Institution: Kingston University

Unit of Assessment: Computer Science and Informatics (UoA11)

a. Overview

Research in the Unit is primarily undertaken in two well-established research centres focused on computer vision, network technologies and their respective applications.

The Digital Imaging Research Centre (DIRC) is best known for its work in intelligent visual surveillance and has developed a significant array of collaborators both internationally and across the range of stakeholders within the industry – most notably, in the security sector. A second cluster of expertise spans a number of applications to medical imaging including computer-aided diagnosis, mass cell screening, and retinal vasculature analysis. Other expertise includes analysis of human body motion, vision for robotics, visual (industrial) inspection and ambient intelligence.

The Medical Information and Network Technologies Research Centre (MINT) conducts fundamental and applied research in network architectures, protocols and applications. The core research areas cover wireless and multimedia networks including 3D video transmission, cross-layer design, emergency communications and network security. The application strand of research includes location-based services with particular emphasis on integration of medical information in bio-information systems as well as in the context of healthcare, with a particular emphasis on mobile health (m-health).

The Centres actively promote interdisciplinary research through collaborations, particularly in the areas of diabetes management and age related illnesses – where medical imaging and mobile technology are utilised to radically change the diagnostics and treatment of diseases, working in an interdisciplinary fashion to bring together clinicians, engineers and scientists to develop patient-centred systems. Within the Centres, research is organised around thematic groupings, focusing on specific topic areas such as 'Visual Surveillance', 'Human Body Motion', 'Quantitative Medical Imaging', 'Bioinformatics & Genomic Signal Processing', 'Component and Distributed Systems' and 'Wireless Multimedia & Networking'.

b. Research strategy

Strategic Aims

The Research Centres (DIRC and MINT) are the principal drivers of the competitiveness and sustainability of research in the Unit. They provide an environment conducive to research and collaboration for academics, researchers and research students to work in.

Building on the existing research strengths in two key disciplines, computer vision (ACM 23), particularly visual surveillance, and network architectures, protocols and applications (ACM 4 & 28), the Unit has developed a research strategy to guide its activity and resource allocation in the assessed period. The following research areas and activities have been given priority:

- diversifying the application areas of computer vision to include domains such as industrial (visual) inspection, visual analytics and tracking – particularly in the context of real-time sports events and quantitative medical imaging to aid diagnostics – while maintaining the lead in the security applications;
- taking an active international role in developing next generation network standards and applications, including architectures beyond 3G, cross layer design, network resources allocation, network performance analysis (ACM 4 & 5), error resilient 2D/3D video transmission, and 2D/3D image/video quality assessment;
- actively pursuing synergies between the two main research domains in areas such as ambient intelligence, 3D video transmission and multi-camera video networks.

Key Objectives

Capacity Building through External Collaborations

Capacity building is a key objective in pursuing excellence in research. A set of measures has been put in place to capitalise on the existing research strengths, forging international partnerships and consortia to acquire substantial resources and expanding the research portfolio. The main resources targeted have been the European Union's research funding programmes, along with other significant international sources such as the U.S. Department of Homeland Security and overseas companies. These strategic decisions have not only brought success in obtaining research funding, but, perhaps more importantly, helped broaden the base of researchers and collaborations with international partners, including both SMEs and large companies such as Robert Bosch GmbH and NTT Docomo.

Reputation Building and International Recognition

In parallel with building capacity, the Unit has made a concerted effort to steadily enhance its reputation in its key areas of research, through international recognition and leadership in selected disciplines. This has been facilitated through: strategically targeted visiting fellowships; significant investment into research studentships; organising international conferences under the auspices of professional bodies such as IEEE; focusing publication on venues of recognised visibility in order to promote research outputs more widely; and engaging with policy making and standards setting organisations, particularly in the areas of networks and communications.

