AI-Inspired Biology: Does AI have something to contribute to Biology?

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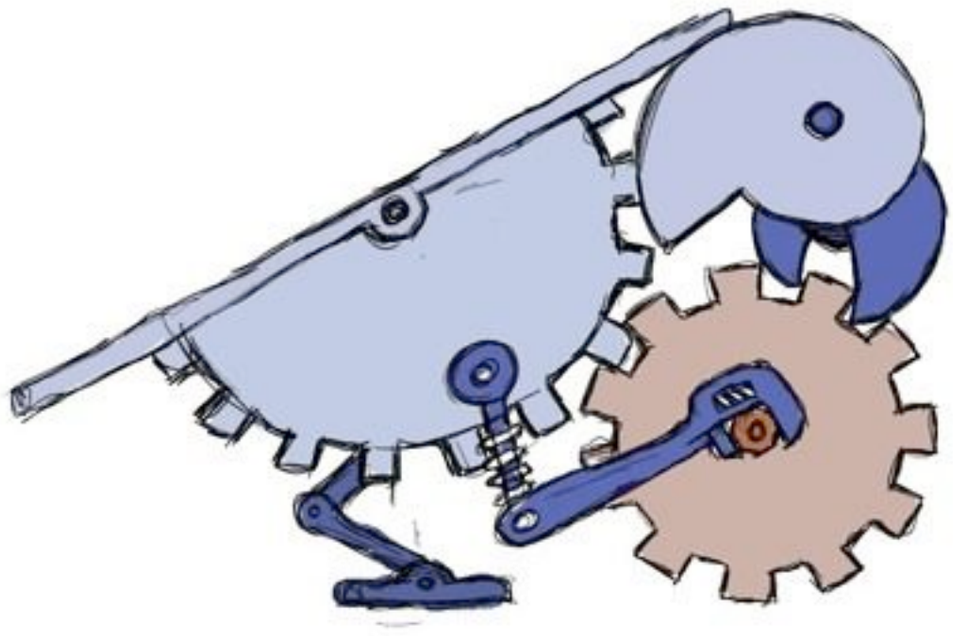

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Outline

- ‘Natural Intelligence’: what kinds of behaviour do we need to explain?

- Problems involved with studying Natural Intelligence

- Variety of ways in which AI can help

- An example from Biology: larva ‘fishing’ using tools in New Caledonian crows

‘Natural Intelligence’: What kinds of behaviour do we need to explain?

New Caledonian crows fishing for larvae


Orangutan locomotion
19 9 1999
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What is interesting about these examples?

- Adjust behaviour depending on the context
- Plan a complex sequence of actions (sometimes, in advance of any action)
- Perhaps predict the effect of their planned action on the environment
- In some cases, behaviour suggests that they appreciate the difference between own competences and those of others - ‘vicarious affordances’



Levels of complexity

- ‘Online’ intelligent control of processes and actions as they happen, sensitive to context

- ‘Offline’ control of processes that are not currently occurring within sensory range, but are possible
    - Requires more abstract (symbolic?) information processing?

