Emergent Technologies in Information and Communication

Dia das Tecnologias Emergentes
Grupo AE5 - TICs

Escola de Engenharia
Universidade do Minho

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TIC Group

The TIC group started with six members from four departments, and now includes the following contributors:

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Emergent Technologies in ICT (TICs)

Our first task was to search for an answer to the question

What is Emergent in Information and Communication Technologies ?

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The European Commission, in the definition of the Framework Programmes' goals in Information Society Technologies (IST), is assisted by an advisory group (ISTAG). In July 2004, ISTAG released a Draft Report in preparation for FP7 on

Grand Challenges in the Evolution of the Information Society.

URL

ftp://ftp.cordis.lu/pub/ist/docs/fet/7fp-pre-6.pdf

ISTAG Grand Challenges

Vision

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This trend (in 7-10 years) includes complex networking of small powerful devices, “smart” and “hidden” devices in distributed self-regulating systems, closer connection with biological and life sciences both in “human augmentation” and biologically inspired computing.

ISTAG Grand Challenges

Projects

ISTAG identified a set of visionary projects

> *. . . leading to "concrete pictures of the future", focusing 8-10 years in the future, that will demand interdisciplinary research and engineering in many key areas and that exemplify application domains of particular promise for growth in Europe.*

ISTAG Grand Challenges

Overview of Projects

- The 100% Safe Car
- The Multilingual Companion
- The Service Robot Companion
- The Self-Monitoring and Self-Repairing Computer
- The Internet Police Agent
- The Disease and Treatment Simulator
- The Augmented Personal Memory
- The Pervasive Communication Jacket
- The Personal Everywhere Visualizer
- The Ultra-light Aerial Transport Agent
- The Intelligent Retail Store

ISTAG Grand Challenges

The 100% Safe Car

- Reduce/Eliminate traffic fatalities
- Overcome human driver limitations (vision, reaction)
- Networked approach, linking cars and local environment
- Gather collective knowledge in vicinity
- Detection of icy/oily roads, jams, incoming cars . . .

ISTAG Grand Challenges

The Intelligent Retail Store

- From barcodes to RFID tags
- Composition/Allergen queries
- Product comparing, alternative products
- Indoor navigation and paths to products
- Client behavior/preferences survey

Future and Emergent Technologies

The vision of Grand Challenges gives some focus to the underlying research areas on emergent technologies. The IST Future and Emergent Technologies (IST FET) in the current EC FP6 programme, finances quality research in the supporting areas and was used as a guide to assess the potential and needs of Emergent ICT R&D in our School of Engineering.

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AE5 - TICs, Approach

Using IST FET as a guide, our group summarized the Objectives and Focus/Approach of each area and started to identify local Competences in the School of Engineering.

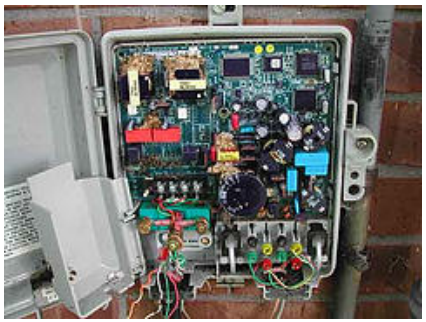
Future and Emergent Technologies

Areas

- CA (Advanced Computing Architectures)
- BIO-I3 and other NEURO-IT related initiatives
- CO (Complex Systems)
- COMS (Situated and Autonomic Communications)
- DC (The Disappearing Computer)
- GC (Global Computing)
- NANO (Emerging Nanoelectronics) EEng AE1
- PR (Presence Research)
- QIPC (Quantum Information Processing and Comm.) Absent?
- RO (Beyond Robotics)

Advanced Computing Architectures

Objectives



Methods for enhancing re-programmability, reconfigurability, and re-usability of components, systems and products and hereby for enlarging the number of items produced for each design.
Methods and tools supporting fast system design, development, verification and testing, and on the other hand, on electronic architectures that support these.

