Thinking with the Body

Half-baked ideas on embodied cognition

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Abstract

- From the initial, old-age considerations on the nature of mind different approaches have emerged. Of special relevance are dualist approaches where mind and body may have strongly different aspects but still need some form of collaboration.
- The embodied cognition movement -may we use this expression- tries to reconcile the apparently multiple quality (duality & unity at the same time sound kind of religious) by means of analysing the ways in which the body may affect cognition: supporting, raising, sustaining, etc. I will propose other approach that may be considered similar to this one or may be perceived as completely apart from embodied cognition and full of panpsychism.
- My proposal is that the mind does not emerge/is-supported-by from bodily processes but that indeed, those bodily processes are the mind itself. I'm not only referring to those processes happening in the brain but, perhaps in the line of artificial life, to all those information-centric processes that constitute the very inner workings of hierarchical structures of life.

Speech Plan

1. Introduce myself / my work
2. Ask some questions
3. Set the proper stance / framework
4. Answer the questions / formalize

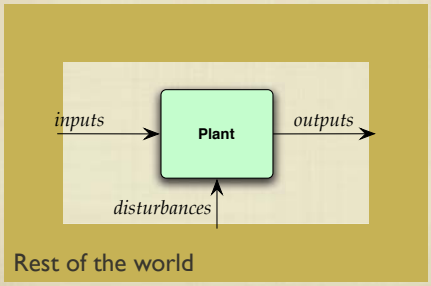
1 Introduction
2 Question(s)
3 Framework
4 Answers

Cross domain Control technology

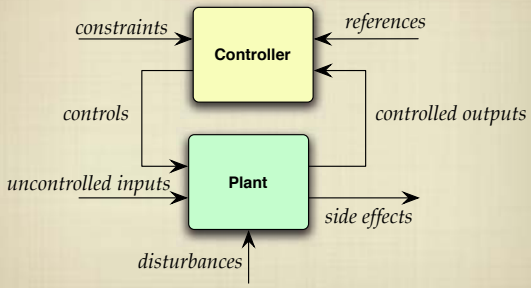
Our engineering problem

- Develop technology for building a **bounded autonomous controller** for any plant no matter how complex
- May imply developing some science

System/Environment



Control Engineering

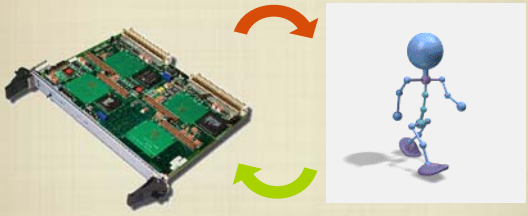


Control Desiderata

Perfect **setpoint achievement** with maximal **disturbance rejection** and total **respect for constraints**

... and consider humans vs machines.

Computer-based minds?



Challenge/Inspiration

Has humans in control !

CHALLENGE/INSPIRATION

HAS HUMANS IN CONTROL !

THINGS WE HAVE TRIED

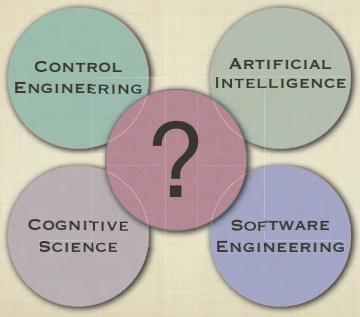
- "Conventional" control engineering
- Artificial intelligence technologies:
  - Expert systems
  - Fuzzy systems
  - Neural networks
  - Genetic algorithms
- ... still in need of solutions

... AND NOW ... COGNITION !

