



Integrating Cognition, Emotion and Autonomy

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ICEA

- = Integrating Cognition, Emotion and Autonomy
- a new Cognitive Systems proposal for an integrated project dealing with embodied cognition
- DISCLAIMER:
 - funding not finally decided yet!
 - so everything I say is under the assumption that the project will be funded ...

"Embodied" Cognition

- "physical bodies"
- RobotCub:
 - "... so-called mental processes are profoundly shaped by the physical structure of the body and by its interaction with the environment. ..."
- Rolf:
 - "not only physical", but also information-theoretic
 - brain, materials, morphology, environment
- Claes:
 - "a motivated subject"

Internal Robotics (Parisi, 2004)

- ... behaviour is the result of the interactions of an organism's nervous system with both the external environment and the internal environment, i.e. with what lies within the organism's body.
- While robotics has concentrated so far on the first type of interactions (*external robotics*), to more adequately understand the behaviour of organisms we also need to reproduce in robots the inside of the body of organisms and to study the interactions of the robot's control system with what is inside the body (*internal robotics*). (p. 325)

Consortium

- Skövde Cognition & AI Lab
- Meyer, Guillot - Animat Lab, Paris
- Wiener – CNRS, College de France, Paris
- Baldassarre, Nolfi, Parisi – CNR, Rome
- Prescott - Adaptive Behaviour Research Group, Sheffield
- Melhuish - Intelligent Autonomous Systems Lab, Bristol
- Figureido - BAE Systems plc., Bristol
- Michel – Cyberbotics Ltd.
- Erdi – Hungarian Academy of Sciences, Budapest
- Sanz - Autonomous Systems Lab, Madrid

ICEA project proposal motivation

- “the emotional and bioregulatory mechanisms that come with the organismic embodiment of living cognitive systems also play a crucial role in the constitution of their high-level cognitive processes, and
- models of these mechanisms can be usefully integrated in artificial cognitive systems architectures, which will constitute a significant step towards truly autonomous cognitive systems that reason and behave, externally and internally, in accordance with energy and other self-preservation requirements, and thus sustain themselves over extended periods of time.”

Emotions (Damasio, 2004)

- ... emotions are bioregulatory reactions that aim at promoting, directly or indirectly, the sort of physiological states that secure not just survival, but ... [also] well-being. (p.50)
- ... emotional responses target both the body and other regions of the brain ... The responses alter the state of the internal milieu (using, for example, hormonal messages disseminated in the bloodstream); the state of the viscera; the state of the musculoskeletal system, and they lead a body now prepared by all these functional changes into varied actions or complex behaviours. (p. 51)

Emotion (Petta, 2003)

- Emotion can be viewed as a flexible adaptation mechanism that has evolved from more rigid adaptational systems, such as reflexes and physiological drives ...
- The flexibility of emotion is obtained by decoupling the behavioral reaction from the stimulus event. The heart of the emotion process thus is not a reflexlike stimulus-response pattern, but rather the appraisal of an event with respect to its adaptational significance for the individual, followed by the generation of an action tendency aimed at changing the *relationship* between the individual and the environment. (p. 257)

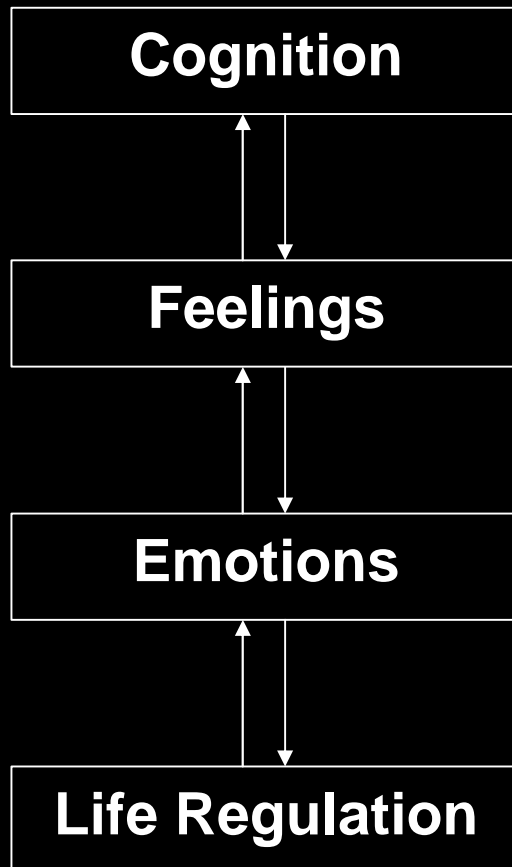
Feeling (Damasio, 1999)

