NARODOWA STRATEGIA SPÓJNOŚCI

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UNIA EUROPEJSKA
EUROPEJSKI FUNDUSZ ROZWOJU REGIONALNEGO

ADVANCED EXPERT PANEL

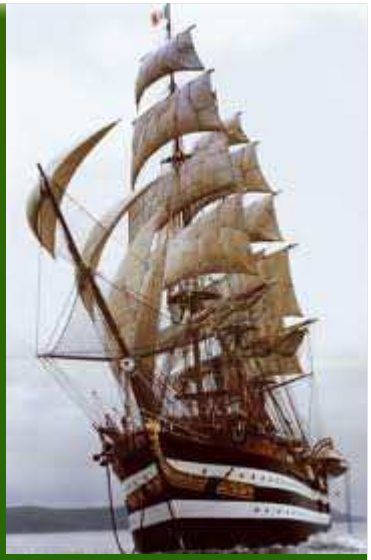
on

„Future Trends in Knowledge Management and Decision Making in Autonomous Systems”

Włodzisław Duch

Supported by the foresight project „Scenarios and Development Trends of the Selected Information Society Technologies until 2025” co-financed by the ERDF within the Innovative Economy Operational Programme (POIG), Action 1.1.1

EU FP7 FET Flagships I



- 6 candidates for FET (Future Emerging Technologies) Flagships Projects, each a 10 year 1 billion EUR programs, in preparatory phase.
- 2 projects will be selected in 2012.
- FuturICT: *Knowledge Accelerator and Crisis-Relief System: Unleashing the Power of Information for a Sustainable Future.*
  What if global scale computing facilities were available that could analyse most of the data available in the world?
- ITFoM: *The IT Future of Medicine*, proposes a data-driven, individualised medicine of the future, based on the molecular/physiological/anatomical data from individual patients. ITFoM shall make general models of human pathways, tissues, diseases and ultimately of the human as a whole.
- Graphene-CA: Graphene Science and technology for ICT and beyond, electronics, spintronics, photonics, plasmonics and mechanics.

FET Flagships II

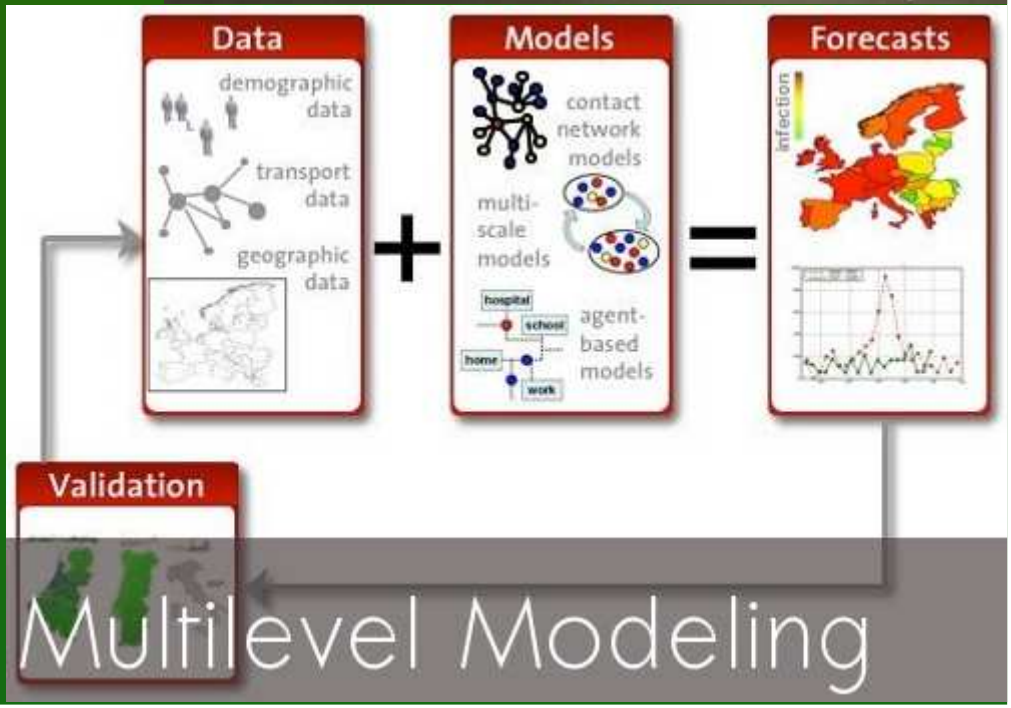
- HBP-PS: *The Human Brain Project*, understanding the way the human brain works could be key to enabling a whole range of brain related or inspired developments in Information and Communication Technologies, as well as having transformational implications for neuroscience and medicine.
- CA-RoboCom: *Robot Companions for Citizens* are soft skinned and sentient machines designed to deliver assistance to people. This assistance is defined in the broadest possible sense and covers all sorts of different settings. Based on multidisciplinary science and engineering, CA-RoboCom aims to develop a radically new approach towards machines and how these are deployed in society.
- Guardian Angels: *Guardian Angels for a Smarter Planet*. Providing Information and Communication Technologies to assist people in all sorts of complex situations is the long term goal of the Flagship Initiative, Guardian Angels.

