Introduction to Mobile Robotics

Robot Control Paradigms

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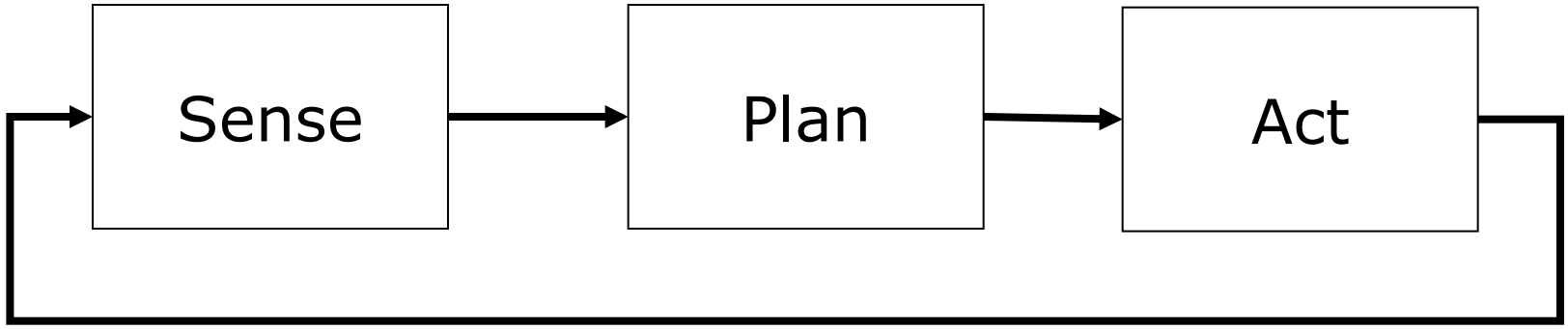
Classical / Hierarchical Paradigm



- 70's
- Focus on automated reasoning and knowledge representation
- STRIPS (Stanford Research Institute Problem Solver): Perfect world model, closed world assumption
- Find boxes and move them to designated position

