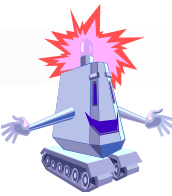# ECE497: Introduction to Mobile Robotics Lecture 6
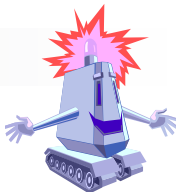
Dr. Carlotta A. Berry

Spring 06 - 07

Quote of the Week

"The danger of the past was that men became slaves. The danger of the future is that men may become robots."
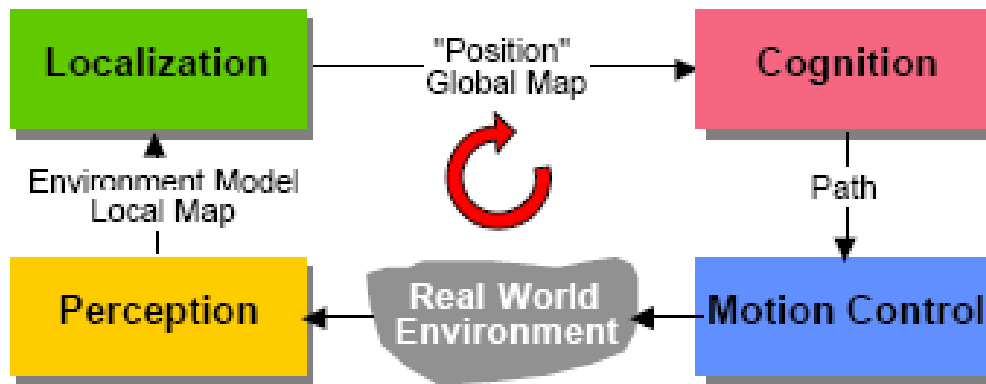
Erich Fromm

Control Architectures/Strategies

- Control Loop
  - *dynamically changing*
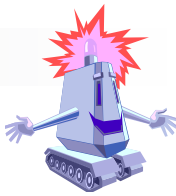 - *no compact model available*
  - *many sources of uncertainty*

- Two Approaches
  - *Classical AI*
    - o *complete modeling*
   - o *function based*
    - o *horizontal decomposition*

| Localization	"Position" Global Map →	Cognition
Environment Model Local Map		Path
Perception	← Real World Environment ←	Motion Control

  - *New AI, AL*
    - o *sparse or no modeling*
    - o *behavior based*
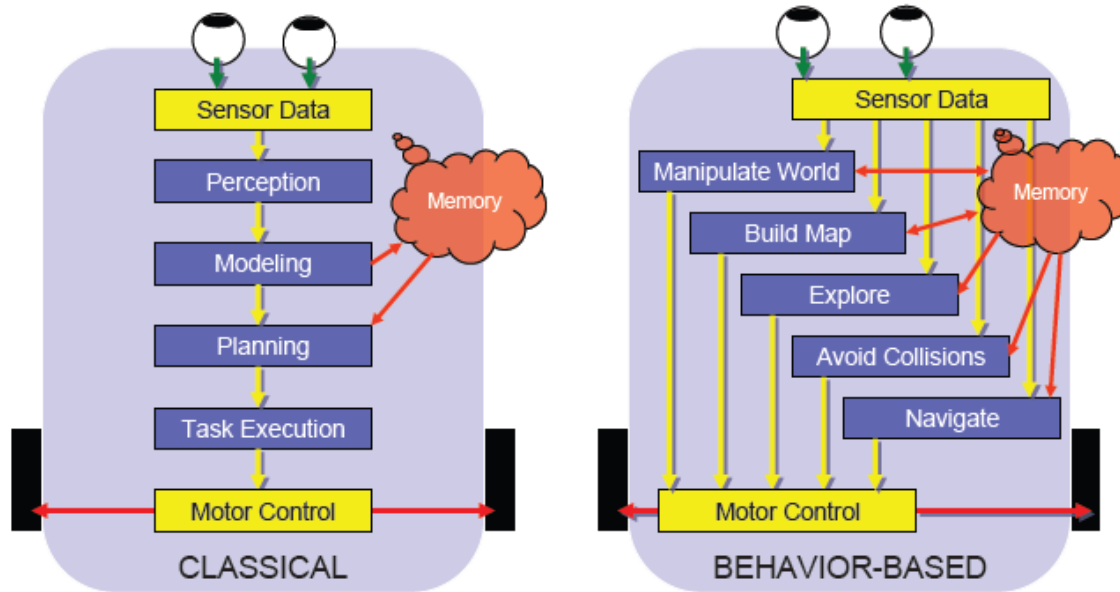   - o *vertical decomposition*
    - o *bottom up*
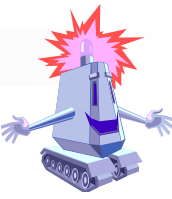
Control Architectures

