Support packages were put in place for researchers having to work from home due to the COVID-19 pandemic.

All pregnant/adopting employees are offered a meeting with HR to discuss entitlements and have a meeting with their line manager to complete a H&S Risk Assessment, agree the level of contact

during leave, and discuss cover needed for their work. The line manager organises cover and can apply for additional resources if required by submitting a post release to the Faculty. Since 2015, the Faculty has allocated £10K p.a. to support career development and transition back to work following six months' leave or more. All staff can make a formal **flexible working** request for a permanent change to their working hours after 26 weeks of continuous work at UEA. CMP has approved all requests for maternity/paternity leave and flexible working requests during the REF period (three staff maternity requests and one research associate flexible working request).

Selection of REF outputs and ICSs

Following the UEA REF Code of Practice, outputs from all ATR staff were considered for possible selection. Staff were asked to put forward up to six of what they considered to be their best outputs to help guide a thorough internal assessment of all of our outputs. Each of these outputs was assessed and graded on a UEA 13-point scale, each by at least two independent ATR staff within the School (staff were informed of the scores/comments for their outputs but assessors' names remained anonymous). A selection of outputs was also sent for external assessment by recognised experts in computer science to provide a calibration for the internal scores. Based on the scores, the outputs in the portfolio were ranked by the Director of Research, Head and Deputy Head of School (*Day*), to inform a portfolio selection whilst ensuring adherence to the REF output assignment rules and the Code of Practice. The gender profile of attributed authors' outputs (21%F) reflects that of the Unit as a whole (16%F).

ICS selection was on the basis of a series of annual review meetings conducted by the School Directors and Faculty Associate Deans of Research and Innovation, the PVC Research and Innovation, and the Impact managers (typically 3M:4F).

3. Income, infrastructure and facilities

Income highlights over the REF period

The UEA value of CMP's research awards over the REF period was £17.9M, the main funders being EPSRC, BBSRC, NERC, UK central government bodies, EU and industry, and over £1.8M was brought in via consultancy, enterprise and training. Key grants in each laboratory were:

Colour and Imaging: *Finlayson* won a five-year **EPSRC Established Career Fellowship** "Future Colour Imaging" in 2019 (EP/S028730/1, £1.04M) in addition to securing EPSRC funding of over £900K (EP/M001768/1, £434K; EP/J005223/1, £465K; EP/P007910/1, £29K) with industrial partners such as Apple and THOUSLITE. The lab also led UEA's part of the successful bid for the "AgriForWards" **EPSRC CDT** (EP/S023917/1, £6.9M) in the area of **agri-food robotics and machine learning** which was awarded to the Universities of Lincoln, Cambridge and UEA. Part of the lab's growing portfolio of research interests in deploying "in the field" computer vision systems is being developed through *Mackiewicz's* ongoing partnership in the **SMARTFISH** EU Horizon 2020 international research project (€6.96M).

Computational Biology: Through two NERC grants totalling ~£1M (NE/K004530/1, £348K; NE/R000883/1, £648K) and sequencing funded in part by the Joint Genome Institute and EI, *Mock* and *Moulton* (Co-PI) are developing new bioinformatics techniques for **marine phytoplankton metagenomics**, leading to new insights into phytoplankton diversity and adaptability, and their potential effect on climate change. Research in **RNA silencing** benefits from sequencing technologies, and through BBSRC funding in two grants totalling ~£600K (BB/L021269/1, £318K; BB/L009307/1, £275K) *Moulton* pioneered new bioinformatics tools for **small RNA next generation sequencing data** together with collaborators in the School of Biological Sciences (BB/H008047/1, £497K; BB/H019979/1, £509K). This has resulted in new tools for small RNA analysis (srna-workbench.cmp.uea.ac.uk). Additional funders for the lab include the Royal Society and the London Mathematical Society.