A Supportive Research Environment

The Unit acknowledges that people are its most important asset. As a consequence, the Unit has made a commitment to developing an environment that nurtures and supports its academic staff, research students and visiting scholars through a series of actions including:

- Support for research activities through an annual appraisal process and a staff development fund;
- Mandatory regular training of research supervisors and dissemination of good practice;
- Regular research seminars to report and discuss novel research ideas and results, inviting both internal and external speakers;
- Weekly research reading groups to encourage debate amongst research students and academic staff;
- Organising scientific conferences to expose researchers directly to world leading research and to facilitate scientific dialogue and exchange of knowledge and information in situ.

This strategy has led to substantial strengthening of the Unit's research culture in comparison with the RAE2008 period, as demonstrated by a significant increase in external funding (+20%) and research student recruitment along with an increased rate of completions, with the number doubling over the assessment period. The overall quality of the outputs has benefitted significantly through the international peer reviewing process and feedback obtained from a wide range of international experts. The number of outputs published, for example, in the IEEE sponsored journals and conferences increased by 35% compared to the 2001-2008 period.

c. People, including:

i. Staffing strategy and staff development

During the period, the Unit has made the strategic decision to focus its submission on a core of internationally recognised researchers (see REF1a). In addition to the continuous development of its research culture, the staffing strategy of the Unit has focused on supporting their research activities, developing their research skills and rewarding the quality of their research output by promotion. As a consequence, a majority of the staff submitted by the Unit were promoted in recognition of their research outputs during the current assessment period: **Barman** (DIRC), **Martini** (MINT) and **Nebel** (MINT/DIRC) were elevated to Reader, and **Dehmeshki** (DIRC) and **Remagnino** (DIRC) to Professor. They all have played a major part in strengthening the research culture, developing valuable research collaboration (e.g. 8 FP7 EU projects) and producing valuable research outputs such as high quality journal papers (see REF2), PhD completions and attracting substantial external research income.

Supporting the career development of all staff and strengthening the Unit's research is addressed through a number of mechanisms. The annual appraisal process is organised in part around a flexible menu of personal research objectives designed to both challenge and develop an individual's activities according to the Unit's strategy. A staff development fund provides the resource to support these objectives by funding, for example, specialised equipment, conference and networking event attendance, and sabbaticals. The work allocation system is a metric-based methodology used to ensure that staff with a teaching commitment have sufficient time for their research. This methodology explicitly sets targets for publication, fund raising and completions, and rewards success with teaching relief. The system also recognises the time associated with research student supervision (approx 2hrs/wk) and FTE contributions to funded projects. A Research Activity Mentoring Programme has been developed to support Early Career Researchers and staff aiming to increase their research activity. Based on frequent meetings, the scheme encourages personal progress monitoring, esteem building and engagement with the research community and research users. A direct impact of this scheme has been the sustained increase of the number of research proposals submitted by staff in the Unit.

The Unit has embraced the vision behind the *UK Concordat to Support the Career Development of Researchers, 2008* and the RCUK's *Research Careers and Diversity Strategy, 2007* and, alongside the university, developed specific mechanisms to support its researchers' career development with a view to developing them as both independent researchers and attractive candidates for future posts. This includes induction into the university organisation and processes, training and supporting academics to deliver performance management, appraisal and career development guidance, embedding of transferable skills training within project plans, training and support for researchers undertaking teaching and demonstrating opportunities and, where appropriate, providing mentors. The success of those schemes can be exemplified by some of the Unit's Postdoctoral Researchers moving on to take up academic positions and fellowships at competitive UK universities, such as Queens University, Belfast and Imperial College, London.

Visiting Scholars contribute to both the vitality of the research culture and the Unit's engagement with the international research community, industry, and national and international bodies. They regularly give research seminars, advise researchers, contribute to journal publications, serve on the committees of international events organised by the Unit and facilitate collaborations with their organisations. In addition, Visiting Professors – seven are currently active in the unit - allow direct contact with decision makers in national and international bodies [Tony Davies (Professor Emeritus, KCL and former IEEE Region 8 Director), Francis Wray (Edinburgh's HPC Centre and EU ICT-program examiner), Sergio Velastin (University of Santiago, Chile and Fellow of IET)] and awareness of the latest industrial developments and opportunities [Derek Jones (Knowledge Software Ltd, software consultancy including involvement in the creation of the C standard since 1987), Steve Ross-Talbot (Director of Global Technology Office, Cognizant Europe) and Anil Hansjee (formerly Head of Corporate Development for Europe, Middle East and Africa, Google)]. This latest link enabled the Unit to win a Google Research Award to investigate ways to increase the persuasiveness of online display adverts without reducing the usability or credibility of the host site. In addition, collaboration with Salah Qanadli (Head of the Cardio-Thoracic and Vascular Unit, Lausanne University, Switzerland) has led to his institution becoming a key partner in a large clinical trial (500 sample data set) currently conducted by **Dehmeshki** to achieve European Certification (CE) and Food and Drug Agency (FDA) certification of his computer aided system for detection and monitoring of aortic abdominal aneurysm.