- Robot control is the means by which sensing and action of a robot are coordinated

- Control architecture
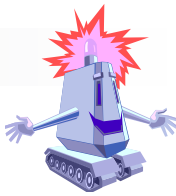 - Guiding principles and constraints for organizing a robot's control system

ECE 497: Introduction to Mobile Robotics
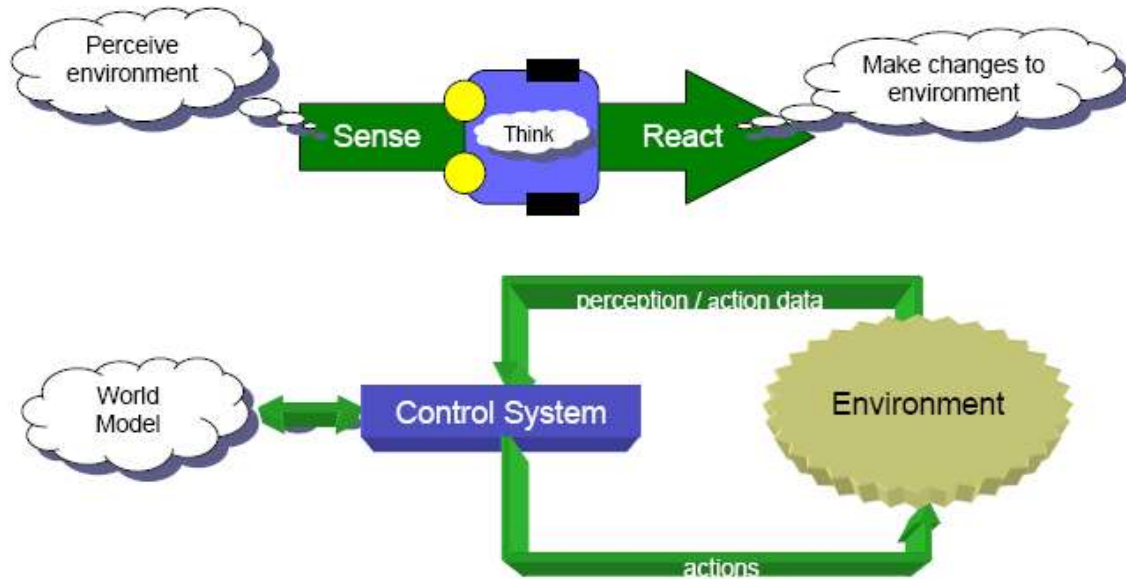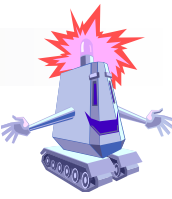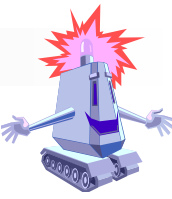
- Classical vs. Behavior-Based processing:

Types of Robot Control

- Reactive Control
- Deliberative (planner-based) control
- Hybrid control
- Behavior-based
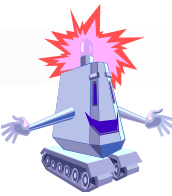
Reactive vs. Deliberative Control

- Reactive Control *(Don't think, react)*
  - ☐ Fast, regardless of complexity
  - ☐ Built-in or learned from looking in the past
  - ☐ Limited flexibility for increased complexity
- Deliberative control *(Think hard then act)*
  - ☐ Involves planning to avoid bad solutions
  - ☐ Flexible for increasing complexity
  - ☐ Slow, speed decreases with complexity
  - ☐ Requires large amounts of accurate information
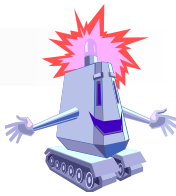
Hybrid Control
## Think and act independently and concurrently