FuturICT

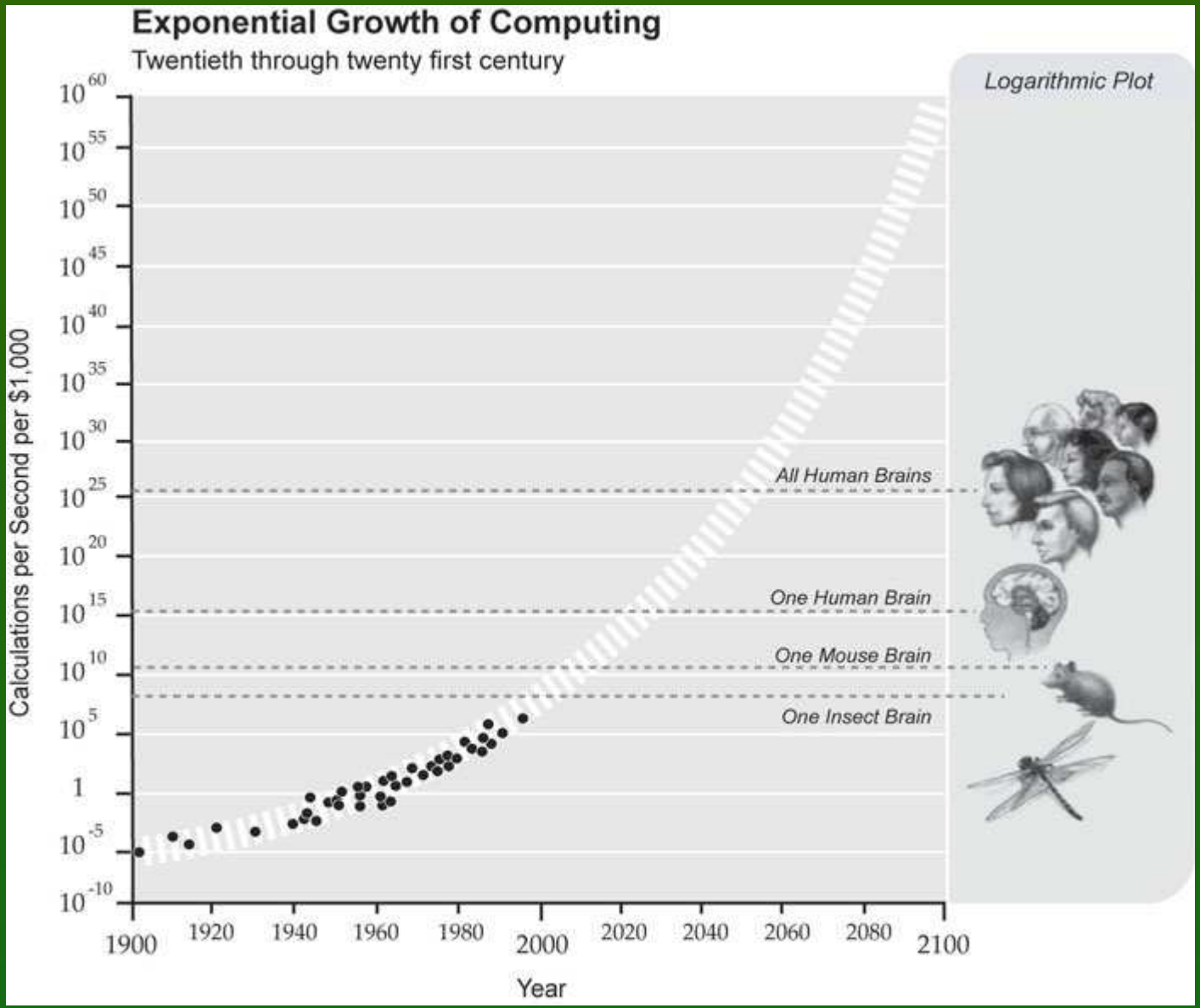
The FuturICT flagship proposal intends to unify hundreds of the best scientists in Europe to explore social life on earth and everything it relates to.

The FuturICT flagship proposal will produce historic breakthroughs and provide powerful new ways to manage challenges that make the modern world so difficult to predict, including the financial crisis.

A bit like Cybersyn project in Chile (1970-73) in real-time cybernetics control of economy.



