Robotics

R&N: ch 25

based on material from Jean-Claude Latombe, Daphne Koller, Stuart Russell

Sensors

- Sensors that tell the robot position/change of joints: odometers, speedometers, etc.
- Force sensing. Enables compliant motion--robot just maintains contact with object (video: compliant)
- Sonar. Send out sound waves and measure how long it takes for it to be reflected back. Good for obstacle avoidance.
- Vision systems

Effectors

- Converts software commands into physical motion
- Typically electrical motors or hydraulic/pneumatic cylinders
- Two main types of effectors:
  - locomotion
  - manipulation

Locomotion

- Legs!
  - traditional (video: honda human)
  - Other types
    - Statically stable locomotion: can pause at any stage during its gate without falling
    - Dynamically stable locomotion: stable only as long as it keeps moving (video: hopper)
- Still, wheeled or tread locomotion like Shakey is still most practical for typical environments
- Other methods: reconfigurable robots, fish robots, snake-like robots. (video: mod-robot)

Manipulation

- Manipulation of objects
- Typical manipulators allow for:
  - Prismatic motion (linear movement)
  - Rotary motion (around a fixed hub)
- Robot hands go from complex anthropomorphic models to simpler ones that are just graspers
  - (video: manipulation)
  - (video: heart surgery)
Problems in Robotics
- Localization and Mapping
- Motion planning

Localization: Where Am I?
- Use probabilistic inference: compute current location and orientation (pose) given observations

Motion Planning
- Simplest task that a robot needs to accomplish
- Two aspects:
  - Finding a path robot should follow
  - Adjusting motors to follow that path
- Goal: move robot from one configuration to another

Configuration space
- Describe robot's configuration using a set of real numbers
- Flatland — robot in 2D — how to describe?
- Degrees of freedom: a robot has k degrees of freedom if it can be described fully by a set of k real numbers
  - e.g. robot arm (slide)
- Want minimum-dimension parameterization
- Set of all possible configurations of the robot in the k-dimensional space is called the configuration space of the robot.

Example
- Workspace for 2-D robot that can only translate, not rotate
- Configuration space describes legal configurations
  - Free-space
  - Obstacles
- Configuration space depends on how big robot is—need reference point

Path planning
- Goal: move the robot from an initial configuration to a goal position
- Path must be contained entirely in free space
- Assumptions:
  - Robot can follow any path (as long as avoids obstacles)
  - Dynamics are completely reliable
  - Obstacles known in advance
  - Obstacles don't move
Assumption #1
- robot can follow any path
- what about a car?
- degrees of freedom vs. controllable
- degrees of freedom
  - holonomic (same)
  - nonholonomic
  - (video: holonomic)

Motion planning
- reduces to problem of finding a path
  from an initial state to a goal in robot’s
  configuration space
- why is this hard?

Reformulate as discrete search
- finely discretized grid
- cell decomposition: decompose the space into
  large cells where each cell is simple, motion
  planning in each cell is trivial
- roadmap (skeletonization) methods: come up
  with a set of major “landmarks” in the space
  and a set of roads between them

Issues in Search
- Complete
- Optimality
- Computational Complexity

Motion planning algorithms
- grid
- cell decomposition
  - exact
  - approximate
- roadmap (skeletonization) methods:
  - visibility graphs
  - randomized path planning

Robotics: Summary
- We’ve just seen a brief introduction...
- Issues:
  - sensors, effectors
  - Locomotion, manipulation
- Some problems:
  - Localization
  - Motion Planning
- Lots more!!