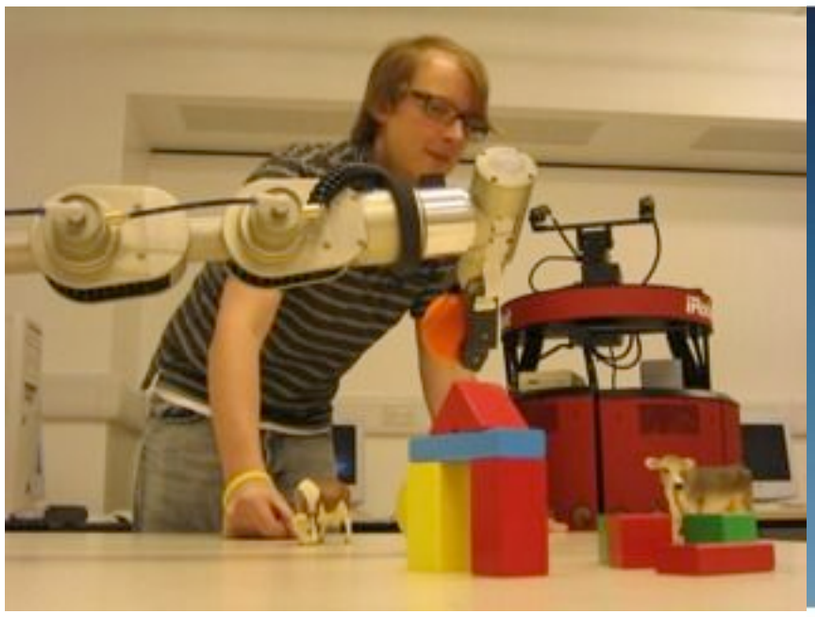
- ‘Planning’ at different levels
    - One or a few steps ahead
    - Selecting a sequence of actions among many, branching possibilities

How does current AI compare?

- Good understanding of the systems involved (though behaviour of artificial systems is currently very simple compared to NI)

- AI has developed concepts and tools to understand complex systems

- Can we use these concepts to help us understand natural intelligence?



Problems with studying natural intelligence

- Information processing system forms a ‘Black box’
    - We know about inputs and outputs, but processing of information in the brain is largely unobservable
        - Changes to the system may result in no observable change
- Our own assumptions can be influenced by our own cognition, which may be different from that of our subjects
- Traditional neglect of individual variation, seeing it as statistical noise, not a source of interesting information

Open problems where progress can be made

- Evolution of complex cognition
    - What kinds of selection pressure promote cognition?
    - How can we characterise differences between human and non-human animal cognition?
- Ontogeny of cognition
    - How do some animals acquire abilities so quickly?
- What are the evolutionary constraints on cognition?

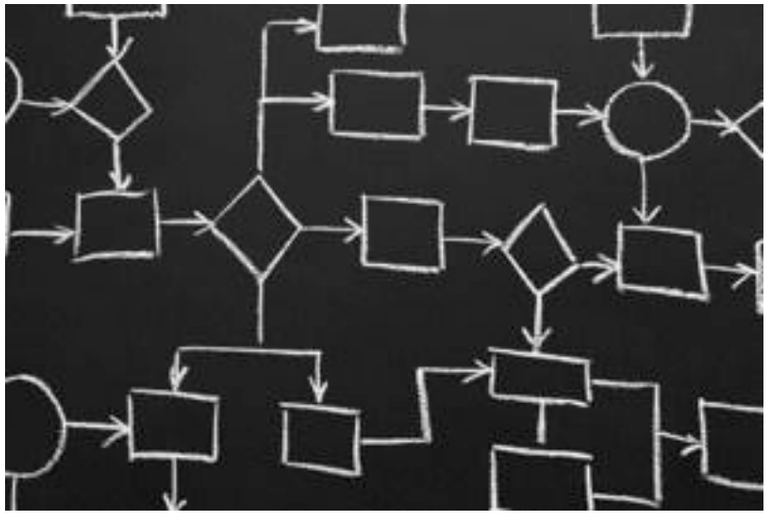
The Designer Stance

Value of construction

Generating hypotheses

How can AI help?

