Human-like artificial creatures

5. Tyrrell & Free-flow hierarchies

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Outline

1. Ethology
   - Konrad Lorenz
   - "psycho-hydraulic model"
2. Tyrrell's architecture
   - virtual animal
   - free-flow hierarchy
3. Comparison

⇨ Netlogo

Ethology

- Ethology is: a study of animal behaviour within a dynamic environment
  - behaviour in natural situations
- Ethology vs. behaviorism
- Ethology vs. animal psychology
- Stronger in Europe than North America
- Heinroth, Huxley, Lorenz, Tinbergen, ...
- Ethogram – a description of the main types of natural animal's behaviour

Behaviour

- Usually understood as a direct response of an a organism to the environment
- Innate behaviour – developmentally fixed
- Learned behavior – modified by experience
  - no "crisp" distinction

Behaviour

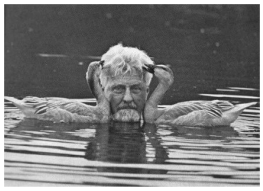
- Fixed action pattern
  - a complex behavioral sequence that is indivisible and runs to completion
  - usually triggered by a sign stimulus (or releasing stimulus)
  - instinctive: typically appears without any previous experience
  - digger wasp
  - vary less within than between species and are highly heritable
    - taxonomy classification
  - more typical within invertebrates than vertebrates, in fish and birds then mammals

Behaviour

- Appetitive behaviour
  - directed toward an attractive object or situation
  - active searching for situations that satisfies the need
  - approaching food
- Consumatory behaviour
  - it directly achieves something
  - appeted stimulus
  - eating food

Konrad Lorenz

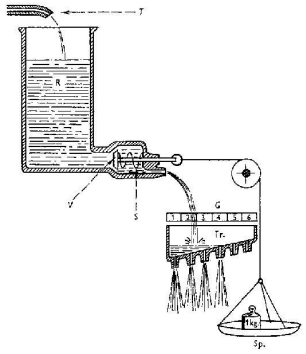
- 1903 – 1989
- 1973 Nobel prize
  - with Tinbergen and Frisch
- Austrian zoologist, ornithologist, one of the founders of modern ethology
- Fixed Action Patterns
  - Whitman, Heinroth
- Imprinting
- Psycho-hydraulic model
- NSDAP



Psycho-hydraulic model

- $V = S_p + (k \times R) - S$)
- S – inhibitory function of higher centres
- k x R – pressure proportional to the volume of water in reservoir R
- T – internal stimuli
- S_p – external stimulus strength
- T_r – intensity of performance of the behaviour

[Lorenz, 51]



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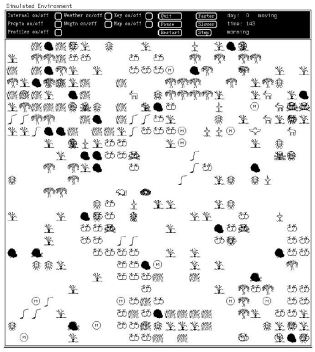
Computational approach to A-S

- What is a computational model of an animal behaviour good for?
  - to analyse the performance of models or theories of action selection not only by 'thought experiment' or mathematical analyses

[Tyrrell, 1993]

Virtual environment

- An animal-like agent lives in an environment with:
  - predators and preys
  - two types of vegetable food (cereal, fruit)
  - water sources and toxic water places
  - dangerous places
  - dens and trees (shades, covers...)
  - mates



[Tyrrell, 1993, (c)]

Virtual animal

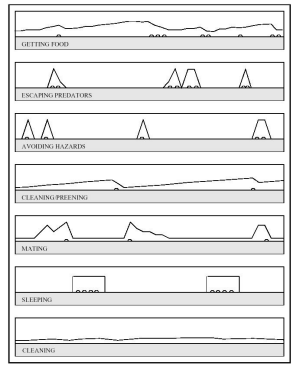
- Features:
  - about 10 internal drives
  - error-prone perception
  - error-prone orientation
  - a memory with forgetting

Virtual animal

- The agent has to perform following tasks:
  - obtaining food and water
  - predator avoidance and vigilance
    - scan for predators
  - dangerous places avoidance and irrelevant animal avoidance
    - edge avoidance
  - staying close to den
  - not getting lost
  - reproduction
  - sleeping at night
  - cleaning and temperature regulation
  - NO procedural learning!

