NEURO-IT.NET

Neuro-IT.net & European Commission
FP 7 Information Workshop
Tour Madou, Brussels
January 16th, 2007

Introduction to the day

- Since its inception in 2002, Neuro-IT.net has tried to establish an operational interface between between Cognitive/Neurosciences and Information Technology

- The main activities of the network have included (amongst others):
  - Support for **small start-up measures** in the different areas, with special emphasis on their transdisciplinary benefit.
  - **Organising** and sponsoring various **Summer Schools** on Neuro-IT and Neuroengineering
  - Organising the review meetings/workshops of several FET **proactive initiatives**
  - Numerous **brainstorming sessions** for developing roadmaps and position papers
  - **Distribution and presentation of the roadmap**; the roadmap has been instrumental, for example, in the preparation of the FP 7 work programme and has flanked other preparatory actions, e.g. ERCIM‘s „Beyond-the-Horizon“ initiative (http://www.beyond-the-horizon.net/)

Introduction to the day

- The original mission statement of Neuro-IT.net was:

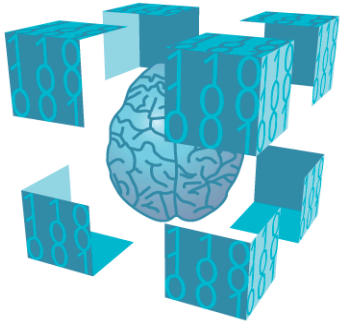
  "The objective is to complement and move beyond the well established NI (Neuro-Informatics) or AI (Artificial Intelligence) domains by fostering research that would benefit both the NS and IT communities by helping solve the fundamental problems linked to the emergence and the modelling of cognitive and awareness processes. The goal is for IT to profit from NS results to improve IT artefacts and for NS to validate models or hypotheses with a better use of IT."

- The leitmotif of the new FP 7 workprogramme summarises five years of reflection and discussion:
  - In the Information and Communications Technology theme proposals are invited that address "**Bio-ICT convergence:** novel computing paradigms, that aim at reverse engineering the information representation and processing capabilities of biological systems for new paradigms in information technology."
  - The Health theme calls for research into **coding in neuronal assemblies,** aiming at understanding the interface between neuronal activity and behavioural performance. Here, an interaction between experimentation and modelling, and therefore a strong neuroinformatics dimension is essential.

Introduction to the day

The agenda for today

09:00	Opening. **Alois Knoll** (TUM)
09:02	Welcome. **Wolfgang Boch** (**Head of Unit, FET Proactive, DG Information Society and Media, CEC**)
09:10	Introduction to the day. **Alois Knoll (TUM)**
	Bio-IT initiatives in FP7:
09:20	ICT FET initiatives **Julian Ellis (CEC)**
09:30	Health theme **Patrizia Tosetti (CEC)**
	Current state of the art in related topics called
09:40	Neuronal coding and computing **Sten Grillner (KI)**
10:05	Getting beyond rate codes: oscillations and attention in the human brain. **Andreas Engel (UKE)**
10:30	**10 min Coffee break**.
10:40	Biomimetic artefacts and VLSI neuromimetic artefacts **Giacomo Indiveri (ETHZ)**
11:05	Bidirectional interfaces **Silvestro Micera (UAB)**
11:30	Biohybrid artefacts **Paolo Dario/Maria Chiara Carrozza (SSSUP)**
	Cooperation issues
12:05	Links with INCF (International Neuroinformatics Coordination Facility) **Jan Bjaalie (INCF)**
12:15	Links with NiSIS (Nature inspired smart intelligent systems) **Davide Anguita (DIBE)**
12:25	Links with ONCE-CS (Complex system) **Jeff Johnson** (**OU**)
12:35	EU-US **Giacomo Indiveri (ETHZ)**
12:45	EU-China **Jianwei Zhang (Univ Hamburg)**
13:00	**Lunch**
14:00	Short Presentation of Neuro-IT Road Map **Alois Knoll (TUM)**
14:20	Open Discussion
	Conclusions and future actions
≤ 16:00	End of meeting



