

Cognition and Control

Bookkeeping



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- ◆ Quiz 4
 - ◆ Is up
- ◆ HW 4 – timing
- ◆ HW 5 – team participation
 - ◆ NEXT week
- ◆ Today: a very fast overview of some really hard topics

Autonomy



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- ◆ Intelligently, self-sufficiently, and safely **perform tasks**
- ◆ Without human control / intervention
- ◆ Learn about environment and tasks
- ◆ Adapt to changing situations
- ◆ Make and execute decisions

How?

Review: Intelligent Action...



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- | | |
|---|--|
| <ul style="list-style-type: none"> ◆ Physical tasks <ul style="list-style-type: none"> ◆ Or physical-related <ul style="list-style-type: none"> ◆ Sensing ◆ Path planning ◆ Understanding / modeling: <ul style="list-style-type: none"> ◆ The robot ◆ The environment ◆ The task | <ul style="list-style-type: none"> ◆ Autonomy ◆ Subtasks: <div style="border: 1px solid red; padding: 5px; margin: 5px 0;"> <ul style="list-style-type: none"> ◆ Knowledge Representation ◆ Search ◆ Planning ◆ Learning ◆ Inference </div> ◆ Coping with uncertainty |
|---|--|

Intelligent Action Needs...



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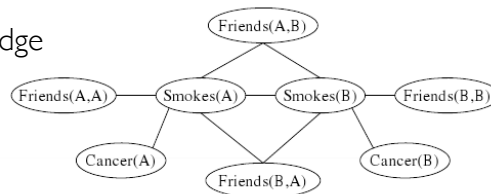
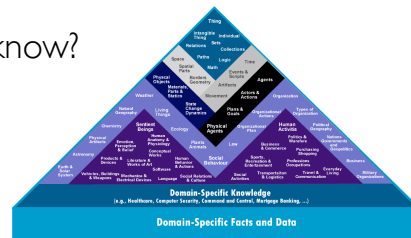
- ◆ Knowledge Representation
- ◆ Search
- ◆ Planning
- ◆ Learning
- ◆ Inference

Knowledge Representation



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- ◆ What does a robot need to know?
- ◆ What would it be useful for a robot to know?
- ◆ Types of knowledge
 - ◆ Background Knowledge
 - ◆ Task-Specific Knowledge
 - ◆ Explicit vs. Implicit Knowledge
- ◆ Representation Choices
 - ◆ Probabilistic?
 - ◆ Human-understandable?

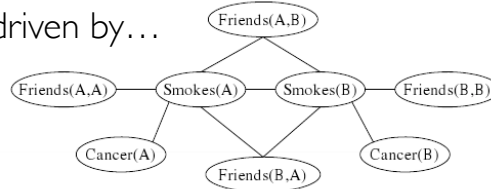
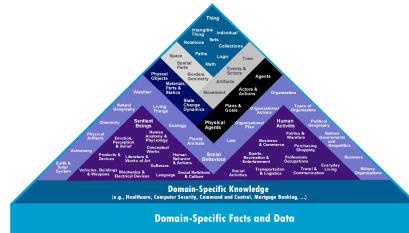


KR: Approaches



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- ◆ Hand-coded knowledge
 - ◆ E.g., maps, object recognition, task descriptions, ...
- ◆ Machine learning
 - ◆ Beforehand
 - ◆ On-the-Fly
- ◆ Representation choices driven by...
 - ◆ Efficiency
 - ◆ Requirements
 - ◆ Our limited abilities

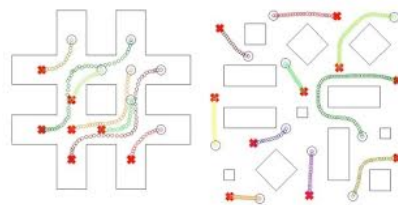
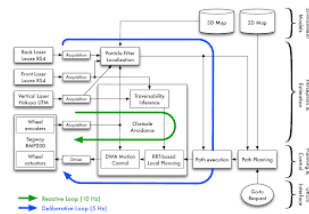


