INTELLIGENT SYSTEMS RESEARCH CENTRE

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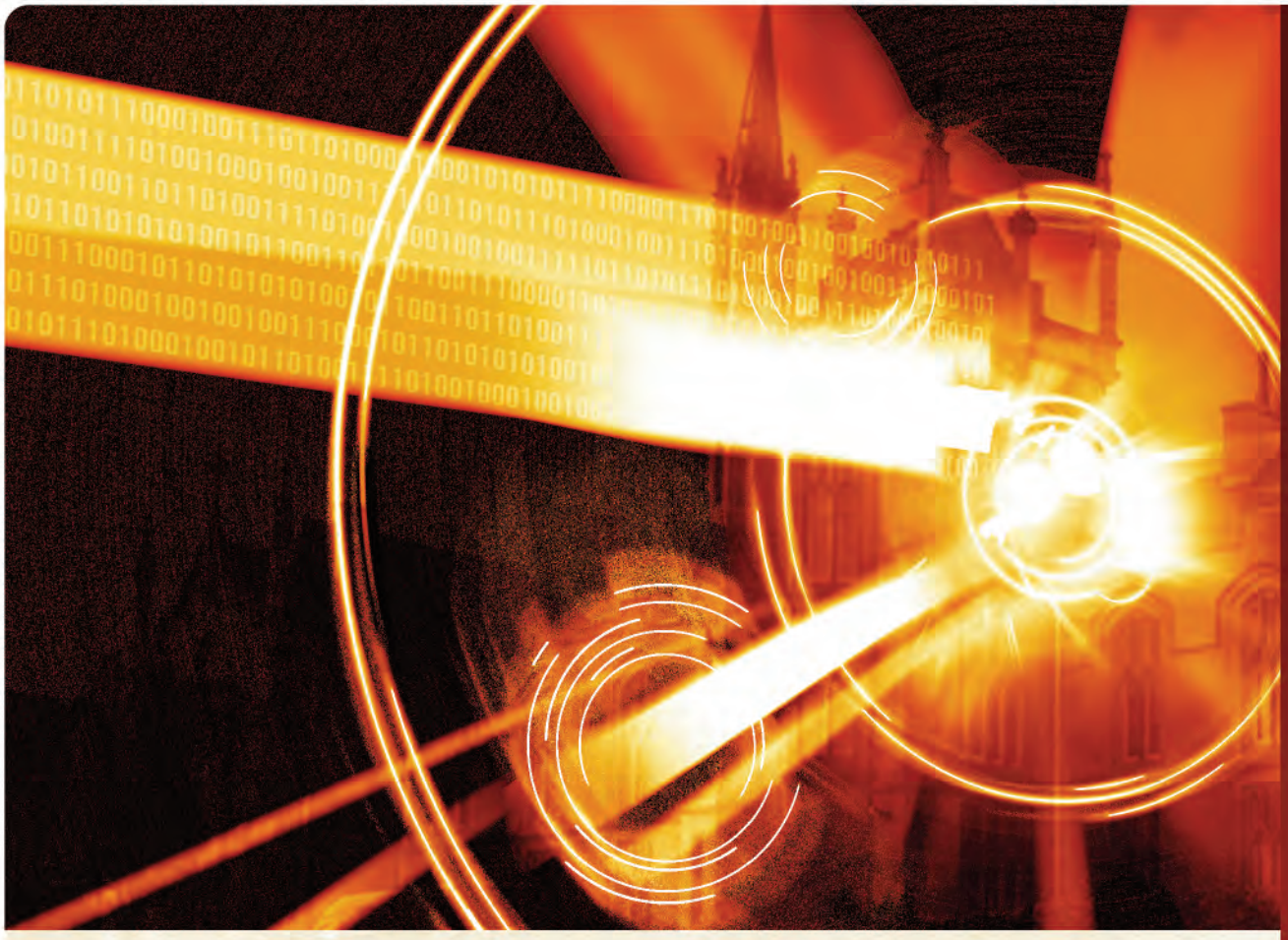

The Intelligent Systems Research Centre (ISRC) is a major research unit within the Faculty of Computing and Engineering on the Magee campus of the University of Ulster, N. Ireland. The Centre is currently working on projects of value exceeding £21 million with funding from InvestNI, the Integrated Development Fund (IDF) via its facilitating body Ilex and the University of Ulster. At this stage of its development the Centre is composed of approximately 50 researchers with plans to expand to 100 researchers within seven years.

The ISRC addresses the topic of intelligent systems in a number of critical areas. The activities of the Centre encompass research into a range of intelligent and hybrid technologies, and include work on neural networks, fuzzy systems, genetic / evolutionary algorithms, hybrid intelligent systems, reasoning, intelligent systems in robotics, wireless sensor networks, robot vision, emulation of sensory aspects of the biological brain in hardware and software, and brain computer interfacing. There is a strong emphasis in the Centre on embedded systems, and in particular the incorporation of greater intelligence into mobile or wireless-enabled embedded systems. The research is being applied to topics as diverse as intelligent embedded systems, bio-inspired systems, evolvable hardware, self-organising and self-adapting computational systems and self-repair of complex embedded systems. The Centre is housed in state of the art research laboratories with an excellent range of experimental equipment. One of the core strengths of the Centre is the multi-disciplinary background of the Research Teams - please see additional inserts for more information on the teams within the ISRC.

