Institution: University of Surrey

Unit of Assessment: UOA 11 Computer Science and Informatics

a. Overview

The Department of Computing was established as an independent department in 1998 within the then School of Electronics and Physical Sciences. Computing research activity at Surrey is structured within research groups, each led by a senior academic who sets the research vision, strategy and direction. The groups are (staffing details are given in Section b):

- **Nature Inspired Computing and Engineering (NICE)**
- **Formal Methods and Security (FMS)**
- **Multimedia Security and Forensics (MSF)**
- **Digital Ecosystems (DE)**

All groups have substantially grown their research base over the period, and interdisciplinary interactions cover a wide range of activities encompassing science and engineering, medical sciences, social sciences and the arts. Research activity is thriving, with an increasing international profile and strong industrial relationships.

In RAE2008 the Department was returned in its own right for the first time, having previously been returned within the Electronic Engineering submission. This underlined the University's strategy of strong support for Computing which has enabled it to establish its own identity and position within the University. That strategy has accelerated over the past 6 years, resulting in a significantly greater international profile: Computing's position in the Shanghai Jiao Tong Academic Ranking of World Universities rankings has reached the top 10 in the UK and top 150 in the World for 2012 and 2013.

b. Research strategy

At the core of the *strategy outlined in the 2008 return* was the continuation of significant investment in the growth of Computing's research volume and quality. There were 8 strategic appointments in the period of internationally leading, research active academics including the key appointment of Jin, and a major increase in PhD numbers, which have more than tripled from a cohort of 22 in 2008 to the current cohort of 69. Growth has consistently exceeded internally defined targets for both high quality journal submissions and PhD studentships per academic member of staff. Citation counts have increased from 118 per academic in 2008 to 165 per academic in 2012 (Google Scholar), and research income per FTE has significantly increased over the period.

As well as further developing Computing's traditional strengths in **Formal Methods**, **Software Engineering** and **Machine Learning**, the research strategy from 2008 has been fourfold:

1. to grow and broaden activity related to **Security** (see below);
2. to strengthen the **biologically-related** research theme (see below and Section c);
3. to deepen Computing's relationships with industry (see Section e);
4. to broaden the range of interdisciplinary research.

In addition to developing closer links with Electronic Engineering, particularly in computer vision and network security, Computing has actively expanded its interdisciplinary collaborations across the University and now has a much broader range of interdisciplinary activity than it did in 2008. As well as individual collaborations, substantial projects include ERIE (Evolution and Resilience of Industrial Ecosystems), a six year £3.3m EPSRC Complexity in the Real World project involving the Surrey Departments of Computing, Mathematics, Sociology and the Centre for Environmental Strategy; and MILES (Models and Mathematics in the Life and Social Sciences, £650k), funded by the EPSRC Bridging the Gaps programme, which has funded 14 interdisciplinary collaborative

projects with Computing, across all four Faculties of the University. External national and international interdisciplinary relationships are further described in Section e.

Research groups

Research is led by senior academics within research groups, collocated so as to encourage skills transfer and collaboration across research groups as well as within them. Each academic and PhD student has a 'home' research group, but there are many interactions and overlaps, e.g. formal methods across FMS and DE, AI techniques in DE and NICE, protocols within FMS and MSF, and in practice each group has a wider research base and range of expertise.

Digital Ecosystems (DE) (Krause, Frohlich, Moschoyiannis, Gillam)

Research Focus: The group's research has been tied into the EU 'Digital Ecosystems' programme since its launch in 2002. The focus of the group's work is on eliminating single points of control or failure in business or knowledge collaborations. This has resulted in significant advances in the group's three main areas: (1) automated generation of information systems from structured natural language (Business Rule) specifications (see Impact Case Study); (2) development of formal models for business transactions and service choreographies without central coordination; (3) closely related to both natural language and business transactions, development of methods for tracking high value IP through supply chains and in Cloud-mediated interactions, without risking exposure of IP.

Staffing: Following departure of former members of the group, Moschoyiannis was appointed to bring strength in mathematical methods for behavioural modeling of complex systems, and Gillam joined to consolidate strengths in natural language, business systems, and Cloud Computing.

