Definitions

Intelligent System

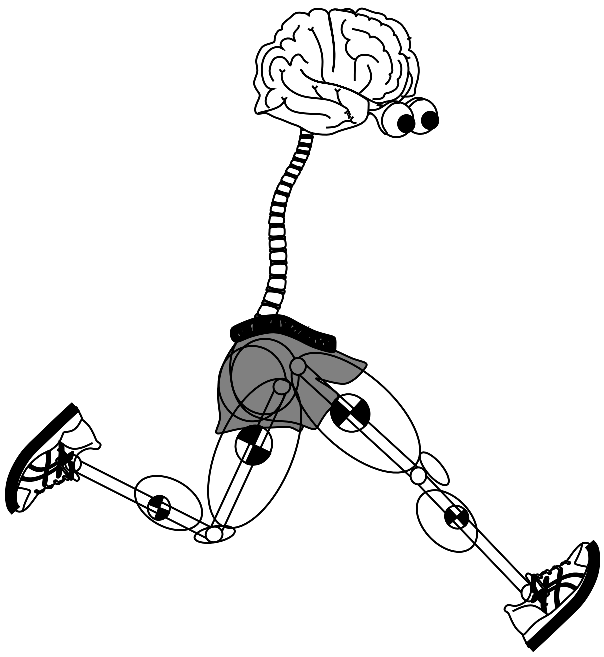
A system is intelligent if it exploits the information it contains regarding its interaction with a **complex** *environment, and the information stream through it, in such a way as to adapt and improve this interaction.*

Intelligent Robot

A machine that is able to extract information from a **complex** *environment and use accumulated knowledge about this environment to behave in a manner that produces utility.*

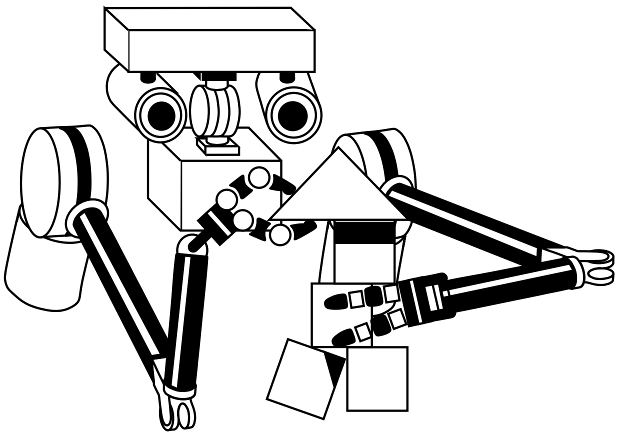
Integrated vs. Intelligent Robot Systems

- complex kinematics, dynamics
- highly redundant musculature/sensors
- neurophysiology - genetic/structural commitment
- **rich interaction with non-stationary and non-linear world**



this guy has limited means of interacting with the world and so could not support all this cortex under evolutionary pressure!

What can we learn from Humans? Structure and Growth: A Model of Development for Robot Systems



- Identify principles by which self-organising computational systems can *model* and partially *manage* the physics of the everyday world.
- Explore how learning and development can be *structured* kinematically, dynamically, and *neurologically* in synthetic (robot) systems.
- Develop mechanisms by which synthetic computational systems can *grow*.

