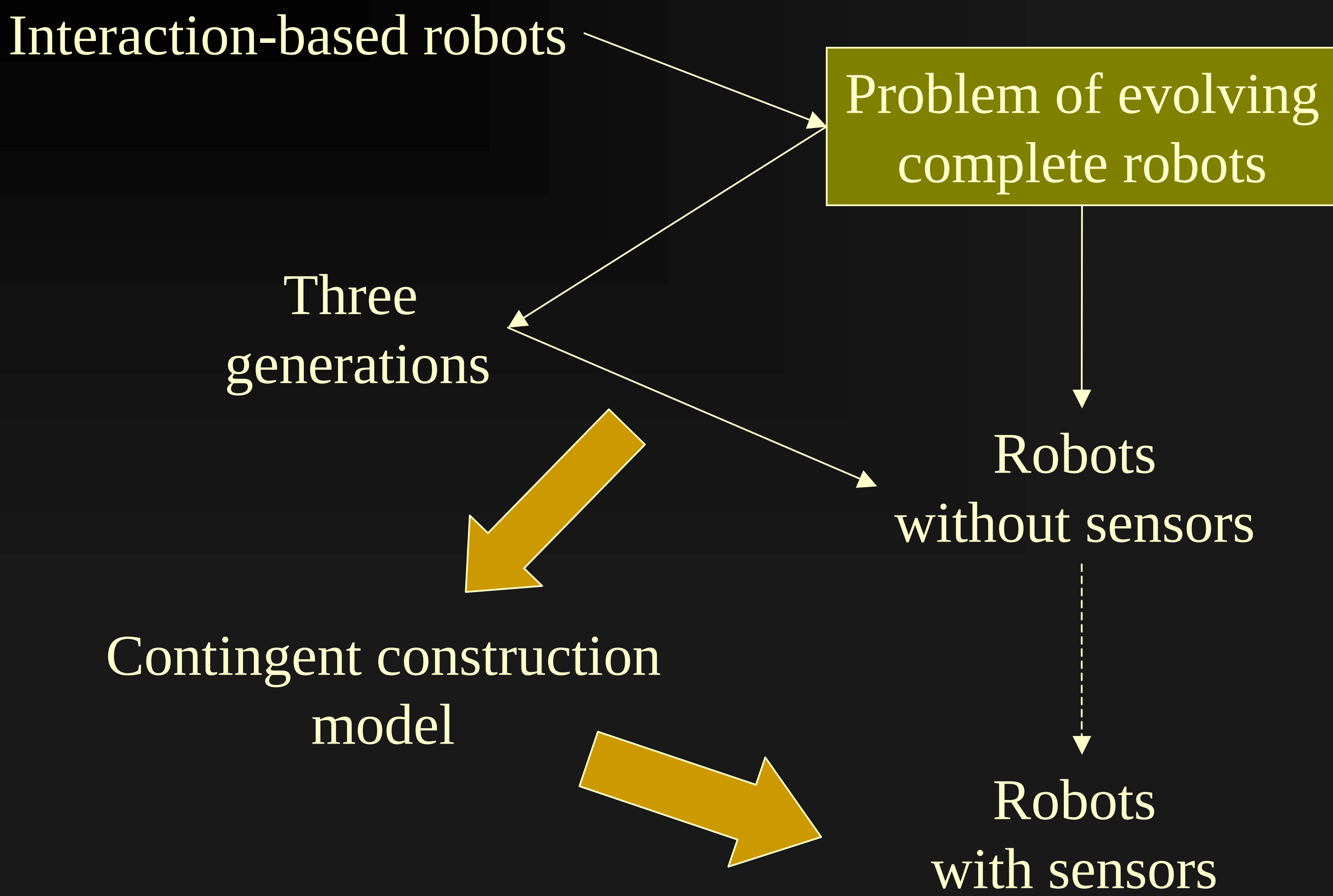
Contingent construction model

Group meeting

Nov 26th, 2002

Outline


Interaction-based robots
Problem of evolving complete robots
Three generations
Robots without sensors
Contingent construction model
Robots with sensors

Background

- Critical deficiencies of robots designed within the symbolic AI approach (Agre and Chapman 84, Brooks 86, Rosenchein and Kaelbling 86)
  - “Brain in a vat” approach
  - Extensive online computation to support “sense-plan-act” approach
  - Dependence on internal models resulting in brittleness in real world operation

- Alternative: Situated, embodied, special purpose, interaction based robots

The evolutionary turn...