- feeling = “the mental representation of the physiologic changes that occur during an emotion”
- while emotions involve bodily reactions, feelings (mental images of those reactions) allow the cognizer to temporarily ‘detach’ its cognitive processes from its immediate bodily reactions
 - e.g. anticipation of bodily reactions in the planning of behavior
 - “as if body loop” (Damasio)
 - a neural “internal simulation” that uses the brain’s body maps, but bypasses the actual body

Feelings of emotion (Damasio, 2004)

- The essence of feelings of emotion is the mapping of the emotional state in the appropriate body-sensing regions of the brain. (p. 52)
- Whereas emotions provide an immediate reaction to certain challenges and opportunities ... [t]he adaptive value of feelings comes from amplifying the mental impact of a given situation and increasing the probabilities that comparable situations can be anticipated and planned for in the future so as to avert risks and take advantage of opportunities. (pp. 56-57)

Levels of Regulation (Damasio, 1999)



complex, flexible, and customized plans of response are formulated in images and may be executed as behaviour

images (representations) of sensory patterns signalling pain, pleasure, and emotions

complex, stereotyped patterns of response, which include primary, secondary and background emotions

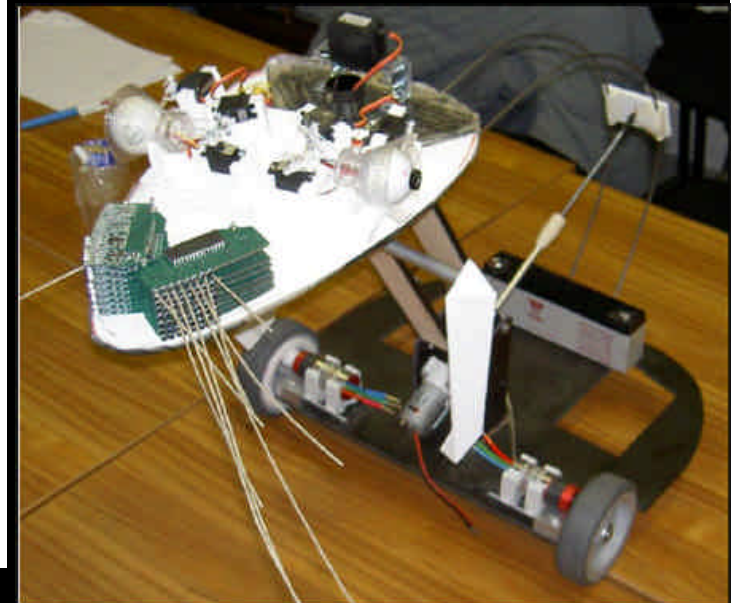
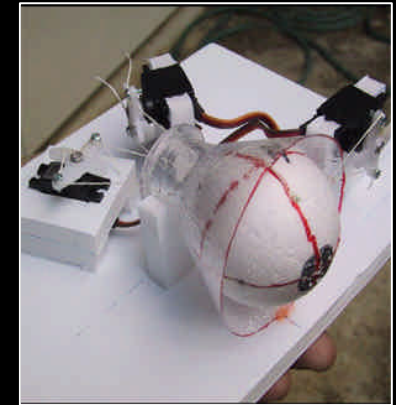
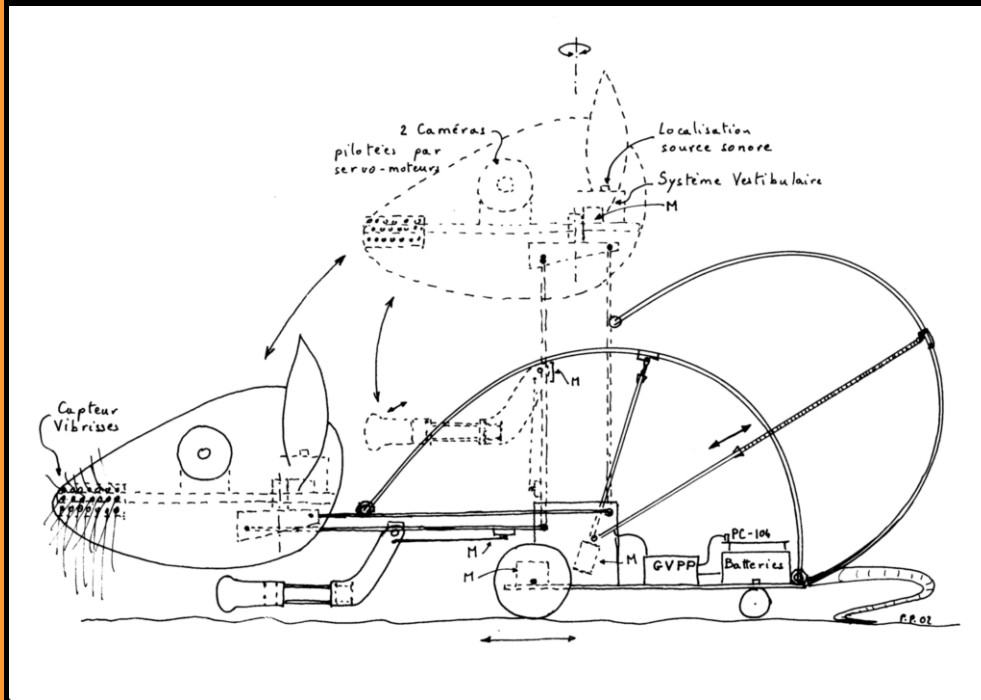
relatively simple, stereotyped patterns of response, incl. metabolic regulation, reflexes, the biological machinery behind pain and pleasure, drives and motivations

The rat as a starting point ...

- Massive literature
- Rather homologous to man
- Clever, intelligent, adaptive, compact
 - a model that works
- Realizable target for a four-year project
 - compared to human
- Complements existing (rather human-centered) Cognitive Systems IPs
- But: will surpass (selected) rat cognitive capacities