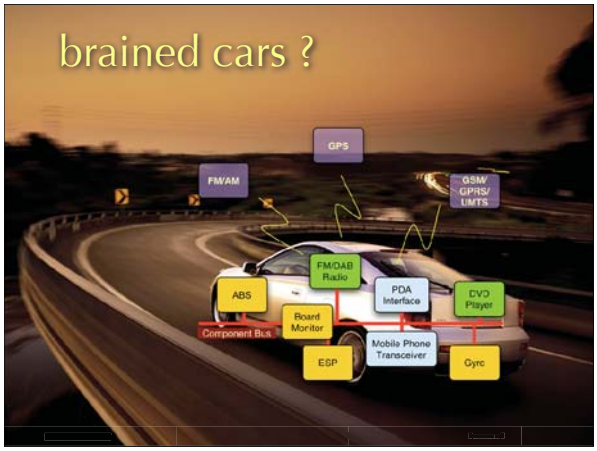
ICEA

REVERSE-ENGINEERING MAMMALIAN BRAINS FOR BUILDING COMPLEX INTEGRATED CONTROLLERS

RESEARCH AREA



brained cars ?



Initial Plans

- Initially I had the plan of asking you some questions:
  - What is a **body**?
  - What is **representation**?
  - What is **cognition**?
- But I have decided that that would consume too much time ... :-)

Humans

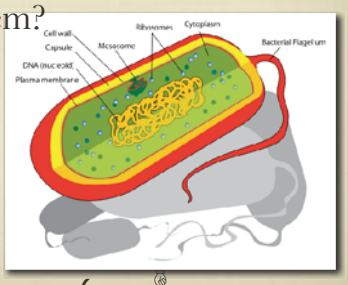
Are **humans** embodied cognitive systems?

Frogs

Is a **frog** an embodied cognitive system?

Bacteria

Is a **bacterium** an embodied cognitive system?



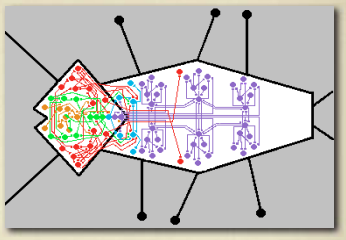
UAVs

Is a **GlobalHawk** an embodied cognitive system?

Cars

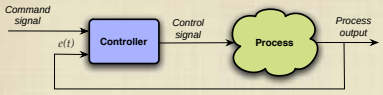
Is a **BMW 530** an embodied cognitive system?

P. Computatrix



Is **Periplaneta Computatrix** an embodied cognitive system?

PID control



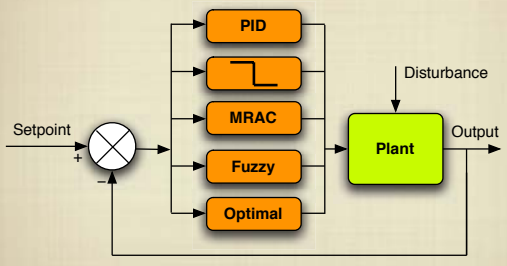
$$u(t) = K_p \cdot e(t) + K_d T_d \frac{de(t)}{dt} + \frac{K_i}{T_i} \int e(t) \cdot dt$$

Is a **PID controller** an embodied cognitive system?

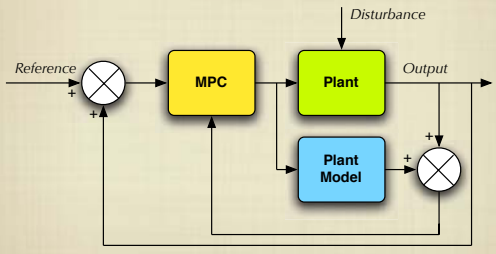
The Name of the Game

The framework from which I will try to answer the questions may be called
~~complex~~ ~~complicated~~
cognitive control framework

