Institution: Nottingham Trent University

Unit of Assessment: B11 Computing and Informatics

a. Context: Research from the Computer Science and Informatics (CSI) Unit at NTU provides support for the activities of a number of bodies in the public and charitable sectors. These include organisations involved in healthcare, disability support, and transport. The ultimate end users consequently include people with intellectual and physical disabilities whether congenital or acquired (e.g., after stroke), sensory impairments (including visual and hearing impairments), older adults who want to remain independent and safe in their own homes for as long as possible, users of public transport systems, and those at risk of exclusion (including migrant workers and refugees, pupils at risk of exclusion and from black and minority ethnic communities).The main types of impact specifically relevant to the CSI Unit's research and their relation to our research groups are:
1. Computational Intelligence and Applications Research Group (CIA): *Health* and *economic* impacts.
2. Intelligent Simulation, Modelling and Networking Research Group (ISMN): *Environmental, economic,* and *public policy and services* impacts.
3. Interactive Systems Research Group (ISRG): *Health, public policy and services, economic, society culture and creativity,* and *practitioner and professional services* impacts.

b. Approach to impact

The NTU strategic plan is strongly supportive of the development of impact of research. The CSI Unit works closely with a wide range of stakeholders from the public and private sectors, clinicians, end user organisations and individuals and these relationships are key to us achieving impact.

Within the ISRG researchers work directly with user groups for the participatory design of systems for cognitive and physical rehabilitation as research had already demonstrated that such approaches develop more effective systems which are less likely to be abandoned by their target audiences, both of which directly promote impact. Examples include with students at the Oak Field School Nottingham meeting monthly for the co-design of technology projects for cognitive rehabilitation, and the Nottingham Stroke Research Partnership Group who we engaged with for the co-design of games for upper limb rehabilitation (ISRG is now part of the Kinect2 Developer Programme). Via the coordination of EU projects the ISRG have worked with key users groups of people with cognitive, physical and sensory disabilities, migrant workers and refugees, young offenders and prisoners with disabilities in Italy, Bulgaria, Romania, Greece, Hungary, Lithuania, Ireland, Sweden, Cyprus and Germany for the user sensitive inclusive design of technologies to promote inclusion and rehabilitation. All of these EU projects systematically record impact in ways that can be used to direct our future research activities. We have also focussed our dissemination activities with those stakeholders who can make a difference, including a keynote to the EU Special Educational Needs Network, by partnering with the Oak Field School Nottingham – a British Council International School Awardee and their extensive international special needs network, lab talks (including to the Rt. Hon David Willetts MP), and via our dedicated Interactive Technologies and Games conference series (http://itag.gamecity.org/) and its academic/practitioner forum.

Within the CIA Group researchers have worked with older adults for the development of a virtual approach to informal care to support their activities of daily living and safety. Within the ISMN Group researchers have developed relationships with key stakeholders in Intelligent Transportation Systems (ITS) to develop the impact of their research including the Sofia Urban Mobility Centre Plc, the Coventry Urban Traffic Control Centre, Transport and Mobility Leuven, Technolution in the Netherlands and Nottingham City Council. These service providers have commented on how our wireless and mobile networking research represents a paradigm shift (to a mostly wireless environment) in ITS, to be 'deployed across major urban theatres throughout Europe and beyond.'

The CSI Unit takes also advantage of the relationships with companies that arise out of our placement schemes at undergraduate and postgraduate level both to disseminate existing research and to inform the direction of future research. The mechanisms for this typically include student projects which answer the needs of their placement provider using research from within the unit. For example a successful MSc placement of Ayodeji Remi-Omosowon at NSK in Newark. His MSc project leveraged optimisation research within the unit and resulted in his employment and

the funding by the company of a PhD to continue the work. The CSI unit has also taken advantage of a number of NTU wide, School of Science and Technology (SST), and internally developed initiatives, expertise and resources to support and enable impact including:

- Knowledge Transfer Partnerships (KTPs): with Nottingham City Homes £48,451; with PA Photos Ltd £102,980; British Geological Survey £136,899; and with Loreus £29,453.
- Support from venture capital for the formation of the spin out company Voicekey Ltd.
- The NTU Future Factories project offering creative solutions to SMEs in the East Midlands wanting to improve their environmental sustainability using our research results.
- Support for the protection of IPR via the College Business Manager, a number of patents have been filed and are either being reviewed in the UK (e.g., Voicekey Ltd, etc)
- A well-structured programme to support translational collaborative research, evidenced in the CSI Unit through 4 TSB and 1 MOD awards to Voicekey Ltd: Network Security: 130356 (£45K); Personal identity management using voice biometrics: 130356 (£7K); Establishing Digital Trust using secure voice verification for high risk applications: 710073 (£96K); Preventing Fraud in mCommerce: 971317 (£49K); & On-device voice verification for BYOD & COTS Mobile Enterprise Devices: DSTLX1000085600 (£50K).
- Engagement with University's Development and Alumni Relations Team, headed by Tim Cobb (leading to funding for the Human Interaction Technologies Lab).
- CSI Unit QR and Research Contingency (RC) Funds.
- International and national conference series that the CSI unit organises: ITAG, Intelligent Environments and the International Conference Series on Modelling and Simulation.
- To facilitate dissemination and hence encourage impact the unit encourages involvement in SST Research Showcase events, the annual School Research Conference and external International Conferences and workshops.
- Engagement with the NHS – we have capitalised on our own network of clinical collaborators to secure joint funding from the National Institute for Health Research and The Collaboration for Leadership in Applied Health Research and Care - Nottinghamshire, Derbyshire and Lincolnshire to fund the home based clinical feasibility trial contributing to Case Study 1, and also more recently with the Plastic Surgery Unit at NUH NHS Trust.

