Non-Symbolic AI lecture 4

EASy

A major difference between Symbolic and Non-Symbolic AI approaches is in modelling, or emulating, Cognition or control – in artificially intelligent machines such as robots.

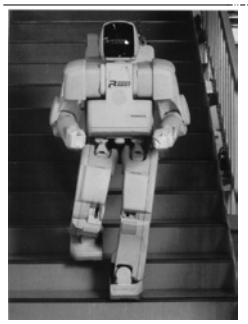
Symbolic, or Classical, AI tended to think in terms of control being focussed within a central, reasoning brain.

Given a task (for a human or a robot) such as 'open the door' or 'catch the ball', Symbolic AI assumes that the task can be turned into a set of propositions, using probably logic and maths.

Then this is now a 'problem to be solved' using the brain as a computer (… or the computer as a brain !)

Robotics is used for …

EASy

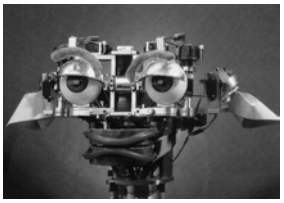


… publicising the technical expertise of car companies – the Honda robot

Robotics is used for …

EASy

… working out how expressions communicate emotions



Robotics is used for …

EASy

… toys

Robotics is used for …

EASy

… and for science

-- as a way of understanding how animals and humans work by trying to build artificial ones.

Artificial Life.

Creating Robots in Man's Image

EASy

Whether or not God created Man in His image, it is inevitably the case that Man and Woman create robots in their image.

Puppets, revealing how we (… those in the robot/cognitive science or philosophy business) really think of ourselves.

Doing 'Philosophy of Mind' with robots has one enormous disadvantage over conventional philosophy … …

… … you cannot fudge things, or appeal to magic!

Brains and Bodies

There is a traditional view that all the intelligence of a creature is in some rational brain – maybe like a computer – and the body is just 'an afterthought'.

Here is an 8-legged walking robot like this – with an "artificially evolved brain" sitting inside the onboard computer.

Cognition

21st Century scientific human cognition
is different from that of
humans 3000 years ago
is different from that of
our ancestors of 2 billion years ago
is different from that of
our descendants of 2 billion years later
(... if there will be any ...)

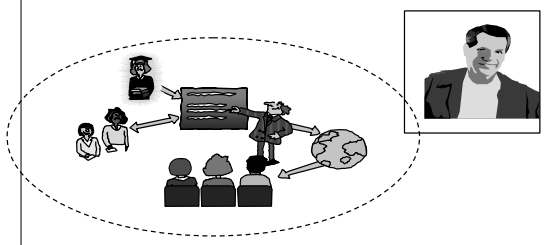
Descartes

Much of classical AI can be traced back to Descartes (early 17thC)

Dualism -- the separation of the mental and the physical.
Cartesian objectivity:

"there just is a way the world is, independent of any observer.
The scientist is a spectator from outside, a God's-eye view"

The view from outside



"The world is physical, knowledge is mental (something different)"

Classical AI

When building robots, this gives Classical AI approach where the robot is a scientist-spectator, seeking information from outside.

"SMPA" -- so-called by Brooks (1999)
- S sense
- M model
- P plan
- A action

Computing a model

The model is 'computed' from the sensory inputs.

But what is the computer metaphor?

The Computer metaphor

A Turing machine is a formal way of carrying out an algorithm -- a list of explicit instructions.

BUT beware of a simple confusion:-

When the astronomer calculates where the moon will be at 12:00 noon on May 1st, she carries out computations. She is a scientist-spectator.

But the moon does not carry out computations -- it 'just moves' in a deterministic way.

Classical AI confusion

The Classical AI approach tends to confuse these two -- tends to (mistakenly) think that "the ~~brain does computations~~".

To clarify: we can use a computer to simulate (predict) the movement of the moon -- even to control a model planetary system.

Similarly we can use a computer to simulate (predict) the dynamics of a nervous system -- even to control a robot with a model 'brain'

-- but this does not mean that the "brain computes" !

'Reasoning all the way down'

The Classical AI approach, obsessed with reasoning and computing, assumed that ***even*** something as simple as walking across the room, maintaining one's balance, required reasoning and computation … …

… … "Sense Model Plan Action" …

… … Brain controlling muscles

But look at this ---

Passive Dynamic Walking

'Natural walking behaviour', stable to small perturbations, can emerge from 'all body and no brain' !
It is the dynamics that count, whether the dynamics arise with or without a coupled nervous system.

Dan Jung's walker movie www.msc.cornell.edu/~ruinalab/pdw.html
"Passive Dynamic Walking", from Tad McGeer

Walking without a nervous system

Alternatives to the Classical Approach

There are different philosophical perspectives such as those of Heidegger / Merleau-Ponty / Wittgenstein
that might affect the way in which one designs robots.

These are difficult people to read, and they say little or nothing about robots !

Nevertheless, they offer a different perspective which has recently been crucially important

Other sources

Brooks 1999. Cambrian Intelligence
Dreyfus 1972. What Computers Can't Do
Winograd and Flores 1986.
Understanding Computers and Cognition.
Pfeifer and Scheier 1999.
Understanding Intelligence
Maturana and Varela 1987.
The Tree of Knowledge

Situatedness and Embodiment

The Dynamical Systems view of Cognition

Heidegger …

…rejects the simplistic objective view, that the "objective physical world is the primary reality that we can be sure of"

He also rejects the opposite idealistic/subjective view that "our thoughts are the primary reality"

The primary reality is our everyday practical lived experience, as we reach for the coffee or switch on the light

This is more fundamental than detached theoretical reflection.