In summary the ISRC seeks to:

- Be an internationally recognised, technological Centre of Excellence located in the north-west region of Ireland, with a mission to perform excellent research in computational intelligence and underpin the emerging computational intelligence and intelligent systems industry while acting as a strong, attractive force for foreign direct investment;
- Attract top quality researchers to the region and expand its reputation as a high technology regional hub;
- Underpin the economic development plans for the region in its attempt to switch from the declining textile manufacturing industries to high technology, entrepreneurial-based companies;
- Assist in the generation of a highly talented and skilled workforce, capable of generating spin-out companies that can compete in a global marketplace;
- Assist the University of Ulster its in desire to expand higher education provision in the north-west as a driver for economic regeneration;
- Complement and extend both existing and proposed technology–based initiatives for job creation, incubation and business formation in the north-west of the island of Ireland.

ISRC OVERVIEW

For further information or any queries regarding the Centre, please contact the Centre Director, **Professor Martin McGinnity** at:
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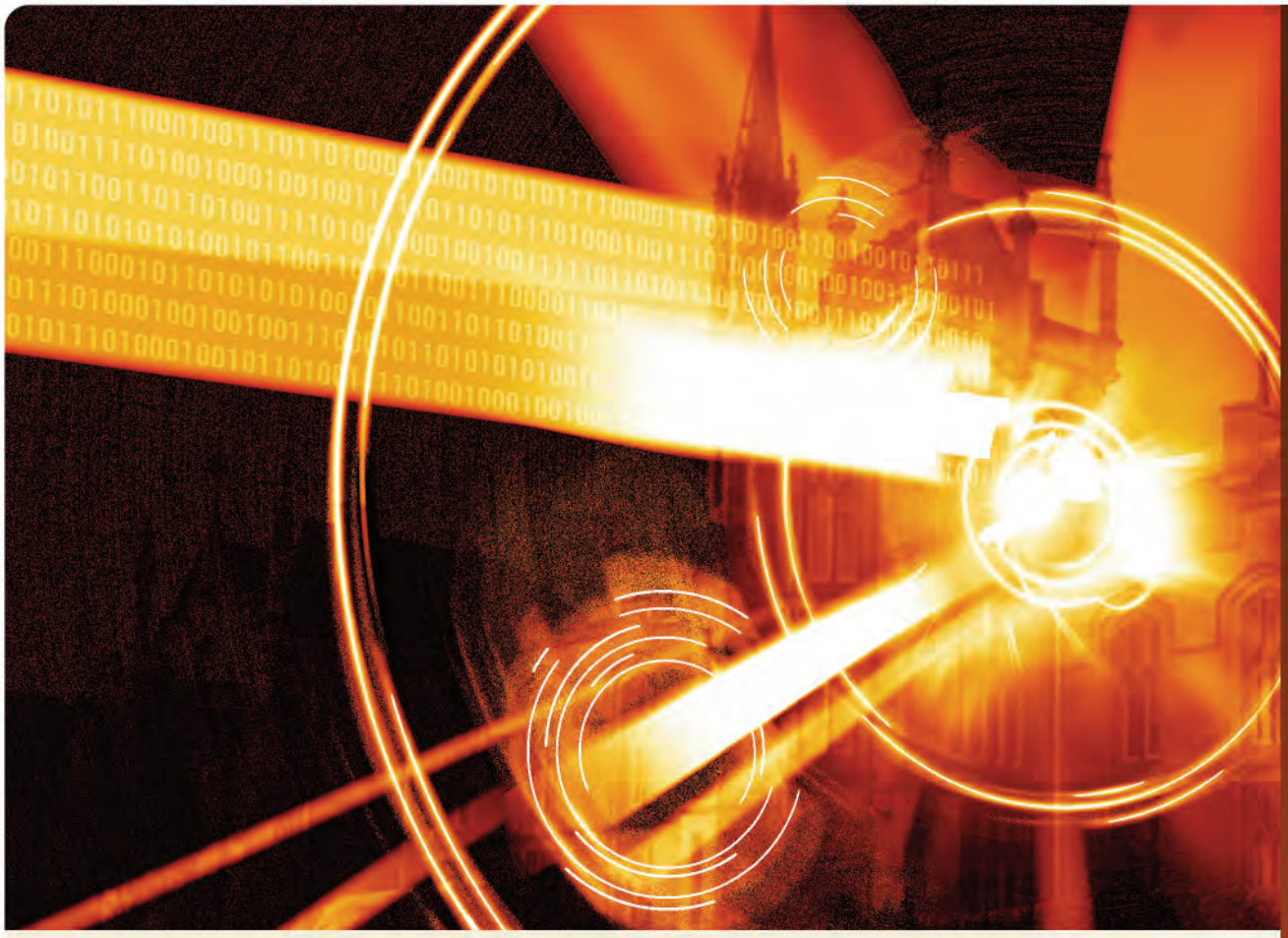

RESEARCH TEAM

BIO-INSPRIRED MODELLING & NEUROENGINEERING

The research focus of this team is the development of computational approaches to neural architectures and characteristics inspired from biology. The unifying theme for team members is the investigation, development and optimisation of large scale neural systems that emulate biological sensory capabilities such as vision, sound and haptics; with the appropriate systems emulated on reconfigurable hardware. Such motivation has encouraged the exploration of spiking neural networks models, their topologies and training regimes.