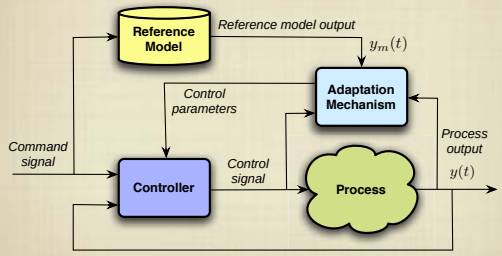
Switching Control



Model-predictive Control

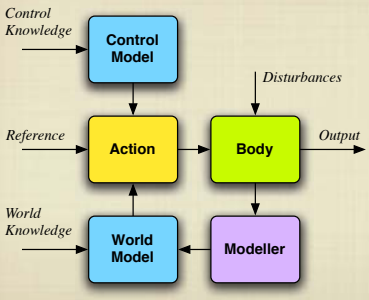


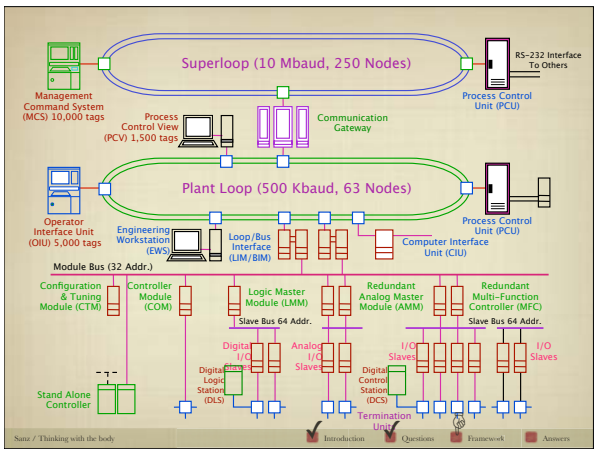
Model-reference control



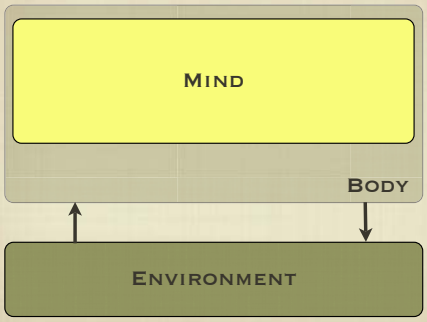
Controlling the Controller !

Expliciting Models

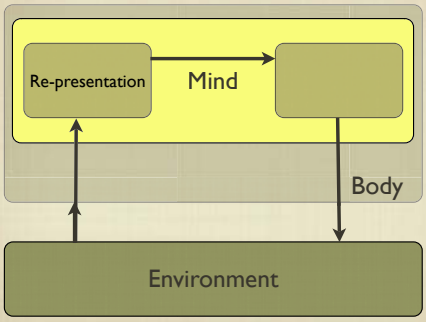




Mind & Body



Mind & Body



What is Cognition?

- **Cognition** is the **process** of **sense-think-act**
- Degenerate cases:
  - sense-act (reaction)
  - sense-think (perception)
  - think-act (proaction)
  - act (engine), think (autist, problem solver?), sense (meter)

What is sensing ?

- Mapping **physical** states into **informational** states (signal transduction in Shanon's sense)
- Information may have any -physical- support (internal or external)
- Sensing may be continuous, periodic (time triggered) or sporadic (even triggered)
- Sensing may be internal

What is Acting ?

- Mapping **informational** states into **physical** states (signal transduction)
- Action may be continuous, periodic (time triggered) or sporadic (even triggered)
- Action may be internal

What's Thinking?

- Knowledge-based information processing

What's Knowledge?

- Knowledge is composed by ***executable dynamic models***
  - Models about some (partial) reality in/out the agent
  - May be executed
    - Over a physical ***execution engine*** (e.g. cerebellum)
    - Over a virtual machine running over a physical execution engine or another virtual machine
  - May be degenerated (e.g. a simple static value)
  - May be embodied (aka "*precompiled*" with the EE)

Models

- Executing a model in an engine provides **cognitive functions**
- Model execution may have many products grounding the **anticipatory interactive processes** necessary for adequate sensing/action (executing model / body/ world / body /model)

Organising Embodiment

- Cognitive functions may be ***extended*** throughout the body discretely (modules) or continuously (fields)
- There may be ***informational (signal) couplings*** between them by means of ***connectors*** (physical / virtual signal channels)