Data Science and Statistics: Through an EPSRC grant (EP/M015807/1, £317K), *Bagnall* has developed **cutting-edge techniques for time series classification**, which has generated new collaboration with the Alan Turing Institute (recognized by two Institute grants totalling £72K). *Kulinskaya's* collaboration with IFoA has funded research on the use of big health and actuarial data for understanding **longevity and morbidity risks** (£788K), and ESRC has funded the development of **smart data analytics for business** and local government (£5.2M), to which *Kulinskaya* contributes. In addition, after competition the Rail Research UK Association has funded *Wang's* development of an intelligence ensemble system for predicting and preventing **train reactionary delays** (£112K). Additional funders include the NIHR, Orthopaedics Trust, NERC, and The Scotch Whisky Research Institute.

Interactive Graphics and Audio: *Taylor* received an **EPSRC Innovation fellowship** for £577K for her work in **digital visual speech** (EP/S001816/1), which builds on *Milner's* £380K EPSRC grant (EP/M014053/1, £380K) for speech animation using dynamic visemes. *Harvey* is Co-PI on the Agri-ForWards EPSRC CDT and also held grants for £50K and £80K to develop vision methods for lip reading (National Crime Agency) and X-ray imagery (Defence Science and Technology Laboratory). Emeritus Professor *Cox* is Co-PI on the MRC grant (MR/P026265/1, £699K) for continuous ambulatory vestibular assessment in collaboration with NNUH. Other funding came from the Home Office (£212K) and various companies (e.g. Disney Research).

The Smart Emerging Technologies Lab: As part of **influencing UK National Funding policy** and the wider research community *Parr* is Co-PI on EPSRC grants including the Internet of Food Things Network Plus (EP/R045127/1, £1.1M) and the UK Research Strategy Community Organisation in Communications (EP/N007824/1, £236K). Recently, *Parr* also acted as lead for CMP's EPSRC-funded **Smart Environments Research Facility** (EP/T024593/1, 100K, with £40K additional support from UEA), which feeds into the School's strategy to support its researchers to further develop and leverage their research with organisations such as the Turing Institute, BT and QI. Through two EPSRC grants, *Buckley* has been involved in establishing a platform for **responsive conversational agents** to enhance engagement and disclosure (EP/S027424/1, £407K) and in developing **people powered algorithms** for desirable social outcomes (EP/R033382/1, £906K), which is pushing forward the lab's cyber-risk agenda.

Funding through research consortia

To address national and international research challenges, CMP **strategically seeks funding and new collaborations** through research consortia. Illustrative examples in the REF period include:

- **EPSRC network**, "Vision in Image Interpretation in Humans and Machines" (EP/L013932/1), which brought multidisciplinary researchers together from areas including psychology and biology.
- **EPSRC network CommNet2** (EP/N007824/1), which developed a robust framework to facilitate the academic innovation process to tackle 21st century ICT.
- **EPSRC network Internet of Food Things Plus** (EP/R045127/1), an interdisciplinary network that defragments and expands the UK's food digital economy.
- **EPSRC Next Stage Digital Economy Hub** (EP/T022566/1, £3.7M for five years), a new centre of excellence in digital innovation with University of Exeter.

Strategy and support for generating income and impact

Our strategy is to develop a **sustainable** income stream for research and impact activities by **mentoring and supporting staff** to develop their research and impact agenda and to help identify funding opportunities with UKRI and beyond. For those that are less established we facilitate strong collaborations with leading peer research groups and make introductions to our industrial contacts (e.g. members of our Industrial Advisory Board). We also **actively encourage** interdisciplinary and collaborative proposals. Future strategy is to grow our funding from EPSRC (e.g. though our new

ATR lecturers), UKRI consortia, and to continue to diversify our funding streams through e.g. commerce/industry and central government sources. We will also look to UKRI cross-council and InnovateUK initiatives ranging across all technology readiness levels.