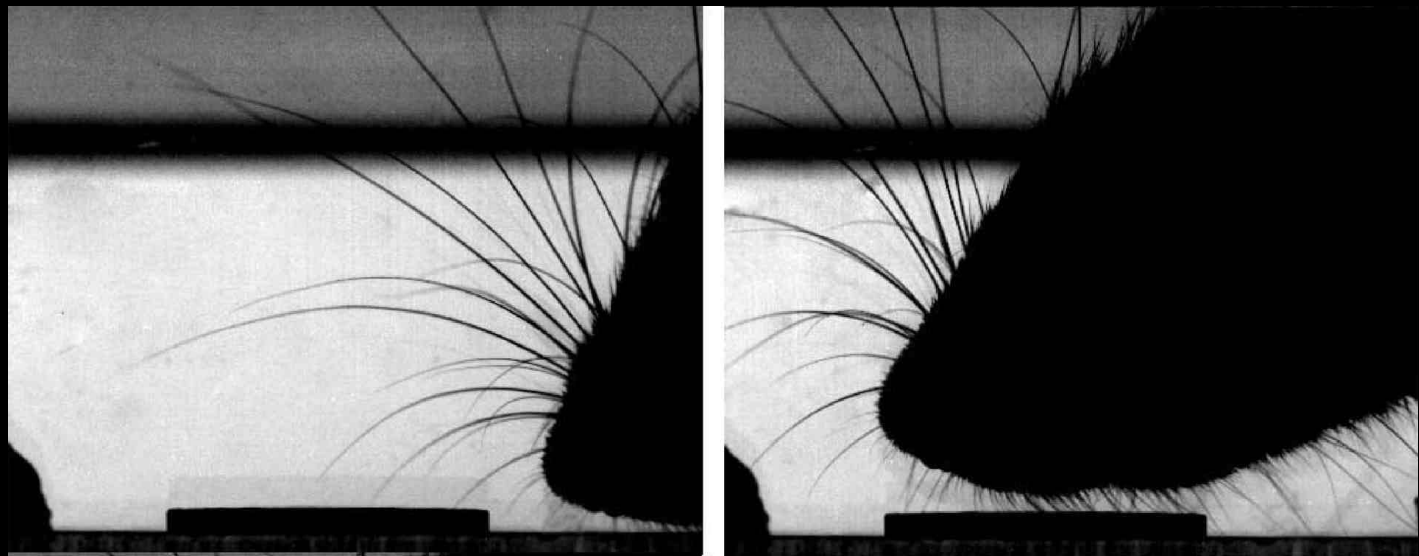
ICEAbot

- Rat-like physical robot platform
- Builds on the Animat Lab's current Psikharpax project



Active whisking platform

- active touch for perception and spatial cognition
 - a neck with 3-DOF two arrays of macro-vibrissae on either side of the snout, and
 - an array of smaller micro-vibrissae that provide a form of tactile 'fovea' for close-up examination of surfaces