Current research is targeted at the emulation and modeling of visual processing capabilities of the human brain and will build on the existing collaboration and establish additional links with the leading neuroscience research in this area. The research demands the development of new learning algorithms, encoding schemes and topologies to facilitate the realisation of the biologically inspired architectures on reconfigurable platforms. Previous research within the group has demonstrated that relatively large architectures can be realised at speeds faster than real-time using a time-multiplexed approach.

While these interim results demonstrate impressive performance, further advances are possible by exploiting the full parallel processing capabilities of the target hardware and optimising the designs through the use of event based and multiplier-less approaches. The research outputs will be exploited via application to sensory fusion in robotics and feature extraction in medical and process control problems.

A secondary area of research is the incorporation of the biologically inspired healing characteristic to FPGA implementations of critical processing applications. Ultimately, this self-repair capability will be an inherent characteristic of the large scale neural implementations.

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RESEARCH TEAM

SERIOUS GAMES & VIRTUAL WORLDS

The activities of the Serious Games and Virtual Worlds Research team focuses on the increasingly important medium of virtual worlds and the application/development of video games technologies in a range of application domains. Specifically the team's areas of research focus include:

- Experiential Based Learning in Virtual environments: Assessing the effectiveness of interactive experiential based learning/serious games in virtual worlds
- VLE\Virtual World Integration: Developing middleware solutions for the integration of virtual learning environments and virtual worlds
- Hardware\Virtual World Integration: Developing middleware platforms supporting the integration of external hardware and sensors into virtual worlds
- Cooperative Behaviour in Non Player Characters (NPC's): The study of emergent cooperative behaviour between intelligent agents
- Optimal Hardware Architectures for Gaming Applications: Investigation of novel hardware architectures which address the current computation bottlenecks of computer games environments.

The team is active in developing partnerships with Industry for example Emergent Technologies, providing access to next generation game development tools (Gamebryo Engine) for teaching and research. Visiting Professors and Industrial Experts provide an important contribution to the team's activities – for examples Ernest Adams, internationally renowned games consultant and veteran of the industry. Every year the team participates in the Dare to be Digital competition showcasing the creative and technical talents of regional graduates and the team is also sponsor of Magee Games and Anime Society at the Magee Campus of the University of Ulster.

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RESEARCH TEAM

AMBIENT INTELLIGENCE

Ambient Intelligence (AmI) refers to electronic environments that are sensitive and responsive to the presence of people. In an ambient intelligence world, devices work in concert to support people in carrying out their everyday life activities, tasks and rituals in easy, natural way using information and intelligence that is hidden in the network connecting these devices. As these devices grow smaller, more connected and more integrated into our environment, the technology disappears into our surroundings until only the user interface remains perceivable by users. In order for AmI to become a reality a number of key technologies are required:

- Unobtrusive hardware (Miniaturisation, Nanotechnology, smart devices, sensors etc.)
- Seamless mobile/fixed communication and computing infrastructure (interoperability, wired and wireless networks, service-oriented architecture, semantic web etc.)
- Dynamic and massively distributed device networks, which are easy to control and program (e.g. service discovery, auto-configuration, end-user programmable devices and systems etc.).
- Human-centric computer interfaces (intelligent agents, multimodal interaction, context awareness etc.)
- Dependable and secure systems and devices (self-testing and self repairing software, privacy ensuring technology etc.)

The research team at ISRC has a combined experience of many decades with multi-disciplinary backgrounds in areas including: concurrent & distributed systems; computer networking; intelligent systems, multi-media; pervasive computing; internet security; development tools for mobile and pervasive applications of wireless technologies; RF systems. One of the focus areas of the team is Location Awareness and several platforms are being investigated, including:

- PlaceLab
- Trapeze Networks LA-200
- Ekahau RTLS kit
- UbiSense Precise RTLS system
- Trolley Scan RFID-radar