Exponential growth of power



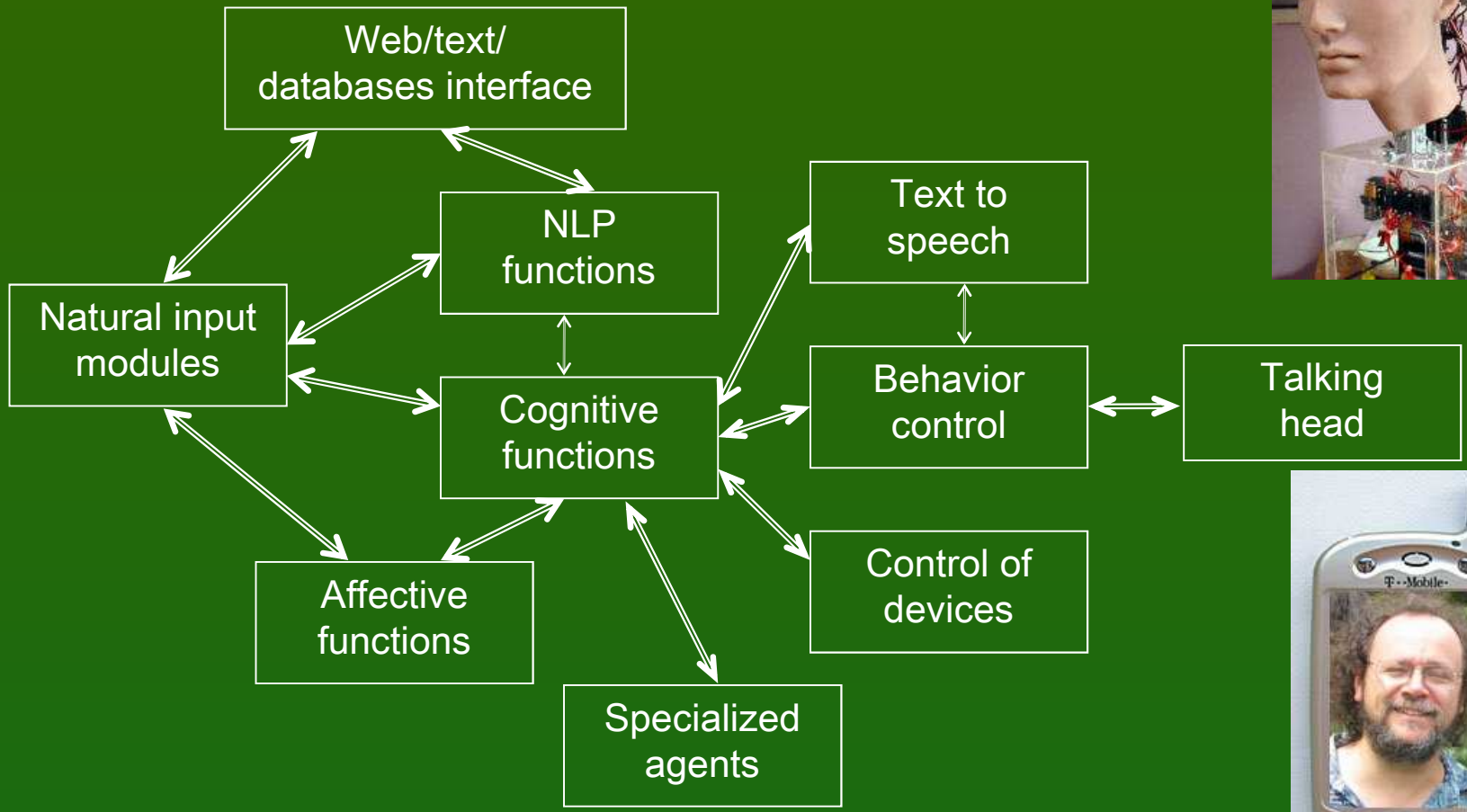
From
R. Kurzweil,

The Law of Accelerating Returns

By 2020 PC computers will match the raw speed of brain operations!