Planning



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- ◆ What does a robot need to plan?
- ◆ Motion
 - ◆ Mobility: where am I going?
 - ◆ Manipulation: how do I move myself?
- ◆ Tasks
 - ◆ Low-level: pick up this piece
 - ◆ High-level: win this chess game
- ◆ Steps to Goals
- ◆ Step Ordering

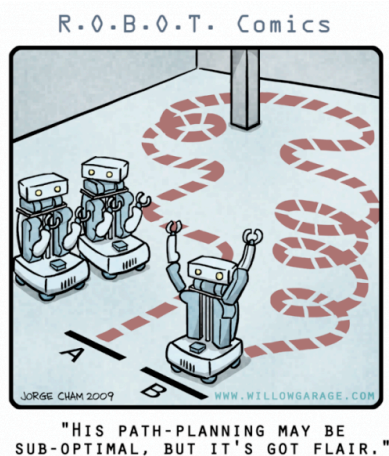


Planning: Approaches



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- ◆ Explicit plan space
 - ◆ Rule-based
 - ◆ Probabilistic
 - ◆ Ordered (scripted)
- ◆ Implicit plan space
 - ◆ Learned task performance
 - ◆ Learning from demonstration
 - ◆ Reinforcement learning
 - ◆ Procedural planning
- ◆ Non-planned (rigid) behavior

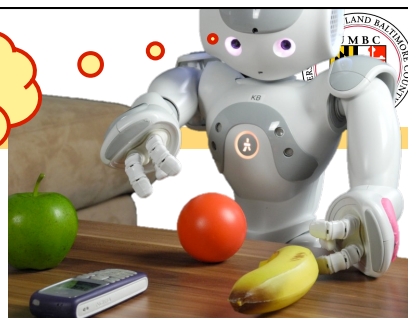


Learning

'orange'?

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- ◆ Why do learning?
 - ◆ Hard to program tasks
 - ◆ More effective performance
 - ◆ Flexibility and autonomy
- ◆ What can be learned?
 - ◆ Previously unknown environment, objects, etc.
 - ◆ Previously unknown tasks
 - ◆ Background knowledge
- ◆ Machine Learning Approaches

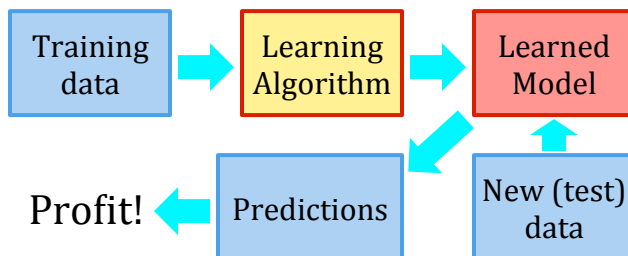


Learning: Approaches



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- ◆ Machine Learning
 - ◆ Approaches: Learning from demonstration, reinforcement learning, real-time search, statistical model-building, feature extraction, ensemble learning, active learning, lifelong learning, reading-based learning, learning to read, ...
- ◆ Fundamental concept: data-driven learning



Inference



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- ◆ What is inference?
- ◆ When?
 - ◆ During planning
 - ◆ During execution
- ◆ Why?
 - ◆ Data integration
 - ◆ Higher-level ideas
 - ◆ Find applications of rules
- ◆ Deduction, Induction, Abduction

$$\therefore \frac{p \rightarrow q}{p} q$$

Search



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- ◆ Knowledge Representation
 - ◆ Which bit of knowledge?
- ◆ Planning
 - ◆ What rules to apply?
 - ◆ Of many steps / paths / subgoals, which is best?
In what order?
 - ◆ What is the goal?
- ◆ Inference
 - ◆ What rules to apply?
 - ◆ What form to apply?
 - ◆ Truth maintenance
- ◆ Learning
 - ◆ Usually NP-complete
 - ◆ Algorithms and learning methods