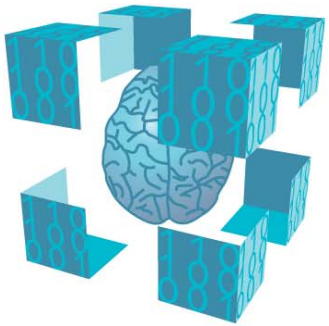


NEURO-iT.NET

A Network of Excellence at the Interface between Cognitive/Neurosciences and Information Technology

Alois Knoll
(Coordinator)

Technische Universität München, Germany
LS Informatik VI – Robotics and Embedded Systems

What is nEUro-IT.net ?

nEUro-IT is ...

... is an emerging discipline characterised by transdisciplinary research at the interface between NS (Neurosciences) and IT (Information Technologies), hopefully linking the two at an operational level with an emphasis on **IT profiting from NS**

nEUro-IT.*net* is ...

... expected to (i) define the field of **Neuro-IT** beyond what is traditionally called Neuro-Informatics and Computational Neuroscience and (ii) the tool for discovering new unexplored research domains that could lead to breakthrough in **Neuro-IT** in the long term

... a medium-sized EU-sponsored network:

- Currently 111 researchers
- 82 institutions and companies
- 16 nations
- 48 key nodes
- 8 steering commitee members

Structural Research Innovation

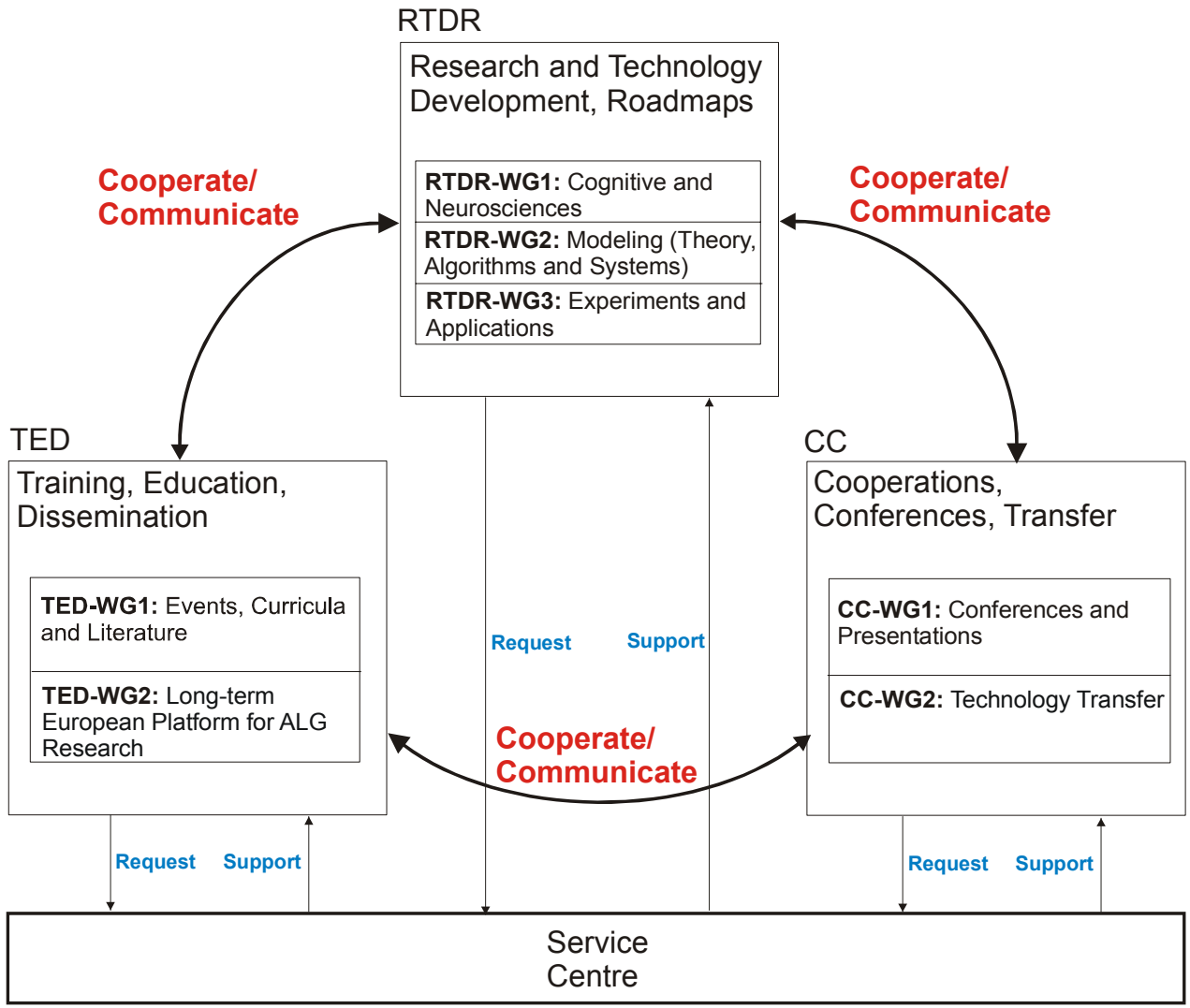
– Research should be targeted at areas that promise IT to benefit from NS results **to improve IT artefacts** (embodied and not) and NS to be able to **validate models or hypotheses** with a better use of IT.