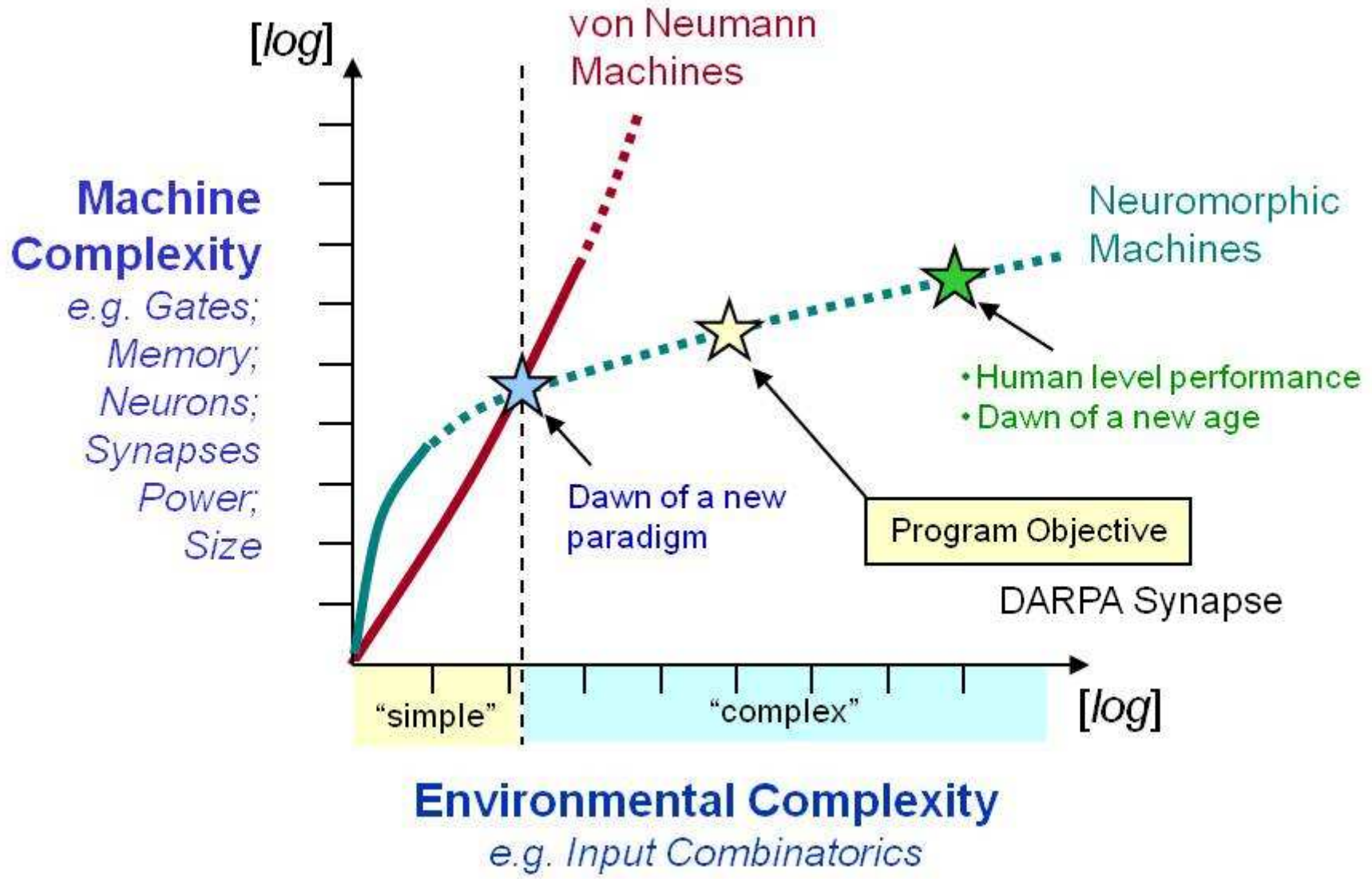
What about organization of info flow?

DREAM top-level architecture



DREAM project focused on perception (visual, auditory, text inputs), cognitive functions (reasoning based on perceptions), natural language communication in well defined contexts, real time control of the simulated/physical head.

Brains and computers



Brains from nanostructures

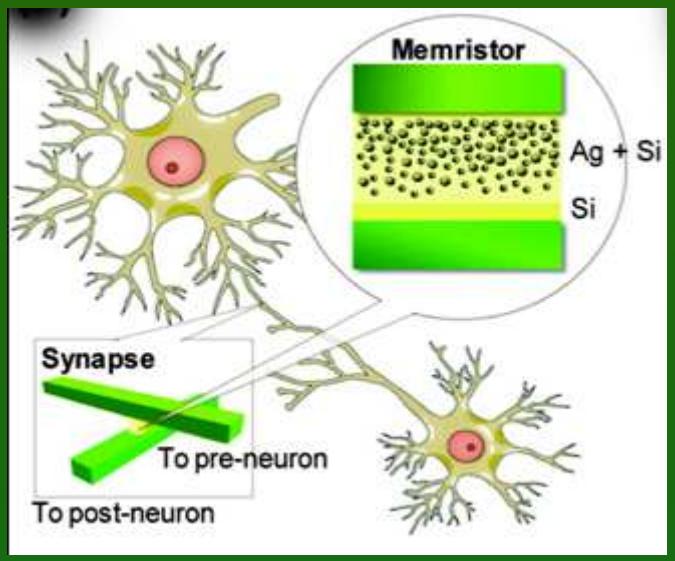
SyNAPSE: Systems of Neuromorphic Adaptive Plastic Scalable Electronics.

Develop electronic neuromorphic machine technology that scales to biological levels.

