CS 378: Autonomous Intelligent Robotics
FRI II

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http://justinhart.net/teaching/2017_fall_cs378/

Today

- What makes a good project?
- Project Ideas
- Team Formation

Good Projects

- Start with a goal
  - A good scientific question
  - A novel method that can be fully implemented
- Your job is then to become informed
  - How do you know that your question is good?
  - How do you know that your method is novel?
  - **Answer: <u>Literature Survey</u>**

What is a literature survey?

The process

- Find out what work precedes yours
- Find the major conferences and journals discussing your topic
- Find what others have hypothesized, and tested
- Is there a standard test regarding your question?

Example: My dissertation

- Previous mirror papers, mirror work in animals
- Robotics & AI conference, psych journals
- Bayesian approaches, image-based approaches
- The “mirror test”

Literature Surveys

- Situate your work in the literature
- In the case of scientific questions, inform your hypotheses and methods
- In the case of development, inform you of the state-of-the-art and help you to make good design decisions

Several Types of Class Projects

- A self-contained research project
- Groundwork for work that the lab will continue
- Development of needed infrastructure

Self-Contained Projects

- Should ask a relevant scientific question
- Should have all development take place during the semester
- Should be thoroughly tested
- Final report should report on scientific findings

Self-Contained Projects

- Example: **No Fair!! An Interaction with a Cheating Robot.**
  - Started as a class project
  - Was completed the following Summer/Fall
  - Asked what happens when a robot cheats.
    - Found attributions of agency, higher participant engagement
- Actually seeing a project through to publication will probably take more than this semester

Recently Published

- Signaling, Teaching, Navigation
  - Passive Demonstrations of Light-Based Robot Signals for Improved Human Interpretability
    - Rolando Fernandez, Nathan John, Sean Kirmani, Justin Hart, Jivko Sinapov, and Peter Stone
  - Appeared at RO-MAN 2018, where I was during your first class
  - Part of a master's thesis
- Semantic Mapping
  - PRISM: Pose Registration for Semantic Mapping
    - Justin W. Hart, Rishi Shah, Sean Kirmani, Nick Walker, Kathryn Baldauf, Nathan John, and Peter Stone, to appear at IROS in October!
  - Rishi's master's thesis will extend this
  - More projects this fall!

Recently Accepted

- Interaction and Autonomy in RoboCup@Home and Building-Wide Intelligence
  - Justin Hart, Harel Yedidsion, Yuqian Jiang, Nick Walker, Rishi Shah, Jesse Thomason, Aishwarya Padmakumar, Rolando Fernandez, Jivko Sinapov, Raymond Mooney, Peter Stone
  - AAAI FS: AI-HRI
- LAAIR: A Layered Architecture for Autonomous Interactive Robots
  - Yuqian Jiang, Nick Walker, Minkyu Kim, Nicolas Brissoneau, Daniel S. Brown, Justin W. Hart, Scott Niekum, Luis Sentis, and Peter Stone
  - AAAI FS: Reasoning and Learning in Real-World Systems for Long-Term Autonomy

In Submission

- 1 paper to AAAI
- 1 paper to ICRA

In Planning

- 1 paper to HRI
- 1 paper to CHI

Projects in Progress

- Building a 3D printable robot head for HRI experiments
- Gaze production with a virtual agent
- Plan summarization
- More semantic mapping work

Groundwork

- Very similar to a self-contained project
- Works on an area or topic of **known** interest to the BWI lab
- More ambitious than self-contained project, not intended to be completed in 1 semester
- Still performs: Lit survey, Development, Testing
- However, where it ends is negotiated with instructor and is more flexible
- Not a guarantee of a scholarship, mentor position, or future employment
  - This may be continued by other members of the lab

Infrastructure

- Not experimentally-based
- Develops necessary equipment or software
- Literature survey used to establish that state-of-the-art techniques are used
- Intended to be completed entirely during the semester
- Testing demonstrates the capability and that the system works
- Still must write all reports
- May have experimental / novel components

Project Idea: Imaging Turntable

- Type: Infrastructure
- Goal: Build and program a turntable that objects rest on for imaging from multiple angles
- Purpose:
  - 3D reconstruction
  - Object recognition
- Immediate Plans
  - Object recognition for RoboCup@Home and Semantic Mapping