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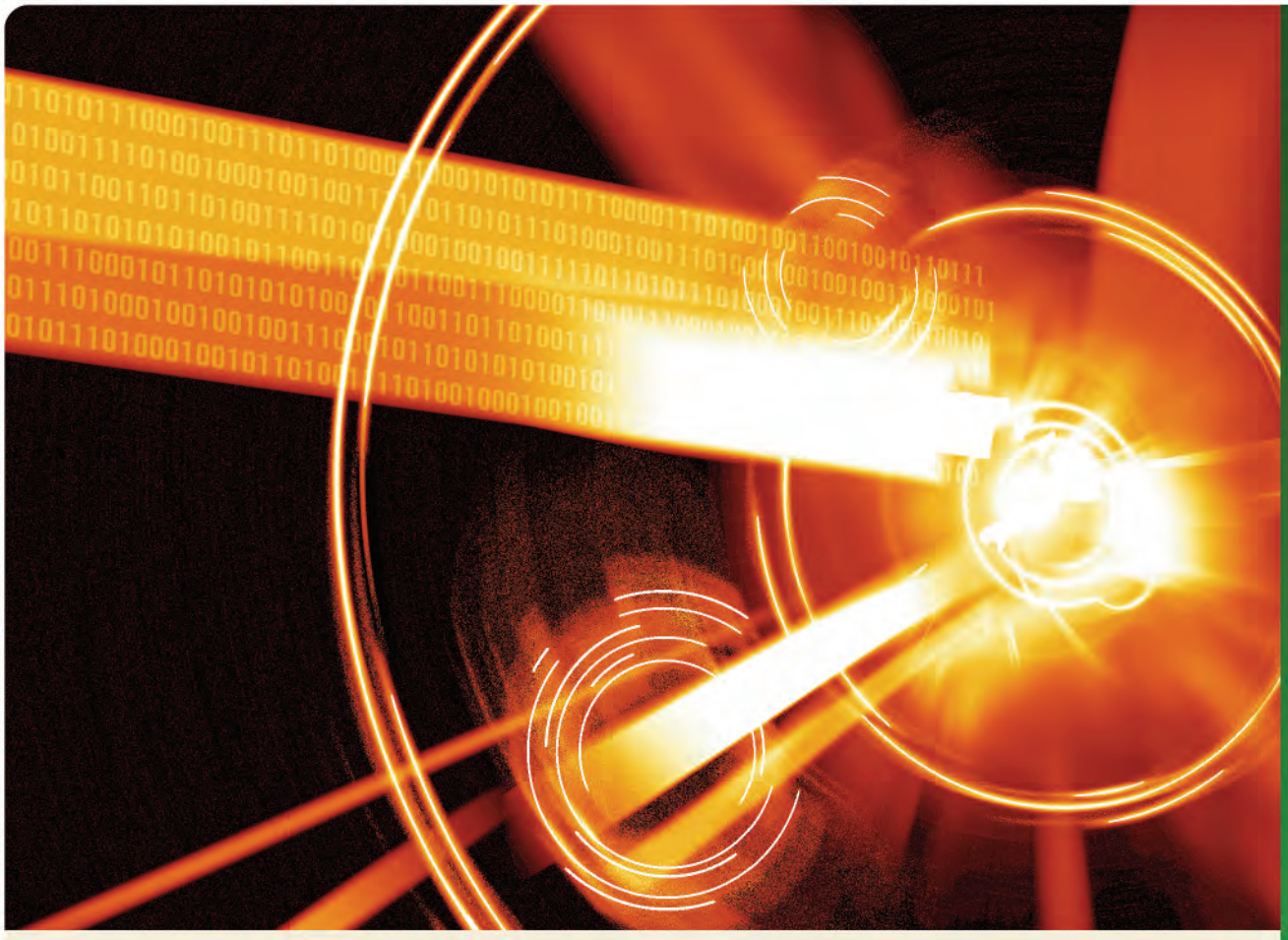

RESEARCH TEAM

COGNITIVE ROBOTICS

The cognitive robotics team at ISRC is a rapidly growing group of academics, post-doctorates and PhD students. In the last decade robotics has stepped out from industrial applications into human society as helpers, rehabilitation devices, welfare supervisors, and entertainment aids. Research in Cognitive Robotics at ISRC spreads across social, humanoid, assistive and industrial robotics with emphasis on learning. The group publishes in the areas of cognitive mobile robotics, robot manipulators, machine learning, biologically-inspired approaches to robot control, artificial intelligence, computer vision, pattern recognition, and knowledge management. Some typical areas of research are as follows:

- Intelligent, autonomous mobile robots
- Robot cooperation, collaborative robotics
- Human-robot interaction
- Sensor signal processing (laser, vision, sonar), sensor fusion
- Robot learning
- Robot navigation
- Analytical robotics, scientific methods in robotics
- Robot simulation and precise modelling of robot-environment interaction
- Novel methods of robot programming, automatic generation of robot control code

Substantial investment has allowed the team to develop a world leading state-of-the art Cognitive Robotics laboratory with experimental facilities in mobile robotics and robotic manipulators. The laboratory has many mobile robots such as Scitos, Khepora, and Pioneer. The laboratory also has a Vikon motion tracking system and an experimental Arm-Camera coordination platform consisting of two 7DOF robot manipulators, each mounted on a mobile platform, and multiple cameras.