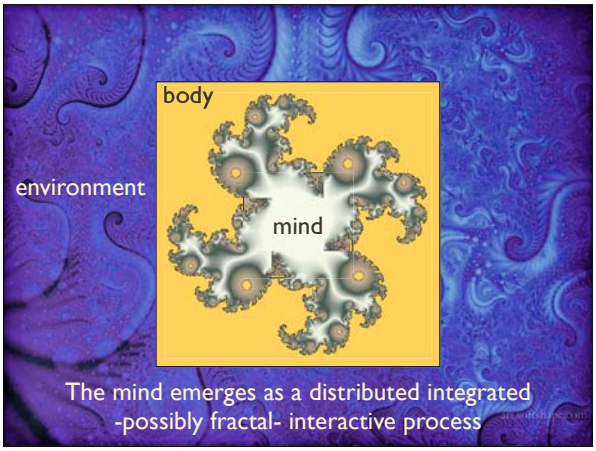
The Thinking Eye

[Lettwin 1959]

- "The output from the retina of the frog is a set of four distributed operations of the visual image. These operations are independent of the level of general illumination and express the image in terms of
  - 1) local sharp edges and contrast,
  - 2) the curvature of edge of a dark object,
  - 3) the movement of edges, and
  - 4) the local dimmings produced by movement or rapid general darkening. "

[Lettwin 1959]

- "The operations thus have much more the flavor of perception than of sensation, if that distinction has any meaning now. That is to say that the language in which they are best described is the language of complex abstractions from the visual image.
- We have been tempted, for example, to call the convexity detectors "bug perceivers.""



Autonomy

- A **cognitively autonomous** system uses only internalized models and execution engines to generate its behavior (an autonomous system does not use sensing).
- A **semi-autonomous** system may have
  - Externalized models (culture / knowledge repositories)
  - Externalized engines (societies / super-extended functionalism)

Interactive Learning

- Learning is **model caring** by dynamical interaction or other methods (upload/creation/adaptation)
  - e.g. learning an executable model of a car (to drive or to repair it)
- Models may include execution engines (executing an executable model of an execution engine renders a new execution engine that can execute other models)
  - e.g. learning chinese or downloading drivers

1 Introduction
2 Question(s)
3 Framework
4 Answers

There's Only One Possible Answer

Yes.

Yes?

- Yes. All those systems are embodied cognitive systems.
  - Implement sense-think-act processes
  - Are grounded on embodied functions (at least P/I, I/P and some EE functions)

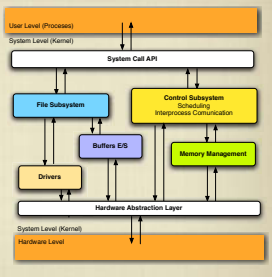
But ...

- Are they realisations of the most general class of embodied cognitive system?
- The answer is **no** because they may be degenerated

Post Comments

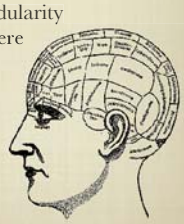
Sense and Act

- Sensing and acting have been defined as transductional but they may be also purely informational (e.g. in layered control analysis it may be useful to consider a particular layer as sensed and acted upon)
- Shared ontology problems?



A BIG DIFFERENCE

- There's a big architectural difference between bio-minds and tech-minds: **Total Coupling**
- While there is some brain functional modularity the fact is that coupling is so high that there is **no real isolation** of functions.
- This is **good** (robustness, cohesion and parallelism) but it is also **bad** (interference, unconstructability, undiagnosability)



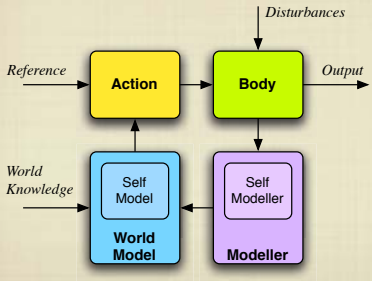
FRACTALITY ?