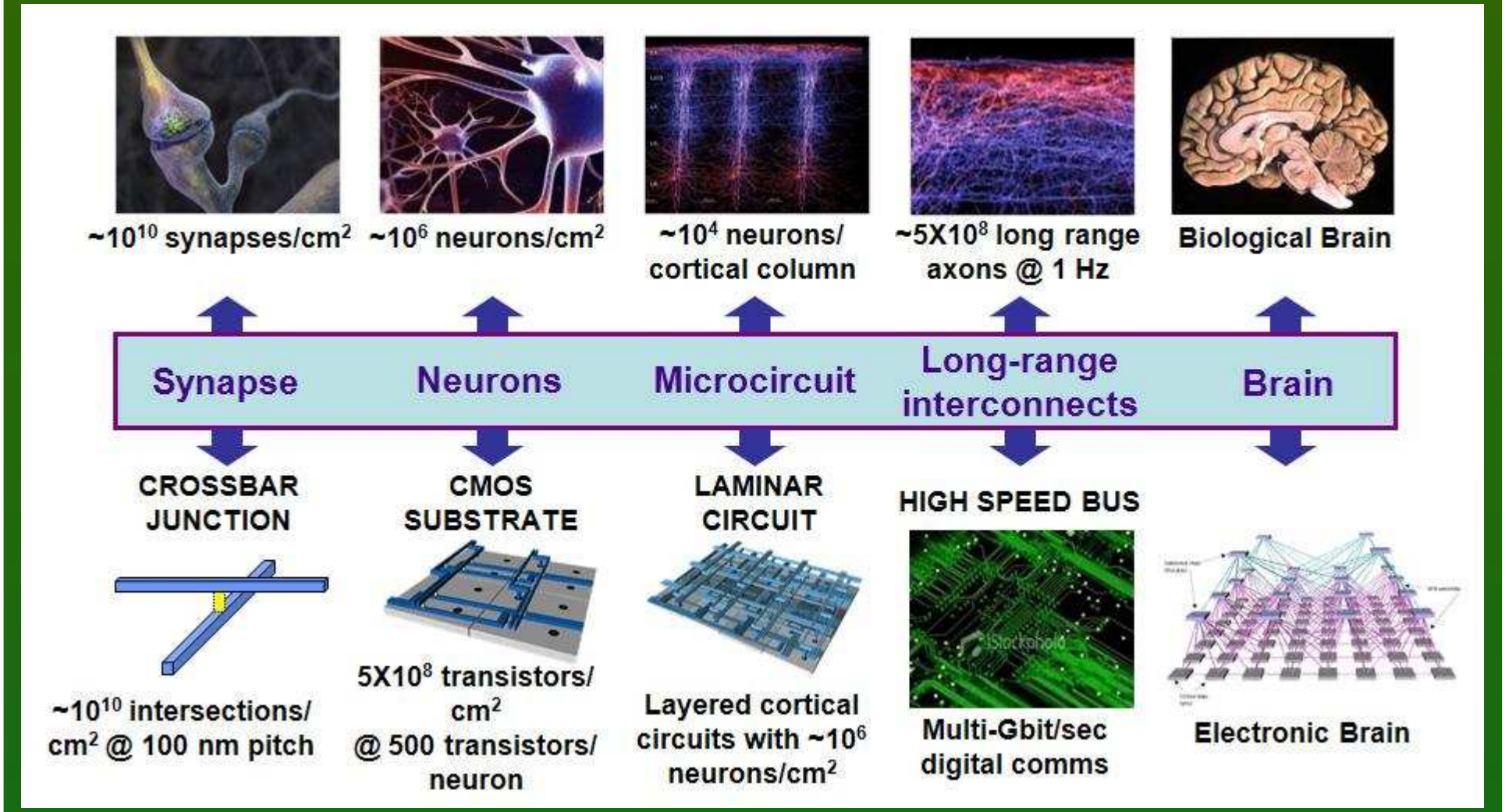
IBM Research (Almaden) is coordinator, HRL Laboratories (HRL), Hewlett-Packard + Cornell, Columbia, Stanford, Wisconsin-Madison, UC Merced Universities with many subcontractors.

So far DARPA gave over 40 million $ to the project, now (2011) in phase 2.

Brain-like chips define a fundamentally distinct form of computational device.