Drives

- Importance of the drive strengths over time



[Tyrrell, 1993, (c)]

Error-prone perception

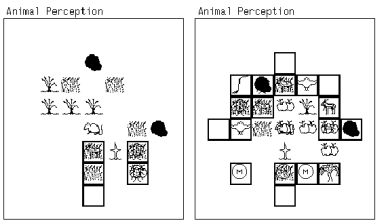


Figure 3.8: Display showing two instances of the animal's perception of its local environment. White boxes around squares indicate that the contents of the square have been incorrectly perceived. The perception on the left occurred when the animal was not in vegetation and chose the action LOOK_AROUND. The instance on the right occurred when the animal chose the action EAT_IF while in a square containing fruit type food.

[Tyrrell, 1993, (c)]

Error-prone orientation

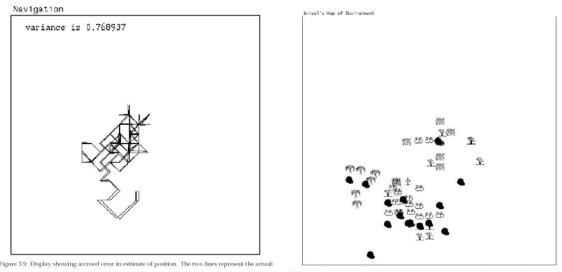


Figure 3.9: Display showing accrued error in estimate of position. The two lines represent the actual and estimated position of the animal. As the animal moves further away from known territory (the centre of the diagram), the animal's estimate of its position becomes progressively more and more inaccurate and the two lines diverge.

Figure 3.10: Display showing the animal's map of the environment after several hundred timesteps. Some features are not recognised on subsequent visits and so are represented more than once. The estimated position of some of the remembered features is not very accurate.

[Tyrrell, 1993, (c)]

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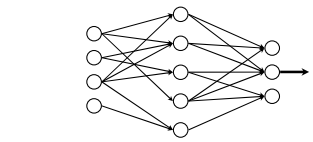
Terminology

What is the action selection model expected to allow for?

- Homeostatic vs. non-homeostatic drive
  - keep the drive in the desired interval
- External stimulus vs. internal stimulus
  - escaping predators vs. cleaning
- Periodic vs. non-periodic
  - sleeping vs. escaping predators
- Continual vs. occasional
  - cleaning vs. avoiding hazard
- Degree of urgency
  - escaping predators (occurs occasionally, but it is extremely urgent)
- Prescriptive vs. proscriptive
  - "has to be carried out" vs. "should not be carried out"
  - eat vs. do not approach hazard

Tyrrell vs. Creatures I

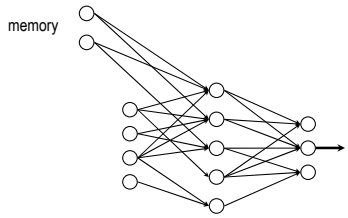


percepts (internal/external)

concepts (learned situations)

actions

Tyrrell vs. Creatures II

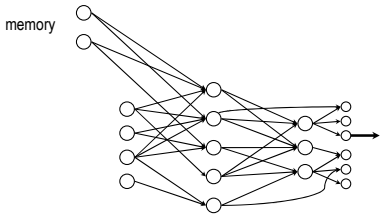


percepts (internal/external)

concepts (learned situations)

actions

Tyrrell vs. Creatures III

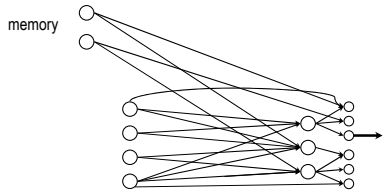


percepts (internal/external)

concepts (learned situations)

hierarchy

Tyrrell vs. Creatures IV



percepts (internal/external)

concepts (learned situations)

hierarchy

Tyrrell free-flow hierarchy

[Rosenblatt & Paton, 1989]
[Tyrrell, 1993]

