Brain Based Architectures for Advanced Robotics

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Self:
Interactive human assisted body map acquisition

Do you speak Robotese?

Self-Other / communication:
Object recognition, Pro-active labelling

Self-Other / communication:
Invariant object/action naming (nouns, verbs)
Distributed Adaptive Control

- autonoetic memory, **consciousness**
- **goal-oriented policies** from sequence learning on state-affect-action triads (model based RL)
- **state space** acquisition of agent-environment interaction from dynamics of the reactive level and action shaping (deep learning & model free RL)
- **reactive** interaction with the environment through drive regulation, homeostasis, allostasis
- the **physical agent** with sensors, effectors, intrinsic dynamics and needs

Robotese-DAC

6 machines @4 cores/32GB RAM.
~20MB/s communication; 50 yarp modules

Verschure (2012) BICA/IEEE
Verschure (2016) Phil Tr. Roy Soc B
Moulin-Frier et al (Submitted)
Motivation  
Personality  
Emotion  
Learning  
Perception  
Cognition  
Consciousness  
(Shared) attention  
Mind reading  
Autobiographical memory  
Navigation  
Proxemics  
Reaching  
Grasping  
Face/gesture recognition  
Natural language interaction  
Compliance  
Touch  
Multiple frames of reference  
Motor control  
Planning ……
Robotics = Synthetic Psychology

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Observation 1:
Advanced robots require advanced real-time integrated control architectures underlying synthetic psychology.
psyche
psyche  flesh
Towards an infrastructure of whole brain modeling: BRAINX3.com

The challenge of WHOLE BRAIN analysis & synthesis
Distributed Adaptive Control: Mapped to the brain
Models of the brain should capture: Anatomy, physiology and behavior, i.e. they must be embodied.
Adequate brain models require advanced robots:

The brain is embodied and the body constraints what the brain does
2002: The silicon cerebellum

Hofstotter et al. (2005) NIPS

Real time control architectures require neuromorphic computational hardware
Distributed Adaptive Control

Neuromorphic computational hardware requires compatible operating systems and principles.
Linking whole brain models with humanoid robots
Conclusions/Questions

• Robots need brains: We need cognitive architectures for robots (and beyond)
  • Real time control architectures require *neuromorphic* computational hardware
• Brain (models) need robots: We need system level theories of brains
  • *Neuromorphic* computational hardware requires compatible operating systems and principles
• Candidate Brain Based Cognitive Architecture:
  • DAC and brainx3.com
Requirements/SPECS for NMC

• Real-time control
• Advanced multi-modal sensing
• Heterogeneous parallel computation
• Large-scale modifiable connectivity
• High bandwidth communication
• RT/Online Accessibility, configurability and control
• Low power
• Environments and tools for interaction
Challenges, Opportunities

• The **AI revolution** is upon us, the non-EU companies are winning, WTA risk, EU cannot miss the boat

• Platforms/Technology should **serve questions** and solutions not vice versa, e.g. FIWARE outcomes

• HBP platforms should be guided by clear and functional **objectives**

• Funding should facilitate **diversity** of science grounded approaches

• We must be **realistic** in defining relation with evolving state of the art in technology and societal needs

• EC must **capitalize** on expertise and effort of research community (CSN I & II experience)

• FET: **excellent** science needs excellent reviewing
The Rehabilitation Gaming System