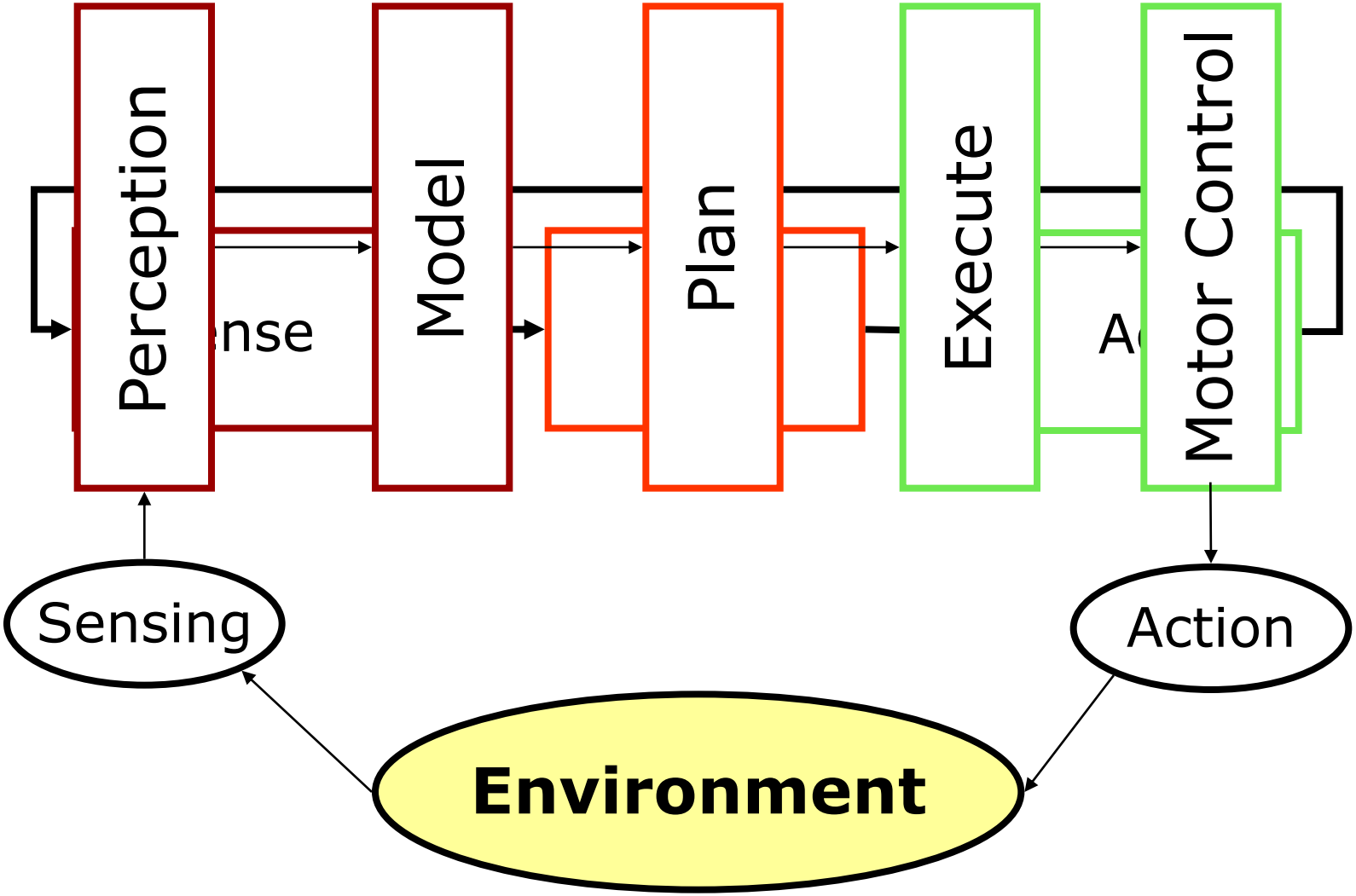
Stanford CART ‘73

Stanford AI Laboratory / CMU (Moravec)

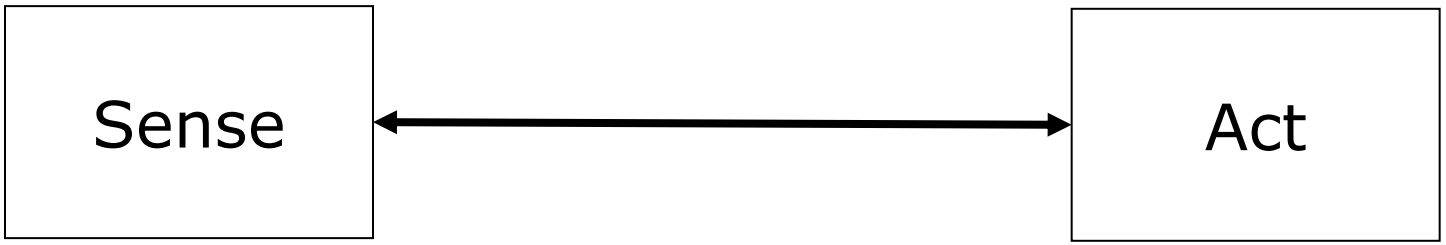
Classical Paradigm
Stanford Cart

1. Take nine images of the environment, identify interesting points in one image, and use other images to obtain depth estimates.
2. Integrate information into global world model.
3. Correlate images with previous image set to estimate robot motion.
4. On basis of desired motion, estimated motion, and current estimate of environment, determine direction in which to move.
5. Execute the motion.