From brains to machines



Source: DARPA Synapse project

Program Outline

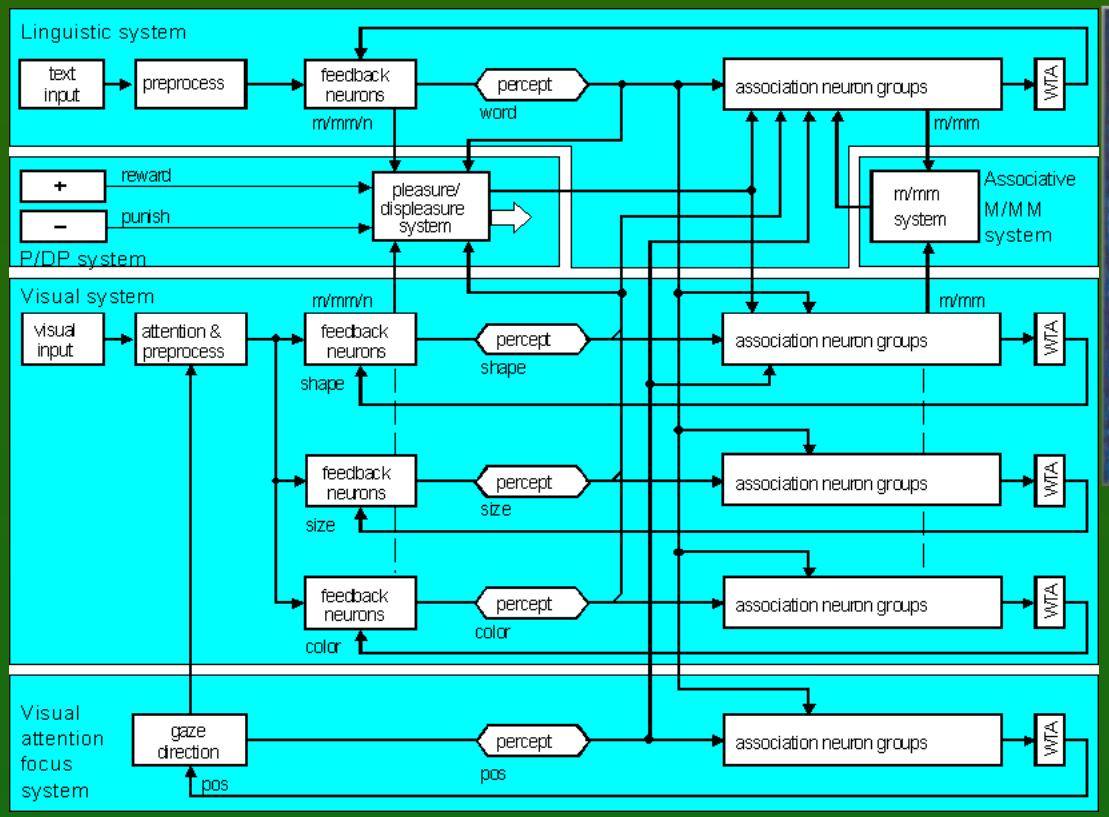
DEFENSE SCIENCES OFFICE

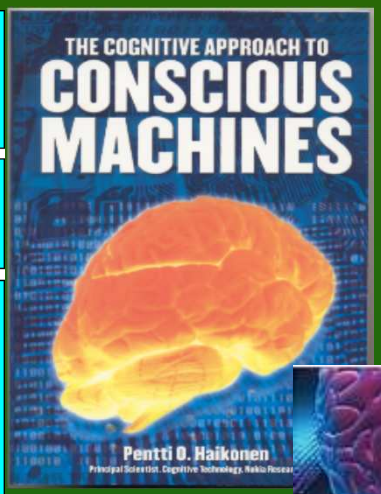
	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4
Hardware	Component synapse (and neuron) development	CMOS process and core circuit development	CMOS process integration	~10^6 neuron single chip implementation "Mouse" level	~10^8 neuron multi-chip robot at "Cat" level
Architecture & Tools	Microcircuit architecture development	System level architecture development	~10^6 neuron design for simulation and hardware layout	~10^8 neuron design for simulation and hardware layout	Comprehensive design capability
Emulation & Simulation	Preparatory studies only	Simulate large neural subsystem dynamics	"Mouse" level benchmark (~ 10^6 neuron)	"Cat" level benchmark (~ 10^8 neuron)	
Environment	Preparatory studies only	Build Sensory, Planning and Navigation environments "Small mammal" complexity	Add Audition, Proprioception and Survival "All mammal" complexity	Add Touch and Symbolic environments	Sustain

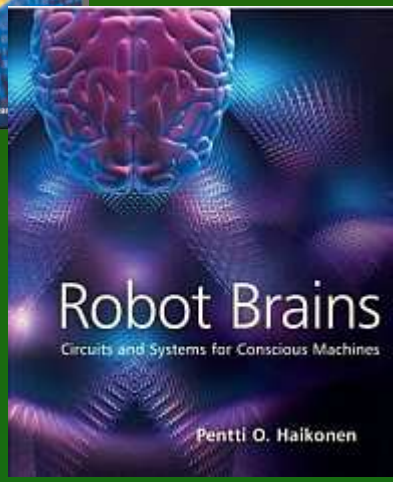
Program Phases 1-4 may be combined per the BAA instructions

Conscious machines?

Haikonen has done some simulations based on a rather straightforward design, with neural models feeding the sensory information (with WTA associative memory) into the associative “working memory” circuits.

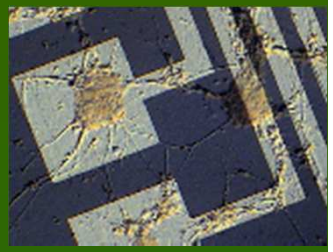






An associative neural processing based brain inspired computational platform, FP7 ICT Call 6 Proposal, FET Proactive. Coordinated by VTT (Finland)+7 partners

The Great Artificial Brain Race



BLUE BRAIN, HBP**:** École Polytechnique Fédérale de Lausanne, in Switzerland, use an IBM supercomputer to simulate minicolumn.

Brain Corporation: San Diego (E. Izhakievich), neuromorphic vision.

BRAINSCALES: EU neuromorphic chip project, FACETS, Fast Analog Computing with Emergent Transient States, now BrainScaleS, complex neuron model ~16K synaptic inputs/neuron, integrated closed loop network-of-networks mimicking a distributed hierarchy of sensory, decision and motor cortical areas, linking perception to action.