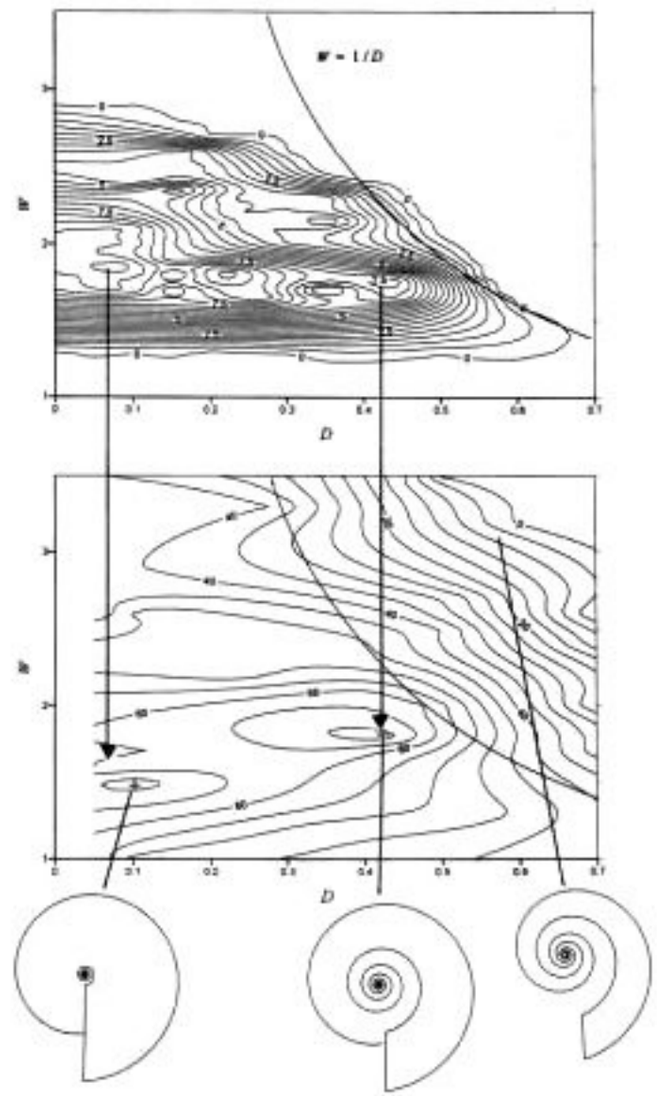
A systems approach



A qualitative approach

The Designer Stance

- Evolution is the ‘designer’, though not working towards a predetermined design
- Biologists usually work from observed behaviour to infer something about selective pressures
- By trying to determine the requirements of the environment first, we can explore the range of possible designs that might fulfil those requirements
- What spaces are not represented by actual designs and why?



Raup 1967

Value of construction

- Biologists have fully-working animals!
- Easy to overlook subtle but important details
- Attempting to construct a working system (even a partial one) reveals gaps in one’s knowledge
- e.g. thinking about role of attention in filtering and prioritising incoming information

Generating hypotheses

- Natural intelligence systems are rich and complex, but mechanisms poorly understood

- AI systems poorer and less complex, but the mechanisms are very well understood

- Capitalise on these complementary systems to generate hypotheses

- Possibilities for manipulation of AI systems which are not possible in natural systems, which can help generate new hypotheses to be tested in natural systems

Systems approach

- AI researchers are responsible for designing the whole process of gathering, processing and acting on information in their systems

- Biologists (and Psychologists) tend to specialise in one part of the system

- Vital to understand how all parts interact and interconnect

- Thinking about these processes in a more abstract way might help us to understand them better

Qualitative approach

- Traditional focus on which species have particular capabilities or at which age a capability develops in humans