Staff are **supported** through means such as grant planning, mentoring and workshops, and targeted funding from CMP's strategic research fund (during the REF period over £79K was made available to staff from this fund). An 'Effective Research Grant Applications' course is run for researchers by UEA, and in their annual research activity meeting ATR staff discuss current/planned research activity and can seek advice on proposal writing. **Research applications are reviewed** by senior research-active colleagues within the School, with feedback provided before the application is submitted, advice is given on receipt of feedback from referees and the outcomes for unsuccessful proposals are discussed. In some cases, feedback is given by a cross faculty committee (e.g. BBSRC and NERC proposals). Junior staff are supported by senior staff to apply for fellowships, e.g. *Taylor* was awarded an **EPSRC UKRI Fellowship in 2018**. Since 2015 the success rate of grant applications by female PIs was generally higher than for their male counterparts.

To inform and encourage new applications CMP and the Science Faculty regularly host **research and funding workshops**. These are often organised thematically for a particular research council in conjunction with the Associate Dean for Research. For example, we had an **EPSRC theme day** in June 2018 with an EPSRC-programme leader giving a keynote talk, several presentations on 'tips to winning funding', a Q&A panel and a networking poster-event over lunch. These **funder-focused events** and **grant writing workshops** are used to disseminate information, exchange tips and thoughts on winning research grants and to allow for networking amongst our research staff and students. They are an excellent way of developing a **positive research culture**: one that is looking ahead strategically for future opportunities for success.

To **support generation of impact**, the School has strategically adjusted its workload model by allocating staff time for this activity where appropriate. In addition, impact activities feature alongside teaching and research in the probation and promotion criteria for staff. Part of the overhead for consultancy using CMP facilities is returned to the School to support further activities. CMP staff have also been **celebrated for their impact** through two high profile events: The Impact and Innovation Awards and Gala Dinner, and the UEA Engagement Awards, which both provide showcases of our innovation and research activities regionally and nationally (e.g. *Finlayson* has been awarded one of only two UEA Innovation Fellowships). There are also programmes to encourage entrepreneurship that are targeted to research assistants and PhD students, who are ideally placed to take forward opportunities to maximise the impact of their work.

CMP also benefits from a **culture of impact** that is woven throughout UEA's academic and professional service structures. To drive forward new initiatives, CMP closely liaises with Associate Dean for Innovation, who chairs the Science Faculty's Innovation Executive on which the CMP Director of Innovation sits. In addition, UEA's Impact Team helps the School to develop its impact portfolio, deliver impact training, co-ordinate workshops and assist staff with evidence gathering. UEA also **supports innovation in CMP by offering grants** that provide support for all stages in the development process. Awards range from small amounts (<£5K) for an Associate Dean of Innovation grant, up to £75K for Innovation Development Fund or Proof of Concept grants. In the REF period CMP received 18 UEA grants and five external grants to develop impact, totalling £332K, e.g. to support the Spectral Edge ICS (£12.5K), automatic real-time speech animation (£14K), and commercialising lip-reading (£16K), and improving seabed mapping accuracy with AI (£37.5K).

Infrastructure and facilities

CMP has a team of four **specialist support staff**, all of whom are graduates in Computing Science, whose duties include expert programming/debugging, support of specialist research hardware and the planning and maintenance of CMP's server infrastructure. This is an invaluable

resource as it enables staff to rapidly obtain assistance with research projects and to respond to new initiatives. The following facilities and equipment are located within the School's 340m² of accommodation dedicated to **research**, and are fundamental to our research and impact activities (new investments in the REF period are noted):