ii. Research students

The increasing quality of research in the Unit has led to it attracting a much larger postgraduate research student population. From a headcount of 57 students at the end of 2008 it has risen rapidly year-on-year, reaching 96 in 2012. It is important to highlight a doubling of doctoral completions (see REF4a) compared to RAE2008, and that nearly half are achieved within 4 years.

This growth and the improving completion rate have been supported by additional supervisor and student training, annual monitoring of supervision teams, and the provision of additional computing resources. Best practices in supervision are promoted and guide the development of individual training programmes. Most importantly, research students are embedded within a supportive

research community which facilitates interdisciplinary exchanges via seminars and other academic activities.

The Research Centres also play a significant role in the provision of training and the career development of their research students. In addition to the subject-specific training provided by specialised modules, both Centres organise weekly Reading Groups and a Seminar Series including internal and external speakers.

Programmes are in place, including subject-based training, to support individual research programmes using postgraduate taught modules and opportunities for specialist training both within and outside the university; research method training; and personal development training including secondments, teaching experience and development of research grants. An explicit part of our student monitoring process has been to ensure that supervision teams engage their students in these training programmes. As part of the progress monitoring procedures, research students are expected to present their work and generate a poster at a faculty event, on a regular basis. These measures have led to a significantly increased level of doctoral completions (see REF4a).

Kingston University has established a PhD training relationship with Azad University, Iran. Azad is a substantial private university - the world's third largest - which sought to provide its lecturing staff with opportunities to study for a PhD abroad. A contract was signed in 2008 that resulted in a total of nine PhD full-time students being recruited into the Unit between 2008 and 2010.

d. Income, infrastructure and facilities

Income

The steady growth of research income and the increasing success in raising external research funds can be attributed to a number of factors. Most important are the maturity of the research centres and their engagement with the research community, users and industries across the UK, Europe and the world.

The current total spent income of £3.25M from 2008-13 exceeds the total of £2.71M accrued over the longer 2001-2008 assessment period. £3.25M represents an average annual income growth of around 20% over the period, which is particularly significant in the current climate of reduced public research funding. 46% of income is from EU Programmes and EPSRC, which includes two EU Marie Curie international fellowships awarded in 2012. The Knowledge Transfer Partnership scheme (21%) is associated with nine projects since 2008. The remaining income is derived from sources such as the Leverhulme Trust, US and UK Governments and prominent industrial partners including Buhler Sortex (UK), Roke Manor (UK), Barco View SA (Belgium), Docomo (Germany), Robert Bosch GmBH (Germany), LG electronics (S Korea) and Siemens (Germany).

This trend of income growth seems set to continue, since the Unit has been already been awarded a further £700k, which has yet to generate any significant spend. Moreover, the Unit is well positioned for the upcoming Horizon 2020 programme, since this new funding comes mainly from 3 EU FP7 projects:

- PROACTIVE - Prediction reasoning and multi-source fusion empowering anticipation of attacks and terrorist actions in urban environments (£268,000)
- BREATHE - Platform for self-assessment and efficient management for informal caregivers (£233,188) (with co-investigators in Units of Assessment 3 and 15)
- SALUS - Security and interoperability in Next Generation PPDR (Public Protection and Disaster Relief) Communication infrastructures (£190,000)

Further analysis of the Unit’s grant portfolio shows that growth comes mainly from non-UK industries and overseas funding bodies: these represented 2.5% of RAE 2008 income sources, whereas they now account for 16%. Moreover, all prioritised areas have contributed to this. LG Electronics (Korea) and Robert Bosch GmbH (Germany) invested in the Unit’s core expertise in visual surveillance, and Motorola (USA) invested in m-health. Areas born from synergies between the Unit’s two main research domains have also attracted foreign research funding: NTT Docomo (Japan) and Siemens (Germany) funded research in video compression and transmission

according to user quality requirements, and the US Department of Homeland Security invested in an ambient intelligence project aiming at smart monitoring of complex public scenes.

