RSS I: Recap, and What's Next?

RSS Lecture 21

Wednesday 15 May 2013

Prof. Teller

TODAY (final class meeting)

- CI-M evaluations (paper)
  - Distributed by Ms. Connor
  - 10 minutes to fill out at end of class meeting
  - Collected by student, returned to WP office
- Recap of RSS
  - Prof. Teller
- Reminder: online subject evaluations!
  - Please fill them out *after* the challenge runs

Key Questions

- What were we trying to do in RSS?
- What we covered this term:
  - In Lecture
  - In Forum
  - In Lab
- Where might you go from here?
  - Other robotics-related activities at MIT and beyond

RSS I: Teaching Objectives

- Intensive introduction to mobile robotics
  - Focus on autonomous mobility & manipulation
  - End-to-end, systems perspective on robotics
  - Exposure to fundamental robotics algorithms
  - Mens et manus: lecture and lab
    - Hands on literally every aspect of a mobile robot
    - Generalists! With depth in some area of interest
  - Course challenge: 4-7 week scope
    - Authentic, intense team-based design experience
    - Flexibility to choose your technical focus, roles
- Communication
  - Briefings, engineering documents, schedules
  - Team techniques, coordination and dynamics
  - Debates: arguing policy and ethical perspectives

Robot Architectural Layers

- Actuators and encoders
  - DC motor, shaft encoder
- Controller board architecture
  - Power, data, low-level control
- Host-based signal-level control
  - PWM to controller; closed-loop feedback
- Reactive behavior w/ analog sensing
  - Braitenberg with photoresistors
- ... All of this was managed by you
  - Code to sample photoresistor values, integrate odometry, control motors etc.

More abstraction layers: ROS

- One of several available robot “O/S’s”
  - Publish/subscribe message abstraction
  - Message-based event handling
  - Odometry and sensor time-stamping
  - Open-source, packages, extensibility
- Alternatives:
  - USC Player/Stage
  - Microsoft RDS
  - CMU Carmen
  - MIT LCM (somewhat lower-level)
  - ...

Higher-level Capabilities

- Object detection & visual servoing
  - Rudimentary computer vision, motion control
- Wall-following / local mapping
  - Filtering and estimation from noisy sonar data
- Global path planning and execution
  - Provided map, cast planning as search
- Manipulation
  - Inverse kinematics of a 3-DOF manipulator
  - Position-controlled servos, integration w/ vision
- Mobile manipulation
  - Coordinated motion, manipulation for building

Things We Didn't Get To

- Practical localization and SLAM
  - Fused odometry, bump, sonar, vision, ...
- State estimation
  - Inference under uncertainty (e.g. Kalman filter), ...
- High-level machine vision
  - E.g. features, structure from motion, object recognition, ...
- Human-robot interaction
  - Speech, gesture, shared mental models, ...
- High-level planning
  - Action selection, unstructured environments, ...
- Distributed operation
  - Communicating & coordinating bots, swarms, ...
  - Human-robot teaming

Whole Areas We Didn't Get To

- Factory automation
- Walking, flying, swimming, climbing robots
- Biologically-inspired robots
- Medical robotics & haptics
- Mobile manipulation robots
- Space robotics
- Learning robots
- Assistive robots & exoskeletons
- Field and service robots
- Evolutionary robotics
- Neurorobotics

Where might you go from here?

- EECS subjects
  - Machine vision, RSS II, Underactuated robotics, Assistive technology, Machine learning, Inference and information, …
- Aero/Astro subjects
  - Real-time systems and software, Cognitive robotics, …
- MechE subjects
  - Robotics, Design of electromechanical robotic systems, Probabilistic methods for robotics, Hands-on marine robotics, …
- Media Lab subjects
  - Human-robot interaction, Human 2.0
- IAP competitions
  - 6.270, MASlab
- UROPs, LA'ing, 6.UAP, MEng, etc.

Robotics Research at MIT

- Research (UROP, UAP, MEng, SM, PhD)
  - RRG (Nick Roy)
  - RLG (Tedrake)
  - RVSN (Teller)
  - DRG (Rus)
  - CMG (Deb Roy)
  - SMG (Breazeal)
  - IRG (Shah)
  - ARES (Frazzoli)
  - MERS (Williams)
  - LIST (Asada)
  - BRL (Kim)
  - HAL (Cummings)
  - IRG (Shah)
  - NSL (Slotine)
  - Biomechatronics (Herr)
  - LISG (TLP, LPK)
  - COE (Leonard)
  - ACL (How)
  - HRG (Hover)

Robotics research post-MIT

- Academic labs
  - Berkeley, Stanford, U. Washington, CMU Robotics Institute, Penn GRASP Lab, Georgia Tech, Virginia Tech, IHMC (Florida Inst. for Human & Machine Cognition), ...
- Industrial labs
  - Honda, Toyota, Mitsubishi, Microsoft, Google, ...
- Government labs
  - NASA JPL, NASA Johnson, NRL, ARL, ONR, NIST, ARDEC, Dept. of Energy, Sandia, ...

Industry (small sample)

- iRobot, Kinetiq, …
- Adept, Kiva Robotics, …
- Jaybridge, Harvest Automation, …
- Mitsubishi (Wakamaru), Aldebaran, Willow Garage, PAL, …
- Rethink Robotics, …
- Boston Dynamics, …
- Intuitive (DaVinci), Titan, …
- Rewalk, Indego (exoskeletons), …
- John Deere, Ford, Honda, Toyota, …
- OSRF (non-profit)

Summarizing…

- Tried to give you a *taste* of robotics:
  - In all its interdisciplinary richness: geometry, inference, estimation, optimization, physics, mechanical engineering, electrical engineering, computer science, cognitive science, …
- … and as an *engineering* endeavor
  - Systems thinking
  - Engineering tools and methods
  - Managing constraints, complexity
  - Spiral dev't, deadlines and milestones
  - Team dynamics

At the end of the day (term!)

- RSS is a real engineering experience
  - Structured component (lectures, labs)
  - Less-structured component (challenge)
- With deliverables, communications
  - Briefings, proposal drafts/revisions, debate
- Regardless of where you are headed
  - We hope that the tools and techniques we practiced in RSS will serve you well
- Best of luck in all that you do next!