Advanced Computing Architectures

Focus/Approach

Architecture research driven by performance, low power and cost and real time operating systems seems a good direction to take advantage of future opportunities.
Some of the research areas are:

- Scalable Processor Architectures
- Low Power Design
- Retargetable Optimization
- System Architectural Tools
- Dependable computing architectures
- Operating systems

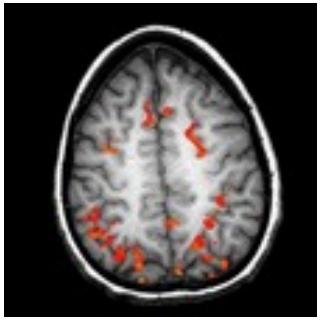
Advanced Computing Architectures

UM/EEng Competences

- Clusters
- Operating systems
- Reconfigurable Architectures
- Fault tolerance OS
- System simulations
- Retargetable simulators
- Application specific OS

BIO-I3 and other NEURO-IT related initiatives

Objectives



Reverse engineering of the brain could overcome the present obstacles to truly intelligent information systems. The objective is to explore new avenues in the design of intelligent information systems that attribute meaning to complex patterns of sensory stimuli and generate sequences of elementary actions that satisfy high-level goals.

The ultimate aim is to build systems that exhibit flexible, autonomous, goal-directed behavior in response to changes in internal and external conditions.

BIO-I3 and other NEURO-IT related initiatives

Focus/Approach

The design and construction of novel intelligent information systems will focus on the following research themes:

- Multidisciplinary characterization of computational properties, structure and other physical constraints of large assemblies of interconnected neurones that process information in the perceptual, motor or cognitive domains and serve as a model for new IT architectures and design.
- Mechanisms of evolution, development and plasticity that support self-construction, and self-repair of artificial or hybrid (biological/artificial) intelligent information processing systems; exploration of hardware and materials suitable for interfacing to the nervous system, or for implementing sensors, processors and actuators in modifiable, adaptive, growing systems.

BIO-I3 and other NEURO-IT related initiatives

UM/EEng Competences

- Artificial Neural Networks
- Evolutionary Computation
- Modeling and optimization of bioprocesses

Complex Systems
Objectives

Understanding the properties of ‘complex systems’ with a large number of highly interconnected heterogeneous elements poses today a grand challenge for system research.
For such systems we can design components and their connections but the problem remains of how to guide them to achieve desired global behaviors, like dependability and adaptability, and how to predict and avoid undesired behaviors, like cascading failures in interconnected infrastructures.
In the life sciences, novel data acquisition techniques provide a wealth of data on living systems but we lack sufficient means to infer models from these data.

Complex Systems
Focus/Approach

One or more of the following research issues should be addressed:

- Multi-scale simulations: Develop methods for the effective computation of systems acting/described on different levels of aggregation.
- Simulation in presence of uncertainty: Develop computational tools that take into account the fact that the models themselves as well as the parameters that they use may be uncertain.
- Reconstruction of system models from incomplete, missing or inconsistent sets of data.

Complex Systems
UM/EEng Competences

- Machine Learning / Data Mining
- Bioinformatics
- Modeling and optimization of bioprocesses
- Artificial Neural Networks
- Evolutionary Computation
- Network theory

Situated and Autonomic Communications

Objectives

This area deals with new paradigms for the design of communication/networking systems where individual components and subsystems react and adapt to their local context and exhibit properties of autonomy, self-organization, wide distribution, technology independence and scale-free.

This encompasses a paradigm shift from architected networks to emergent aggregation of heterogeneous network capacity. Such shift is expected to induce cross-layer approaches, redefining traditional protocol stacking models.

Situated and Autonomic Communications

Focus/Approach

The design of self-organizing networks involves the study of interaction properties among individual units that react to each other and to the environment.
This involves both a multi-disciplinary approach at the theoretical level (new network information theory, random graphs, complexity theory, genetic algorithms, game theory, ...) and focus on security, coordination, sensoring, evolvability, stability and resilience.

Situated and Autonomic Communications

UM/EEng Competences

- Sensor Networks
- Computer Communications
- Distributed Systems
- Networking Technologies (hardware/software)
- Wireless network access and error control

The Disappearing Computer

Objectives

As an emerging area, this initiative aims to investigate “(...) how information technology can be diffused into everyday objects and settings, and to see how this can lead to new ways of supporting and enhancing people’s lives that go above and beyond what is possible with the computer today”.

Closely related areas, known as Ubiquitous Computing, Pervasive Computing and Ambient Computing, have recently attracted considerable attention from the scientific community worldwide

The Disappearing Computer

Focus/Approach

The major research challenges in an effort to implement the DC concept have been identified as:

- Interaction design – how to design the interaction between humans and “disappeared computers”, and also between humans in a DC ambient.
- Sensing and context – how to perceive the situation of a user or how to describe a particular ambient.
- Discovery – in a highly distributed computing environment, with multiple sources of information and services, how to discover and select the appropriate resources for a given situation.
- Privacy, trust, and security – management of personal information (such as location), and trust associated with information and services.

