RSS I: Recap, and What’s Next?

RSS Lecture 21
Wednesday 14 May 2014
Prof. Teller

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: adopting policy and ethical perspectives

Robot Architectural Layers

• Actuators and sensors
  – DC motor, shaft encoder

• Controller board architecture
  – Power, data, low-level control

• Host-based signal-level control
  – PWM to controller; closed-loop feedback

• ... All of this was managed by you
  – Code to sample and filter sensor 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, 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.**

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**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)
  - SKL (Karaman)
  - LIST (Asada)
  - BRL (Kim)
  - NSL (Slotine)
  - Biomechatronics (Herr)
  - LISG (TLP, LPK)
  - COE (Leonard)
  - ACL (How)
  - HRG (Hover)
  - TBD (Rodriguez)
Robotics research post-MIT

- **Academic labs**
  - Berkeley, Stanford, U. Washington, CMU Robotics Institute, Penn GRASP Lab, Georgia Tech, Caltech, Brown, Virginia Tech, IHMC (Florida Inst. for Human and Machine Cognition), ...

- **Industrial labs**
  - Honda, Toyota, Microsoft, Google, ...

- **Government labs**
  - NASA JPL, NASA Johnson, NRL, ARL, ONR, NIST, ARDEC, Dept. of Energy, Sandia, ...

Industry (small sample)

- FANUC, ABB, Honeywell, Siemens, GE, ...
- iRobot, Kinetiq, ...
- Adept, Kiva Robotics*, ...
- Aldebaran, ...
- Rethink, Boston Dynamics*, Meka*, ...
- Intuitive (DaVinci), Titan, ...
- Rewalk, Indego (exoskeletons), ...
- John Deere, Harvest Automation, ...
- Ford, Honda, Toyota, ...
- OSRF (non-profit)
- Google
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!
Lastly

• Reflection
  – Please email it to us by midnight Thursday

• Online subject evaluations!
  – Please do them