 - based on high-speed digital videography of real rats



ICEAsim

- Rat-like simulation platform
 - based on Cyberbotics' Webots robot simulation toolkit (cf. AIBO)
 - used by all modelers
 - based on ICEAbot
 - but with additional features: active whiskers, metabolism, etc.
- Will be made available for free as a (standard) tool for research

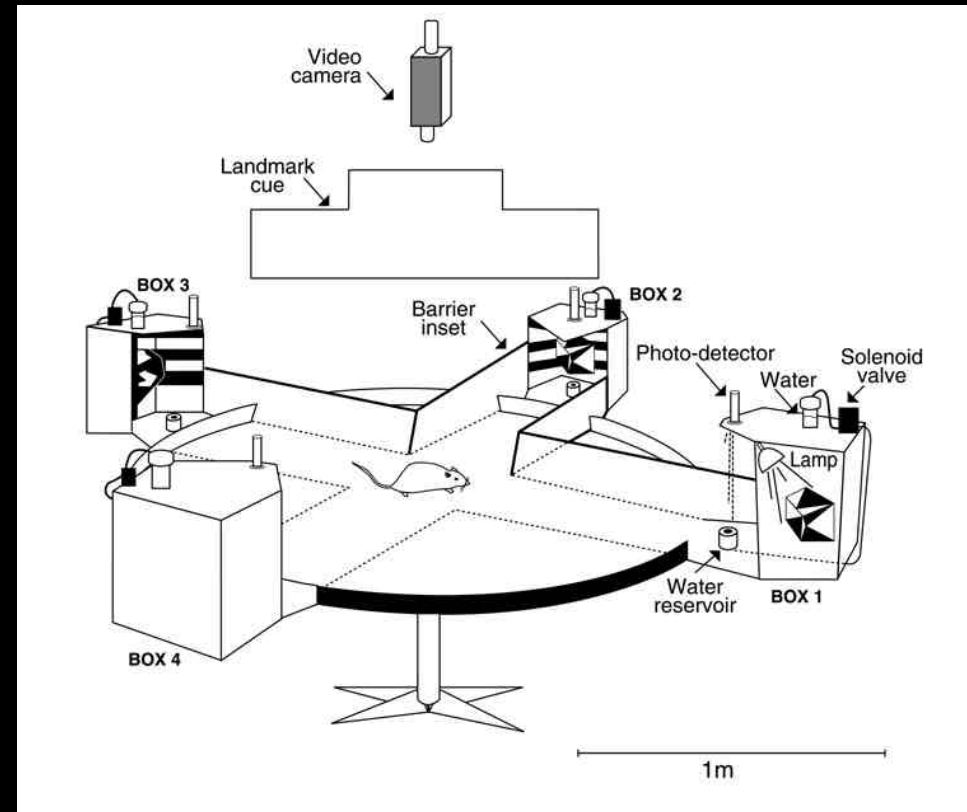
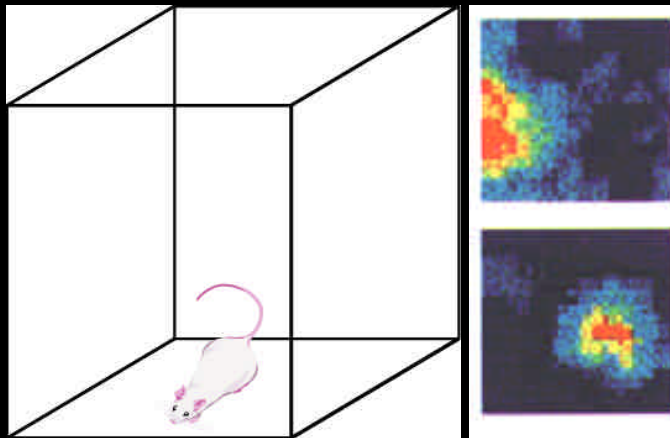