The Disappearing Computer

UM/EEng Competences

- Communication networks
- Mobile communications
- Distributed systems
- Mobile computing and ubiquitous systems
- Human interfaces
- Security and privacy
- Artificial intelligence
- Geographic information systems

Global Computing
Objectives

“A global computer is a programmable computational infrastructure distributed at a worldwide scale and available globally.”.
The vision encompasses more than GRID technology (sharing of computer power and resources) since it requires the creation of novel computational paradigms, linguistic mechanisms and implementation techniques that will support the deployment and management of the aimed global computing environments.

Global Computing
Focus/Approach

The focus is placed on the four issues of security, resource usage and management, scalability, and distribution transparency. To this aim, research effort is expected to include the following themes:

- Methods and infrastructures for trust
- Abstraction mechanisms
- Components and modularity
- Programming languages concepts and support
- Algorithmic principles
- Autonomy, adaptability, and self-organization
- Interoperability
- Design support and software techniques

Global Computing
UM/EEng Competences

- Peer-to-Peer Systems
- Distributed Systems
- Programming Language Design
- Formal Methods
- Parallel Computing
- Clusters
- Cryptography
- Resource optimization / load balancing

Presence Research

Objectives

The aim is to convey the sense of being there as well as that of communicating, participating, acting, doing, influencing and changing things there - emotionally, cognitively, bodily and physiologically. Therefore, implicit rules, expressive and nonverbal communication, as well as motivational states are some of the essential features required in future systems for presence and interaction.
In addition, technologies for multimodal interaction (visual, acoustic, haptic, etc.), combined with high-quality, situation sensitive and bi-directional presence, are also a core requirement of future systems that would make it possible for people to experience and live different realities (virtual, augmented, and mixed), possibly as a different personality or at a different time.

Presence Research

Focus/Approach

The objective is to create novel systems that match human cognitive and affective capacities and re-create the different experiences of presence and interaction in mixed reality environments. Research should focus on the integral combination of the following three main research issues:

- Understanding different forms of presence, encompassing aspects of perception, neurological processing, cognition, interaction, emotions, affect and culture.
- Designing and developing essential building blocks that capture the salient aspects of human presence and interaction, as described in item above.
- Developing novel systems, able to generate or support different levels and types of presence and interaction in a multitude of situations.

Presence Research

UM/EEng Competences

- Augmented Reality
- Virtual Reality
- Image processing
- Artificial Intelligence
- 3D Reconstruction
- Parallel Computing
- Modeling of human emotions
- Gesture Recognition
- 3D Vision

Beyond Robotics
Objectives

Addresses “the development of physical mobile artifacts that could serve as companions to humans, function as bionic parts augmenting human capabilities, or act as autonomous microrobot groups.”
The development of hybrid bionic systems requires smooth integration of sophisticated robotic and information systems with human perception-action systems using bi-directional interfaces with the human nervous system.
Finally, the development of autonomous heterogeneous microrobot groups opens up interesting issues for their coordination, adaptation, self-organization and evolution to operate in open-ended, real environments in order to jointly attain a global task.

Beyond Robotics

Focus/Approach

- Robust perception – Deals with developing perception systems having true cognitive abilities that can be used for understanding situations and tasks and for interacting with humans and the environment.
- Task and environment adaptation - Deals with the capacity of both embodied and situated artifacts of self-organizing and self-evolving, so as to best adapt and accommodate changing environments and tasks.
- Interaction – Flexibility and versatility of its interfaces. E.g. direct interfaces to the nervous system or more traditional multi-modal interfaces could be considered.

Beyond Robotics

UM/EEng Competences

- Non-linear dynamical theory
- Signal processing
- Control engineering
- Multi-sensory perception
- Vision
- Artificial intelligence
- Learning
- Sensors
- Embedded systems

TIC Group Agenda

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- Keep and disseminate up to date information on ICT Emergent Technologies.

Images and Resources

All images in this presentation are either public domain or creative commmons and have been obtained in www.flickr.com.

IST FET

http://www.cordis.lu/ist/fet/home.html