– Complement and move beyond the already well established research domains by fostering research that will benefit both the NS and IT communities by helping solve the fundamental problems linked to **the emergence and the modelling of cognition and awareness processes**.

– More specifically, issues may the design of models, e.g. for
  - physical and mind adaptation; eventually physical *growth* and *mind development*,
  - human-artefact and artefact-artefact interaction,
  - artefact emotion expressions and
  - advanced operational sensorimotor systems
  - ...

Neuro-IT.net: Structure

- **Core-group:** Consortia from FET proactive initiatives
- **Launch date:** Oct. 1, 2002
- **Steering committee:** 8 members
- **Funding period:** 4 years



- **The *non-standard* activities** of Neuro-IT.net **include**:
  - **Symposia** on a topic/function across all disciplines, e.g. “from the visual cortex to computer vision systems and back”
  - **Fellowships** for immersion in biology for engineers and hardware/software design for biologists (up to 12 months to get hands-on experience)
  - Organisation of **ateliers** in which working groups visit each other for a limited period of time to actually work together on a specific question to profit from each other’s equipment (e.g. fMRI systems).
  - Organisation of a public high-level scientific **tournament** with live demonstrations and the development of prestigious prizes
  - Support for **small start-up measures** in the different areas, with special emphasis on their transdisciplinary benefit and potential for later research proposals emerging from them (departure from the sole service character of traditional NoEs)
  - Annual **Venice Summer School** on Neuro-IT and Neuroengineering (in prepraration)
  - **Regular brainstorming sessions for developing roadmaps and position papers**

How do we compile our roadmap for Neuro-IT?

- Define medium-term and long-term **"grand" challenges** with an **emphasis on working systems**
- Identify what methods contributing to the project goals are available today, what has to be developed, and which of these developments can be used in (ideally: many) other sample technology applications
- Sharpen our image of what Neuro-IT is (and what not) and how the content areas of the field can be conceived
- Define priorities for research areas

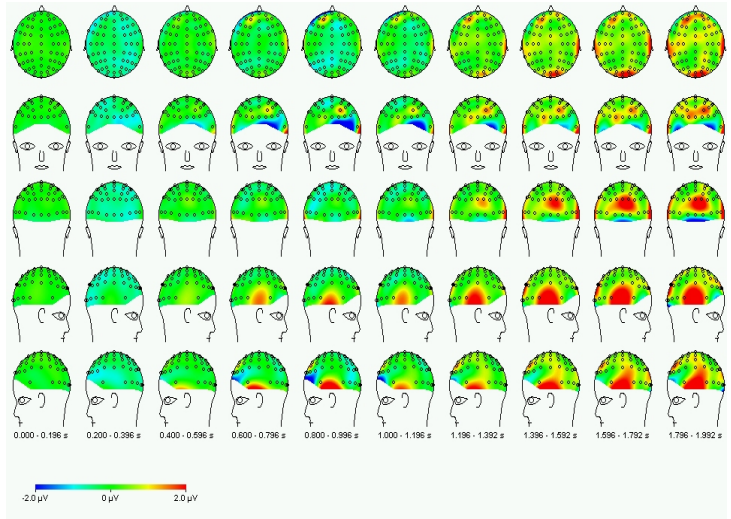
Grand challenges

Goal

To augment human interaction with their environment by enabling direct control of sophisticated robotic (sensorimotor) and information systems using *non-invasive* bidirectional brain interfaces at an appropriate level of the cognition system.

Example realisations include:

- full-immersion teleoperation of remote exploratory vehicles equipped with non-human sensors, ranging from microendoscopes to deep sea vehicles with acoustic sensing → total telepresence/teleaction over long distances (mental control of spaceships).
- repairing damaged human sensorimotor systems with tightly-interfaced prostheses.
- reintegrating a severely disabled person into society, for example enabling a congenitally quadriplegic person to perform tasks such as monitoring and directing an air traffic control system by direct "experience" of the airspace.



