COMP3411: Artificial Intelligence

Extension 2. Reactive Agents

Outline

- History of Reactive Agents
- Braitenberg Vehicles
- Chemotaxis
- Behavior-Based Robotics

Reactive Agents

- choose the next action based only on what they currently perceive, using a “policy” or set of rules which are simple to apply
- unable to remember, plan or logically reason
- interesting behaviors can “emerge” from these simple rules

History of Reactive Agents

- 1948 Alan Turing (importance of embodiment)
- 1969 Herbert Simon (parable of ant on beach)
- 1984 Valentino Braitenberg (Vehicles)
- 1991 Rodney Brooks (“Intelligence without Reason”)
- 1995 Lego MindStorms

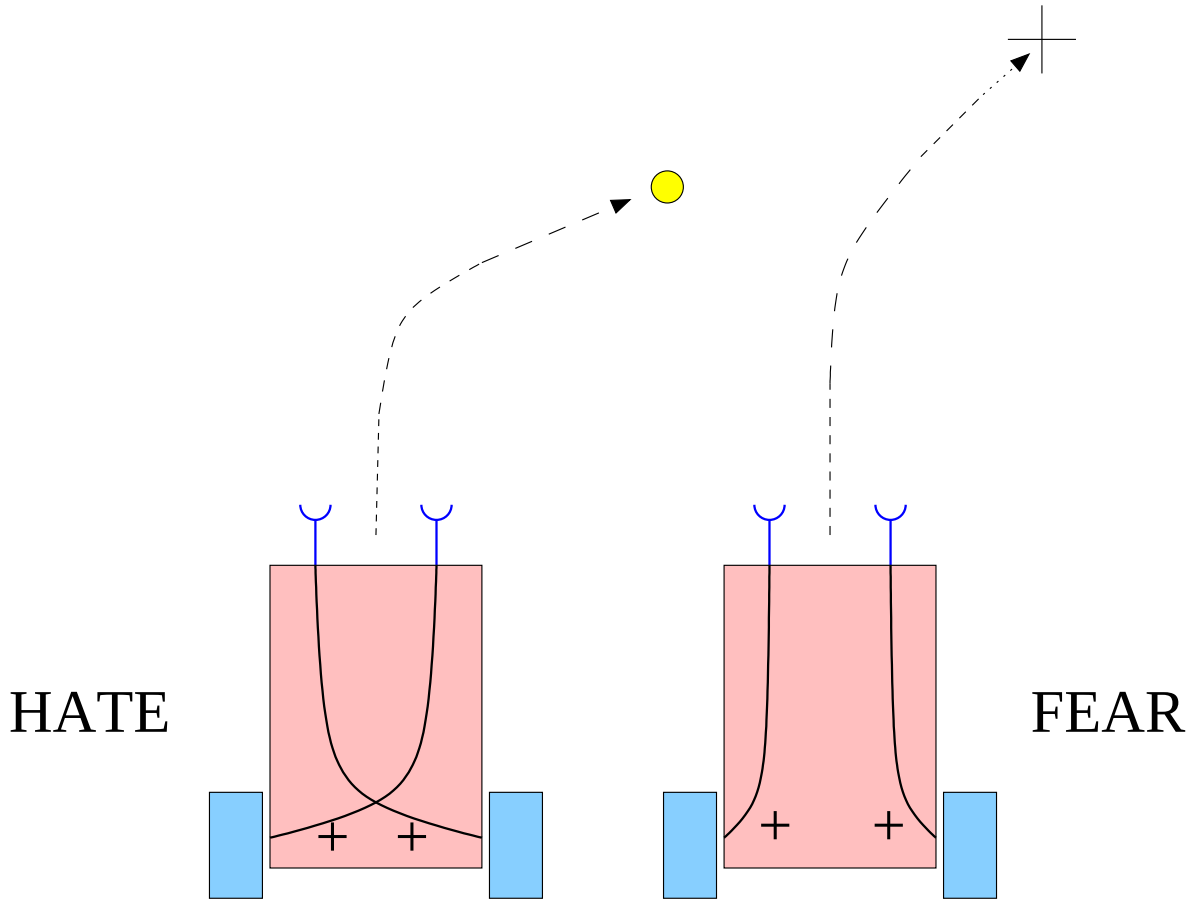
Braitenberg Vehicles

- Braitenberg showed how simple arrangements of sensors and motors can lead to surprisingly sophisticated behavior
- simplest vehicles have two wheels and two sensors
- sensors respond to a light source
- response is inversely proportional to distance

