Today’s Class

- Bookkeeping
- Summary and carry-over: design axes
- HRI Metrics

Project Milestones

1. Research question – February 18th
2. Technical implementation status report – March 22nd
3. User study design – March 31st
4. Implementation and study demo – April 18th–22nd
5. User study analysis – May 5th
6. Presentation – May 3rd & 5th, May 17th
   - We may reschedule this, if everyone (unanimously) prefers.
7. Write-up and Video – May 10th

Project Milestones 1-4

1. Research question
   - Write a one-paragraph abstract of your intended project
2. Technical implementation status report
   - One-on-one or group meeting with professor
3. User study design
   - Describe the human-robot interaction user study
4. Implementation and study demo
   - Demo system, walk through study with professor

Project Milestones 5-7

3. User study analysis
   - Quantitative, qualitative and statistical analysis of results
6. Presentations
   - Conference-style research presentation
     - 20 minutes each including questions, back-to-back
7. Write-up and Video
   - Conference paper style write-up of results
     - Video of system, user trials, etc.
     - Later classes, research presentations, …
   - This is often good to incorporate into presentations!
On Tuesday’s Show...

- Defining a Human-Robot Interaction
  - What is a robot? What is a “human interaction”?  
- Domains and Tasks
  - Search and rescue, assistive, extreme conditions
  - Military and police, entertainment, education, home
- How do you design or describe an HRI system?  
  - What are its interaction characteristics?

Design Axes for HRI Systems

- How direct is the interaction?
- How autonomous are the robot(s)?
- What kind of group are the robot(s) in?
- What information is exchanged and how?
- How much learning or adaptation are required?
- What is the setting?
- How do you answer these questions?
  - What is the task or domain?

Information Exchange (II)

- The medium
  - Seeing
  - Hearing
  - Touch

“Put the pot there and hand me the sugar, please”

OKAY

Group Makeup

- Humans and robots – how is it structured?
  - 1-1, many-many, 1-many, many-1, 1-0, 0-many,…
  - Related to autonomy, task, and trust
- Who has authority? Who has responsibility?
  - When does the human not have pure authority?
  - Timing? Task-based?
- What is optimal?

Adaptation

- What can be learned?
  - Task domain; task actions
  - Changes in environment or goals over time
  - Communication style and kind
  - Authority and communication flow
- What can change?
  - The task? The authority? Agent capabilities?
  - Over what span of time?
  - In response to what information?
  - What agent(s) should do the learning?

Practical Discussion

- Search & Rescue
  - Hors d’oeuvres, anyone?
- Assistive Robotics
  - Transfer
  - Social
  - Wheelchair
- Space/Extreme Conditions
  - Surgical
- Directness
- Autonomy
- Group Structure
- Information exchange
- Adaptation and Learning
(HRI) Research Metrics

What are you trying to determine?
1. Does the system work?
2. How well does it work?
3. Does it do its task?
4. Does it improve things?
5. Is it worth the cost?
6. Is the approach good?
7. How do you improve it?

What do you need to know to do it?
1. What task is it doing / problem it is solving?
   - Hypothesis
2. Compared to what?
   - Baseline
3. What parts work well?
4. By what measure of “goodness”? Of “cost”?

Universal HRI Metrics

- Common tasks
- Common biases and confounds
- Task-specific metrics
- Overall metrics
- Effectiveness and Efficiency

Common Robot/HRI Tasks

- Navigation
  - Getting from point A to point B
- Perception
  - Awareness of environment – building correct “model”
- Management
  - Coordinate agents collaborating on a task
- Manipulation
  - Interaction with objects, often with grippers
- Social interaction
  - Modeling social world, obeying norms

Common Research Problems

- To confound: v. a confound, n.
  - In statistics, a confounding variable (a confound) is an extraneous variable that correlates with the dependent variable and the independent variable.
  - Can cause incorrect estimates via failure to account for a confounding factor.
  - Example: is this robot a good lunch companion?
  - 99% of survey respondents say yes.
  - …and it’s the day after everyone gets an A on my midterm.
  - Confounds are systematic, not random
  - There is a relationship, you just haven’t modeled it!

Discussion Questions

- Is a “universal” set of HRI metrics a good idea?
- Is the suggested set good?
- What would you use?
- What HRI questions does this cover? Fail on?
- Does this toolkit appeal?

Navigation Metrics

- Localization (finding oneself in a map):
- High- and low-level navigation
- Obstacle avoidance
- Effectiveness:
  - Does it get there?
  - How far does it get? How much ground is covered?
  - Does it follow the right path?
  - Does it avoid obstacles? Or progress past them somehow?
**Navigation Metrics**
- Localization (finding oneself in a map);
- High- and low-level navigation;
- Obstacle avoidance;
- Efficiency:
  - How long does it take?
  - How much human time is taken up?
  - How much time is taken per obstacle!

**Perception Metrics**
- Percentage of signal received and interpreted;
- Accuracy of classification (of room, objects, ...);
- Confusion Matrices;
- Extent (size/quantity) and motion measures:
  - Robots', objects', or area's ...;
  - Size;
  - Distance;
  - Speed;
- Efficiency: battery, time;
- Operator confidence and fusion; operator time.

**Management Metrics**
- Fan-out: how many robots can one person control?
- What's the assumption there?
- Intervention response time:
  - Time the robot spends waiting for operator help;
  - Recognizing the need, sending the signal, waiting, ...
  - Could this be zero? How?
- Autonomy discrepancies:
  - How well can a human decide on a level of robot autonomy?
  - How fast?
  - Based on what?
    - Trust, situation, situation awareness ...

**Manipulation Metrics**
- Computation costs:
  - Grasp planning, motion planning, ...
- Contact errors:
  - Collisions: type, cost;
- To which I will add:
  - Grasp selection metrics;
  - Calculation of manipulation selection.

**Social Metrics**
- Is the interaction...
- Human-like? Pleasant? Efficient? ...
- Is the robot persuasive?
- What is the trust relationship? Before? After?
- How engaged does the human(s) feel in the interaction? With the robot?
  - Interest, affection, ...
- Social compliance: does the robot successfully follow the unwritten rules? The expectations!

**Quantitative Measures**
- Quantitative: associated with an objective, measurable, and verifiable characteristic;
- Amenable to statistical manipulation;
- Quantitative data defines; qualitative data describes;
- Examples:
  - How long did this take?
  - How many balls are in the right bin?
  - How many times did you drop it?
  - Was it fun?
  - Was it fast enough?
Common HRI Metrics

- How much of a task was performed without intervention?
- Is this really quantitative?
- Depends how the question is phrased!
- How long did it take to complete a task?
- Subjective ratings: how well did the robot do?
  - Did it analyze the situation correctly?
  - Would a human have done better?
- Was the human/robot balance good?

Human Metrics

- Does the operator understand the situation?
- Is the operator’s workload correct? Useful? Stressful?
- Does the operator understand the robot?
  - Its abilities?
  - Its state?

Robot Metrics

- Does the robot understand the robot?
  - Its abilities? Its state?
- Does the robot understand the operator?
  - His/her abilities? State?
  - Does it adapt accordingly?
- Is it appropriately autonomous?

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