Formal Methods and Security (FMS) (Schneider, Cruickshank, Heather, Manulis, Treharne)

Research Focus: The group aims to develop theory and application of formal methods and their integration, and research in security foundations and applications. The main emphasis of the security research over the period has been developing a leading position in the area of verifiable voting systems, particularly the translation of theory into practice (see Impact Case Study), and the growing of our cryptography activity. Formal methods research over the period has focused principally on developing the theory and application of the integrated method CSP||B. and its extension to Event-B. On the practical side the focus has been on its application to safety verification within the railway domain.

Staffing: The strategic recruitment of Manulis in 2011 augmented the group's expertise in cryptography, in security modeling and proof, and in network and web security, which all dovetail well with existing activity.

Multimedia Security and Forensics (MSF) (Ho, Jiang, Li, Poh)

Research Focus: The group is concerned with the interplay among multimedia security and forensics technologies. This covers research in digital watermarking and authentication, data hiding, steganography and steganalysis, and multimedia content protection, with particular attention to video. More recently the focus has been on image forensics for camera identification, anomaly detection, forgery and tamper detection. The activity has broadened to encompass biometrics, usable security involving multimedia human-computer interface, and their applications for image, video, audio and binary content.

Staffing: The group made three appointments since 2008 central to its strategy for growth: Jiang with expertise in image, video and digital media processing, Li in multimedia coding and human factors in cyber security, and Poh in pattern recognition with applications to biometrics.

Nature Inspired Computing and Engineering (NICE) (Jin, Casey, Cheong Took, Clark, Gruning, Sanei, Tang)

Research Focus: The group aims to build up computational models for understanding biological and social intelligence found in nature, with particular interest in neural information processing in

the brain and the organizing principles of neural and morphological development from the evolutionary perspective. The group is also concerned with developing efficient computational algorithms, inspired from natural intelligence and built on mathematical and statistical foundations, for solving complex real-world problems, targeting problem spaces in high value-added engineering domains (aerospace and automotive for example), as well as domains in autonomous systems such as swarm robotics, healthcare and bioengineering with strategic societal impact.

Staffing: Following the appointment of Jin to lead and refocus the group, two further appointments were Sanei in signal processing, particularly in neuroscience and the biomedical field; and Cheong Took in novel approaches to signal processing and neural networks.

Future strategy

Central to the Department's future development is the growth of activity around three main thematic headings which reinforce current activity but also cut across group boundaries. Within each theme there is a **foundational** element developing understanding and theory, and **application** to specific problem domains and to building practical solutions. The practical application of theory is an important driver for the foundational research, providing a testing ground and a source of more fundamental challenges. The themes are:

Computational Intelligence and Machine Learning, and its applications. Activity on *foundations* within this theme includes work on understanding and mimicking information processing in biological systems, such as the brain, in decision-making, visual and audio signal processing and biometrics. The more *applied* activity is concerned with the application of biologically inspired techniques to complex engineering design, bioinformatics, and biomedical engineering (**NICE**). Learning and optimization techniques are also applied in a wide range of other applications, including computer forensics, biometrics (**MSF**) and fraud detection (see Impact Case Study) (**DE**).

The theme of **Security and Reliability** has a strong *foundational* aspect, with fundamental research on cryptography, steganography and steganalysis, digital forensics, digital watermarking, provable security, formal modeling methodology, and development of semantic foundations for formal tools (**FMS, MSF**). *Application* areas cover a wide range across the cyber-security spectrum, include the development of new cryptographic schemes, network security protocols, formal modeling of access control railway signaling systems, secure electronic voting, digital rights management, image and video forensics, biometrics and usability and human factors (**MSF, FMS**).