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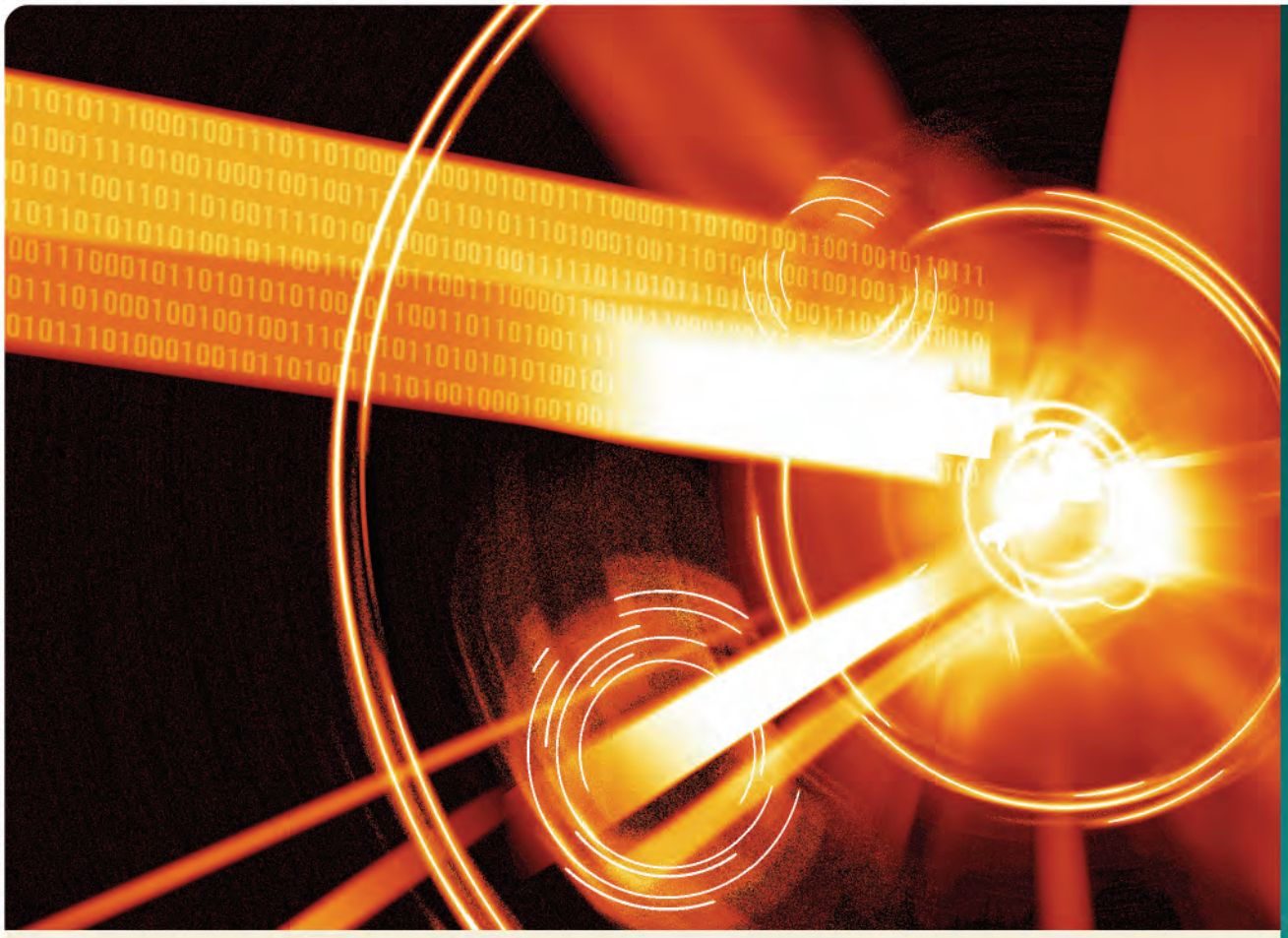

RESEARCH TEAM

CREATIVE TECHNOLOGIES

The Creative Technologies team focus on the computer processing and understanding of signal and symbol input from at least speech, text and visual images in terms of semantic representations with key application areas in music, drama, dance, design, computer games, film, TV & radio, art and storytelling. This is an interdisciplinary field, involving theories, models and technologies from Engineering and Science in terms of Computing and Artificial Intelligence with development of multimodal and intelligent multimedia systems, but also from Humanities in terms of Cognitive Science, Psychology and Linguistics.

Example software systems being developed by the team include:

- **CONFUCIUS**
  taking natural language text as input and automatically producing output in the form of 3D animation, spoken dialogue and non-speech audio
- **MemoryLane**
  automatically creating natural language stories as output based on life-cached data
- **TeleMorph**
  conducting automatic generation of multimodal presentations based on available bandwidth
- **MediaHub**
  focusing on semantic representation, media fusion and synchronisation and constituting the hub of a distribute multimodal processing platform
- **SoFI (Song Form Intelligence)**
  addressing the automatic replacement of missing data in music streaming over bursty wireless networks
- **Olympia**
  a virtual learning environment for the teaching of Physics (e.g. Momentum).