Classical Paradigm as Horizontal/Functional Decomposition

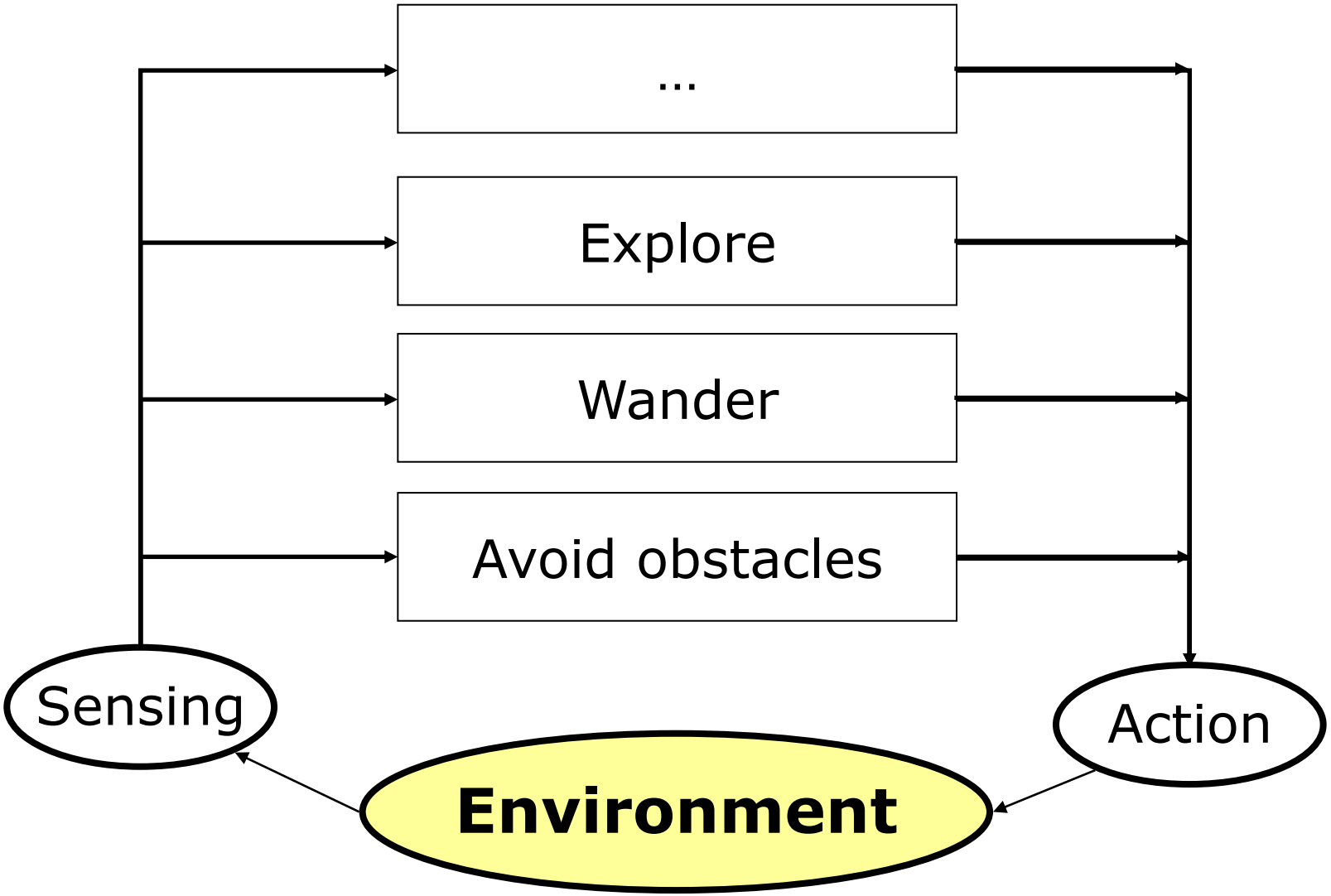


Reactive / Behavior-based Paradigm



- No models: The world is its own, best model
- Easy successes, but also limitations
- Investigate biological systems

Reactive Paradigm as Vertical Decomposition



Characteristics of Reactive Paradigm

- Situated agent, robot is integral part of the world.
- No memory, controlled by what is happening in the world.
- Tight coupling between perception and action via behaviors.
- Only local, behavior-specific sensing is permitted (ego-centric representation).

Behaviors

- … are a direct mapping of sensory inputs to a pattern of motor actions that are then used to achieve a task.
- … serve as the basic building block for robotics actions, and the overall behavior of the robot is emergent.
- … support good software design principles due to modularity.

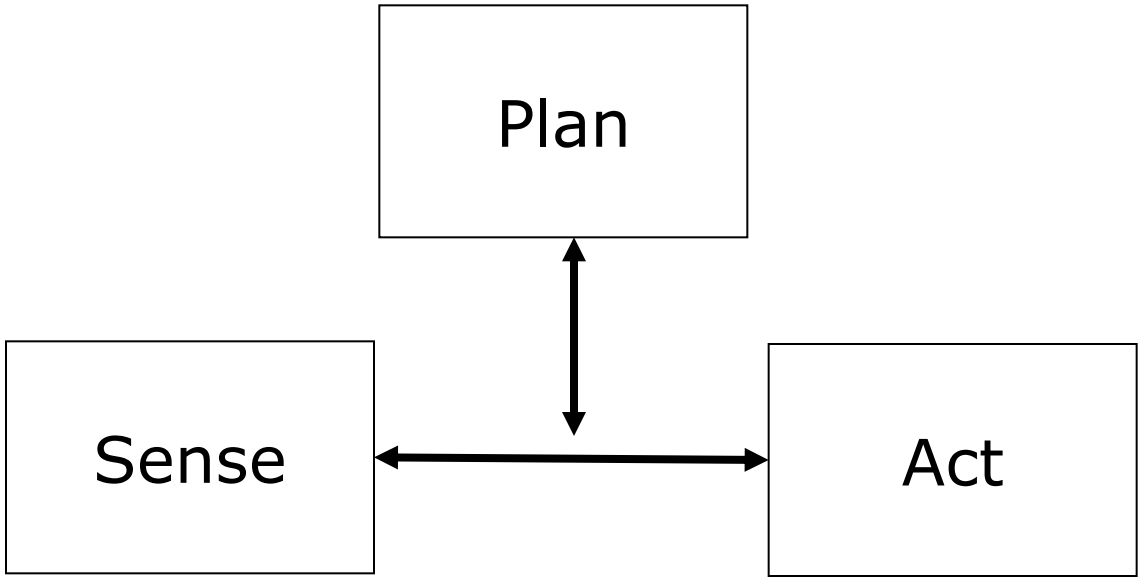
Subsumption Architecture

- Introduced by Rodney Brooks ’86.
- Behaviors are networks of sensing and acting modules (augmented finite state machines AFSM).
- Modules are grouped into layers of competence.
- Layers can subsume lower layers.
- No internal state!

Layers

- 0: Avoid contact with obstacles
- 1: Wander aimlessly around
- 2: Explore the world
- 3: Build a map of the environment
- 4: Notice changes in the static map
- 5: Reason about the world in terms of identifiable objects and perform tasks
- 6: Formulate and execute plans
- 7: Reason about behaviors of things and adapt plans accordingly

Hybrid Deliberative/Reactive Paradigm



- Combines advantages of previous paradigms
  - World model used for planning
  - Closed loop, reactive control

Discussion

- Imagine you want your robot to perform navigation tasks, which approach would you choose?
- What are the benefits and drawbacks of the behavior based paradigm?
- What are drawbacks of the subsumption architecture?