Research under the **Digital Economy** theme is primarily concerned with expanding the scope for innovation. Our vision is to develop dependable infrastructures to support decentralized collaborations, lowering barriers to entry into the digital marketplace. At the *foundational* level attention is on formal underpinning of adaptive and responsive choreographies for interaction (**DE, FMS**). In terms of *application* we seek innovative ways of exchanging and sharing knowledge (**DE**), with particular focus on agility in information systems development and deployment, and on Big Data technologies: dependable cloud and analytics.

c. People, including:

i. Staffing strategy and staff development

Computing's recent *recruitment strategy* has been to concentrate on recruiting high quality active researchers to consolidate and improve our research profile; and to recruit more staff at a senior level to provide direction and leadership. 8 new academic staff have been recruited in the period, including two Professorial appointments (Jin from Honda Research Institute, and Jiang from Bradford), a Reader (Sanei from Cardiff) and two Senior Lecturers (Manulis, from CASED, Darmstadt, and Li from Konstanz). Appointments at Lecturer level were Moschoyiannis (behavioural modelling), Poh (pattern recognition) and Cheong Took (signal processing). Five promotions to Senior Lecturer have also been awarded over the period, following through on the previous strategy to appoint academics early in their career and develop them. The key appointment has been that of Prof Yaochu Jin, to provide senior leadership and direction for the

NICE group following a review of that group's activities and a period without a senior academic as head of the group. Since RAE2008 four staff have moved to more senior positions elsewhere: Hippisley (now Professor of Linguistics, Kentucky), Schaathun (now Professor at Alesund), Antonopoulos (now Professor and Head of School of Computing and Mathematics, Derby), Mitchell (now Director, BCS Academy of Computing). Two staff, Shields and Browne, have retired.

Computing has a *sabbatical leave policy* and plans for staff sabbaticals on an annual basis. In the 2008-2013 period five staff been granted sabbatical leave: Schneider, Heather, Treharne, Clark and Frohlich. *Fellowships* awarded to staff in open competition include a Swiss National Science Foundation Advanced Researcher Fellowship 2008-10 (Poh); a German Research Foundation (DFG) funded 5-year Fellowship 2008-2013 (Li); and two Leverhulme Trust Senior Research Fellowships (Heather 2010-11, Treharne 2013-14), both to support sabbatical leave.

The Department is active in hosting international *visiting scholars*, and over the period has had visitors from India, China (including China mainland, Hong Kong, and Taiwan), Italy, Malta, Brazil, Poland, Russia, Japan, Germany and Israel. Visitors are provided with full office and IT facilities and are fully integrated into the life of the Department. Surrey academic staff have also spent time away on collaborative visits, in Germany, China, Singapore, US, Australia, Luxembourg, the Netherlands, and Russia.

***Staff development**:* With regards to implementing The Concordat to Support the Career Development of Researchers, the University of Surrey undertook, in 2011, an institution-wide gap analysis and developed an action plan, on which further investment was based. The Researcher Development Programme, in addition to its services for PGR training (see below), also offers a growing workshop programme for Early career Researchers (ECRs) as well as experienced researchers, covering topics including research project management, publication, funding and impact. A new Research Staff Lunchtime Series has been developed to discuss topics with experienced academic and research staff from all areas in the University. Additionally, the Staff Development Service work alongside HR to offer a comprehensive staff development programme and to promote the appraisal system (Staff Development Review).

Newly appointed ECRs have a probationary period of three years, and are assigned a senior colleague as an academic mentor, advising on their development as an academic and researcher, and monitoring their progress. Probationers are initially given light administrative and teaching duties, are provided with financial support for recruitment of PhDs and RAs, are given funding priority for conference attendance and are encouraged in new research directions and development of their collaborative network within and outside the University.

All academic and RA staff have an annual formal appraisal with their line manager or research group leader as part of the appraisal process, designed to ensure that they are performing well in relation to their agreed targets, to discuss research plans and achievements, and to identify support and training opportunities.