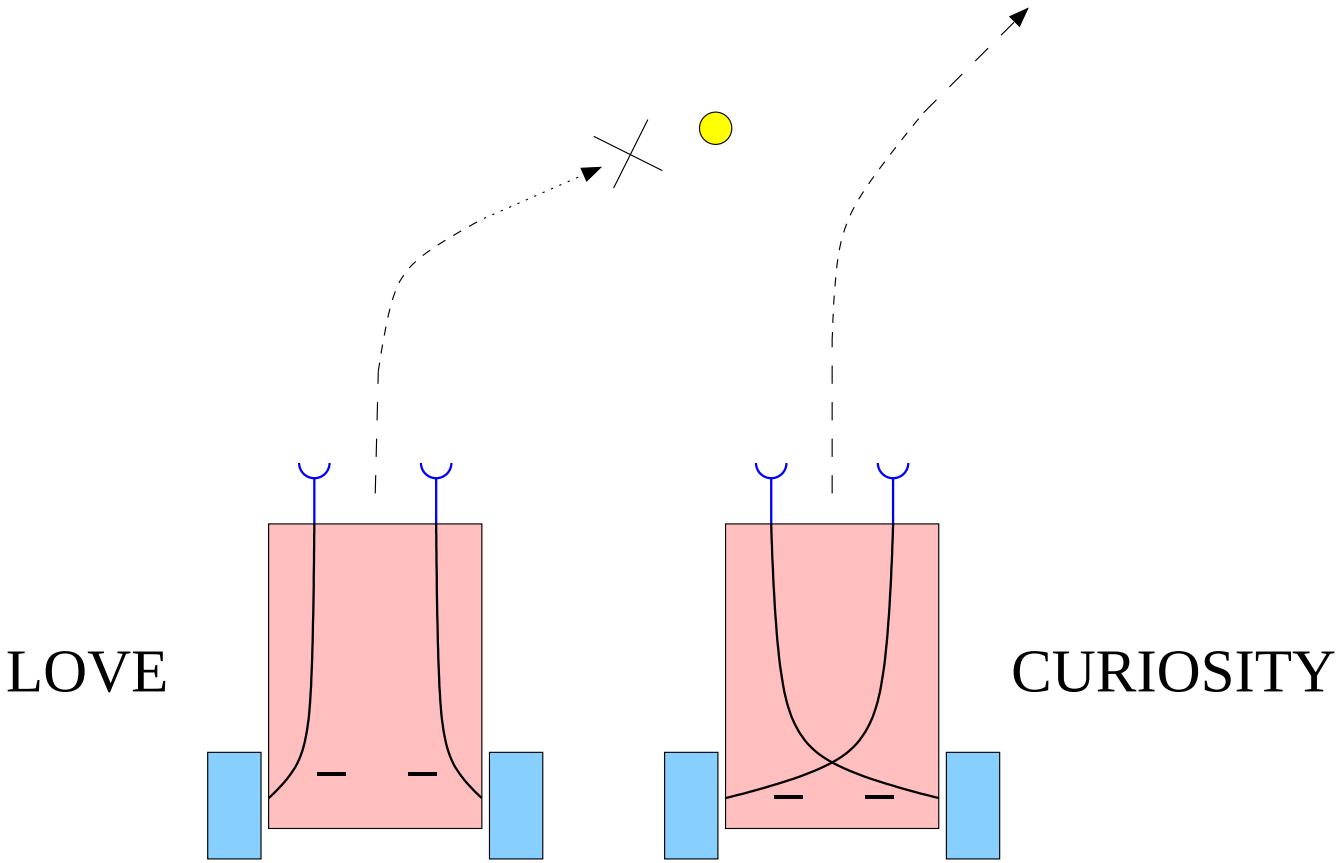
Braitenberg Vehicles

- connections can be
  - straight or crossed
  - excitatory (+) or inhibitory (−)
- leads to four behaviors
  - hate
  - fear
  - love
  - curiosity