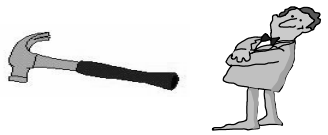
Reasoning only came later …

This actually makes sense from a Darwinian evolutionary perspective (though Heidegger would not say this)

-- our human language / reasoning powers arrived only 'recently' (last few 10,000 years, 100,000s ?)

From a phylogenetic and ontogenetic view,
we are organisms/animals first
-- thinking humans only later.

What comes first?



Our unreflective tool-using is primary
-- only when something goes wrong do we need to switch into 'reflective' mode.

Any lessons for robotics?

This is true (Wittgenstein suggests) even for language skills:

"In general we don't *use* language according to strict rules -- it hasn't been taught us by means of strict rules either"

What lessons for robots from these alternative views? At first sight, they are negative and unhelpful !

For everyday robot actions this implies we should do without planning, without the computational model, without internal representations ... . but what should we do instead ?

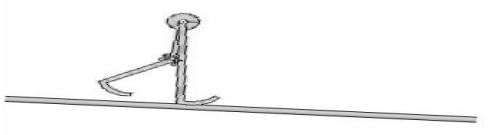
Dynamic skills all the way up?

Perhaps rather than 'Reasoning all the way down' …

… we should think in terms of 'Dynamic skills all the way up'

Two initial lessons -- cognition is

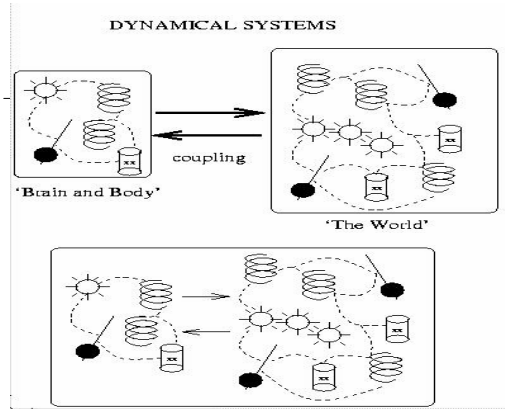
- Situated: a robot or human is always already in some situation, rather than observing from outside.
- Embodied: a robot or human is a perceiving body, rather than a disembodied intelligence that happens to have sensors.



The Dynamical Systems view of Cognition

...animals are endowed with nervous systems whose dynamics are such that, when coupled with the dynamics of their bodies and environments, these animals can engage in the patterns of behavior necessary for their survival"

Beer & Gallagher 1992.



A Crucial Difference

What is one crucial difference between the Classical AI approach and the Dynamical Systems approach ?

Classical AI and computational approaches do not take account of time --
'life as a series of snapshots

Dynamical Systems approach --
time is central, 'life as process'

How can you design Dynamical Nervous Systems?

Brooks' Subsumption architecture is one way.

Evolutionary Robotics is another.
(Something crudely like the way we humans were designed !)

Subsumption architecture (1)

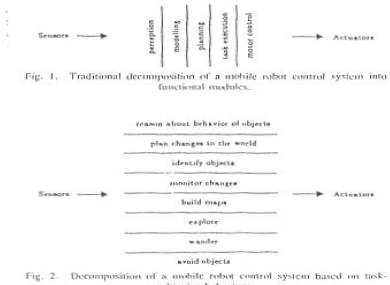


Fig. 1. Traditional decomposition of a mobile robot control system into functional modules.

Fig. 2. Decomposition of a mobile robot control system based on task-achieving behaviors.

(1a)

SENSORS >>>>> PERCEPTION >>> MODEL >>> PLANNING >>> TASK EXECUTE >>> MOTOR CONTROL >>>>> ACTUATORS

Traditional decomposition of a mobile robot control system into functional modules

Brooks' alternative

Brooks' alternative is in terms of many individual and largely separate **behaviours** – where any one behaviour is generated by a pathway in the 'brain' or control system all the way from Sensors to Motors.

No Central Model, or Central Planning system.

(1b)

SENSORS >>>>>>

REASON ABOUT BEHAVIOR OF OBJECTS
PLAN CHANGES TO THE WORLD
IDENTIFY SUBJECTS
MONITOR CHANGES
BUILD MAPS
EXPLORE
WANDER
AVOID OBJECTS

>>>> ACTUATORS

Decomposition of a mobile robot control system based on task-achieving behaviors

Subsumption architecture (2)

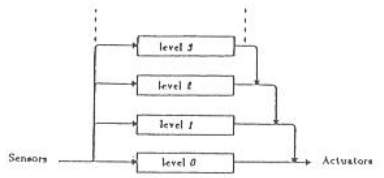
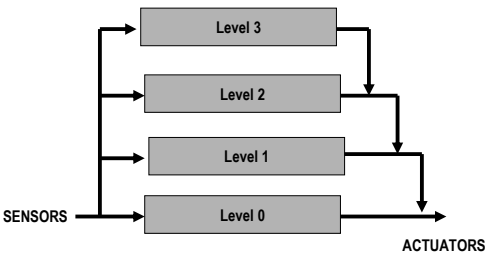


Fig. 3. Control is layered with higher level layers subsuming the roles of lower level layers when they wish to take control. The system can be partitioned at any level, and the layers below form a complete operational control system.

(2a)



Control is layered with higher levels subsuming control of lower layers when they wish to take control.

Subsuming

'Subsume' means to take over or replace the output from a 'lower layer'.

The 2 kinds of interactions between layers are

1. Subsuming
2. Inhibiting

Generally only 'higher' layers interfere with lower, and to a relatively small extent – this assists with an incremental design approach.