- Combination of reactive and deliberative control
- Reactive layer (bottom): deals with immediate reaction
- Deliberative layer (top): creates plans
- Middle layer: connects the two layers
- Typically called the "three-layer systems"
- Reactive and deliberative layers have different time-scales and representations (signals, symbols)
- Hybrid control is one of the two dominant control paradigms in robotics

Behavior-based Control
## Think the way you act

- Inspired by biology
- Same capabilities as hybrid control
- Act reactively and deliberately
- Built from layers but no intermediate layer
- Has uniform representation and time-scale
- **Behaviors** – concurrent processes that take inputs form sensors and other behaviors and send outputs to a robot's actuators or other behaviors to achieve some goals
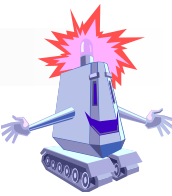
Behavior-based Control, cont.
Think the way you act

- Thinking performed through a network of behaviors
- Uses distributed representations
- Responds in real-time (reactive)
- Allows for a variety of behavior coordination mechanisms
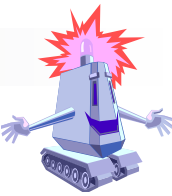
Differences in types of control
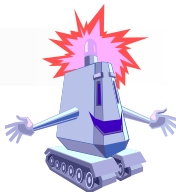
- **Time – Scale**
  - How quickly does the robot respond to the environment compared to how quickly it senses and thinks
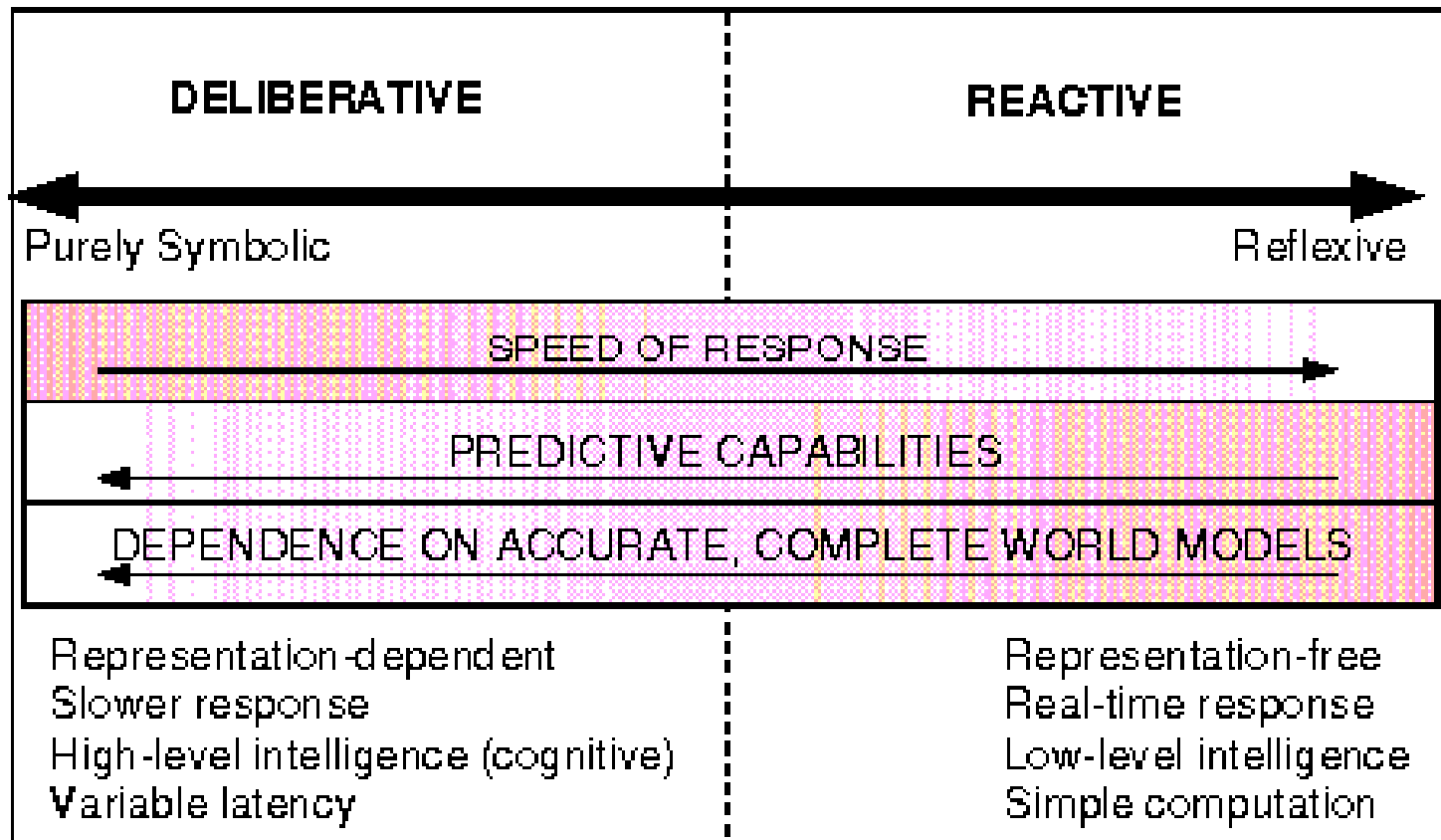
- **Modularity**
  - How is the control system separated into modules and how do they interact with each other
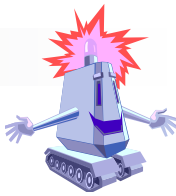
- **Representation**
  - The form in which information is stored in the robot