Braitenberg Vehicles



Braitenberg Vehicles

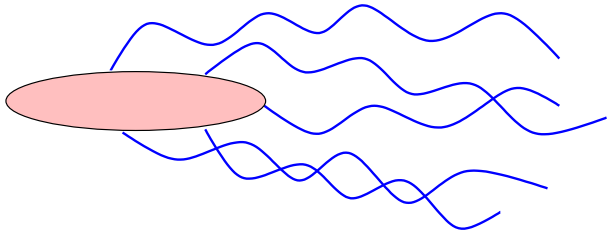


Chemotaxis

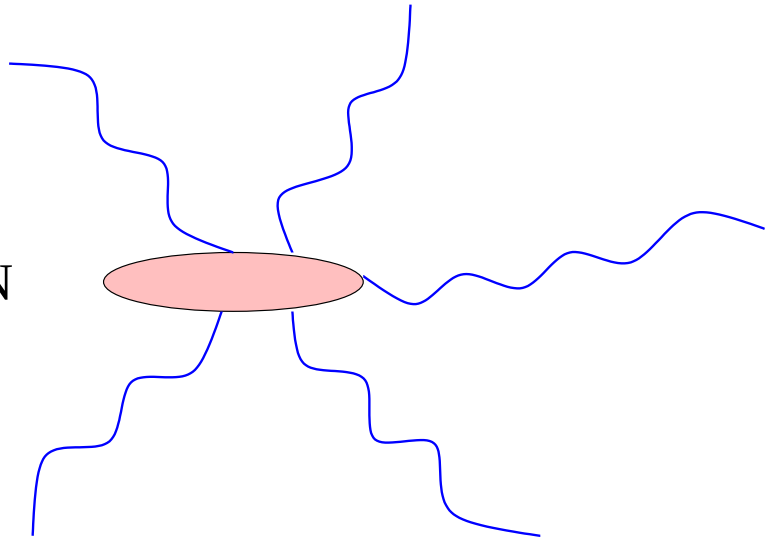
- Many single- and multi-cell organisms can direct their movement to swim to areas with higher (or lower) chemical concentration
- bacteria use flagella to propel themselves
  - anti-clockwise rotation $\rightarrow$ linear motion
  - clockwise rotation $\rightarrow$ tumbling motion

