Cognition and Control

Bookkeeping

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

- 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?**

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**Review: Intelligent Action...**

- Physical tasks
  - Or physical-related
    - Sensing
    - Path planning
- Understanding / modeling:
  - The **robot**
  - The **environment**
  - The **task**
- Autonomy
- Subtasks:
  - Knowledge Representation
  - Search
  - Planning
  - Learning
  - Inference
  - Coping with uncertainty
Intelligent Action Needs...

- Knowledge Representation
- Search
- Planning
- Learning
- Inference

Knowledge Representation

- 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**

- 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**

- 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

- 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

- 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

'HIS PATH-PLANNING MAY BE SUB-OPTIMAL, BUT IT’S GOT FLAIR.'
Learning: Approaches

- 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

![Diagram of the learning process]

Inference

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

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