CogSysI Lecture 14: Robotics

Intelligent Agents
WS 2006/2007

Part III: Multiagent System

Physical Agents: Robotics
Mobile Robots

NASA’s Sojourner (Mars, July, 1997) and Asimo humanoid robots
Mobile Robots

Marc Raibert’s legged robot

Sony AIBO
Robot Categories

- Manipulators: controllable joints
  Industry (over a mio world wide), hospitals

- Mobile Robots: moving with wheels or legs
  unmanned land vehicle (e.g. planetary rovers),
  unmanned space vehicle, autonomous underwater vehicle

- Humanoid Robots

- Prothetetic devices, intelligent environments, multibody systems (swarms)
Robot Hardware

- Sensors
- Effectors
- Power (electric motor)
- Frame
Sensors

- Passive: cameras, capture signals generated by other sources
- Active: sonar, send energy which is reflected back (provide more info but increased power consumption, danger of interference)
- Range finders: sonar (land, underwater), laser, radar (aircraft), tactile, GPS
- Imaging: cameras
- Proprioceptive sensors (e.g. for odometry)
Laser Range Scanner
Effectors

- Degrees of Freedom (DOF)
- 1 DOF for each direction an effector can move
- E.g. free-moving robot: 3 DOF for location \((x, y, z)\), 3 DOF for orientation (roll in \(x\), pitch in \(y\), yaw in \(z\))
- 6 DOF define the kinematic state (pose)
- Dynamic state: includes rate of change for each dimension (velocity)
- Robot joints: 1, 2, or 3 DOF
Stanford Manipulator

(5 revolute joints, 1 prismatic joint, 6 DOF)
Non-holonomic Robots

- More DOF than controls
- e.g. car: 2 controls (move fwd/bwd, turn) but 3 DOF ($x$, $y$, orientation)
- holonomic robots are more easy to control (move car sideways to park)
Perception

- Determining own position and position of landmarks, obstacles, moving objects
- Localization: given map and observed landmark, update pose distribution
- Mapping: given pose and observed landmarks, update map distribution
- Simultaneous localization and mapping (SLAM): given observed landmarks, update pose and map distributions
Localization

Compute current location and orientation (pose) given observations:

\[ X_{t+1} = X_t + A_t Z_t - A_{t-1} Z_{t-1} - A_{t-2} Z_{t-2} \]

Dynamic Bayes Network
Updating Belief States

Filtering

current state: \( P(X_t|z_{1:t}, a_{1:t-1}) \)

update

\[
P(X_{t+1}|z_{1:t+1}, a_{1:t}) = \alpha P(z_{t+1}|X_{t+1}) \int P(X_{t+1}|x_t, a_t) P(x_t|z_{1:t}, a_{1:t-1}) \, dx_t
\]

recursive calculation from corresponding estimate one time step earlier

continuous values: integration, discrete values: summation
Types of Localization

- tracking (initial position known)
- global localization (initial position unknown)
- kidnapping problem (object may disappear and reappear)
Simple Kinematic Model

\[ \hat{X}_{t+1} = f(X_t, v_t, \omega_t) = X_t + \begin{pmatrix} v_t \Delta t \cos \theta_t \\ v_t \Delta t \sin \theta_t \\ \omega_t \Delta t \end{pmatrix} \]

where \( X_t = (x_t, y_t, \theta_t)^T \)

- \( v_t \) is translational velocity
- \( \omega_t \) is rotational velocity

For physical robots: modelled with Gaussian distribution
Kinematic Model

\[ x_i, y_i, v_t \Delta t, \theta_t, \omega_t \Delta t, \theta_{t+1} \]

\[ h(x_t) \]

\[ x_t, x_{t+1} \]

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Range Scan Sensor Model

left pose is more likely to have generated the scan
Mapping
Motion Planning

Plan in configuration space defined by robot’s DOFs
Configuration Space
Current Trends

- Autonomous navigation
- Working in teams of mixed experts (rescue league)