- Harvey et al. (1992) argued for automated controller design for interaction-based robots
  - Human design of controllers difficult due to problems characterizing low level interactions
  - Evolution is blind to difficulties
  - Neural networks more robust to noise compared to LISP programs (as in Brooks)
- The Evolutionary Robotics research program

Consequences - I

- Automated controller design:
  - Novel, unforeseen solutions
  - Wide applicability (FPGAs, flying robots, unit-modular robots, etc.)
- Descriptive style of research
  - Organism model for specific neurobiology questions
- Shift of emphasis from robot to meta-robot level
  - Representation, EC parameters, network, etc.

Consequences - II

- Number of problems (Mataric and Cliff 96?)
  - Role of simulators
  - Time for evolution
  - Physical wear due to evolving in the real world
- Difficulty explaining success, failure and empirical anomalies
  - No criteria for behavioral convergence
  - Opaquely complicated systems
  - Unforeseen interactions beyond system model

Systemic issues

- Empirical difficulties COULD be revealing:
  - Tension arising from technical and philosophical assumptions
  - Fundamental peculiarities of embodied, evolved artificial systems

- Analytical insights into these difficulties:
  - Minimal simulations (Jakobi 95)
  - Embodied Evolution (Watson, Ficici 97)
  - Design strategy of “body first, brain last” could itself be the problem (Pollack et al. ‘00)

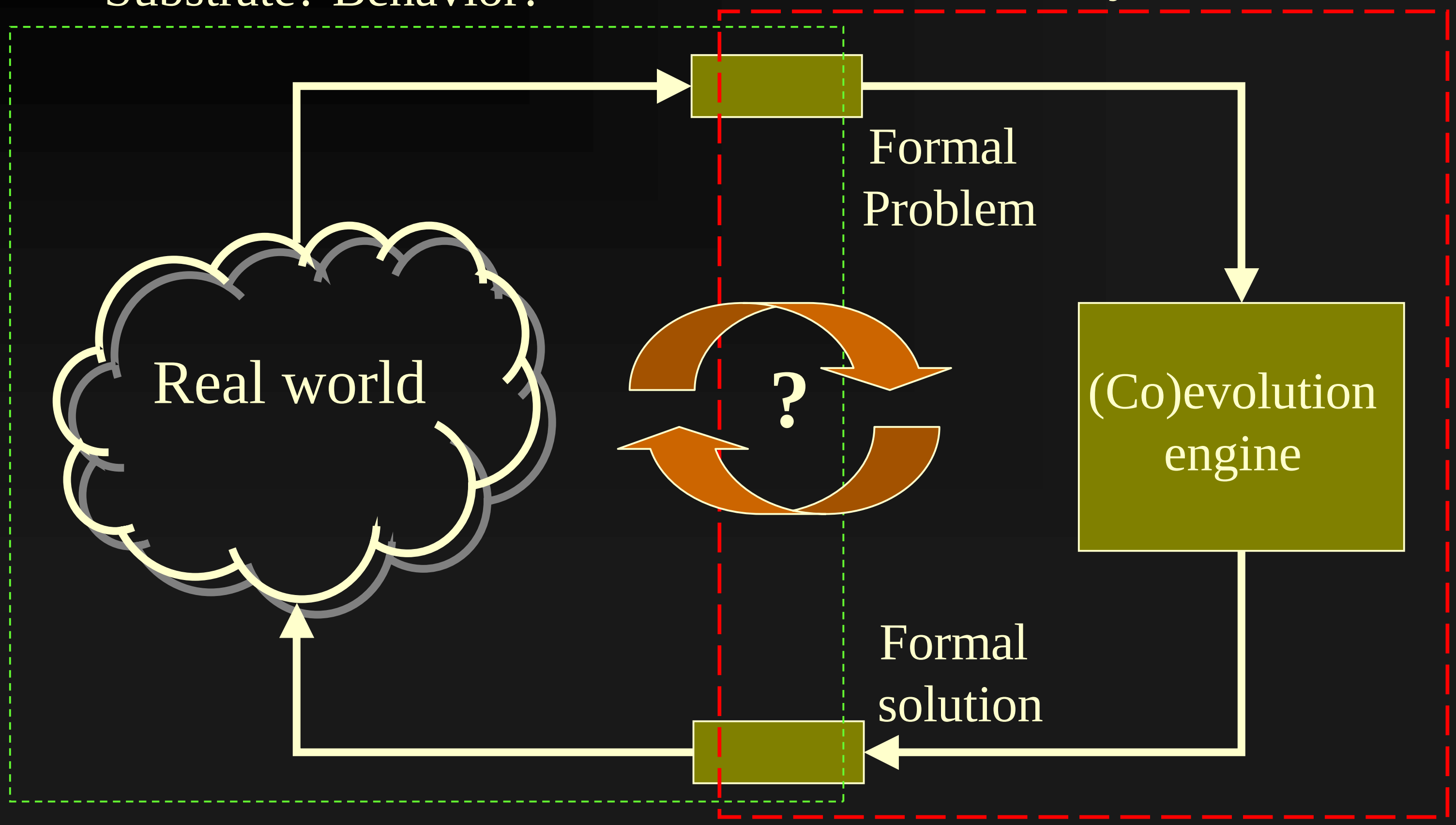
Evolving “body” and “brain”