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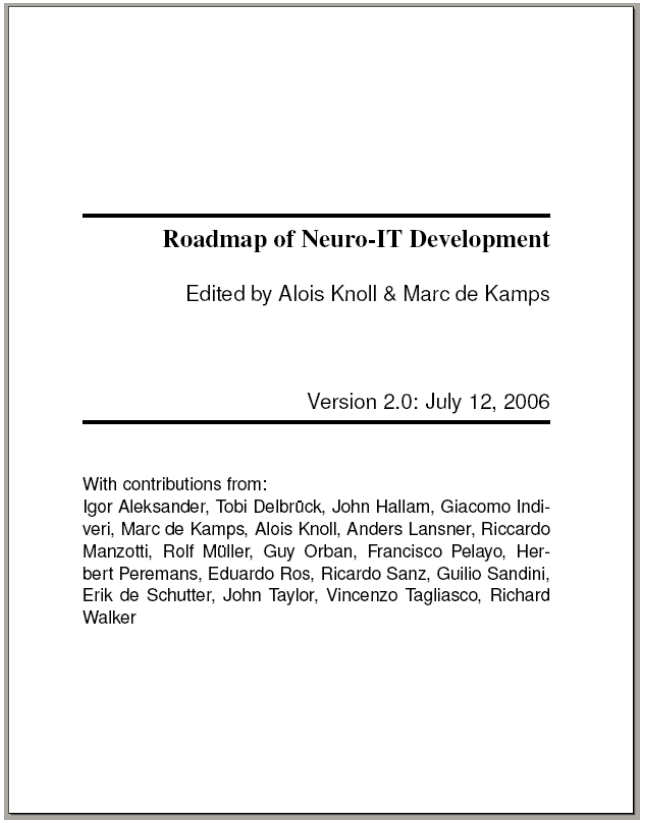
A Quick Tour
of the Neuro-IT Roadmap

Alois Knoll (TU München)

Roadmap: Motivation

Purpose of the roadmap document

- Reference for researchers: which research directions can be expected to be supported by the EC
- Strategic (funding) and scientific relevance: document has been instrumental in preparation of recent FET-BIOI3 call, FP 7 workprogramme discussions, etc.
- Roadmap is instrument for keeping Neuro-IT competitive (towards quantum computing, nano technology, ambient intelligence, grid technologies in FP7)!
- Scientific topics in the Roadmap have generated widespread interest ... and the roadmap continues to be a „live document“
- Since roadmap is an important political instrument: keep up-to-date, deliver contributions, express your support for the kind of research described there!



Roadmap of Neuro-IT Development

Edited by Alois Knoll & Marc de Kamps

Version 2.0: July 12, 2006

With contributions from:
Igor Aleksander, Tobi Delbrück, John Hallam, Giacomo Indiveri, Marc de Kamps, Alois Knoll, Anders Lansner, Riccardo Manzotti, Rolf Müller, Guy Orban, Francisco Pelayo, Herbert Peremans, Eduardo Ros, Ricardo Sanz, Guilio Sandini, Erik de Schutter, John Taylor, Vincenzo Tagliasco, Richard Walker

How have we compiled the roadmap for Neuro-IT?

- Definition of medium-term and long-term **„grand“ challenges** *with an emphasis on working systems.* Means: brainstorming meetings and web consultations

- Identification of (1) the range of methods contributing to the project goals available today, (2) what has to be developed, and (3) which of these developments can be used in (ideally: many) other sample technology applications

- Wrote them down and circulated them!

Challenges for Neuro-IT – "Brainship project"

Goal

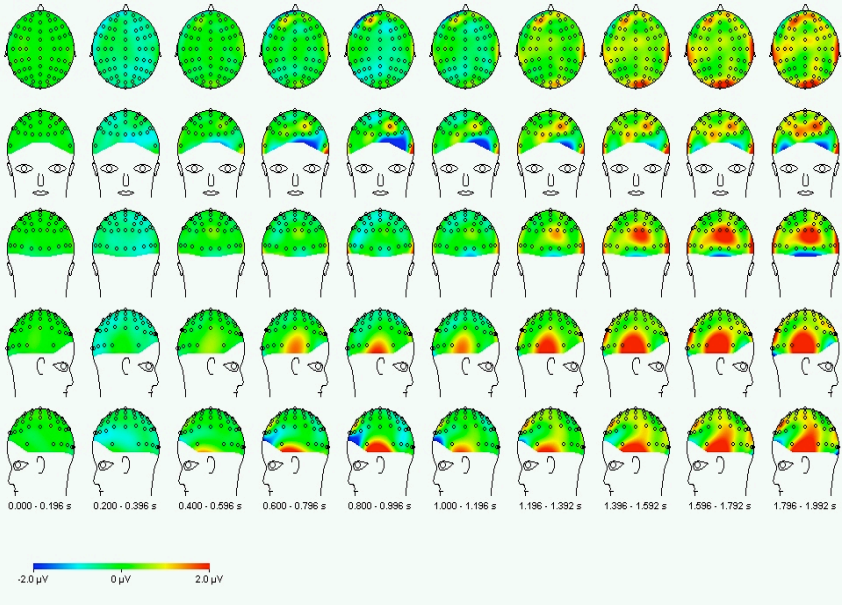
To augment human interaction with their environment by enabling direct control of sophisticated robotic (sensorimotor) and information systems using *non-invasive* bidirectional brain interfaces at an appropriate level of the cognition system.