The following list illustrates how our approaches detailed in this section have led to impact within our research groups and their research activities:

ISRG: Via our relationships with end users/engagement with NUH NHS/ITAG/QR&RC Funds:

Research Activity 1: Developing and evaluating the efficacy of serious games, virtual environments, robotics, and assistive technologies for cognitive rehabilitation:

Impacts: Impacts on *public policy and services* by *changing educational practices* in special educational needs schools; Delivering *economic* impacts by beneficiaries using training materials to gain employment.

Research Activity 2: Developing and extending methods of user sensitive inclusive design.

Impacts: Delivering impacts on *health* and *society, culture and creativity* by involving participants with a range of disabilities and those at risk of exclusion in research thereby *improving the user experience* by promoting *their ability to make informed decisions*; Delivering *economic* impacts with the sustained development of a social enterprise (Greenhat Interactive), enhancing their reputation in this area.

Research Activity 3: Evaluation of desktop, mobile and ARIA applications to determine whether contemporary access techniques provide more accessible, more exploitable and deeply embeddable approaches.

Impacts: Delivering impact on *public policy and services* by extending existing and widely used open standards WAI-ARIA of the W3C; Delivering *economic* impacts via the development and evaluation of new open source, web, desktop and ARIA applications promoting the work-ability of people with disabilities across Europe, reducing the burden on developers to make applications /services accessible, and envisaged widespread adoption contributing to EU global leadership.

Research activity 4: Development and evaluation of technologies for stroke rehabilitation.

Impacts: *Health* impacts - A large scale home-based feasibility trial has been carried out.

ISMN: Via relationship with key public sector stakeholders, QR and RC Funds:

Research Activity 1: Simulation and testing of novel Message Delivery Protocols in ad-hoc networks, and seamless fusion of algorithms for real time data in traffic simulation models.
Impacts: Delivering impacts on *public policy and services,* the *economy* and the *environment* through the development of Intelligent Transportation Systems leading to reduced travel times, better business performance, reduced pollution (including CO_2) and reduced congestion.

CIA: Via relationship with end users, KTPs, venture capital, IPR, unit conferences, QR/RC Funds:
Research Activity 1: predicting the behaviours of older users in ambient intelligent environments.
Impact: Impacts on *health* and *society, culture & creativity* through the development of new technologies for ageing well, and by engaging them with research.
Research Activity 2: Investigation of the use of Spiking Neural Network Systems as a more biologically plausible speaker verification method.
Impact: *Economic* impact via formation of Voicekey Ltd, a CSI Unit developed spin out company.
Research Activity 3: Optimisation using Artificial Intelligence Techniques.
Impact: *Economic* impact at NSK bearings in Newark. Improvement of business performance through more efficient working practices.

c. Strategy and plans:
Our Strategic Priorities include the development of wider engagement of end user communities to promote the impact of our research, to offer opportunities for the refinement of technology/methods in light of user feedback; to clearly document impact of the Unit's influence on decision making of national and international governing and strategy setting committees; to pursue the current commercial opportunities for spin out companies; and to promote awareness and perception of our research at NTU through the Research Centres, our own conferences, and regular representation with KTNs and equivalent networks informing key agencies to influence government.

In the future the CSI Unit will attempt to further embed the culture that recognises the value and importance of impact, and involve both academic and research staff in the process. We will continue to exploit NTU-based initiatives and further enhance our own initiatives to deliver impact, particularly where these have been successful. It will also work with Heads of Departments to provide staff with the time to deliver impact; delivery of impact will be included in the Personal Contribution Development and Review process. We will continue to work with the NTU Research Grant Capture Team, notably to facilitate relationships with companies and organisations in order to attract funding through partnership. We will capitalise on our consultancy work to develop partnerships which could lead to collaborative research and opportunities to secure further funds from TSB (for example our collaboration with Professor Monica Whitty at Leicester leading to the successful 'Preventing Fraud in mCommerce' TSB project: 971317). We will establish an 'Impact task-force', bringing together academic staff with experience of delivering impact with staff whose research has the potential to achieve impact.

d. Relationship to case studies
Case Study 1: Using interaction technologies to help people tackle the effects of stroke and other impairments A range of impacts associated with this case study are highlighted in section b (approach to impact). It has been supported by QR & RC Funds, Future Factory Funds, and a VC Bursary Award for a PhD studentship (Markerless Tracking Technology for Stroke Rehabilitation). One of the key members of staff involved in delivering impact in Case Study 1 has had a 6 month sabbatical (David Brown). The Alumni Relations Team has helped secure funds for equipment for the Human Interaction Technology Lab associated with Case Study 1. The College Business Manager has helped to develop IPR agreements based on Open Source and Creative Commons approaches to ensure maximum impact of our research outcomes to often deprived communities. The research in this case study is extended in accessible ways to user communities via the ITAG conference series. The NTU press office has also helped to maximise impact.
Case Study 2: Wireless and Mobile Computing for Sustainable Urban Mobility and Social Inclusion. A range of impacts associated with this case study are highlighted in section b (approach to impact). It has been supported by QR funds for equipment, conference fees and travel – every year £8 000 has been allocated to the ISMN group for support of research activities. The research has also benefited from three NTU competitive innovation awards (2007-2009). The students coming to NTU under the auspices of the Erasmus program (2 from Naval Academy, France; 2 from Bulgaria every year) also contribute significantly.