CS 188: Artificial Intelligence
Fall 2009

Advanced Applications:
Robotics / Vision / Language

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Many slides from Sebastian Thrun, Pieter Abbeel, Jitendra Malik

Announcements
- Grades in glookup:
  - W1-2, P1-3, Midterm (and all regrades)
  - Let us know if there are any issues
- Contest: qualifiers!
  - Congrats to current qualifiers
  - Qualification closes on 11/30

So Far: Foundational Methods

Now: Advanced Applications

Autonomous Vehicles

Grand Challenge: Barstow, CA, to Primm, NV

150 mile off-road robot race across the Mojave desert
Natural and manmade hazards
No driver, no remote control
No dynamic passing

[DEMO: GC Bad, Good]
An Autonomous Car

Actions: Steering Control

Sensors: Laser Readings

Readings: No Obstacles

Obstacle Detection

Readings: Obstacles

[DEMO:]

Obstacle Detection

Trigger if |Z_i - Z_j| > 15cm for nearby Z_i, Z_j

Raw Measurements: 12.6% false positives
Probabilistic Error Model

HMMs for Detection

Environmental Tracking

Sensors: Camera

Object Recognition

Shape Context

Raw Measurements: 12.6% false positives

HMM Inference: 0.02% false positives

Count = 4

Count = 10

Compact representation of distribution of points relative to each point

Vision slides adapted from Jianda Malik
Shape Context

Similar Regions
Color indicates similarity using local descriptors

Match for Image Similarity

Vision for a Car

Self-Supervised Vision

Complex Robot Control
Robotic Control Tasks

- Perception / Tracking
  - Where exactly am I?
  - What's around me?

- Low-Level Control
  - How to move from position A to position B
  - Safety vs efficiency

- High-Level Control
  - What are my goals?
  - What are the optimal high-level actions?

Low-Level Planning

- Low-level: move from configuration A to configuration B

A Simple Robot Arm

- Configuration Space
  - What are the natural coordinates for specifying the robot's configuration?
  - These are the configuration space coordinates
  - Can't necessarily control all degrees of freedom directly

- Work Space
  - What are the natural coordinates for specifying the effector tip's position?
  - These are the work space coordinates

Coordinate Systems

- Workspace:
  - The world's (x, y) system
  - Obstacles specified here

- Configuration space
  - The robot's state
  - Planning happens here
  - Obstacles can be projected to here

Obstacles in C-Space

- What / where are the obstacles?
- Remaining space is free space

Example: A Less Simple Arm

[DEMO]
Probabilistic Roadmaps

- Idea: sample random points as nodes in a visibility graph
- This gives probabilistic roadmaps
  - Very successful in practice
  - Lets you add points where you need them
  - If insufficient points, incomplete or weird paths

High-Level Control

- Demonstrate path across the “training terrain”
- Run apprenticeship learning to find a set of weights \( w \)
- Receive “testing terrain” (a height map)
- Find a policy for crossing the testing terrain.

High DOF Robots [DEMO]

Videos from Pieter Abbeel, Jean-Claude Latombe