Project Idea: Imaging Turntable

- Scope of work:
  - Design & manufacture or purchase a turntable
    - 3D printing, machining, servos, drivers, arduino
  - Controller for turntable
  - 2D/3D image capture
  - 3D point cloud merging, stitching, reconstruction
  - Device calibration for turntable & camera

Project Idea: Task Re-Entry

- Type: Infrastructure & Long-Term Research
- Goal: The BWIBot should be able to perform one task, be requested to perform another task, then return to the original task.
- Purpose: Enable the BWIBot to have its tasking interrupted

Project Idea: Task Re-Entry

- This is a pretty big challenge
- Consider this
  - The robot’s task involves navigating from place to place.
  - It is interrupted.
  - Now it’s in a new place. Is its old plan still valid? What parts are done? Which have been undone? What must change?

Project Idea: Drive Up and Say Hi

- Type: Long-Term Research
- Goal: What should a service robot be able to do? What do people want?
- Purpose: Learn what people want from a BWIBot, support long-term interaction.

Project Idea: Drive Up and Say Hi

- How it unfolds is like this.
  - Have the robot “patrol.”
  - See if people talk to it, if you can approach them.
  - Record exactly what they say.
    - What did they want the robot to do?
    - How did they say it?
    - Can we do it?
  - Implement what they asked.
    - Have the robot do that.
    - Record what they say.
    - Where does the interaction break down?
    - Can we accommodate all of the interactions people want?

Project Idea: Object Delivery Follow-Up

- Type: Infrastructure
- Goal: Make an in-publication system work better.
- Purpose: Improve interaction quality, speed.

Project Idea: Object Delivery Follow-Up

- Recently, we submitted a paper where people ask the robot to find an object, pick it up, and deliver it to someone.
- Parts of this process can be slow, or lack robustness.
- The idea here is to re-implement this using newer pieces of infrastructure, and to improve some pieces that work slowly or use older techniques.
- This would support long-term BWI research and make the BWIBot all-around “better.”

Project Idea: New Arm / New Robot

- Type: Infrastructure
- Goal: Get new robot with UR5 arm working
- Purpose: We have a new UR5 arm which will go onto a new robot. The purpose is to get that project started.

Project Idea: New Arm / New Robot

- We received a new UR5 robot arm, which will go onto an updated arm robot.
- Need to get the arm performing grasps.
- Need to get it mounted onto the new robot base.
- Need to get the whole system working.

Project Idea: Speech & Language Speed-Ups

- Type: Infrastructure
- Goal: Speed up parsing, integrate Google Wave
- Purpose: Portions of our speech pipeline are slow. We want them fast and good for BWI.

Project Idea: Speech & Language Speed-Ups

- In recent work we have sometimes had problems because the robot takes a long time to parse natural language utterances. The idea here is to do a faster re-write of the same program to speed parsing.
- Similarly, we use festival for speech production, but Wave appears to be promising for speed and quality improvements.

Project Idea: The TRI Challenge

- Type: Other
- Goal: Participate in the TRI Challenge.
- Purpose: Adapt our infrastructure to solve TRI Challenge problems on a bi-monthly basis.

Project Idea: TRI Challenge

- Toyota builds the Toyota HSR.
- They have invited us to participate in the TRI Challenge, which is like a mini RoboCup@Home.
- If your group does this, you will be a part of our TRI Challenge team, and learn skills relevant to our RoboCup@Home team.

Project Idea: Door Sign Classifier

- Type: Self-Contained / Groundwork
- Goal: Build a classifier to identify door tags.
- Purpose: Integrates into PRISM in order to help it read more door signs.

Project Idea: Door Sign Classifier

- PRISM is our system for semantic mapping / semantic SLAM
- The idea here is partly that the system can read the building signage and mark it into the robot's map.
- You would build a classifier (using deep learning) to classify what is and is not a door tag.

