Centre for Electronic Systems Research (CESR)

The CESR is engaged in both fundamental and applied research to improve the control and operations of industrial processes and to enrich the quality of life and services for the 21st century needs. The technological emphasis is on establishing a sound theoretical and practical understanding of new and potentially significant advances.

Research interests focus on the interface with the real world and involve areas such as bio-nanotechnology (Lab-on-a-Chip for point-of-care-diagnostics), GNSS and wireless technologies based LBS systems for blind navigation, biometrics, use of ultrasonic and electromagnetic acoustic guided wave for NDT, fundamentals of charge particle dynamics, measurement systems for pharmaceutical drug aerosol characterisation, medical electronics, pattern recognition, image processing, theory and application of neural networks, evolutionary hardware, and human factors in product and system design. The Centre investigates processes and mechanisms found in nature to inspire alternative approaches to the design and implementation of intelligent electronic systems. The scientific objective of the Centre will be to investigate underpinning scientific fundamentals necessary to develop algorithms and measurement techniques to implement intelligent electronic systems capable of efficient control and operations of industrial processes and health care systems.

The Centre consists of 6 academic staff:

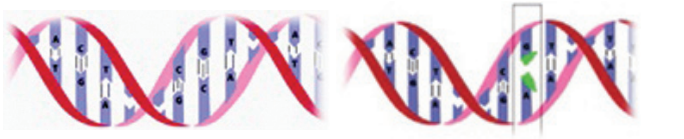
Professor Balachandran, Professor Stonham, Dr Abbod, Dr Boulgouris, Dr Kalganova, Dr Garaj, 4 postdoctoral researchers, 32 research students and 2 Visiting Professors.

Current activities

Research Projects

Artificial Intelligence Systems

Artificial intelligent techniques are employed in modelling of DNA mismatch repair expression and microsatellite instability in transitional cell carcinoma of the bladder and to improve the accuracy of the bladder cancer prediction. These models are then compared with conventional statistics using experimental molecular biomarkers, including p53 and the mismatch repair proteins. Development of support system for anaesthesia monitoring and control based on hierarchical structure containing fuzzy reasoning adaptation, supervision, surgical evaluation and alarm conditioning is underway. Different techniques based on signal processing, rule-based fuzzy logic control, wavelets, neuro-fuzzy modelling, genetic algorithms and real time control involving instrumentation interfaces will be pursued in the future. The research will also be undertaken to investigate implementation of smart, fuzzy and intelligent techniques for biomedical applications and development of blackboard intelligent system based on multi-agent control system for Cryogenic test equipment for electronics assessment, and Plasma Assisted Chemical Vapour Deposition.

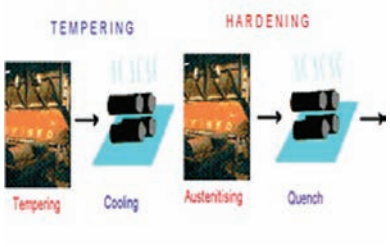


DNA with base-pairs *DNA with mismatched base-pairs*

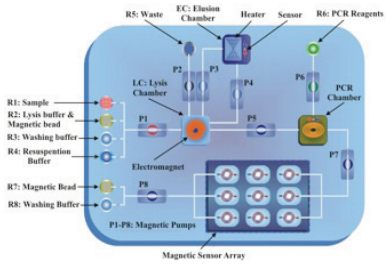
Artificial Intelligent Techniques are used in Modelling DNA Base-Pair Mismatch

Bio-nanotechnology

The on going research in bio-nanotechnology is focused on the development of a fully integrated micromachined microfluidic device for point-of-care diagnostics. This is a nucleic acid detection system capable of accepting whole blood as a crude biological sample, followed by on-chip DNA extraction, purification, PCR amplification and electrochemical detection in a manner that allows for micro litre samples to be screened for infectious pathogens with sample-in-sample-out results in less than 30 minutes. The proof-of-concept of DNA extraction from whole blood has been successfully demonstrated using switching magnetic fields. Numerical modelling of a novel electrochemical DNA sensor has been completed and the proof-of-concept studies are underway. The research will continue to address the challenging issues associated with the system integration of all the functionalities including PCR, electronic control and embedded software. Future research will be directed towards system design modification to accommodate other biological samples. The application areas will be extended to bacterial, viral and fungi detection in food, forensic, bio-defense and veterinary environments.



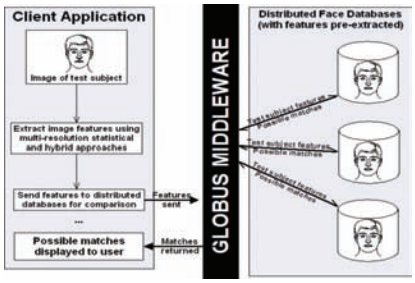
Artificial Intelligent Techniques applied to Steel Making Process



Integrated Micromachine Microfluidic Chip for Point-of Care Diagnostics (Doctor-on-a-Chip)

Biometrics and Security

Recently, a biometric door-lock based on finger print technology was successfully completed by the CESR in collaboration with an industrial partner. Research is being pursued in developing multimodal biometric fusion algorithms using fingerprint, voice, face, and gait recognition data. This will be further extended to incorporate wireless security and the fusion algorithms will be modified to achieve secure communication using cellular and WiMax networks in health care and commercial transaction applications.