Bacterial Motion

LINEAR MOTION



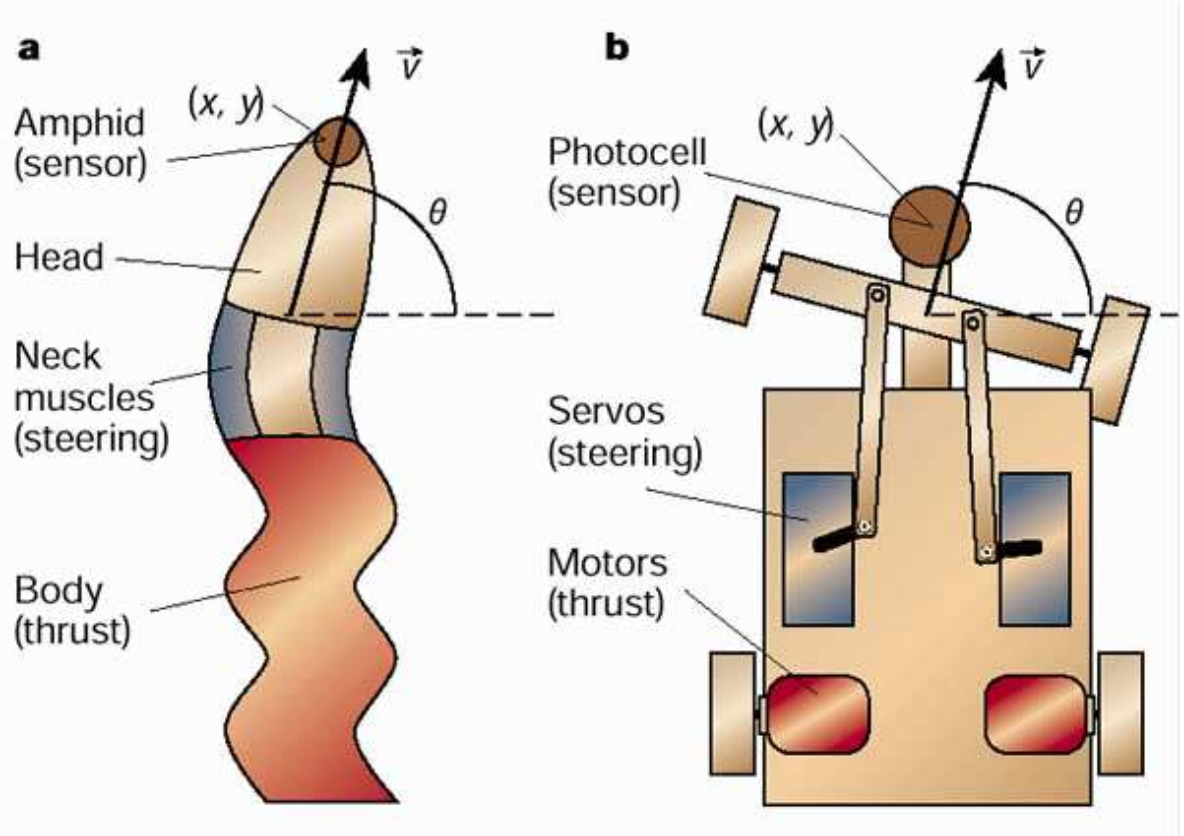
TUMBLING MOTION



Chemotaxis

- normally, bacterium switches between linear and tumbling motion, producing a random walk
- if it senses that it is heading in the “right” direction, it will lengthen the current period of linear motion
- in this way, it can successfully move toward food sources and away from toxins

Robot Model of Nematode Worm



from Barbara Webb, “Robots in invertebrate neuroscience”, Nature 417 (2002)

The Swiss Robots

Q: What rules are these robots using to “clean up” the pucks?

The Swiss Robots

The rules used by the Didabots:

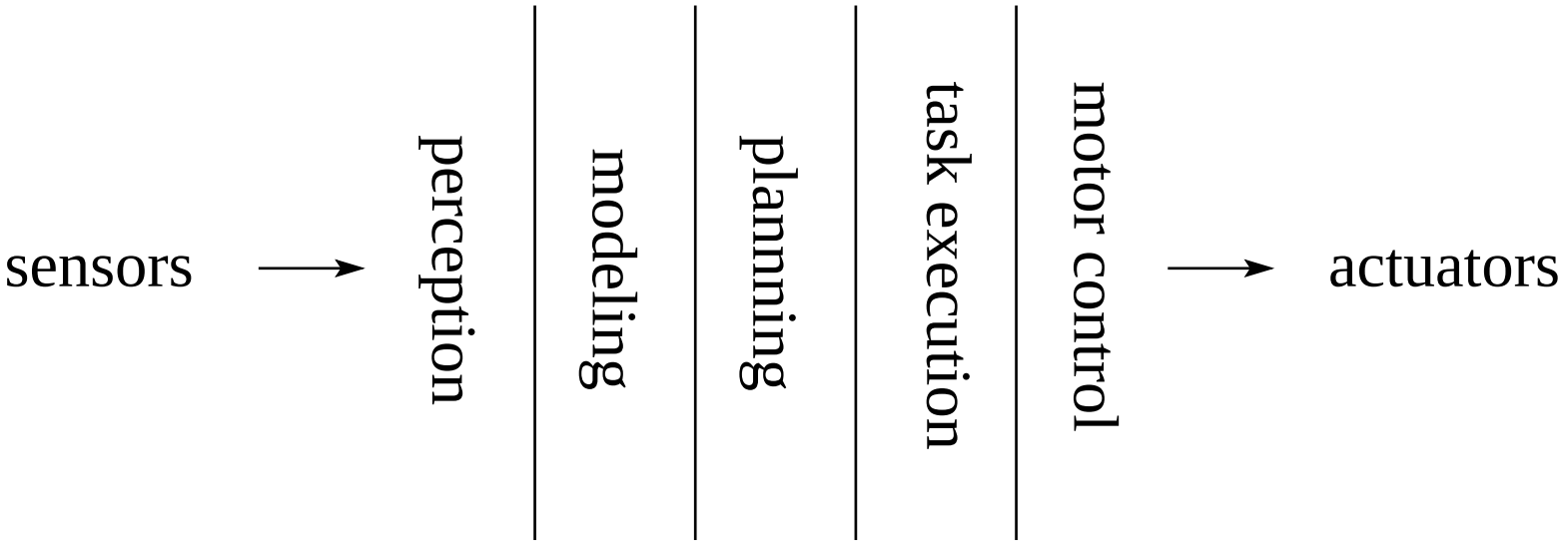
- normally, move forward
- if you detect an obstacle to the left or right, turn away from it
- if you detect an obstacle directly in front, move forward