Problem areas

- Neural interfacing & representations
- Shared control / partial autonomy
- Ethics & Society (different cultures for different communities)
- Sensor/motor/control must be tightly coupled, but perception/ decision/action is not well understood neither in robotics nor in neurosciences
- Sensors and actuators with performance as good as, or better than, natural ones

Goal

- Build an artefact that autonomously (and in a self-stabilising goal-directed way) grows
  - **the size of its body,**
  - **the aptitude of its sensorimotor skills and**
  - **its general cognitive abilities**

  by a factor of ten within ten months
- Employ biological/ecological principles (e.g. re-use, self-repair, structural coupling) for optimising energy-efficiency, life-time, need for dedicated materials, etc.

Example realisations include

- Platforms for simulating developmental biology/psychology on a real machine
- Truly physically adaptive robots: controllable epigenetics – for specific environments (e.g. for large factories, remote planets) and tasks
- Edutainment: the ultimate toys that show behaviour development „my *real* real baby“

Q: What is a roadmap? ....

A: ... A comprehensive document ...

- Summarizing the state of the art
- Outlining areas of future research for the next 5 to 10 years

→Useful for formulating a basis for funding programmes

→Serving as a reference for scientists (finding partners, especially from other disciplines)

Problem areas

- Bodily growth: Materials for muscles and support structures, substrates for the brains, power supply (e.g. through organic „food“)
- Layered control: System must control the body during the body‘s growth phase – while it grows itself
- (Higher) cognitive functions: what instincts, what degrees of freedom, what structures are predefined, what can be determined at „run-time“
- How can the final shape develop from initial genetic information and how can the system remain stable?

Goal

- Design an architecture that is fully computer-operational, can control an (embodied) artefact in real-time and autonomously develops
  - **Attention control**
  - **Self-awareness**
  - **Access consciousness**
  - **Phenomenal consciousness**

  for selection of perception and action, monitoring internal states, experience emotions, controlling memory

Example realisations include

- Truly intelligent "situated artificial communicators", e.g. for human-machine interfaces of learning systems
- Truly "mentally adaptive" robot systems with qualitatively new problem solving abilities

Goal

- Create a framework for *complete* brain simulation (analogy of the "virtual cell")
- Virtual brain has the potential to model all known effects and phenomena ... and eventually runs in real-time ... on different levels of granularity

The virtual brain ...

- is one way of integrating knowledge (and software!) from various disciplines into one package, presupposing a *meta*-Database design for unifying vocabulary, giving access to the scattered knowledge in the diverse disciplines and – as an important side-effect – implicitly creating a true multidisciplinary overview of brain science
- Can be used to experiment 'in Silico' (lesions, neurotransmitters, ...)
- Can be used together to map functions from 'wetware' to 'hardware', i.e. which brain functions can be mapped to current technology
- Allows non-experts to study phenomena outside their own field of expertise
- Allows various scales of simulation

The virtual brain is a protocol ...

- that provides a 'large-scale' structure (anatomical, functional databases, large-scale networks, mean-field approximations)
- that allows a 'plug-in' of more detailed simulations where necessary

Goal

To provide the methodological infrastructure and the "neuro-knowledge" base in such a way that they are suited for use in "bio-inspired IT" applications of the other challenges

Problem Areas

- Individual neurons have been studied in detail: on the genetic and molecular level, using patch clamp techniques etc.
- The brain as whole has been addressed by fMRI, EEG, PET, etc.
- But there is a gap between the study of individual neurons and the whole brain: the supraneuronal level, i.e. local cortical networks, cortical columns
- The supraneuronal level is important for Neuro-IT: it embodies the computational principles that we want to endow artefacts with

Potential research topics

- Development of completely new scanners/contrast agents (and multi-electrode recording devices, e.g. >1000 electrodes and more than 5 brian regions) for *moving* subjects over an extended period of time
- Processing methods enabling the fusion of these measurements to different non-invasive brain imaging modalities: PET, fMRI, MEG, etc.
- Development of *mathematics for brain sciences* (e.g. beyond the correlation techniques currently in use)
- (Unified) Theory of of brain function at neuronal, network, functional, region and system level.

Roadmap-Timetable

- The roadmap is a public "live document", which will be extended and updated at regular intervals throughout the lifetime of nEUro-IT.net.
- The **first official version** will be submitted to the CEC after another roadmap-meeting of the Steering Committee in Brussels on **October 6, 2003.**
- A "**WWW-Consultation**" will start in the next couple of days, encouraging the whole community to contribute **ideas** and suggestions for **concrete first steps**.
- **Contributions to Draft Version 1** will be possible until **July 31, 2003**. Major suggestions, e.g. addition of further challenges, will not be accepted after this deadline.
- **Contributions to and comments on Draft Version 2** will be accepted until **September 15, 2003**. All contributions will have to fit within the scopes of the grand challenges.

Find more information at ...

http://www.neuro-it.net

... join the network, take part in the web-consultation and ...

help define and shape the future of Neuro-IT!