1. **Motion capture Suite and Sound Room:** Provides facilities used by the Interactive Graphics and Audio lab, to drive forward research in areas such as avatar research and speech recognition.
2. **Advanced graphics Suite:** 20 high end workstations with specific graphics cards for video and graphics-related research. Investment of £30K in 2016.
3. **Colour Vision Room:** A dark room containing an extensive suite of specialised equipment for vision research including a spectroradiometer.
4. **Virtual Reality:** A dedicated VR workstation with Oculus Rift VR headset, an Oculus Rift Go Portable device and a 3D Scanner. Investment of £13K in 2017.
5. **UAVs:** DJI Phantom Unmanned Aerial Vehicle capable of shooting stable high-definition video for graphics research and M300 Drone with integrated SenSys Magnetometer. Investment of £6K in 2017 and £40K in 2020, respectively.
6. **AI Server:** Server with four high end GPUs, large memory capacity and fast storage for use with AI and Data Mining research. Investment of £10K in 2017.
7. **Cyber Security Lab:** A *new lab* running on a separate network and infrastructure dedicated for Cyber Security. It has high-end workstations, servers, switches, and IoT devices for research. Investment of £80K in 2019.
8. **Core Capital Research Equipment:** Grant for HPC/Multicore and Medical Sensor equipment to support research of established and early-career researchers/PhD students from across CMP, and in support of projects linking with Norwich Medical School and School of Environmental Sciences (EP/T024593/1, £100K, +£40K UEA, 2019).
9. **GPU farm:** A new Nvidia GPU farm to support AI research in e.g. deep learning and bioinformatics. Investment of £280K via a UKRI capital award to UEA in 2020.
10. **D'Arcy Thompson Suite:** Situated in the heart of the School, a multifunctional room with kitchen facility acting as a focal point for facilitating research interactions, holding events (e.g. annual PGR day and seminars), and for informal PGR/RA lunch gatherings. £300K has been allocated by UEA to refurbish it and the near-by Wolfson PhD lab to accommodate the EPSRC CDT in Agri-food Robotics.
11. **Productivity East:** CMP is actively involved in a new £7.4M regional hub for engineering, technology and management, one of whose primary research themes is computing sciences and which houses CMP 3D-printing (e.g. investment of £25K in 2015). Intelligent Digital Manufacturing will be a **core theme for collaboration** bringing in CMP expertise in AI/IoT/5G/Cloud and Vision-Imaging.
12. **High Performance Computing Cluster:** A centrally provided cluster available to all researchers across UEA and used extensively by CMP's research labs. The HPC has seen a year-on-year investment of £520K since 2014. It now consists of 425 computer nodes, 10 GPU nodes and 6 huge memory nodes, providing 8312 CPU cores, all powered by Intel Xeon processors.

Collaborative use of research support and infrastructure

In a **cross-NRP initiative**, a COVID-19 mass testing Webapp was developed by a **team of CMP academic and support staff** within the Norwich Testing Initiative in collaboration with EI (see doi.org/10.1093/pubmed/fdaa194). A mass-testing scheme was subsequently launched at UEA to support ongoing COVID-19 testing for new and returning students and staff, and extended to provide testing for staff, visitors and students across NRP institutions, which uses CMP research capital equipment to host the system.

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

Research collaborations, networks and partnerships

Collaborations with external academics, industry and stakeholders are promoted by our Research Committee and our Industrial Advisory Board. They bring **vitality to the School's research and advance its impact**. Notable additional examples of research consortia to the ones listed in the previous section include:

- The Colour and Imaging lab has organised and taught at the BMVA Summer School in Computer Vision, 2018/2019 and, with the support of the Society of Imaging Science and Technology, established the new annual London Imaging Meeting conference in imaging science.
- *Bagnall* and *Lines* collaborate with a **global network of researchers** to develop novel algorithms and open tools for time series classification and regression (e.g. Alan Turing Institute, Dublin, California and Monash Universities). This includes sktime, a Python toolbox for learning with time series data, initially funded through a UKRI Tools, Practices and Systems grant.
- *Hayward* collaborates with Professor Kitao at the **Tokyo Institute of Technology**, having been awarded a number of grants to visit him including a "Research Abroad and Invitational for International Collaboration" grant (2018) and a JSPS Bridge Fellowship (2015).
- *Parr* is part of the **BT Global Research & Innovation Programme** which has assembled international research institutions to explore the impact of COVID-19 on the future of work and society and the role of ICT.