Behaviour-Based Robotics

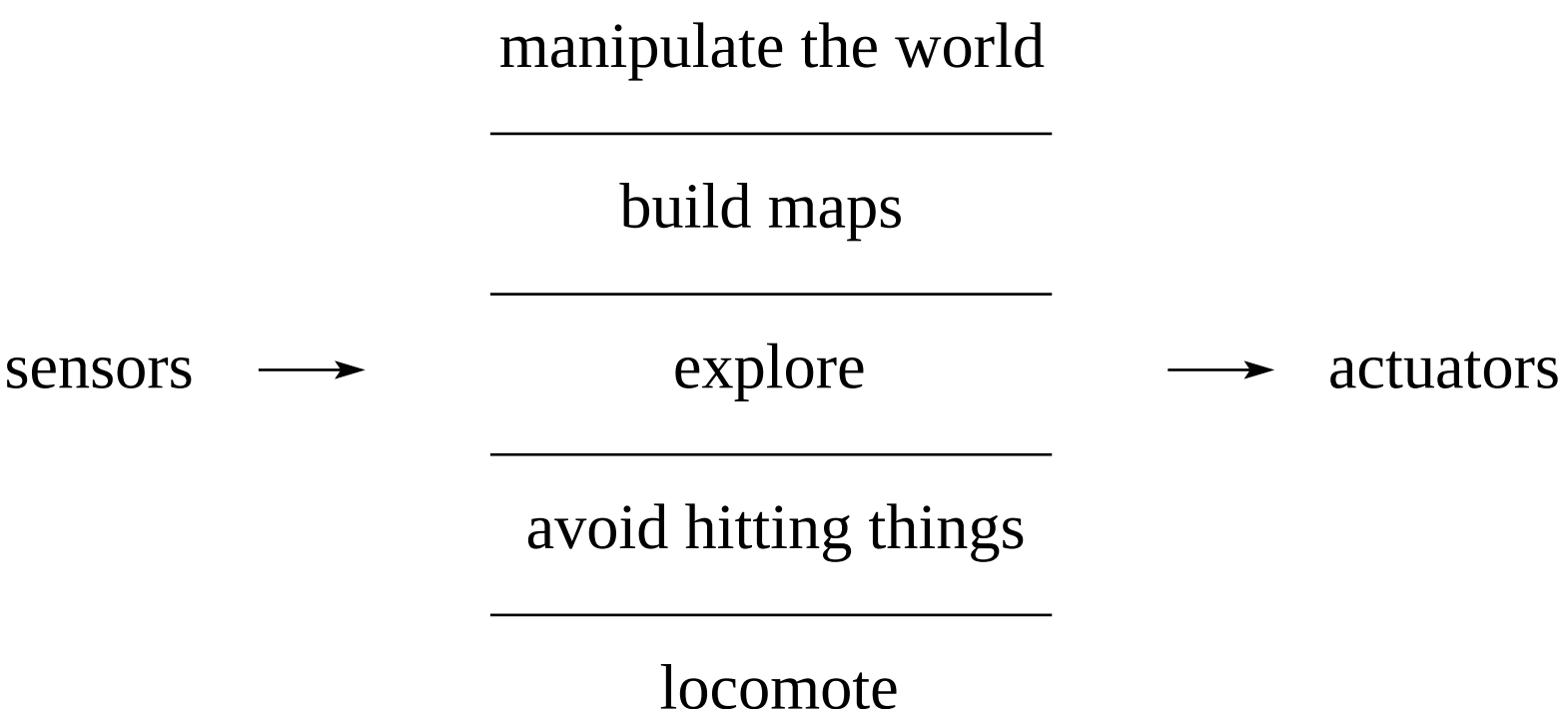
Introduced by Rodney Brooks in the late 1980's as a challenge to "Good Old Fashioned AI" (GOFAI)

- robots should be based on insects rather than humans
- tasks like walking and avoiding obstacles rather than playing Chess
- abandon traditional horizontal decompositon
  - Sense $\rightarrow$ Plan $\rightarrow$ Act
- replace with vertical decompositon or "subsumption architecture"
  - each layer can connect sensing right through to action

Horizontal Decomposition



Vertical Decomposition



Modern Perspective

- Each layer in the vertical decomposition is a behavior
  - low-level behaviors like “avoid hitting things” are reactive, connecting sensors directly to actuators
  - mid-level behaviors like “build maps” make use of a world model
  - high-level behaviors make use of world model and planning
- higher level behavior may take control from lower-level behavior
  - e.g. if the low-level behavior has gotten “stuck”
- lower level behavior may take control from higher-level behavior
  - e.g. to avoid getting burned, or falling down a staircase

References

- Valentino Braitenberg, “Vehicles: Experiments in Synthetic Psychology”, MIT Press, 1984.
- Rolf Pfeifer & Christian Sheier, “Understanding Intelligence”, MIT Press, 1999.
  - `http://www.ifi.unizh.ch/ailab`
- Rodney Brooks, “Cambrian Intelligence: the Early History of the New AI”, MIT Press, 1999.
  - `http://www.csail.mit.edu`