- Evolving by repeated building and testing (as in evolving controllers, FPGAs, etc) is not a viable option
- Vicarious evolution of complete robots (F-L-H)
- Repeated problems related to this distance from the world

Crude taxonomy

Technology?
Substrate? Behavior?

"Open-ended" evolution?
Chemistry? Simulator?



System organization?

Echoes from GOFAI

"....Studying how humans solve problems belongs to cognitive psychology. How computers solve problems belongs to artificial intelligence. Robotics studies how computers solve problems requiring interaction with the environment. As similar processes are often used, there is frequent exchange of ideas among these three sub-disciplines..."

- Herbert Simon (Problem Solving, MITECS)

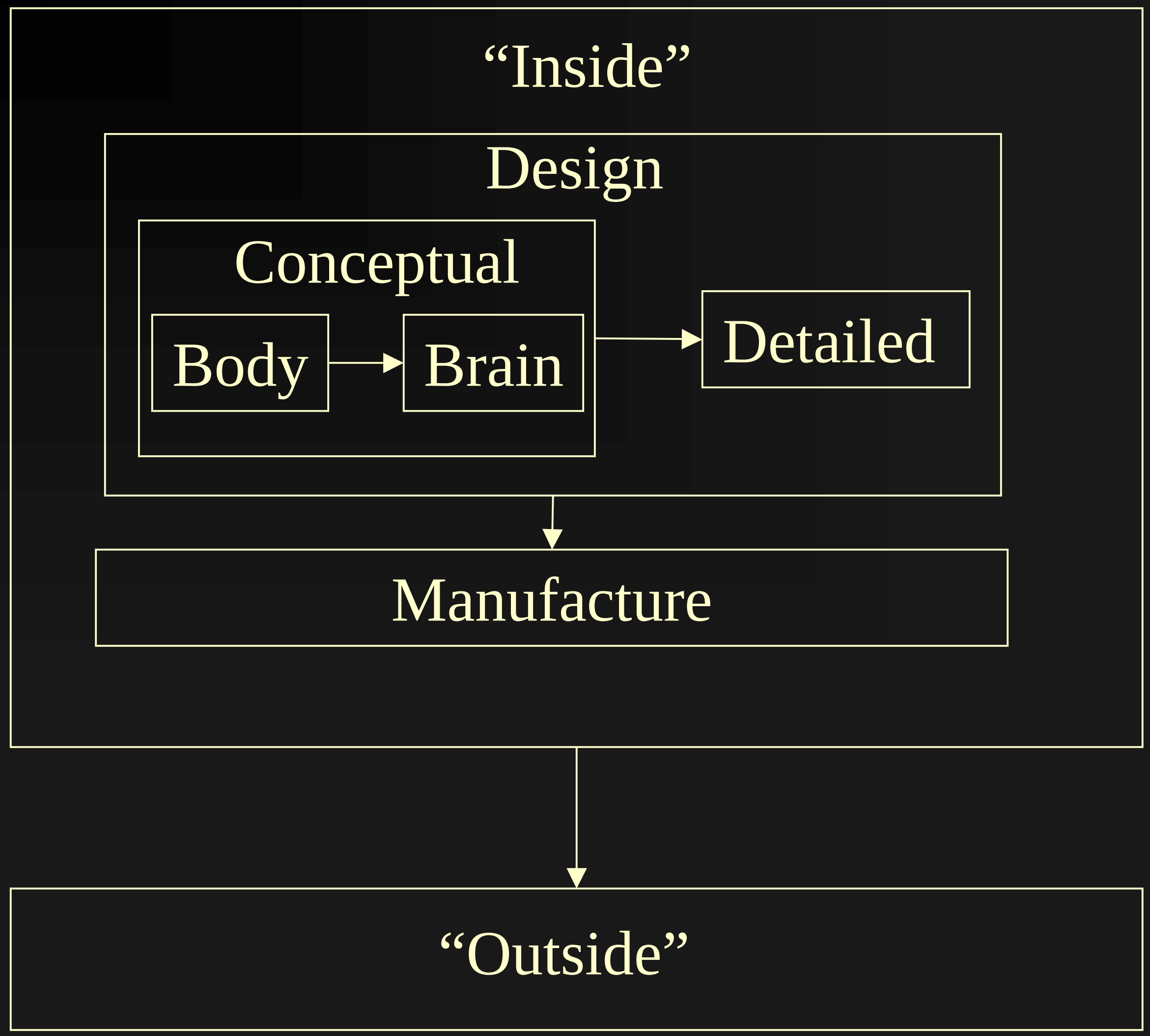
Core problem

- How can we organize and interface digital computation and the “real world” to get behavioral complexity starting from very close to a clean slate?
    - IMPORTANTLY: Without falling into the same traps as GOFAI

Typical challenges to claims:

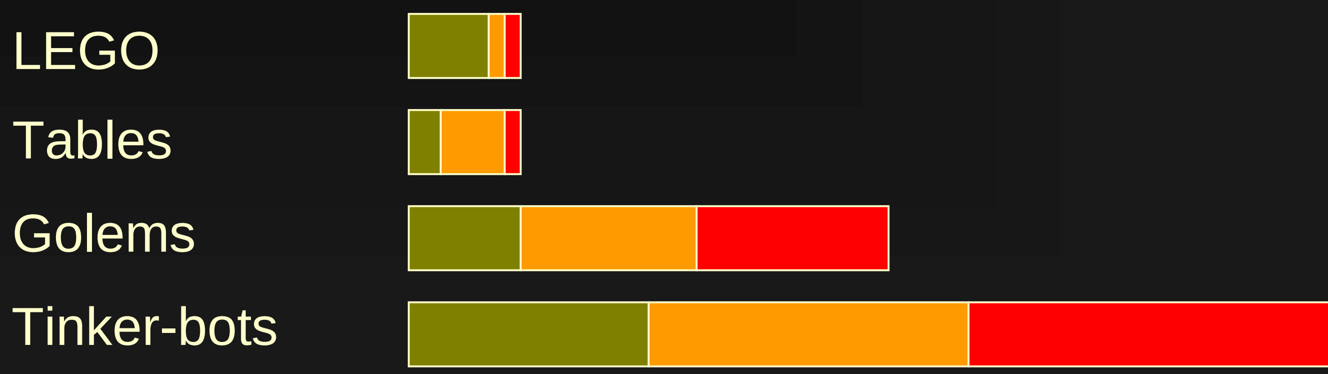
- Nature of dependence on simulation
- Accounting for human knowledge
- Models of reference (Bits -> real world)
- Way the problem is decomposed
- Implicit hierarchies and dichotomies