Project Idea: Smart Obstacle Avoidance

- Type: Self-Contained / Groundwork
- Goal: Differentiate between people and static obstacles to improve navigation
- Purpose: Make the robot navigate in a smarter, smoother fashion

Project Idea: Smart Obstacle Avoidance

- Right now the robot treats people as obstacles when navigating.
- The problem with this is that the robot needs to be farther from people than it does from the wall, so it has a hard time navigating narrow spaces.
- Sometimes the robot reroutes around a person when it should, instead, simply wait for them to pass.
- Differentiating between the two means that the robot will be able to move better through doorways and other small spaces, or not replan around a non-static obstacle.

Project Idea: Visual Localization

- Type: Self-Contained / Groundwork
- Goal: Localize the robot using vision
- Purpose: Reduce steps to localize the robot, improve performance when localization is lost

Project Idea: Visual Localization

- Recall in FRI I that you needed to localize the robot on startup.
- This can also be a problem when the robot changes floors, or navigates the atrium, where furniture frequently changes position.
- In this project, you’re trying to localize the robot based on vision input, to remove the initial localization step and improve performance when localization is lost.

Project Idea: 3D Printer

- Type: Self-Contained / Infrastructure
- Goal: Build a 3D Printer
- Purpose: I need a 3D printer. The EER is across the street. That’s too far.

Project Idea: 3D Printer

- I’m a 3D printing enthusiast and I’ve build a HyperCube 3D printer
- For this we would build a HyperCube Evolution 3D printer, with all of the bells & whistles
- This isn’t so much “research” as “fun and useful.” It probably won’t train you appropriately if you’d like to be a mentor or RoboCup@Home participant.

Project Idea: Multi-Robot Communication

- Type: Infrastructure
- Goal: Communicate information between multiple robots for multi-agent coordination
- Purpose: The BWIBots work as a fleet, but what if they could work **together** as a fleet, handing off portions of tasks or coordinating large-scale behavior.

Project Idea: Multi-Robot Communication

- Harel wants this for multi-agent coordination for tasks such as providing directions to visitors.
- Rishi wants this for multi-agent coordination for large-scale map-building.
- Your job would be to implement the ways that the robots share data across physical robots.

Project Idea: Elevator Navigation

- Type: Self-Contained / Infrastructure
- Goal: Program the robot to recognize, push the buttons on the elevator, and navigate in and out.
- Purpose: Get the robot to navigate between floors by riding the elevator.

Project Idea: Elevator Navigation

- We’ve wanted to do this for years, but it’s tough.
- Need to visually recognize and read the elevator buttons.
- Need to work out the navigation.
- Need to work out pushing the buttons.

Project Idea: Verbal Navigation Instructions

- Type: Self-Contained / Groundwork
- Goal: Have the robot provide verbal route instructions to a person.
- Purpose: The BWIBots can provide directions to visitors, but only by driving in front of them. We'd like for them to be able to say, "Your classroom is on the 3rd floor. Go up the elevator and take a left."

Project Idea: Verbal Navigation Instructions

- Lots of work has been done on processing verbal instructions into a navigational plan.
- This is processing a navigational plan into verbal instructions, in order to communicate them to a person.

Project Idea: Getting to know you

- ..getting to know all about you.

- Type: Self-Contained / Groundwork
- Goal: Have the robot build a model of each person it interacts with so it can identify if it is the same person.
- Purpose: This is over long and short time-scales, for multiple reasons.

Project Idea: Getting to know you

- Picture a conversation with the robot and 5 people. How do you know which person asks a question if they aren’t facing you?
- If you are following someone, or if someone is following you, how do you know if it’s the same person?

Group Formation

- Break into groups of 3-4 students
- Collect
  - Your names
  - A project you'd potentially be interested in working on from the list
  - A project idea not from the list
  - Areas of computer science, AI, or robotics that interest you
  - Then email me this information
    - hart@cs.utexas.edu

Project Idea Recap

- Ideas
  - Imaging Turntable
  - Task Re-Entry
  - Drive Up and Say Hi
  - Object Delivery Follow-Up
  - New Arm / New Robot
  - Speech & Language Speed-Ups
  - TRI Challenge
-
  - Door Sign Classifier
  - Smart Obstacle Avoidance
  - Visual Localization
  - 3D Printer
  - Multi-Robot Communication
  - Elevator Navigation
  - Verbal Navigation Instructions
  - Getting to know you

Instructions

- Break into groups of 4 students
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