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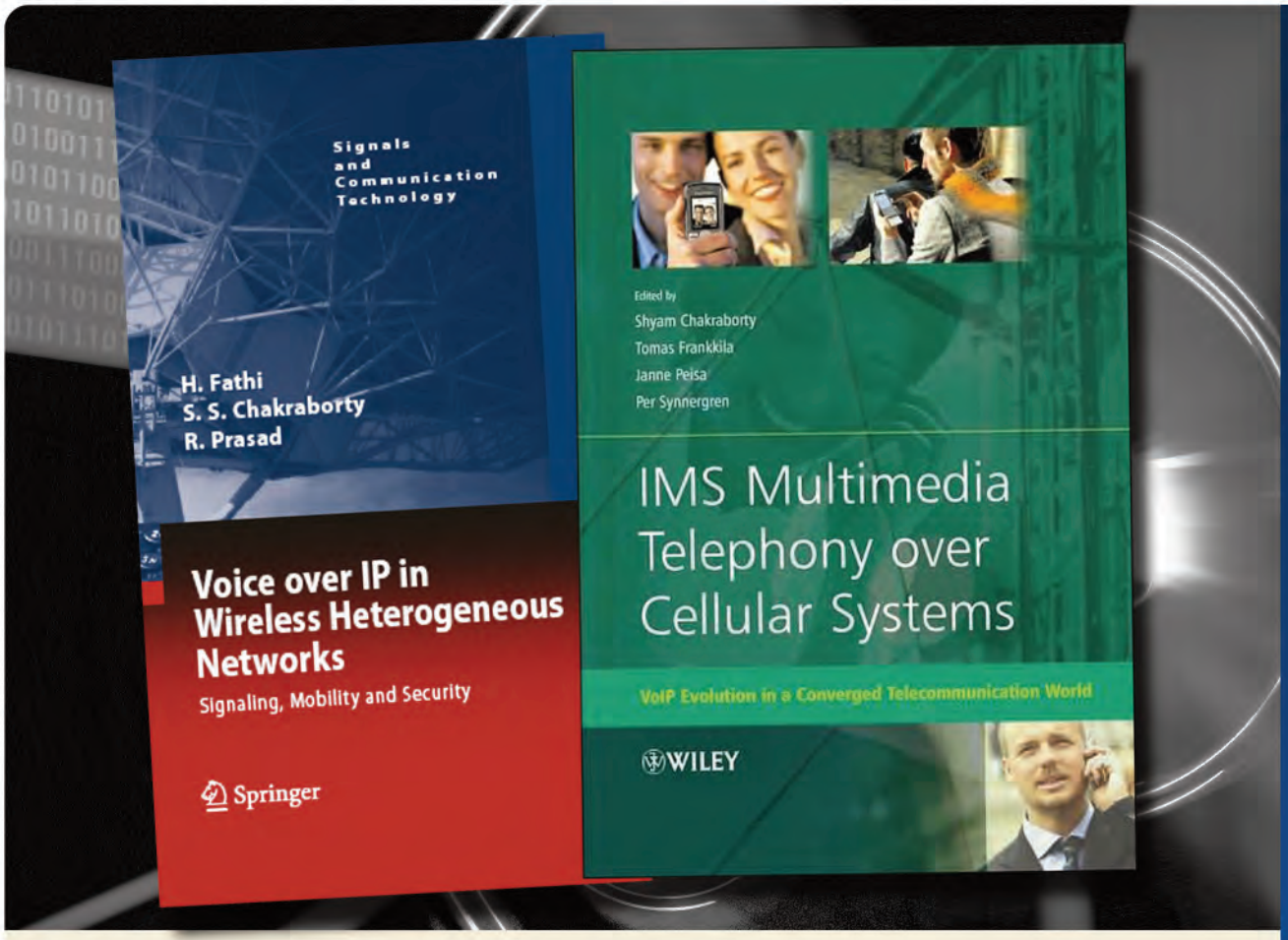

RESEARCH TEAM

WIRELESS & SENSOR NETWORKING TECHNOLOGIES

The focus of WSNT will be in developing World Class research in infrastructure and infrastructure-less networking. Particular emphasis will be in the following areas:

- Next Generation Networks (NGN)
- Mobility, security and QoS management in wireless networks
- Specific basic technologies such as 3GPP/LTE, Zigbee, Wibree etc.
- IETF standardisation efforts for example, 6lowPAN
- Underwater Sensor Networks (UWSN)
- VoIP and multicasting, etc.
- Industrial and health care applications

This team will also follow on with the multi-award winning Derry Wireless City Project. This project funded by the Department of Enterprise, Trade and Investment (DETI) Broadband Flagship initiative was a 2-year collaborative project between the University of Ulster at the Magee campus, Derry, North West Regional College (NWRC), Derry City Council and DETI. The project objective was to create an innovative Wireless City, with a number of complementary elements: wireless campus (educational), wireless city (civic aspect), and wireless walls (tourism).