Interdisciplinary collaboration is a critical path for CMP's research and impact. Illustrative examples include:

- **Magnacarta**, a project with historians to bring an 800-year-old document into the 21st century. Primarily funded by AHRC and co-led by *Day* with colleagues in the School of History, it tracked down lost originals of the Magna Carta and created an online database about the document. It is available as part of an **online resource for members of the public** (magnacarta.cmp.uea.ac.uk/).
- *De Iglesia* has been part of The National Institute for Health Research (NIHR) **Health Protection Research Unit in Emergency Preparedness and Response**, led by King's College London, in partnership with Public Health England (PHE), and Newcastle University. Established in April 2014, it has received £3.6M over five years to support its research.
- The **Multi-Disciplinary drifting Observatory for the study of Arctic Climate** programme is the largest Arctic research expedition in history (Nature's 10, 2020). Through Professor Mock, School of Environmental Sciences and *Moulton*, UEA is leading the associated metagenomics project which will provide critical new insights into **the polar ecosystem and climate change**.

To generate new links and collaborations, CMP maintains a strategic research fund that provides *ad hoc* funding for **consortium building**, **conference attendance** and similar activities. Staff can apply for funds by filling in a simple form which is reviewed by the Research Director, Deputy Head and HoS. Over £78K was made available to staff from this fund in the REF period. CMP also maintains an active **research seminar** programme, augmented by seminars held by the individual labs. CMP contributes to funding of seminars and provides facilities for visitors to stay and carry out research within the School. For staff who recently joined the School, a '**Minute of madness**' event was organised by *Taylor* in 2019, as well as **inclusive social events** (e.g. a paella cooking afternoon organised by *De La Iglesia*), to kindle new collaborations and foster team-work. CMP has also arranged **bespoke meetings** with key stakeholders (e.g. Birds of a Feather meetings). New links and research/impact activities are also forged through CMP's **honorary faculty/visiting researchers** (37 during the REF period) and research visits (over 100 researchers formally visited the School in the same period).

Relationships with key research users

To strategically develop impact, CMP maintains **strong links with industry** at many levels, from local SMEs to large multi-nationals. These links are built and overseen through the School's **Industrial Advisory Board** which includes leading figures from industry, including senior representatives from BT, IBM, Siemens, Aviva, Thyngs, and Intel. Notable examples of our links include:

- *Apple* – Through his EPSRC Established Career Fellowship, *Finlayson* collaborates closely with Apple who are ideally placed to evaluate and integrate his research.
- *Aviva* – the School has a long-standing collaboration with Aviva which is a major player in the UK economy, with its general insurance based in Norwich. Research on statistical approaches for electronic health records in actuarial applications was funded by **the IFoA** (£788K) in collaboration with **Aviva** and the **Norwich Medical School**.
- *BT Research - Parr* was the lead co-author and is now chief scientific advisor of a major project worth over £28M with the **BT Research & Innovation Team** which established the BT Ireland Innovation Centre in collaboration with Ulster University.
- *Greater Anglia and Network Rail - Wang* built up a consortium with some of their employees, which won a Rail Standard and Safety Board (RSSB) big data sandbox competition in 2017 and was awarded a **Rail Research UK Association** grant (£112K) to study the feasibility of using AI to predict and prevent train delays. Prototype software, presented at the **RSSB's exhibition conference** in London 2019, is under development.

Wider evidence of impact

Consultancy is carried out through SYSCo which gives industry, business and government direct access to expertise in the School (see Section 1). Amongst over 58 consultancy contracts in the REF period, illustrative examples include the **Urban Modelling group**, which supports a wide range of projects from illustrating planning applications through to enhancing tourism and visitor attractions (www.urbanmodellgroup.co.uk/), and *Lapeer's* work with **Bombora** to develop and build immersive video-based applications for mixed reality (e.g. viewing properties in the UK housing market, <https://eira.ac.uk/case-study/driving-innovation-in-the-property-management-industry-through-virtual-reality/>).

Spin-out companies are based on technology developed by the School, and sometimes incubated through UEA Consulting, e.g. Spectral Edge Ltd.