a sensor, a stimulus

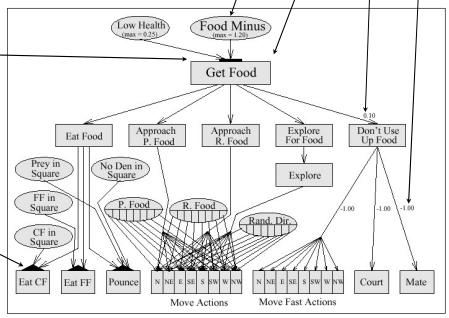
an action, a subsystem

weight

inhibition

addition

multiplication

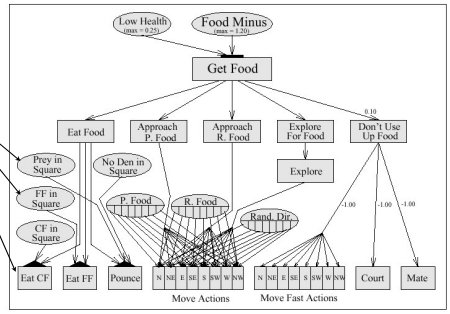


[Tyrrell, 1993, (c)]

Tyrrell free-flow hierarchy

[Rosenblatt & Paton, 1989]
[Tyrrell, 1993]

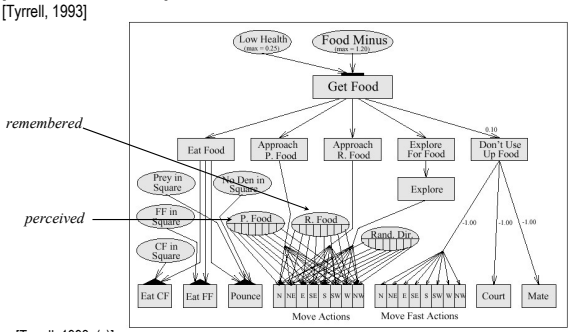
cue stimulus



[Tyrrell, 1993, (c)]

Tyrrell free-flow hierarchy

[Rosenblatt & Paton, 1989]
[Tyrrell, 1993]



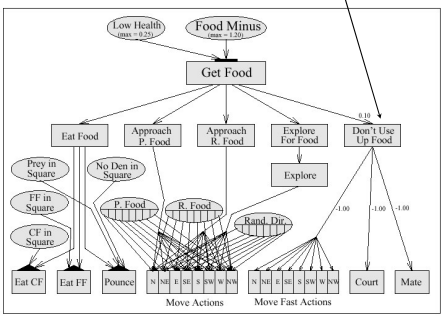
[Tyrrell, 1993, (c)]

Tyrrell free-flow hierarchy

inhibition

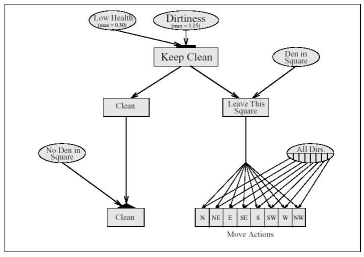
[Rosenblatt & Paton, 1989]
[Tyrrell, 1993]

What would happen without inhibition?



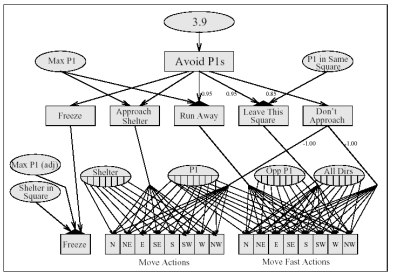
[Tyrrell, 1993, (c)]

If den-in-square do A, otherwise B



[Tyrrell, 1993, (c)]

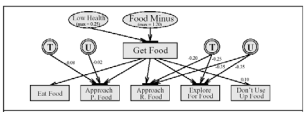
Options



[Tyrrell, 1993, (c)]

Parameterization

- ...is hard [Bryson, 2000]
- Penalties
  - consumatory > app.
  - temporal, uncertain
  - in fact, it introduces reactive planning priorities
- Combining preferences from the same node or different nodes
  - a different utility function for each node



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Tyrrell vs. if-then reactive planning

- Tyrrell ASM allows for "compromise choice"
  - contrary to r. p.
- Tyrrell ASM avoids winner-take-all at every layer
  - consequence: computational cost
  - contrary to r. p.
- Tyrrell ASM allows for more actions that can accomplish the same goal
  - as well as r. p.
- Temporal and uncertainty priorities allow for modeling of priorities in the r. p. manner (but it is more complicated than in r. p.)
  - as well as r. p.

Does it avoid rigid switching?
How to avoid rigid switching using Tyrrell ASM?

Tyrrell vs. Creatures

- More robust behavior
  - hierarchical approach
- Memory
- Task switching with respect to internal drives
- No learning!

How could we learn the weights?

End.

References

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