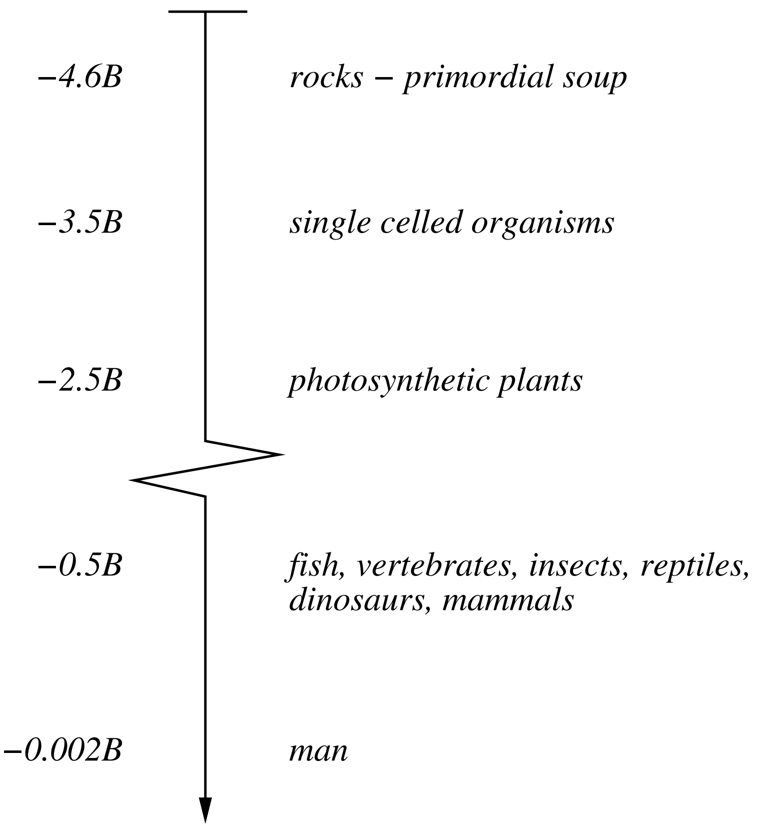
What has Evolution to say about Intelligence? - Life on Earth

Suppose that we define *Intelligence* to be competence in environments comparable in complexity to the natural environment on earth.

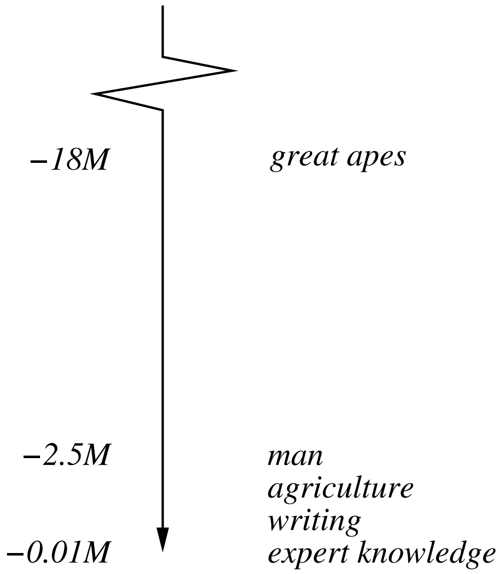
This implies that the environment ultimately decides what is intelligent and what is not.

1953 Miller−Urey

ammonia + H_2O + H + CH_3 + *ENERGY* $\longrightarrow$ *amino acids* *alanine* + *glycine*



The Human Age



Brooks, Morevec, et. al.

...moving about in our complex environment well enough to survive and flourish is the toughest problem that life on earth has yet faced...

...this is where evolution has concentrated most of its effort.

conjecture:

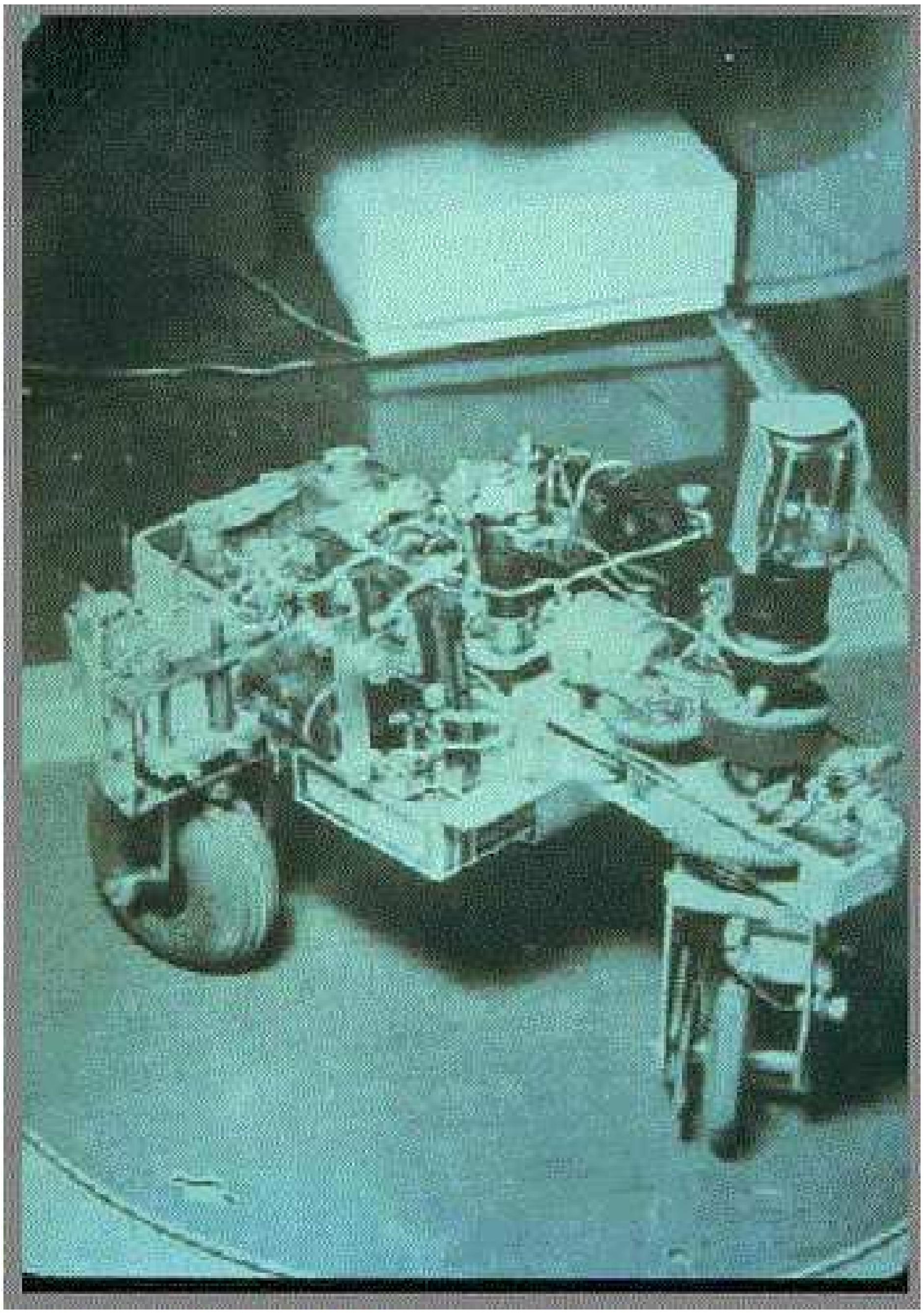
"...problem solving, language, expert knowledge, and application, reason, etc, are all pretty simple once organisms developed sufficiently complex/expressive bodies and tackled "reacting" in complex/natural worlds."

"Intelligence" happened because it had to!

Early Embedded Control System
Grey Walter's Tortoise

- 1953 - Product of cybernetic research
- One motor with 2 valve control circuit
- Two sensors: light and bump
- Light sensor always faced in direction of motion
- Behaviors
  - Seek light (rotates until light found)
  - Head toward weak light (once light found)
  - Back away from bright light
  - Turn-and-push to avoid obstacles: avoid obstacle overrode light response
  - Recharge battery - strong source perceived as weak light with low battery, once charged backs away from plug.
- From lowest level to highest:
  scan, move to/from light, avoid-obstacle

