Robotics Overview

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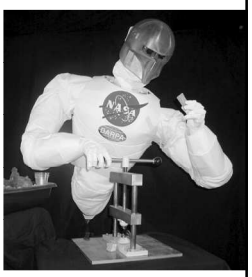
CPS 170

What is robotics?

- Mechanical man ideas go back at least to the Greeks
- Term comes from Czech playwright Karel Capek (or perhaps from his brother Josef) ~1917-1921
  - "robota" (obligatory work)
  - "robotnik" (serf)
- "Robotics" first used by Asimov in 1950
- Agents with physical embodiment
  - Sensors
  - Effectors
- Human-shaped robots = humanoids

Common Robot Applications

- Industry and agriculture
  - Building cars
  - Harvesting crops
- Mapping and Exploration
  - Mines
  - Mars
- Transportation
  - Delivery of mail/equipment
  - Military applications
- Medical devices
- Household aids
- Entertainment
- Human augmentation



Robot Effector Types

- Many effector types simply move the robot
  - Wheels
  - Tracks
  - Legs
- Robot arms/hands
  - Usually not attached to mobile robots (some exceptions)
  - Used in factory automation

Robot Effector Complexity

- Degree of Freedom (DOF)
  - Independent direction of movement
  - Rigid body in space = 6DOF (X, Y, Z, yaw, roll, pitch)
- Dynamic state (DOF x2 for derivatives)
- Effective DOF can be > true DOF
  - e.g. car (2 actual, 3 effective)
  - effective > true = nonholonomic

Types of Robot Sensors

- Cameras
- Laser/Sonar/IR range finders
- Microphones
- Odometers
- Inertial sensors
- GPS
- Force/Torque/touch sensors

Perception

- Perception is often a probabilisitc inference problem
- Want P(S|O) (state given observations)
- Model P(O|S) (sensor model)
- Use Bayes rule
- Localization (position estimation) is an HMM tracking problem (next lecture)

Motion Planning

- Planning is typically done in configuration space
- Configuration space includes
  - Physical position
  - Orientation
  - Joint Angles
- Path planning problem: Find path between two points in configuration space

Challenges of Configuration Space

- Problems are typically specified in a working space – which underdetermines the configuration
- Obstacles
  - Problematic in “real” space
  - Even simple shapes become complicated in configuration space

Approaches to Planning

- Cell decomposition (discretization)
  - Break continuous space into discrete cells
  - Plan using search or MDP (covered later) techniques
- Discretization issues
  - Doesn’t scale well with dimension
  - Only an approximation

Approaches to Planning

- Skeletonization
  - Define a graph of connected points in free space
  - Planning = search on the graph
- Problem: Constructing the graph
- Probabilistic Road Map (PRM)
  - Randomly spray points
  - Discard illegal ones
  - Connect nearby ones
  - Plan on resulting graph
  - Incomplete in general
  - Succeeds WHP under some assumptions

Executing Plans

- Skeletonization assumes deterministic movement – may require replanning
- MDP techniques (discussed in detail later) devise a universal plan for all (discrete) states
- Control theory can be used for continuous problems to keep the robot on track

Reactive Control

- Some say that roboticists over-formalize
- Reactive control advocates hard coding simple, reactive mechanisms
- Works very well for some problems
- Does it scale?

Conclusions

- Robotics is a huge field – as large as AI itself
- Fertile ground for many AI techniques
- Involves many issues not directly addressed by typical AI approaches
  - Sensing issues
  - Effecting issues