Nested dichotomties



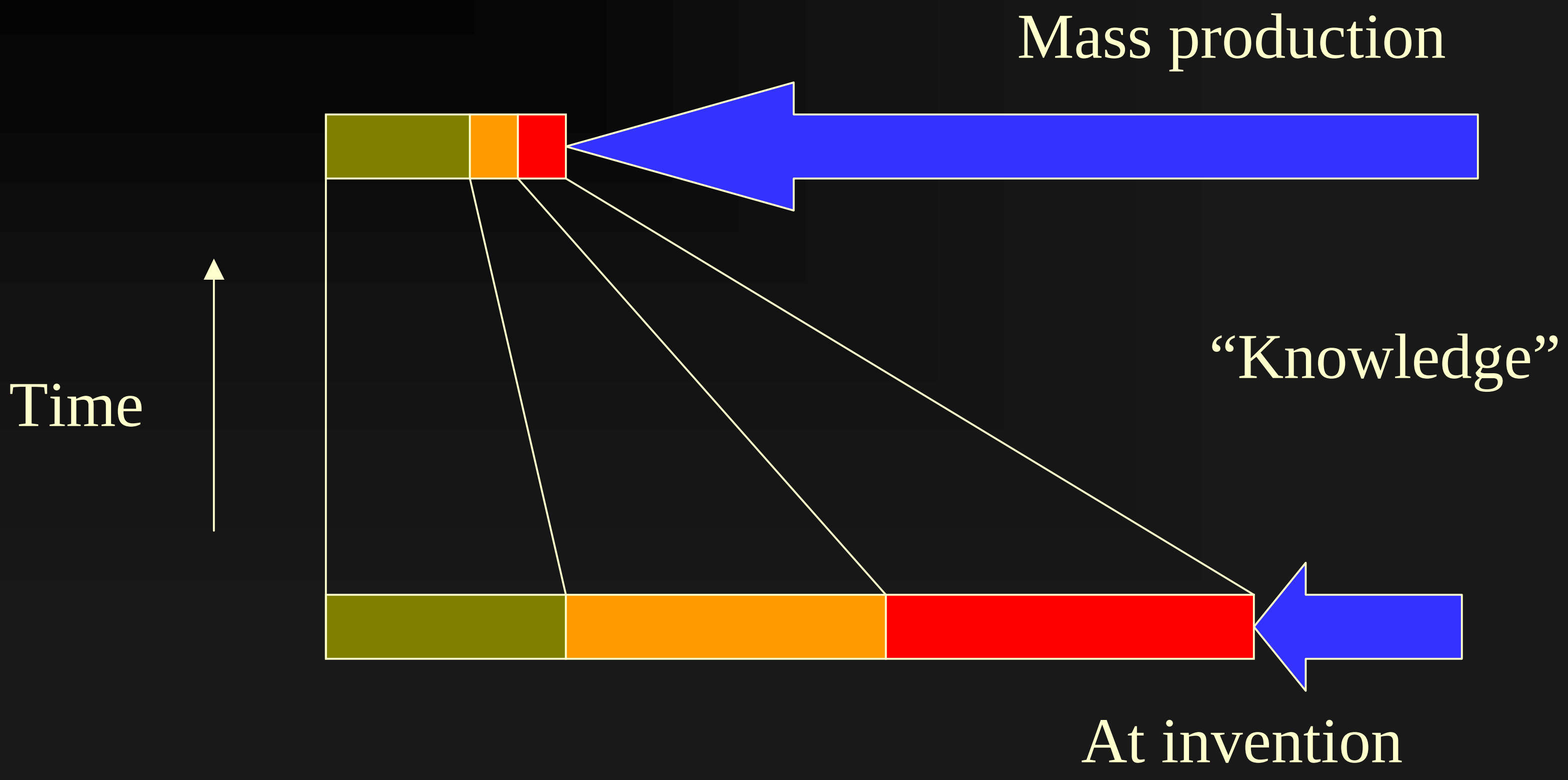
Contingent construction

- Observation: The evolved robots seem to vary significantly in "difficulty" (human involvement) of physical realization



'Difficulty' ~ Writing code, fix syntax errors, making it work right

Intuition from industrial settings



(Whitney et al. 94)

“Knowledge”

- Construction:
  - To <u>fabricate</u> the desired designs successfully
  - To successfully <u>manufacture replicas</u> of design on demand
  - To successfully <u>manufacture replicas</u> of design <u>economically</u>

- Tension:
  - “Creativity” of evolution
  - Knowledge deficiency in construction of radically novel designs

Contingent construction model

- How can this tension be accounted for by an analytical model?
- Under what conditions can it be resolved?

Next

- Work out model on white board....