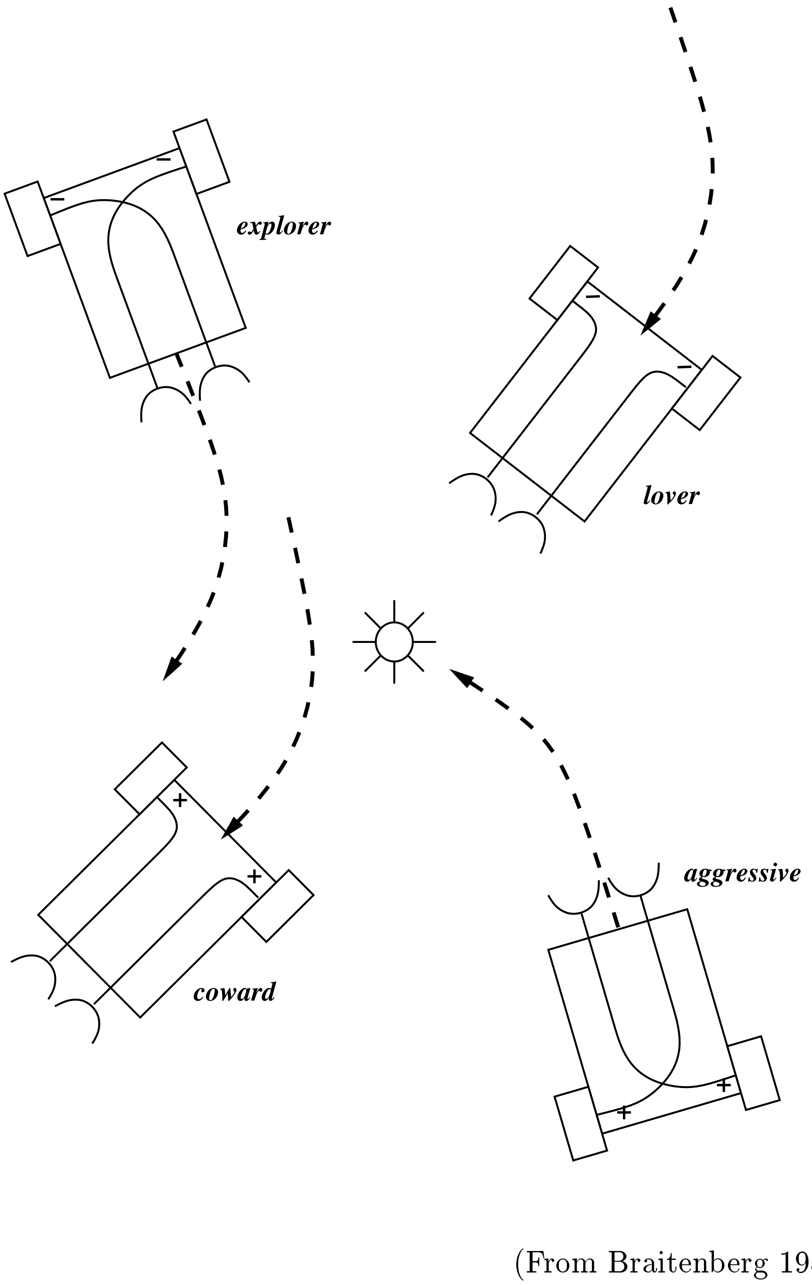
Early Embedded Control System
Grey Walter's Tortoise



Early Embedded Control System
Braitenberg's Vehicles

- Simulation study (1984)
- Sensors mapped to motors via simple analog logic
- Synthetic psychology — seemingly complex behavior results from relatively simple sensorimotor transformations.
- Inhibitory and excitatory influences (sensors on motors)
- Range of vehicles created - e.g., Coward, Aggressor, Lover, Explorer.
- Inflexible custom machines

Example of Reactive Control
Braitenberg machines



(From Braitenberg 1984)

Example: Raibert's Hopping Platforms

http://www.ai.mit.edu/projects/leglab/robots/robots.html