***Supporting Equality and Diversity**:* The University of Surrey recognises the benefits of a diverse community and as a public body the University is also committed to meeting its legislative responsibilities under the requirements of the Equality Act 2010. In support of embedding equality across the University, all Computing staff have undergone the University's equality and diversity training, and Computing actively engaged in Surrey's successful submission for Athena SWAN Bronze status in April 2013. One member of staff (Treharne) is on the Aurora Women's Leadership Programme. Computing supports the University's Flexible Working Policy; during the period one Computing staff member was granted a reduction in hours on return from paternity leave, and another became part-time to enable him to develop his consultancy and software services company. In making academic appointments, Computing advertises widely, encourages applications from under-represented groups, and has a broad international composition of staff.

ii. Research students

Computing has a strong and integrated postgraduate research culture. PhD students work in shared offices to foster interaction and support, and are also supported by social events organised by the PhD Representatives, involving students and staff. The location of the PhD offices is embedded within the Department alongside the academic staff and this also contributes to the supportive and welcoming environment for students. 34 students have been awarded PhDs over the period and the cohort has grown to 69 students (from 22 in 2008).

***Support for Part-time/Distance Doctoral Researchers**:* Over the period 2008-2013 the Department has graduated 3 part-time PhD students and has 8 part-time and Distance Collaborative PhD students registered in November 2013. All part-time students are provided the same office, equipment facilities and training opportunities as full-time students, and attend the University on a regular basis for supervisions and review meetings. There is also a programme with King Abdulaziz University, Saudi Arabia, to provide joint supervision of married female faculty staff who are unable to study in the UK. 1 PhD graduated from this programme during 2008-2013, with a further 6 joint PhD students currently registered. Each student has a Surrey principal supervisor and a second supervisor. They are supported by regular video conference calls and by at least one on-site visit per year from the Surrey supervisor.

***Training and Support**:* Research students receive subject specific training as well as generic research and transferrable skills training. Subject-specific training is tailored to the student in conjunction with the supervisor, and includes intensive courses organised by academic staff. It can also include attendance on relevant MSc modules or externally run training courses and events, e.g. Complexity Science in the Real World PhD programme, Oxford External concurrency courses, and attendance at summer schools and advanced schools, e.g. Sao Paulo School of Advanced Science on e-SciBioenergy, Marktoberdorf, Bertinoro, CASED and the Isaac Newton Institute.

PGR progress monitoring includes weekly or fortnightly student-supervisor meetings, a 6-month report, and an annual review, reported to the University Research Degrees Committee. There is also a Confirmation process after 12 months (full-time), which is the main formal assessment process for research students in order to continue to a PhD. Three RDP workshops (see above) are compulsory for all PhD students: “Welcome to YOUR PhD”, “The Confirmation Process”, and “Preparing for the PhD viva”. These University-wide programmes also include courses for PhD students on thesis writing, poster presentation, presentation skills, the viva voce examination, as well as a course on “Success beyond Surrey” which prepares PGRs for their career.

Since 2004 Computing has run an **annual PhD conference**, for postgraduate research students to submit and present their work. First year students are required to submit posters, and second year students to submit and present papers. In addition to providing early conference experience to students in a supportive environment, it attracts high-profile motivational speakers (e.g. Bob Kowalski; Sir Alan Rudge, ERA Foundation Chair), and provides a community-building event for dissemination and communication of research between the PhD cohorts. Its long running success has provided the inspiration and model for the University-wide annual PhD conference.

PhD students are expected to attend at least one leading conference and present a paper during their PhD, and the Department provides each student with an allocated fund, as well as providing a general fund for students requiring funding for further conferences and training. Examples include IJCNN, ICFEM, ECCB, CEC, ICANN, ICASSP, EUSIPCO, PKC and CLEF. Students are also supported to present at PhD special sessions and attend PhD-focused events such as BCTCS.

CASE studentships and industrial relationships are an important part of the PhD project portfolio, providing a closer research connection with key groups within industry and providing test-beds for research transfer. A total of 7 industrial CASE collaborations since 2008 include Thales, AWE, Charteris, Consult Hyperion, and Intellas UK Ltd. There have also been two Microsoft Research Europe PhDs, and a 6 month secondment to Xerox Research, Grenoble.