Spectrum of robot control

DELIBERATIVE	REACTIVE
Purely Symbolic	Reflexive

SPEED OF RESPONSE →

← PREDICTIVE CAPABILITIES

← DEPENDENCE ON ACCURATE, COMPLETE WORLD MODELS

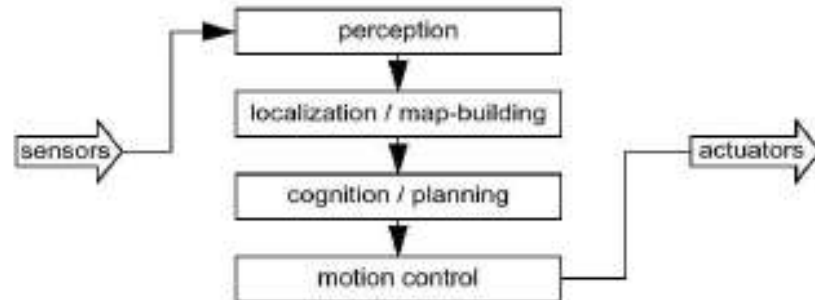|	
Representation-dependent	Representation-free
Slower response	Real-time response
High-level intelligence (cognitive)	Low-level intelligence
Variable latency	Simple computation

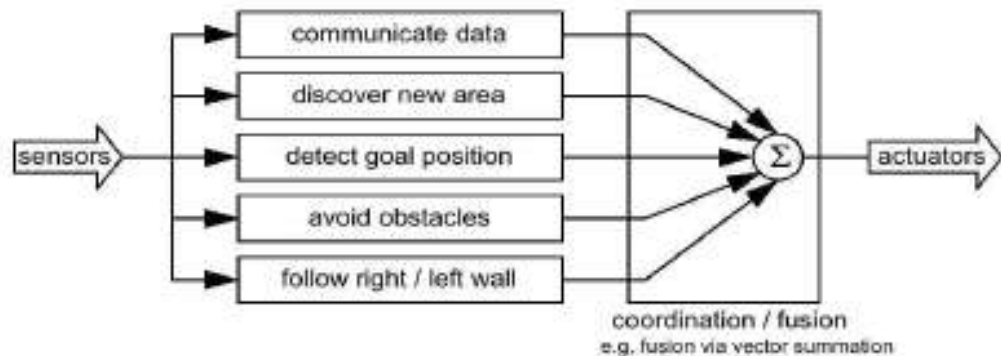From "Behavior-Based Robotics" by R. Arkin, MIT Press, 1998
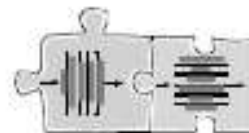
Two Approaches