Software based directly on research undertaken in CMP is made freely available for professional and public users. Notable examples include:

- The **BBSRC-funded UEA small RNA Workbench software** (<http://srna-workbench.cmp.uea.ac.uk>). Since its release in 2012, this has been downloaded more than 24,500 times.
- The **DynDom website** (<http://dyndom.cmp.uea.ac.uk/dyndom/>) is the foremost site for hosting databases on protein domain movements and tools for their analysis, and is now part of an ELIXIR Implementation Study.
- **sktime** is a toolbox for time series analysis developed with the Alan Turing Institute (<https://www.turing.ac.uk/research/research-projects/sktime-toolbox-data-science-time-series>).

Short courses are offered for business and industry, based on our research. These include 'Knowledge Discovery and Datamining' (a five-day course, which was run in 2018 for members of the Dubai Police) and 'Dependence modelling using multivariate copulas with applications' (annual three-day course).

Engagement with local schools and teachers is made through providing academic "taster" sessions, exposing students and teachers to our research interests e.g. digital animation. We host the **Norfolk Hub of Computing at School**, an initiative to promote the uptake of computer science at GCSE and A-level, as opposed to ICT. *Mayhew* has organised a **Scratch-Off annual event** since 2012 for 7-14 year olds to compete in pairs on programming challenges, and we visit Schools to spend a day with **female Year 8 students** to introduce them to computer programming. Aimed at GCSE and A-Level/T-Level students, CMP has also participated in presenting its research by invitation from BT in the **British Science Week** for last two years and is invited again in 2021.

Public engagement with our research is also made through meetings with other organisations and within the national and international press, TV and radio. Notable examples:

- *Buckley*: British Science Association 1-year Media Fellowship in 2018, plus a placement in SkyNews London for a month (14 articles on science news on Sky News website).
- *Harvey*: Awarded Worshipful Company of IT Professionals sponsored Professor of IT at Gresham College in 2018 (www.gresham.ac.uk/professors-and-speakers/richard-harvey/). Lectures are streamed live on YouTube and Facebook live (Harvey's Gresham College Youtube lectures have received over 38.8K visits).

Contributions to and recognition by the research base

CMP staff have contributed and been recognised through **numerous activities** covering the full range of the discipline, including involvement in learned societies, journal refereeing and editorship, invited lectures, participation in and organisation of conferences, and membership of grant/influential committees. Notable examples include:

Leadership in the academic community

- *Harvey*: **Fellow British Computing Society**.
- *Kulinskaya*: **Elected member** of the International Statistical Institute.
- *Parr*: **MBE** in the 2018 New Year Honours, for services to developing telecoms infrastructure in Northern Ireland.
- *Parr*: Leading the development of China-UK collaborations as part of the creation of the **China-UK Technology Innovation Centre**.

Committee memberships

- *Finlayson, Lapeer, Parr*: **EPSRC Full Peer Review College Members** (*Lapeer* received recognition for outstanding contribution).

- *Hayward*: External project member for the **Ochanomizu University's Program for Leading Graduate Schools**, Ochanomizu University, Tokyo, Japan 2013-2020.
- *Parr*: Technical adviser to the **EPSRC ICT Programme** for the specification, evaluation and review of the *EPSRC National Dark Fibre Infrastructure Service* (NDFIS) during 2018/2019.

Conference organization

- *Finlayson*: Series Chair, **The London Imaging Meeting**, a new yearly, topic-based conference in imaging science launched in 2020.
- *Huber*: Program committee co-chair, **ACM-BCB Workshop on Algorithms in Bioinformatics**, USA, 2019.
- *Moulton*: Co-organiser of one-week phylogenetics conference, **Banff International Research Station**, Canada, February 2018.

Keynote talks

- *Finlayson*: International Conference on Digital Image Computing, Sydney, 2017.
- *Iglesia*: The 2nd Information Systems Forum, Oman, 2018.
- *Parr*: IEEE Globecom, Abu Dhabi, 2018.

Editorships

- *Bagnall*: Ed. Board, Data Mining and Knowledge Discovery.
- *Milner*: Assoc. Ed., EURASIP journal of Audio, Speech and Music Processing.
- *Parr*: Assoc. Ed., IEEE Access Journal/The Computer Journal.