Research students have been involved in technology application and transfer, most notably the company '*Thoughtified'* founded in 2009 by two PhD students on the analysis and visualisation of big data. The company has recently (2013) been bought by the AI Corporation keen to acquire and apply their technology to the problem of fighting fraud (see Impact Case Study). Software outputs of projects are made available for download where possible, the most notable examples being the Surrey University Library for Forensic Analysis (SULFA) arising from PhD work in video forensics, and the 'Readability Report' plug-in arising from computational linguistics PhD research.

Destinations: Our graduating PhDs go into a variety of careers, including PDRA positions in the UK and internationally, often progressing to academic positions. International PhD students have returned to academic positions in their home country, e.g. Greece (Exarchakos), Iran (Makkiabadi, Ferdowsi), China (Xia), Malaysia (Yusoff). Other destinations include DSO National Laboratories Singapore, AWE, DSTL, Ericsson, Qinetiq, GE Aviation, and BAE Systems Detica.

d. Income, infrastructure and facilities

Research Income*:* Since the last RAE, the strategy has been to diversify sources of research funding, and to obtain support for pathways to impact. The Department provides strong bid support and internal reviewing mechanisms for proposals. The most significant grants over the period have been funded by EPSRC (Bridging the Global Digital Divide; Digital Economy; Research in the Wild; Reactive mode), AHRC, EU, Leverhulme Trust, BBSRC, KTA funding, and the German Research Foundation, as well as organisations such as the Surrey Wildlife Trust, Santander, AWE Ltd, Microsoft, Kodak, BT, Royal Surrey County Hospital, and the Home Office. Translation of research into industry has been funded through expert services and consultancy to a total of £520k over the period, including KTPs totalling £437k; and also more recently by EPSRC Impact Acceleration Account grants and two TSB projects awarded with a total value of £335k, with a third TSB project about to start. Less emphasis is placed on individual consultancy and professional services, as Computing prefers to work with partners at a strategic level through KTPs and collaborative research projects.

Over the period 2008-2013 the total research spend has been £3.4m, and research income in Computing has grown sharply from £20K 2008/9 per staff FTE per year to over £40k by 2011/12. The grant portfolio at the end of 2013 has a total value of £3.2m, with funding secured to 2016.

Computing constantly monitors its research programmes to make sure they are aligned with UK and EU priority areas. With regard to EPSRC themes, DE fits naturally with Digital Economy, FMS and MSF with Global Uncertainties, and NICE with Manufacturing the Future. For Government priorities, DE's research fits with the BIS project Foresight Future of Cities, and FMS and MSF deliver into the UK Cyber Security strategy. At the European level for Horizon 2020, Computing is aligned with the following Societal Challenges: Inclusive Societies with respect to the inclusive innovation activity, Secure Societies with (FMS and MSF), Climate Action with respect to energy efficient computing, and Health and Wellbeing through improvements to diagnosis (NICE) and better use of health data (DE). Within Key Enabling Technologies, part of DE's research sits within ICT for Digital Content and Creativity. DE also delivers into infrastructure and services within Future Internet, and smart embedded components and devices, and NICE is relevant to robotics.

Infrastructure and Facilities*:* The Department of Computing occupies the second floor of the Alan Turing Building, which was custom-refurbished at a cost of £750k under the University's strategy for the development of Computing. The floor houses all academic staff, PhD students, visitors and local administrative support, research labs, social space, and a showcase seminar room. It is approximately 30% larger than the previous premises and some rooms were initially used by other Departments. The Department's growth has now led to full occupation of the space.

The Department has a state of the art computing environment providing both Windows and Linux servers, and all staff and students are provided with their own machines, which are kept up to date on a regular rolling basis. Specialist Computing technical support comes from the Faculty IT Support team which procures, maintains and supports all of the Faculty specialist computing equipment and student labs, manages licences, and provides robust research-related web hosting,

e.g. for the Surrey University Library for Forensic Analysis (SULFA) database. In terms of High Performance Computing (HPC) facilities, the Department runs its own 128-core HPC Cluster, and has access to one of the world's fastest supercomputers, Tianhe-IA, at the National Supercomputing Centre in Tianjin, China through Jiang's collaboration. The Department also has access to other Faculty HPC facilities. The Faculty strategy going forward will be to unify and expand the various HPC facilities into a Faculty-wide facility. The Department also provides dedicated lab space for the research groups, including a small-scale wind tunnel and robotics equipment for the NICE group. The University provides generic IT support and further student lab facilities.