Face Recognition Using Multi-resolution Statistical Approaches

Fingerprint Sensing System

A nanotechnology-based fingerprint sensor with liveness detection, based on sweat pore activity, is being developed to enable more accurate authentication and to achieve improved FAR and FRR rates.

A further area of research is the study of chaotic behaviour in electronic circuits and the conditions for such behaviour. This offers potential for new data encryption strategies. Future research will also focus on the use of nanotechnology-based antenna arrays for the development of new fingerprint sensors. In conjunction with the above, research is also carried out in the areas of voice, face, and gait recognition, with the intention to combine all developed technologies within a wider, multimodal, biometric framework.

Charge Particle Dynamics

The research activities in charge particle dynamics will continue with the focus on bipolar charge measurement of pharmaceutical aerosols. Intelligent drug dispensing devices will be developed using NEMS/MEMS technology in close collaboration with pharmaceutical industries. The existing lung deposition model will be further extended to incorporate 3-D alveolar region and implemented on a virtual reality cave. Electrohydrodynamics of nanospray formation and charge droplet stability will be investigated using Molecular Dynamic simulation. Electrokinetics of nanoparticles and biological molecules will be investigated to better understand material surface properties and interface phenomena.

Simultaneous Measurement of Size and Charge Distribution of Pharmaceutical Drug Aerosols using Phase Doppler Anemometer

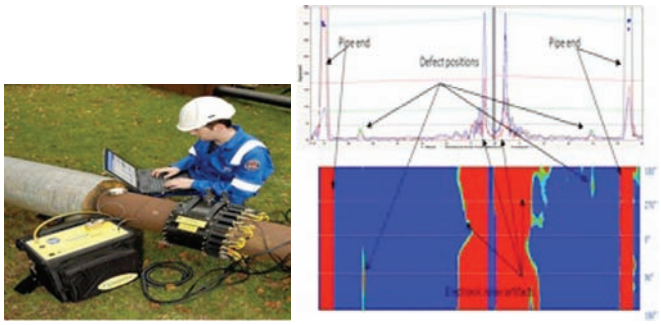
Ultrasonic and Electromagnetic NDT

Guided wave ultrasound has been exploited for NDT in pipes, flexible risers, rails and sheet piles. Collaborative research is being pursued with an industrial partner to investigate propagation of dispersive modes and mode coupling in such structures. Focused beams and time reversal techniques are being exploited to minimise unwanted mode coupling. Advanced digital signal processing techniques are used to improve the resolution of crack detection based on guided wave ultrasonic signals. Research is also carried out to develop an embedded system based on Field Programmable Gate Arrays (FPGA).

Recent efforts have also been directed towards the data collection and signal processing of seismic data in order to seek precursors to earthquake activity. A further avenue of research which is currently being pursued is the peizo-electric effect occurring in

massive structures. Rocks in the earth's crust when subjected to stress, emit electromagnetic radiation. This can be detected at the earth's surface and research is underway to detect patterns in these emissions and correlate them with seismic activity.

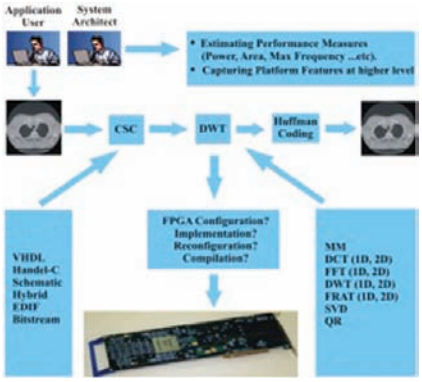
The same phenomenon is being exploited in the built environment to provide a non destructive testing approach to building structures.



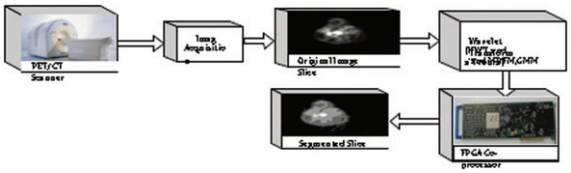
Guide Wave Ultrasonic Non-destructive Testing Systems for Pipe Inspection and Results Showing Defects

Image and Vision Systems

The main aim of this project is to develop a real time system based on multi-resolution statistical algorithms for medical image segmentation. 3-D medical image processing is a very computationally intensive process which leads to high power dissipation. A range of design methodologies and arithmetic techniques will be investigated such as distributed arithmetic and systolic arrays to reduce the area/time complexities and power dissipation in the system. The system will be tested and evaluated on different Field Programmable Gate Array (FPGA) platforms. Multiresolution and statistical algorithms such as wavelet/rigdlet transforms, and Gaussian Mixture Modelling (GMM) will be accelerated on reconfigurable hardware.