Project elements

- overall volume: about 100 person-years of research
 - about 10% neurophysiology, rat experiments
 - about 80% comp. modelling, robotics, systems integration
 - about 10% theoretical integration
- alternative breakdown:
 - three main 'chunks', 25% each
 - central ICEA integrated robot platforms
 - motivated spatial cognition/behaviour
 - emotion-based representation/cognition
 - smaller 'chunks'
 - layered self-defense architecture
 - energy autonomy

Spatial behavior & cognition

- rat neurophysiology
- computational neuroscience models at different levels

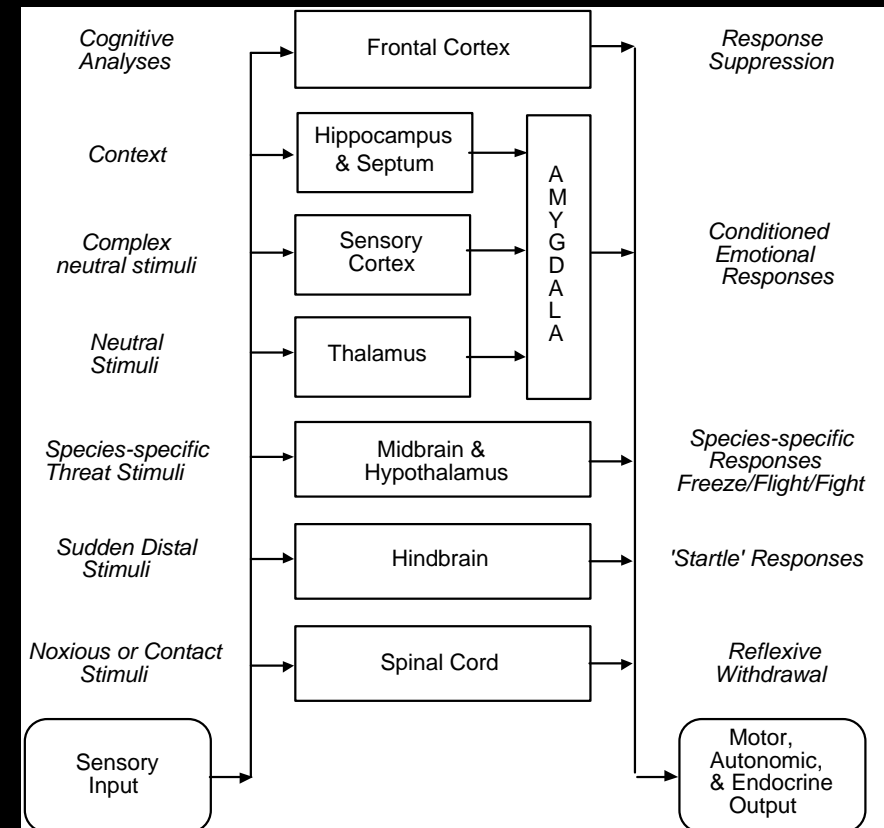


Mammalian brain structures modeled

- *cortex* - planning, motivation, working memory, and analysis of sensory data
- *cerebellum* - anticipation, prediction
- *amygdala* - emotion and classical conditioning