- Classical AI
  (model based navigation)
  - *complete modeling*
  - *function based*
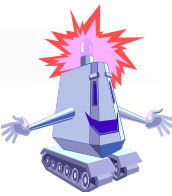 - *horizontal decomposition*

- New AI, AL
  (behavior based navigation)
  - *sparse or no modeling*
  - *behavior based*
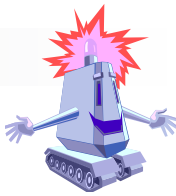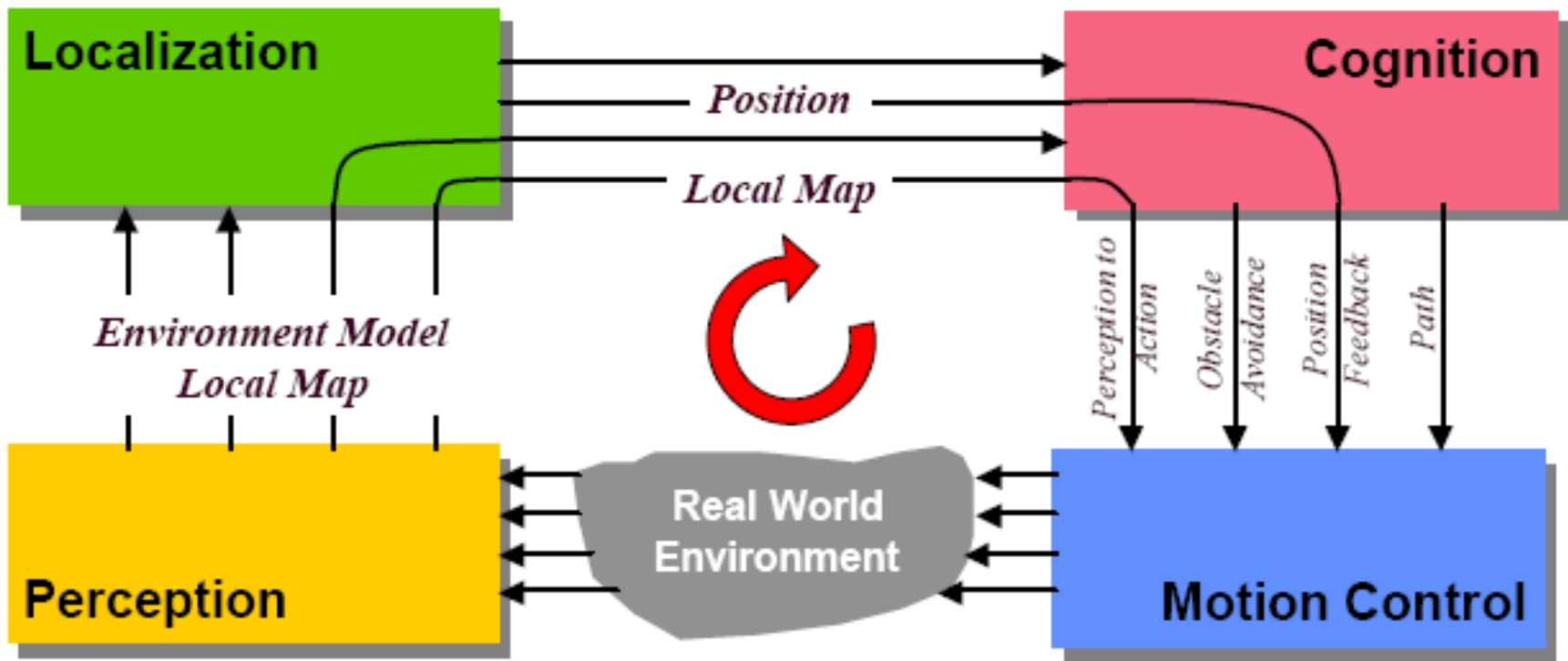 - *vertical decomposition*
  - *bottom up*

- Possible Solution
  - *Combine Approaches*

Mixed Approach

Control of Mobile Robots

- Most functions are 'local' and do not involve localization or cognition
- Localization and global path planning are slower and should be performed only when needed
- This is similar to what human beings do