C2: 2009 IBM Almaden built a cortical simulator on Dawn, a Blue Gene/P supercomputer at Lawrence Livermore National Lab. C2 simulator re-creates 10^9 neurons connected by 10^{13} synapses, small mammal brain.

IFAT 4G: Johns Hopkins Uni (R.Etienne-Cummings) Integrate and Fire Array Transceiver, over 60K neurons with 120M connections, visual cortex model.

NEUROGRID: Stanford (K. Boahen), developing chip for ~ 10^6 neurons and ~ 10^{10} synapses, aiming at artificial retinas for the blind.

Human Centered Technology

2011, June: Nevada legalized driverless cars.

2011: IBM Watson won in Jeopardy, answering questions that are non-trivial for humans.

2011: IEEE CIS Task Force "Towards Human-like Intelligence" group run by Jacek Mandziuk & Włodek Duch.

2012: Confluence of Humans with Computers EU panel in preparation for "Horizon 2020" framework.

Human Centered Technology (HCT): ICT may help in many ways to control one's own behavior, overcoming addictions, flaws of character, mental disorders, maintain better self-control (neurofeedback + TMS), increase creativity, dynamically control brain plasticity for learning & psychotherapy, estimate optimal brain arousal, games may develop new skills, including empathy, decrease impulsive behavior, learn to optimize long term behavior.

IDoCare: Infant Development and Care for development of perfect babies!

Initially for Home 201

Problem: about 5-10%
causes problems in th
Identification of cong

Solution: permanent
and analysis of their r
cognitive developmer
Key sensors: suction r
motion detectors, auc

Potential: market for
only let parents to he

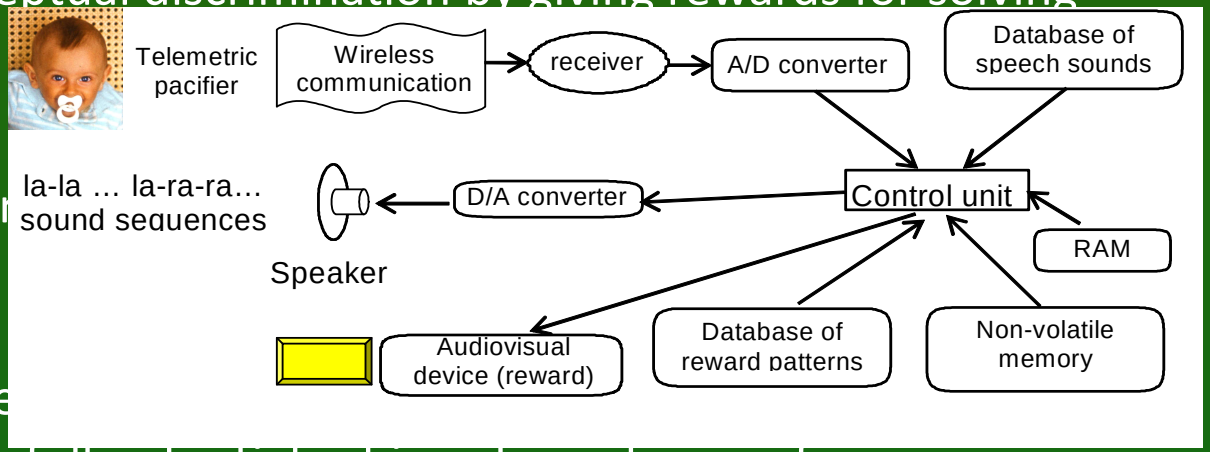
IDoCare intelligent crib

Revolutionary enhancement of baby monitors: **intelligent crib** with wireless suction, motion detector and audio/visual monitoring, plus software for early diagnostics of developmental problems.

Hardware: embedding pressure and temperature sensors in telemetric pacifier, for monitoring and feedback of baby's reactions to stimuli.

Software: signal analysis and blind source separation; interpretation of baby's responses, selection of stimuli and comments for parents.

Home applications: monitoring, diagnostics, preventive actions by enhancement of perceptual discrimination by giving rewards for solving perceptual problems.



Children love to be sti
environment that will

Active learning may ge
cognitive skills to their full potential achieved now by very few.

Real & computational creativity

How to increase cooperation between distant brain areas important for creativity?

John H. Gruzelier (Imperial College), SAN President

α–θ neurofeedback produced "professionally significant performance improvements" in music and dance students. Neurofeedback and heart rate variability (HRV) biofeedback. benefited performance in different ways.