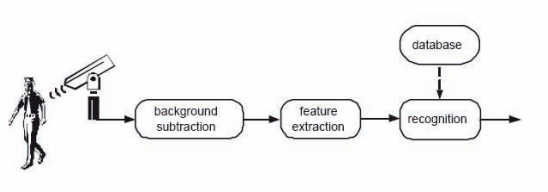
Audio Visual Speaker Identification Using Multiresolution Statistical Approaches



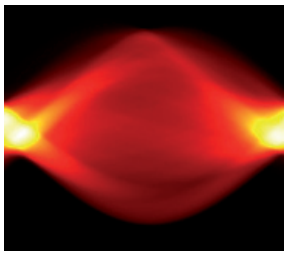
Efficient Reconfigurable Architectures for Medical Imaging

Visual Surveillance and Reconfigurable Computing

Visual surveillance research in CESR focuses on the recognition of individuals and their activities using innovative surveillance and behavioral analysis technologies. This research involves the development of algorithms for gait recognition, i.e., identification based on walking style, and activity recognition. The objective of the project is to achieve accurate identification of individuals and interpretation of their activities in an unobtrusive way using a network of visual sensors. To this end, both holistic methods and model-based methods have been investigated and a number of working systems have been developed. We are currently planning the implementation of some of the developed technologies using reconfigurable hardware. Reconfigurable Computing and image/vision research in CESR are focusing on pioneering future directions in machine vision systems through the integration of image/video processing software and hardware. It is expected that the combination of image/video processing software and hardware expertise will enable the development of novel surveillance paradigms.



Visual surveillance system for identity and activity recognition

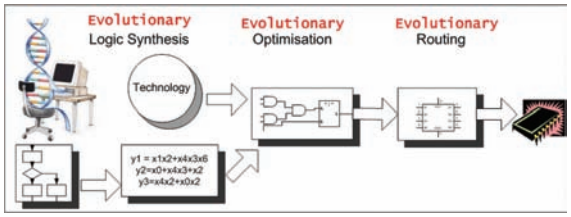


Gait recognition template based on Radon transform

Evolvable Hardware

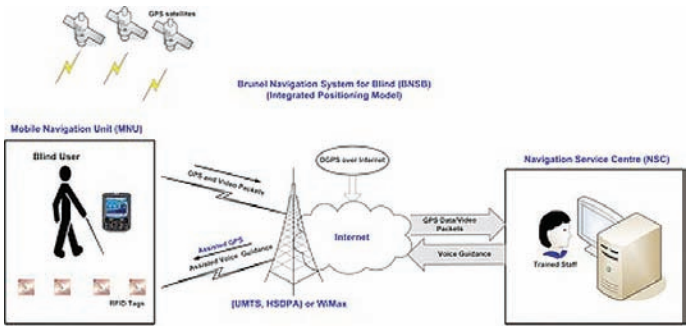
Development of advanced software and hardware-based multi-chip modern intelligent techniques for design and optimisation of logic circuits (mainly use of evolutionary computation and evolvable hardware). The developed system

is able to design and optimise some parts of the logic circuits automatically without human participation on either software or hardware. Evolutionary design of logic circuits (so called evolvable hardware) is applied for both extrinsic (software-based) and intrinsic (hardware-based) systems. Evolvable hardware combines the use of evolutionary computation to design and optimise the combinational and analogue logic circuits. The approach has been significantly improved by use of bi-directional incremental evolution as well as unconstrained evolution.



Principles of Evolvable Hardware

Images generated using AI techniques



Brunel Navigation Systems for Blind

Location Based Services (LBS)

Research in GPS navigation has resulted in a patented system for blind navigation (Brunel Blind Location Based Service). Generally, LBS products should also satisfy most end users' requirements and incorporate privacy in the communication links. One of the main challenges of BBLBS is the performance of the received GPS data in terms of accuracy and precision; especially while navigating the blind in urban environments where availability of GPS signals is limited and high accuracy levels are needed. To overcome this difficulty, a new architecture is being implemented that is based on integrating several navigation systems. This architecture will extend the Differential GPS (DGPS) method to be used for wide area correction coverage using the Ordnance Survey GPS network. The wide area DGPS method will be integrated with wide area correction signals from EGNOS satellites and from the SISNET server. This hybrid system will work as an augmentation system that utilises the best available correction signal; thus increasing the reliability and integrity of Brunel Blind LBS System. Another complementary area of research that is being pursued is human factors in the design and control of system products, environment and services. Application of visual ethnography methods are used in user requirements.

Evolutionary Design

This research is concerned with development of hybrid intelligent systems that are capable to solve relatively complex problems. The hybrid intelligent systems include combination of evolutionary computation techniques, bi-directional incremental evolution, fuzzy logic, neural networks, expert systems and swarm optimisation. The creative features of evolutionary computation are used to design 3D paths, wireless network and images.

Facilities

The Centre has well equipped laboratories and computing facilities and the ongoing research is funded by: EPSRC, MRC, EU FP7, Pfizer, AstraZeneca, TWI, Global Bio Tec, Agilityds, Xilinx Andor, Miragex, Zonegard, Sheffield Forgemasters, London and Scandinavian Metallurgical Co Ltd, EA Technology, GE, BUSM, CORUS and Caterpillar.

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