Infrastructure and facilities

The Unit has a dedicated 20-node Linux High Performance Computing (HPC) facility (200 processor cores & 20TB storage) that is an important resource for the Unit's research centres. It has been essential to the development of machine learning based classifiers designed by the Unit in areas including protein bioinformatics, action recognition and people tracking. In addition, HPC is core to the activity of the 'Component and Distributed Systems' group whose research has been supported mainly by industrial partners including Red Hat, Amentra, Hattrick Software Ltd, Cognizant Ltd, Systonomy and ITI.

The Unit has also been building customised facilities in order to further its recent activities in ambient intelligence and 3D video compression and transmission, comprising:

- a 'smart room' equipped with an array of sensors to monitor an individual activities. Equipment currently includes video and range cameras. It is planned to be completed with motion and pressure sensors.

- a '3D' video laboratory to conduct 3D subjective assessment of video data quality and capture content in full HD 3D video. This facility, which will include High Spec 3D display and 3D video camera, has been designed according to the recommendations from the international communication standards body (ITU-R BT-1438 standard procedure for stereoscopic video quality evaluation) so that it can become a certified laboratory.

e. Collaboration or contribution to the discipline or research base

Over the last decade, both DIRC and MINT have constructed networks of collaborators across the full range of stakeholders in their respective disciplines.

DIRC's Visual Surveillance research group, for example, has funded collaborations which include transport operators (Transport for London, London Underground and the Rome Public Transport Authority), government, police and security agencies such as the National Policing Improvement Agency, the Home Office Scientific Development Branch and the Metropolitan Police, security providers and technology providers. For example, DIRC led a research programme part-funded by a large national company, Roke Manor Research Ltd. This research investigated the tracking of individuals in crowded scenes, which is acknowledged to be an important and difficult task, for the automatic interpretation of scene activity from CCTV data. The project resulted in six publications, and included active input from Roke specialists (Turkbeyler and Sparks). At the end of the project, the research student completed a technology handover phase in which the software was recompiled on the Company computing systems, and extensive documentation was written.

During the assessment period, DIRC has diversified into new areas including sporting events – DIRC's impact in the Paralympics 2012 in collaboration with Channel 4 is explained in detail in the Impact Case Study 1, "Social and economic benefits from development of sports tracking technology". DIRC has also set up a very productive on-going collaboration with the Swiss company Buhler AG through their London subsidiary that makes rice-sorting equipment (Buhler Sortex). One project has involved an investigation into the on-line inspection of rice to detect broken grains. This was successfully undertaken by a PhD student part-funded by Buhler, which has enabled Buhler to take the project forward to the production phase and install a prototype device in a demonstration environment to be shown to mill-owners. The system is able to improve the efficiency of rice production by as much as 1-2%, which equates to a saving of several million tons of rice a year worldwide. A patent for this technology has been submitted by the company, which was co-authored by scientists at the company and members of the Unit.

Interested in the change of behaviour of personnel under stress, the US Air Force Office of Scientific Research funded collaboration between DIRC and the School of Nursing at Kingston University to monitor simulated nursing practices. Computer vision techniques are being developed to automatically capture and describe the behaviours of the student nurses to support pedagogic feedback and identify good and bad practice.

MINT has expanded significantly into the area of m-health applications, in a true interdisciplinary manner, extending its range of stakeholders by embracing expertise from life sciences and the medical arena, including NHS partnerships and King's College, London. The global impact of the concept of m-health can be illustrated by the creation of several dedicated global alliances on m-health such as the Continua alliance, the m-health alliance and the World Health Organization working groups on m-health: Professor Robert **Istepanian**, the Director of MINT, has been appointed as Vice-Chair of its focus group on e-health looking in particular at machine-to-machine (M2M) communications and relevant standards by the international communication standards body (ITU).