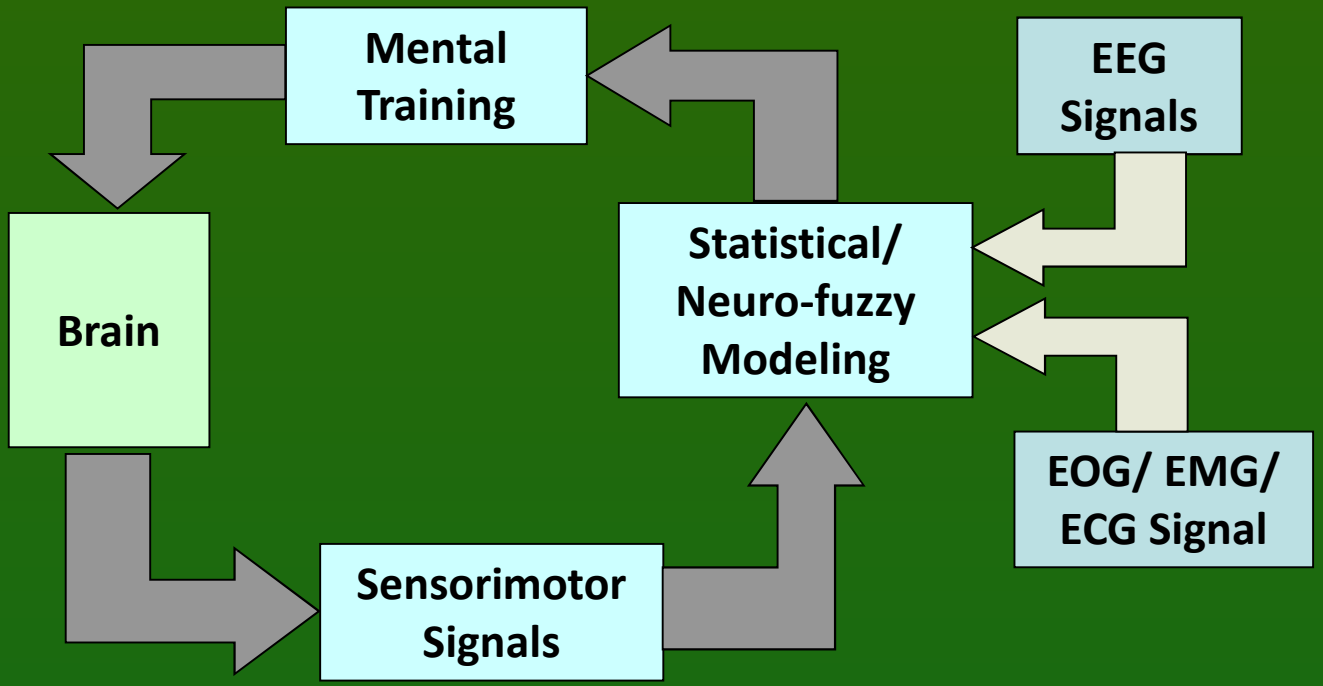
Computational creativity, insight, curiosity simulation of brainstorming, is a growing field – **Neuroculture** series of conferences in Torun.

BrainGene server that invents new names the way people do.

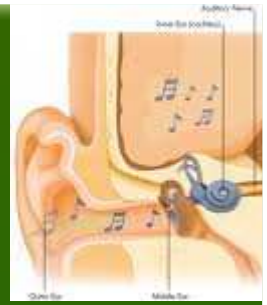
Duch W, Intuition, Insight, Imagination and Creativity.
IEEE Computational Intelligence Magazine 2(3), 40-52, 2007.

Pilichowski M, Duch W, Neurocognitive Approach to Creativity in the Domain of Word-invention. Lect. Notes in Computer Science 5507, 88–96, 2009

EEG based Neuro-feedback



Imagery Agnosia



New branch of neuropsychology: imagery agnosias.

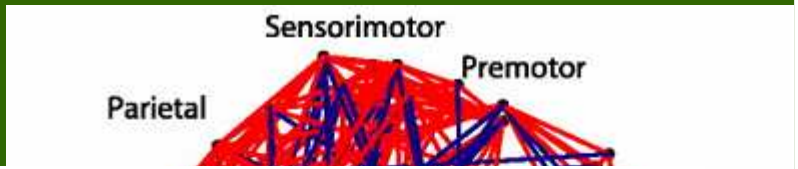
Classical agnosias ~30 major types: alexia, akinetopsia, alexithimia, many visual types: prosopagnosia, simultanagnosia, semantic agnosia , form, color …

Little access to perceptual imagery in visual, auditory, tactile or gustatory mode.

Without internal feedback the only way to learn about plans formed by the brain is to act and observe results: trying to play an instrument in this condition is like blindsight, maneuvering blindly in the auditory space, without the ability to imagine results of next move (hitting piano key).

- Learning to play music without imagery is difficult – how far can one go? Which key do I have to press if I have no idea how it will sound like?
- Recognition memory is fine, but it is difficult to repeat or remember simple melodies (memory-motor map).
- No problem to read & improvise music, higher cognition is fine.
- Conscious mental rehearsal is not possible.
- Immediate feedback may help?

Individual differences



- Norma
  influe
- What
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- This d
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How will t

Poor visua
memory, r
puzzles, d

Men vs. w
thinking? What can't we learn about ourselves from internal information flow?

At PC/FC level less interferences from sensory areas, so imagination, creativity, reasoning are fine, perhaps even better than average.