Bio-inspired and and behaviour-based robotics (BBR)

Autonomous robots, TME290

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Introduction

Moving around is not everything

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- We know how to navigate in the local frame, and avoid obstacles
- We know how to plan a path and how to follow it

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What if the robot needs to do different things, and autonomously select what task to do?

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- In most real-world applications, *rapid reactions* and *adaptive behaviours* are needed

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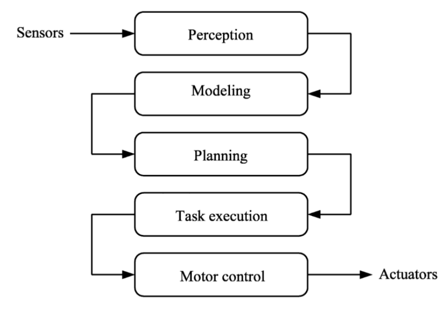
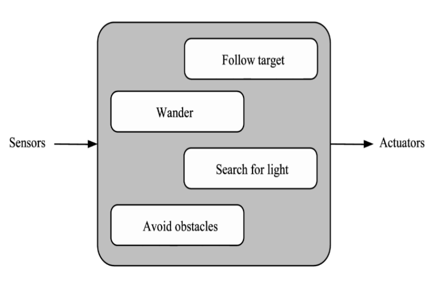
  - Focused on basic survival-related behaviours
  - Strongly influenced by (the brains of) relatively simple biological organisms (e.g. insects)
- In the framework of **behaviour-based robotics** (BBR) one normally defines a set of **isolated robotic behaviours** (or brain processes)

Data flow in classic AI



- In **classical AI** intelligence is decomposed into functional modules

Data flow in behaviour-based AI



- In **nouvelle AI**, intelligence is built from a set of *basic behaviours*, from which *intelligent behaviour* is thought to emerge: **BBR**

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- Thus, **biologically inspired** methods are logical

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- **Phenomenological model** is a common approach:
  Describes the behaviour using a simple set of equations, i.e. without taking the detailed neural activities into account

Behavioural layers of action

Four different kinds, or levels, of behaviours:

- Reflexes
- Taxes and kineses
- Fixed action patterns
- Complex (adaptive) behaviours

Generally good starting-points when designing AI in robotics.

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  - **Warm-up**: Maximum intensity reached only after a while
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  - **Fatigue**: Reduced intensity even if the stimulus remains unchanged
    Possibly a result of *neurotransmitter depletion* (the synapses "run out of fuel")

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  - **Thermotaxis**: Movement along a temperature gradient

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- Example: Wood lice move less if the level of humidity is high

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- Temporal extension beyond that of the stimulus
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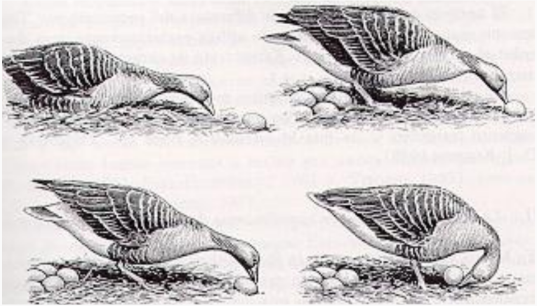

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- Example: Navigation of the desert ant *cataglyphis fortis*

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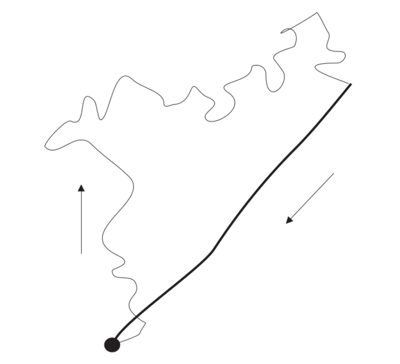

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- Ephemeris function: Cataglyphis can also compensate for the motion of the sun in the sky

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- This is another example of **sensor fusion**!

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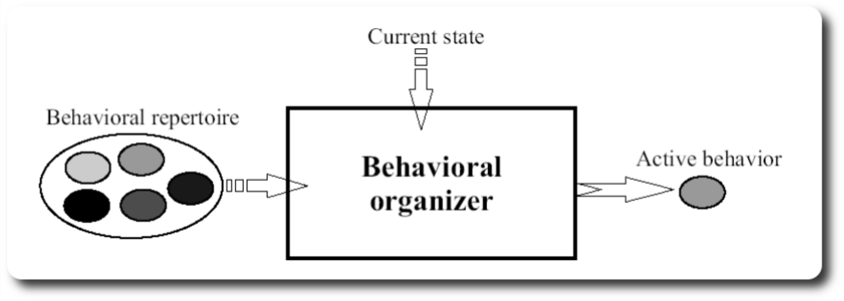

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  - Restore energy
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- **Decision-making** is simply the coordination of behaviours

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- Behavioural fusion, or blending: A combination of more than one behaviour is activated at a time (sharing actuation infrastructure)

Coordination patterns

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    - Finite-state machines (FSMs)
    - Artificial neural networks (ANNs)
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- Example also capable of behaviour blending:
    - Motivation-based modelling (utility functions)

Subsumption architecture

- Finite-state machines (FSMs), representing the behaviours, are wired together in a behaviour network
- Higher level behaviours can *suppress* the lower level behaviours for some amount of time
- Modular architecture: New behaviours can be added "on top" of existing behaviours
- However, requires extensive manual tuning, which in practice limit the number of behaviours.

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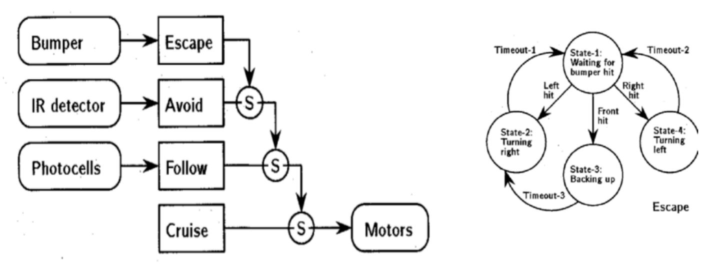

Figure 1: A behaviour control program (left). The 'Escape' behaviour FSM (right).

- Subsumption was developed by Prof. Rodney Brooks at the MIT AI lab in the 1980s.

Motivation-modelling

- Each behaviour is associated with a benefit
- Overall states are in general degrading over time
- To keep a positive state, continuous action is needed

Generating behaviour structures and behaviour tuning

In the end, behavioural modelling comes down to coordination and tuning of simple isolated components.

- How can we model a behavioural system?
- How can we tune behaviours and their interaction?