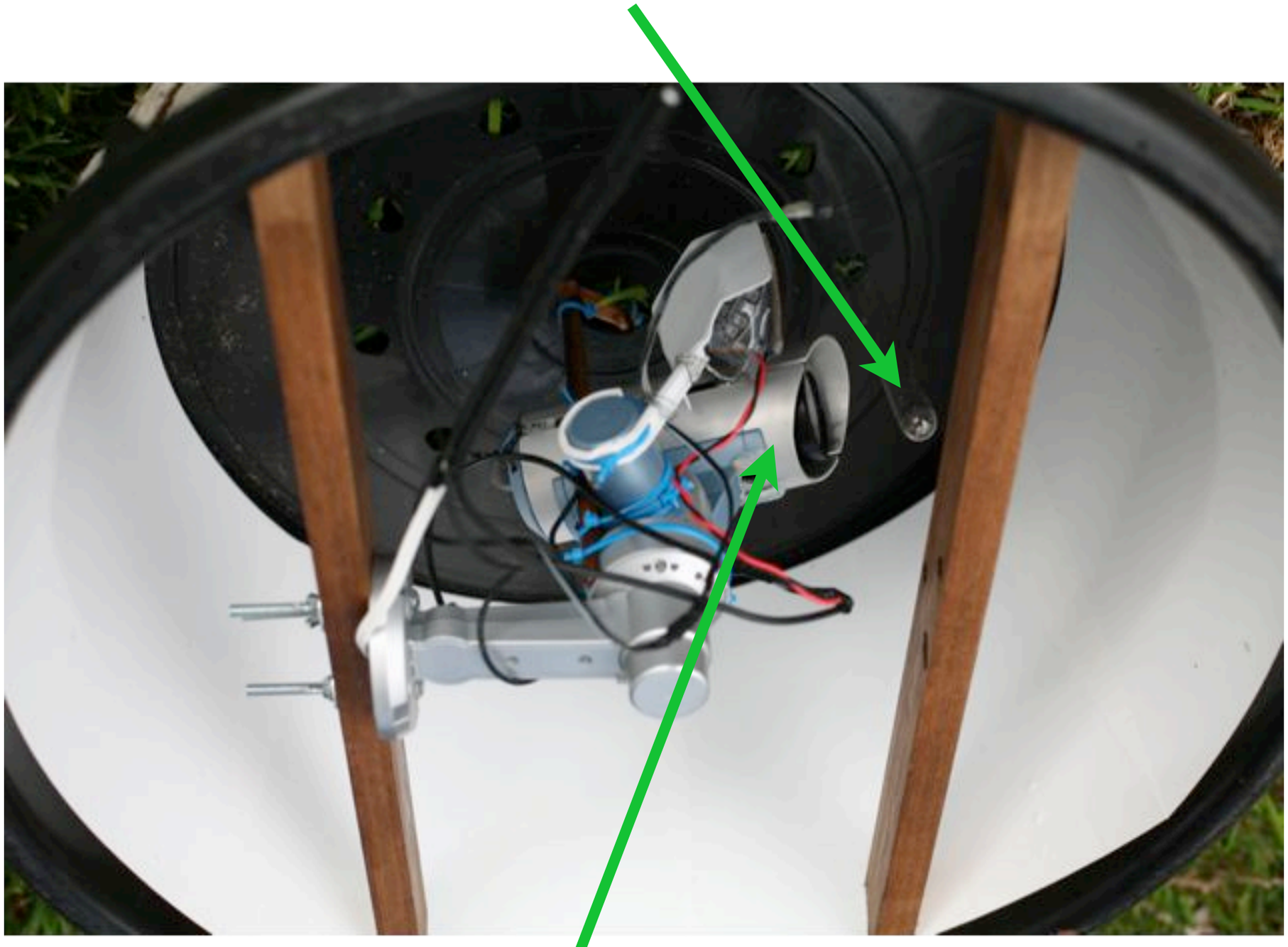
- But just as important to think about:
  - Individual differences and their origins
  - How the behaviour develops and the necessary conditions involved
  - Under what conditions the capability fails

- → Develop processes and logic used by AI researchers to debug programs

Example: New Caledonian crows fishing for larvae

Photo by Jolyon Troscianko

test tube with larva



infrared video camera, moves between tubes

Where do we go from here?

- More communication between the fields (like this Symposium!)
- More cross-disciplinary publications
    - Wider acceptance of papers outside field by journals?
- Develop a common terminology, or at least an understanding of the ways in which terms are used in each field
- Open mind and realistic expectations about what can be achieved!

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