One of the key successes of the deployment of m-health has been the DelPHE-Iraq project funded by the UK government's Department for International Development. As part of one of the first m-health intervention studies in the developing world, the mobile chronic disease management system developed within the MINT centre was applied in Iraq to aid people suffering from diabetes. The result showed positive impact in terms of health, culture and education in almost 150 individuals. Moreover, two centres of excellence in Iraq for e-health and m-health have been established using funding from the Iraqi government.

New expertise in Wireless and Multimedia Networks has recently emerged within MINT, securing in total around £1M since 2007-08 and leading to the creation of a spin-off company, UbiTech Ltd. This is underpinned by research of international standard, membership of the Wireless World Research Forum and standardisation groups (IEEE 1907.1 & IEEE P3333.1) and partnerships with international partners from the EU (FP7 projects) and Japan.

Activities in bioinformatics exemplify interdisciplinary research taking place at an international level. Conducted in collaboration with a bioengineering group at Wroclaw University of Technology, Poland, this work has been supported by a series of grants from the British Council, the EU, the Royal Society and the Polish National Centre for Science. This has led to several joint publications in a leading bioinformatics journal (BMC Bioinformatics), participation in the CASP9, an international contest for protein structure prediction, and the award of a Polish national prize for a jointly supervised research student.

In addition to research collaborations, members of the Unit have contributed to and exerted influence on their academic communities through a variety of activities including:

- **Membership of Advisory Boards**:

  Barman, **Jones** and **Nebel** are members of the EPSRC College (**Nebel** also reviews for the BBSRC and MRC). **Hatton** is a member of the British Standards Institute C Panel IST5 and the International Standards Organisation SC22 Panel on Vulnerabilities in Programming Languages. **Jones** is a member of the Advisory Board of the Swedish Defence Research Agency funded Institute Centre of Excellence in Sensors, Multi-sensors and Sensor Networks. **Martini** contributes to the IEEE Multimedia TC Quality of Experience and Media Streaming Interest Groups.

- **Chairing conferences**:

  International IEEE Workshop on Computer Vision in Computer Games 2010-2013, (**Argyriou**), Workshop Organiser 8th IEEE International Workshop on Visual Surveillance 2008-2010 and Chair International Workshop on Video Event Categorization, Tagging and Retrieval 2009 (**Jones**), Chair IEEE International Workshop on Visual Surveillance 2008, BMVA Technical Meeting on Human Articulated Motion 2009 (**Makris**), Workshop Chair of European Symposium on Mobile Media Delivery 2008 and International Mobile Multimedia Communications Conference 2009 First IEEE International Workshop on Cross-Layer Operation Aided Multimedia Streaming 2011 and IEEE International Workshop on Streaming and Media Communications 2011 (**Martini**), IEEE Workshop on Performance Evaluation on Recognition of Human Actions and Pose Estimation Methods 2011 (**Nebel**), IEEE International Workshop on Visual Surveillance 2008 (**Jones**).

- **Journal Editorships and Editorial Boards**:

  IEEE Software, Journal of Open Research Computation (**Hatton**), International Journal of Mobile Multimedia, IEEE Transactions on NanoBioScience, IEEE Transactions on Information Technology in Biomedicine, IEEE Transactions on Mobile Computing, The Journal of Information Technology in Healthcare (**Istepanian**), Image and Vision Computing (**Jones**), ICST Transactions on Distributed Multimedia (**Martini**), Computational Biology Journal, Journal of Proteomics & Bioinformatics (**Nebel**), International journal of Computer Networks and Communications, Expert Systems, Image and Vision Computing, IEEE Transactions on Automation, Science and Engineering, International Journal of Robotics and Automation, International Journal of Ambient Computing and Intelligence, International Journal of Signal Processing, Image Processing and Pattern Recognition, Pattern Analysis and Applications (**Remagnino**)