- Possibly robust encapsulated cognitive functions can be analysed in a similar way using afferent, core and efferent processes
- That renders an **agents-within-agents** cognitive organisation

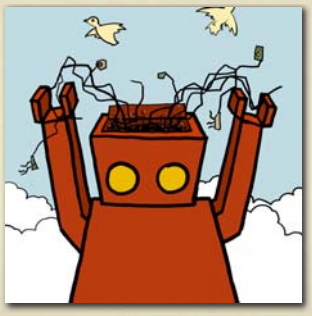
AN ENGINEERING CHALLENGE

- Build functions/modules that have:
  - Strict interfaces (e.g. elimination of undesirable side effects)
  - Robust function provision (e.g. sensors that are only affected by the measured magnitude ! inner partial state is a *clean* representation)

FOCUS OF RESEARCH

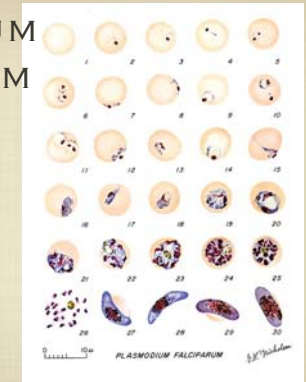


ACCESS TO EMBODIMENT



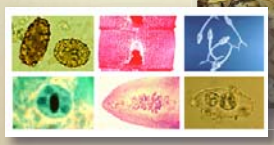
PLASMODIUM FALCIPARUM

What body?



Extended Bodies?

- Parasitic
- Saprophytic
- Symbiotic



rewording ?

- It is not just that
  the mind is **affected-by/emerges-from/is-supported-by** bodily processes;
- but indeed that
  those bodily informational processes **are the mind itself.**
- Obviously, I'm not only referring to those processes happening in the brain but, perhaps in the line of artificial life, to all those information-centric processes that constitute the very inner workings of the hierarchical structures of life.

Emotion Hypothesis

- **Emotions are synthetic signals** produced by specific embodied modules that are **broadcasted** to all (just many?) cognitive functions hence **globally setting body-wide functional states**
- May be also broadcasted externally to serve as inputs to extended functions (e.g. frighten your enemy)

The End

The Thinking Body

Ricardo Sanz

[Lettwin 1959]

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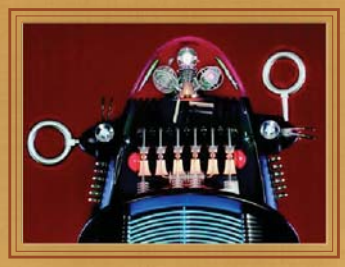
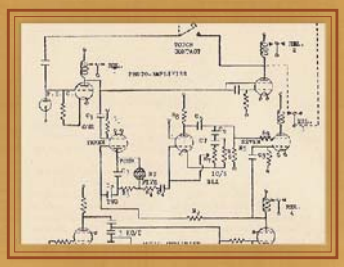
[Lettwin 1959]

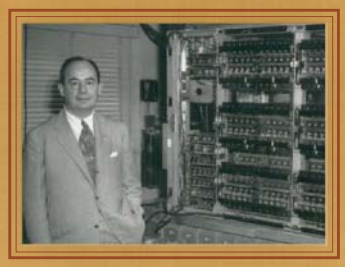
- "Such a fiber ... responds best when a dark object, smaller than a receptive field, enters that field, stops, and moves about intermittently thereafter.
- The response is not affected if the lighting changes or if the background (say a picture of grass and flowers) is moving, and is not there if only the background, moving or still, is in the field.
- Could one better describe a system for detecting an accessible bug?"



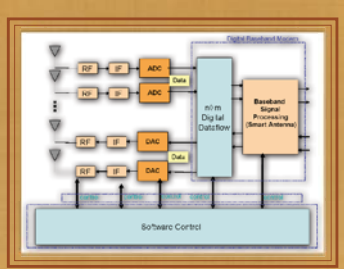
Thinking Brains



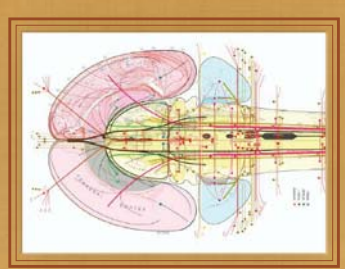
Machina Speculatrix



Thinking Relays



Thinking Antennas



Thinking Brains

Thinking Cables

Big Bodies

McGyver in an Island

- Extended minds?
- Or **good, old-fashioned cognitive capabilities**?