At the University level, opportunities to support enterprise activities are actively supported by the University's Research and Enterprise Services unit. A £13.2m library extension opened in 2011, followed by redevelopment of research space for archives and special collections in 2012. The top floor of the library has been refurbished for PGR use only, in response to feedback from the PGR survey (PRES). The electronic journals portfolio has been significantly expanded during the period and now almost all computer science journals and conference proceedings of interest are available electronically, as well as over 300,000 e-books, 140 databases, and digitised e-theses, all accessible on and off campus. New Surrey theses will routinely become available online via Surrey's Open Access (OA) repository Surrey Research Insight (SRI), and the ProQuest database. Significant quantities of digital backfiles of journals have also been acquired to provide a broad and deep research collection. The University has an OA strategy, informed by recent RCUK policy developments, with Gold OA in operation, funded by the University, starting in Spring 2013. Green OA has been in operation for many years, facilitated by SRI, incorporating an internal publications database (Symplectic Elements) and an externally visible institutional repository (Eprints).

e. Collaboration or contribution to the discipline or research base

All research groups routinely lead and participate in projects that involve collaboration with other internationally leading research groups, and with industry, aligned with our research objectives. Many of these collaborations are interdisciplinary. The most significant examples of research relationships are: UCLA on the brain/computer interface (Sanei); QinetiQ on complexity and optimisation problems, e.g. self organisation of UAVs (Jin); Airbus and Honda on aeronautics and aerodynamic design (Jin); Invensys Rail and Swansea on railway safety modelling (Schneider, Treharne); Victorian Electoral Commission, Luxembourg and Melbourne Universities on verifiable electronic voting (Schneider, Heather); the Chinese National Supercomputer Centre in Tianjin University, China on high-performance scientific computing (Jiang); IPO/Wolfson Microelectronics on audio watermarking (Ho, Li); LSE on development of Internet infrastructure for digital business ecosystems (Krause); Socio-digital Systems Group at Microsoft Research Cambridge on domestic technologies in sound and image (Frohlich); Centre for Advanced Computing Algorithms and Cryptography, Macquarie University (Li); Moorfields Eye Hospital on diabetic retinopathy diagnosis (Tang); CASED, Darmstadt on group oriented signatures and cryptographic protocols (Manulis); Tokyo University and Imperial (Cheong Took). Surrey is a founder member of the EPSRC CryptoForma Network (formed in 2009) bridging formal methods and cryptography, which involves over a dozen UK universities (e.g. Kent, Royal Holloway, Bristol, UCL, Birmingham, Southampton).

Computing maintains a close involvement with Industry to ensure specific research activities are directed in a way that addresses long-term societal needs as well being academically valid. Computing increasingly finds that this loop, with research outputs transferred to Industry and then with research questions being fed back, is a powerful way of stimulating its research programmes and directing them to maximise both societal and academic impact. Specific examples of this include work on: digital forensics with the Home Office (Ho, Li); citizen science with Tiger Nation, Zoological Society of London and the Surrey Wildlife Trust (Krause); energy budget estimation for Internet transactions with Memset Limited and the Energy Efficient Computing SIG of the ICT KTN (Krause); Business Process Modelling and Information Systems with Rulemotion (Krause); Toxicological Risk prediction with Lhasa Ltd (Krause); Formal security modelling with Thales (Ho, Treharne); digital forensics with Surrey Police (Ho).

Computing actively supports academic interaction with industry through its Industrial Advisory Board and by funding opportunities for developing new collaborative links, and has a senior academic (Krause) as its Director of Business and Enterprise. Strategic relationships are also developed with companies such as IBM, Anritsu, Consult Hyperion and AI Corporation, building up links through the placement of professional training year students, graduate recruitment, research-related undergraduate and MSc projects, and scholarships for PhD projects. These relationships are also firmed up through strategic visiting chairs, for example Steve Legg (IBM), RAEng Visiting Professor, Gloria Benson (Consult Hyperion) and George Saleh (Moorfields Eye Hospital).