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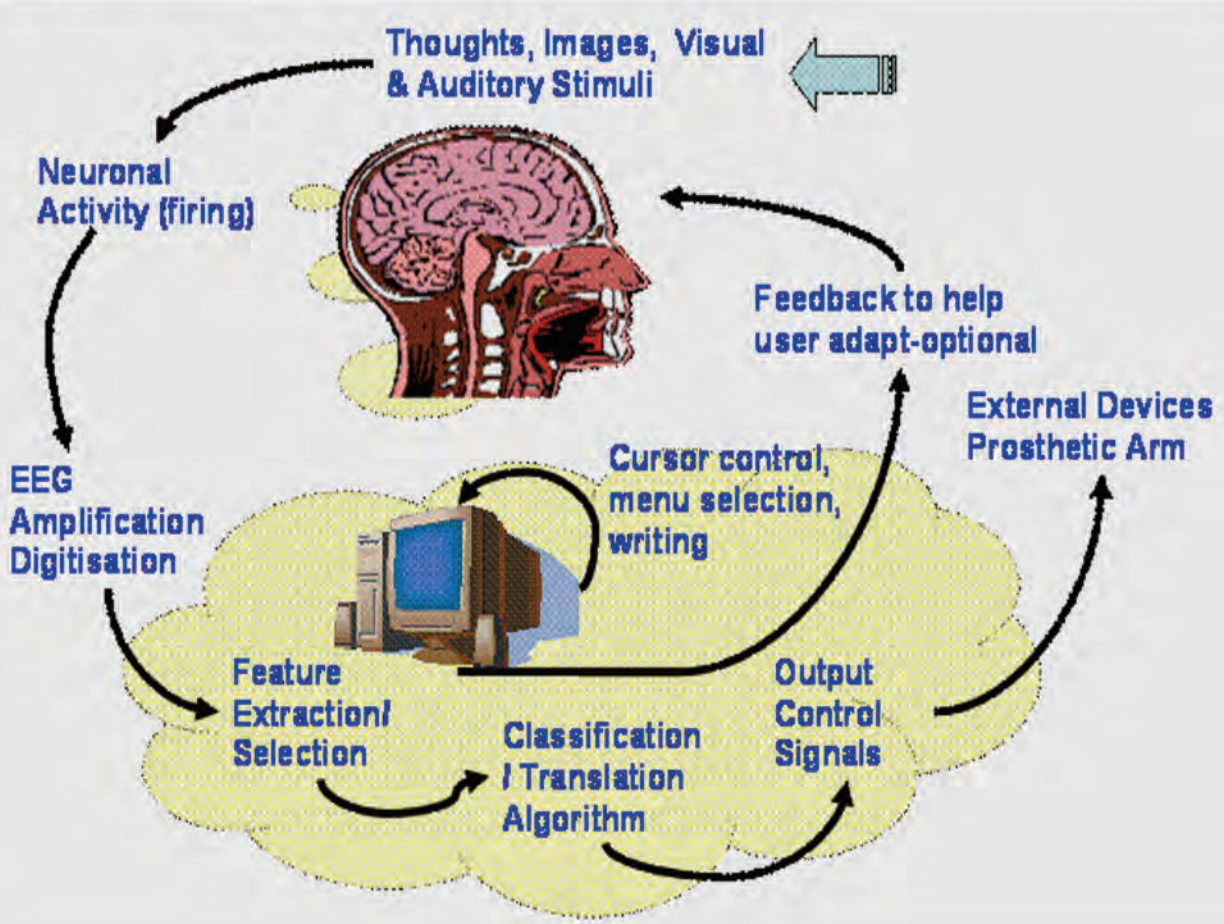

RESEARCH TEAM

BRAIN COMPUTER INTERFACING & ASSISTIVE TECHNOLOGIES

The brain-computer interface and assistive technology (BCIAT) research team's work encompasses both theoretical and applied aspects of intelligent assistive systems development primarily based on the processing of brain signals with the primary objective of increasing independence and improving quality of life of people with disabilities due to old age, injury or disease. Brain-computer interface (BCI) systems facilitate real-time translation of the electrical activity of the brain (acquired from electrophysiological signals such as EEG) into commands to control devices. They do not rely on muscular activity and can therefore provide communication and control for those who are severely paralyzed (e.g. locked-in). BCI systems may also help actuate a supportive rehabilitation device resulting in enhanced motor restoration in post-stroke paralysis. Beyond medical applications, a practical BCI offers general users an additional and independent communication channel based on trained brain signal patterns alone. This opens up promising opportunities for a range of novel applications such as computer games with intuitive control strategies and advanced virtual reality (VR) scenarios.

The BCIAT's theoretical work focuses on fundamental research in self-organising hybrid intelligent systems based mainly on computational intelligence techniques. This is with the aim of developing systems that can effectively address the real-world problems associated with biological systems having complex non-linear, uncertain, and time-varying characteristics. In the applied work, the development of innovative and practical brain-computer interface (BCI) systems for communication and restorative training purposes is strongly emphasised. The team have already done promising work towards advanced BCI algorithm design for EEG signal pre-processing, feature extraction, classification, and feedback design based on computer games and virtual keyboard.

The team's work is supported by local and international funding agencies. Members of the team have recently teamed up with the Indian Institute of Technology in Kanpur to investigate how to develop intelligent robotic devices that could help people with severe disabilities achieve greater independence. The three-year project is jointly funded by the Indian and UK Governments under the prestigious UK-India Education and Research Initiative (UKIERI). UKIERI grant-aids collaborative projects between higher educational institutions in the UK and India.