- *basal ganglia* (incl. nucleus accumbens) - action selection sequencing, and reinforcement learning (operant conditioning)
- *hippocampus* - spatial and contextual memory
- *superior colliculus* - orienting
- *hypothalamus* - drives
- *brain-stem* - bio-regulation and pattern generation

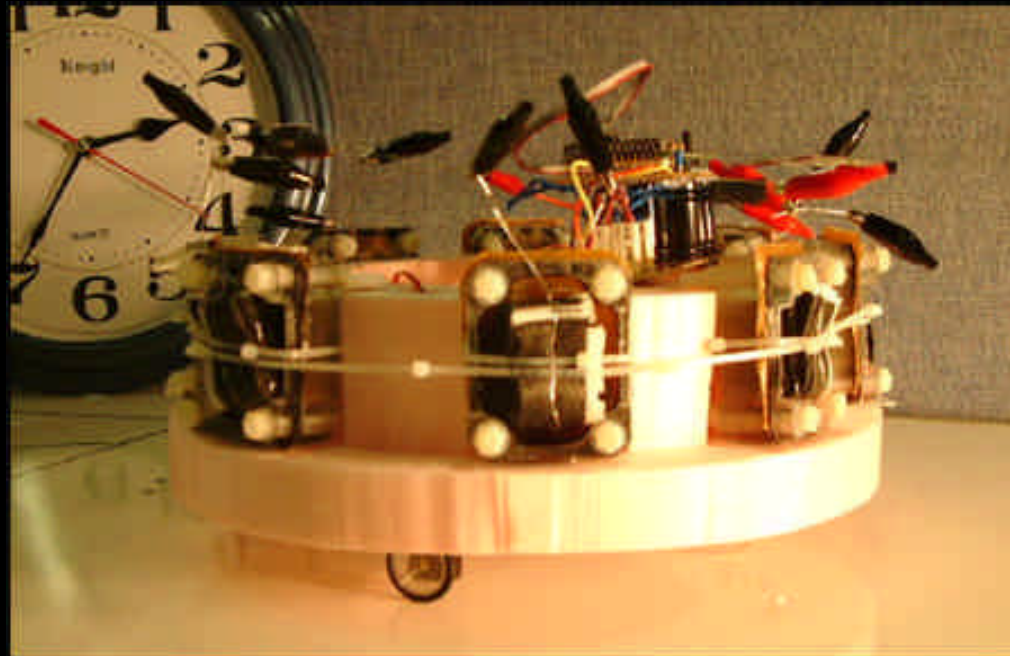
BAEbot

- Layered defence architecture on an all-terrain vehicle



BREADbot

- "Bio-regulation and energy autonomy with digestion"
- Based on the IAS' current work on energy autonomy using microbial fuel cells
- Coordination of internal homeostasis and effective foraging behavior



RobotCub vs. ICEA

- Human

- Focus on

- manipulation
- -
- social interaction
- development
- -

- humanoid robot platform

- Rat (++)

- Focus on

- active touch
- navigation
- motivated individual
- -
- interdependence of bioregulation, emotion, feeling, cognition

- rat-like simulation platform