Exemplars of Academic Leadership

Learned Societies/professional bodies: Jin is Vice-President Elect of the IEEE Computational Intelligence Society; Staff Fellowships of professional bodies include FBCS (Gillam, Ho, Jin, Schneider), FInstP (Ho), FIET(Ho, Jiang), FIMA (Krause), and FRSA (Frohlich); Ho, Jin, Li and Sanei are IEEE Senior Members. Gruning was elected to the executive committee of the European Neural Network Society. Clark is a Fellow of the Linnean Society. Schneider is on IFIP WG1.7 (Security Foundations) and WG1.8 (Concurrency). Several members of Computing are on IEEE Technical Committees.

Editorships: Gillam is founding editor of *Journal of Cloud Computing: Advances, Systems and Applications*, Ho is editor-in-chief of *International Journal of Digital Crime and Forensics*, and *Journal of Information Security and Applications,* Krause is editor (Computing and Software) of IET Journal of Engineering, and Frohlich is founding editor of *Personal and Ubiquitous Computing.* Computing staff also hold 20 associate editorial positions, including 9 on IEEE journals, letters and magazines, 7 on Elsevier journals, and 1 on a Springer journal.

Distinctions/prizes: Jin was awarded *Distinguished Lecturer, IEEE Computational Intelligence Society* 2012; Frohlich won the *RCUK Digital Economy 'Telling tales of Engagement' prize* 2012. Moschoyiannis and Krause won the *2010 RuleML challenge*, Poh won three prizes at International Create Challenge 2013, and seven staff (Frohlich, Ho, Krause, Jin, Moschoyiannis, Poh, Sanei) have won best paper awards at conferences since 2008.

Advisory/Reviewing: Gillam was author and consultant on two EPSRC-JISC commissioned reports on aspects of Cloud Computing for Research. Frohlich was a member of the 2010 CIHE Task force on Creative, Digital and IT Industries. Cruickshank spent two periods on secondment to ETSI as a security expert. Ho and Jin have reviewed for FP7, and staff have reviewed for 10 countries. Gillam, Frohlich, Jin, Krause, Sanei and Schneider are on the EPSRC College of Peers, and Krause and Schneider have participated on EPSRC Panels.

Conference/programme chairs: Since 2008 members of the Department have chaired and/or organised 13 conferences, including: E-Voting and Identity 2013 (Schneider, Heather), Automated Verification of Critical Systems 2013 (Schneider, Treharne), Digital Forensics and Watermarking 2008, 2009 (Ho), IEEE Advanced Video and Signal-Based Surveillance 2011 (Ho), Pacific Rim Conference on Multimedia 2012 (Ho), IEEE Multiple Criteria Decision Making 2009, 2011, 2013 (Jin, Founder), IEEE Computational Intelligence in Dynamic and Uncertain Environments 2013 (Jin, Founder), IEEE Computational Intelligence in Bioinformatics and Computational Biology 2012 (Jin), Formal Methods and Cryptography 2011 (Schneider), Public-Key Cryptography 2012 (Manulis), Cryptology and Network Security 2012 (Manulis), Integrated Formal Methods 2012 (Treharne), IEEE Statistical Signal Processing Workshop 2009 (Sanei), IEEE Machine Learning for Signal Processing 2013 (Sanei, Ho). There were also 250+ programme committee memberships.

Keynote/plenary/invited talks: Computing staff have delivered 24 keynote and plenary talks since 2008. Highlights include 3rd int. conf. on Singular Spectrum Analysis and its Applications, 2012 (Sanei); 1st ACM Workshop on Information Hiding and Multimedia Security, 2013 (Ho); Design, Semantics, Form and Movement 2013 (Frohlich); IEEE Symposium Series on Computational Intelligence, 2013 (Jin); 6th Learning and Intelligent Optimization Conference 2012 (Jin); 2nd IEEE World Congress on Nature and Biologically Inspired Computing, 2010 (Jin).