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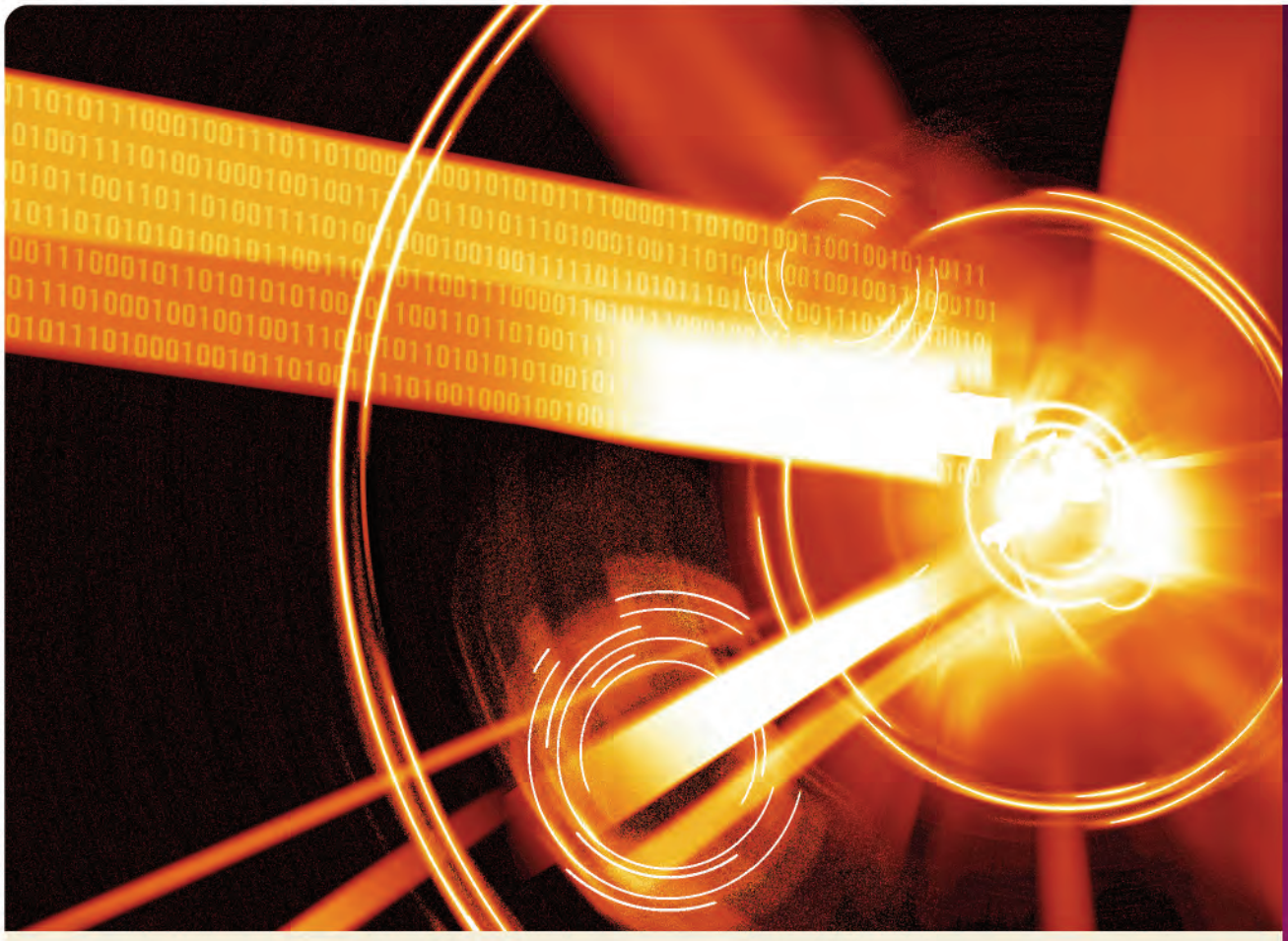

RESEARCH TEAM

NANOELECTRONICS

Mission Statement:

To EMulate Biologically inspiRed ArChitectures on hardwarE (EMBRACE)

- aligns with the UK Design Vision: 'Grand Challenges in Microelectronic Design - uGC4 Building Brains.
- aims to support the implementations of large-scale spiking neural networks (SNNs):
  - accommodate high inter-connectivity between neurons
  - support the flexibility of reprogramming
  - support learning for adaptation of synapse connectivity and resource allocation
- Merge programmable NoCs with low power, small geometry spiking neuron cells to provide a platform which realise efficient scalable SNN architectures - EMBRACE.
- Support fault tolerant computing.

Current Challenges:

Provide a hardware platform that can realise large scale spiking neural network (SNNs) implementations, and support:

- complex inter neuron connectivity with low device area overhead
- low powered learning synapse and neuron cells, and interconnect
- adaptability to allow re-programming of different SNN topologies

Key Goals of EMBRACE:

- Merge programmable NoCs with low power, small geometry spiking neuron cells to provide a platform which realise efficient scalable SNN architectures - EMBRACE.
- Demonstrate a neural-based fault tolerant information processing systems using EMBRACE platform.

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