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



Challenges for Neuro-IT – "Factor 10 project"

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

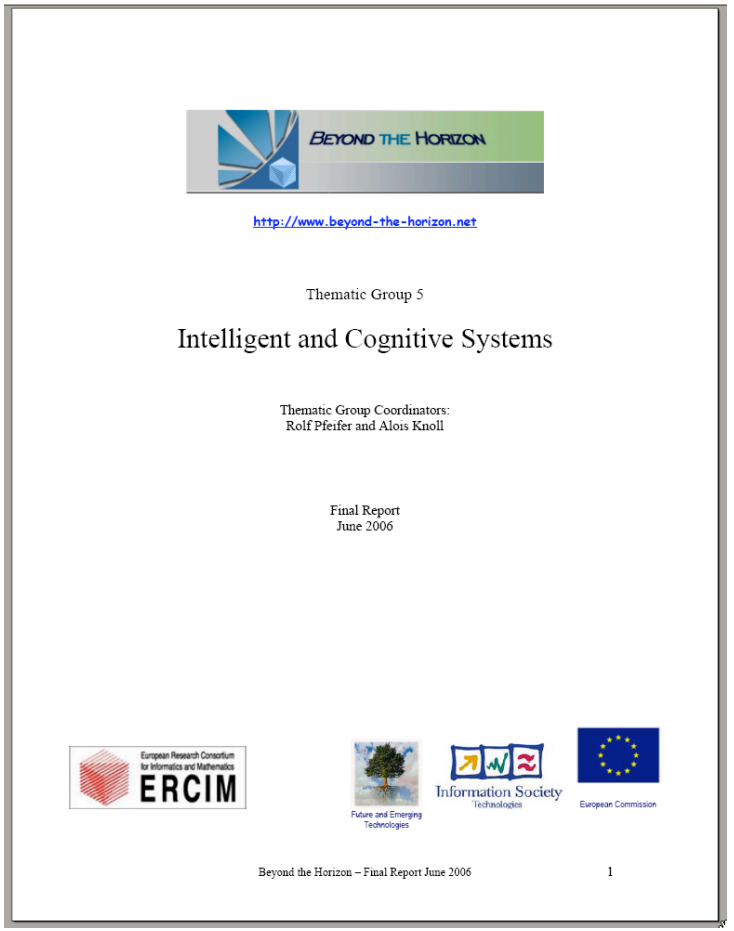
- Platforms for simulating developmental biology/psychology on a real machine
- Truly physically adaptive robots: controllable epigenetics – for specific environments (e.g. for large factories, remote planets) and tasks
- Edutainment: the ultimate toys that show behaviour development „my *real* real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

Challenges for Neuro-IT – "Factor 10 project"

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?

➢ The issue of growth and growing materials is a major area in FP 7 (following the discussions in “Beyond-the-horizon“)


BEYOND THE HORIZON

http://www.beyond-the-horizon.net

Thematic Group 5

Intelligent and Cognitive Systems

Thematic Group Coordinators:
Rolf Pfeifer and Alois Knoll

Final Report
June 2006

European Research Consortium for Informatics and Mathematics
ERCIM

Future and Emerging Technologies

Information Society Technologies

European Commission

Beyond the Horizon – Final Report June 2006 1

Challenges for Neuro-IT – "Conscious machines"

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

Challenges for Neuro-IT – "Brainprobe project"

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 brain 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.

Summary

- Roadmap is an interesting and important guideline and reference document
- Roadmap will continue to be developed in the future
- The community is invited to join the development process – at any time!

Questions for discussion

- What practical steps can be taken to improve cooperation between research domains and across disciplines in order to reinforce the European neuro-IT community?
- How to expand the Neuro-IT roadmap to include other areas that are concerned with Bio-ICT convergence? What about NiSIS, ONCE-CS and other roadmaps?
- Which topics in the roadmaps should be elaborated more in the future and which are critical for further progress?
- What are the expectations of the research community about how the ICT, Health and ERC workprogrammes will develop in this field?
- Are further similar workshops needed? When, where and about what?