Robot Learning from Human Teachers

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In the LfD framework, what does each component study?
Human Social Learning
Overview

- As learners, children have
  - Motivation to interact
  - Motivation to imitate

- How to model the learning interaction?

- As a teacher, how to scaffold this learning process?
Children’s motivation to interact
What enables a child to interact?
- Being able to recognize, seek proximity to, and interact with (caregivers)

A big assumption
- Children assume that the caregiver has their best interest

Assisted imitation
- A dynamic turn-taking activity

How to model this turn-taking activity?
• One recent HRI focus
  • Modeling engagement and turn-taking dynamics in interaction

• Examples
  • Partner robot – Generate connection event [1]
  • Social robot – Control multimodal dialog [2]
  • Conversational service robots – Controls task-based dialog [3]
Generating connection event

• Engagement between a human and a humanoid robot

• Assume both human and robot can perform
  • Look at the other’s face, objects on the table or “away”
  • Point at objects on the table
  • Nod the head (up and down)
  • Shake the head (side to side)
  • Speech (not available for now)
Generating connection event

- Connection events include
  - Directed Gaze
  - Mutual Facial Gaze
  - Adjacency Pair
  - Backchannel
Robot generates non-verbal behavior that contributes to HRI engagement.
Generating connection event

Process human-initiated CE

engagement recognition

human-initiated CE’s
robot-initiated CE’s
turn fragments

gaze/point inhibit

engagement generation

symbolic vision

engagement statistics

speech & gestures
## Evaluation

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1) Melvin seemed more like a human than a robot.</td>
<td>3.43</td>
<td>2.27</td>
<td>.55</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>2) Melvin looked at the table and the puzzle pieces at appropriate times.</td>
<td>6.21</td>
<td>4.47</td>
<td>.73</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>3) Melvin always looked at me in a natural way.</td>
<td>4.57</td>
<td>2.73</td>
<td>.58</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>4) Melvin looked at me at appropriate times.</td>
<td>6.21</td>
<td>2.40</td>
<td>.46</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>5) I always knew what object Melvin looked at.</td>
<td>6.07</td>
<td>3.80</td>
<td>.83</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>6) I could easily tell which objects Melvin looked at.</td>
<td>5.71</td>
<td>3.40</td>
<td>.72</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>7) I looked at Melvin’s face often.</td>
<td>6.07</td>
<td>5.00</td>
<td>.50</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>8) I made eye contact with Melvin frequently.</td>
<td>5.43</td>
<td>4.00</td>
<td>.62</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>9) I always knew what object Melvin pointed at.</td>
<td>6.57</td>
<td>3.13</td>
<td>.72</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>10) I could easily tell the object that Melvin pointed to.</td>
<td>6.43</td>
<td>3.07</td>
<td>.70</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
Switch between multiple situated modules
Switch between multiple situated modules

- Bottom-up method
Implementing interaction dynamics

• The basic strategy of implementing interaction dynamics
  • Develop situated modules for various situations.
  • Define episode rules for sequential transition.
  • Modify implemented episode rules (rules of negation) to suppress execution of the situated modules for a particular long-term context.
Switch between expert models

• Requirements for conversational robot intelligence model
  • Integration of dialogues and physical actions
  • Handling multiple task domains
  • Interruption handling
  • Parallel task execution
  • Extensibility

• Goal
  • Build a dialogue and behavior controller
Architecture for conversational service robots

- Recognition results, confidence scores, etc.
- Speech and image recognizers, sensor interpreters, & information integrators

Behavior and dialogue controller

- Multi-modal action
- Robot & human positions, etc.

Action Executor

- Physical action commands
- Text

Hardware controller

- Microphones
- Cameras
- Sensors
- Robot hardware

Speech synthesizer

- Speaker
Change in primitive tasks and experts

Diagram:
- **Task**: setting task → Tell person A to go to the client → task planning
- **Primitive Task**: understand messaging request → go to A → tell A the message
  - **Expert**: Select according to the first human utterance → request understanding in the message domain → physical action planning for approaching → information providing expert for messaging
- **Lower-layer modules**:


Review paper


Assignment 10 – Due Nov 13

• Refer to “Research paper review guidance”
  • https://docs.google.com/document/d/1oVmjZSj09YY_PsutFf6UBMm3Ly18_VHOvk_Yno-7k5M/pub

• Prepare 4-6 presentation slides
  • Good presentation slides will be rewarded with additional credit and will have a chance to give a 5-min presentation in coming lecture
  • More opportunity coming soon
Children’s motivation to imitate
Children have motivation to imitate

• Like-me bias
  • An inclination and ability to map self and others’ actions

• Theory of “legitimate peripheral participation”
  • Children want to participate adults’ world
  • Get out of subordinate learner role, and be able to choose what to do
  • Strong motivation for learning
Teacher – Method to impose influence

- Given the motivation of imitate, there are several ways that the teacher can influence the learner
  - **Stimulus enhancement**
  - Emulation
  - Mimicking
  - Imitation
Teacher – Method to impose influence

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All the four methods benefit self-exploration

- Particularly when the target goal is rare occurrence

Which is the “best”?

- Depend on the nature of problem, and current behavior of social partner
How to create learning motivation for robot?

• Reinforcement Learning
  • Reward novel experience

• Developmental learning [1]
  • Integrate self-motivation and curiosity
  • Build a control system to continue to adapt to new problems
How to Scaffold the learning process?
Human teacher scaffold robot learner

• Human can help robot with hard problems in learning

• Three methods for scaffolding
  • Direct robot attention
  • Dynamic scaffolding
  • Externalize and modeling meta-cognition
Direct robot’s attention

• Effect of social gaze
  • Lots of studies in HRI

• Example
  • Teach a robot as if parenting a baby
  • How to?
Example – Parenting robot

- Parents (human teacher) alter their actions when interacting with infants, compared to when interacting with adults
  - Put longer and more pauses between actions
  - Exaggerate actions
  - Decompose a rounded movement into several linear movements
- Baby (robot learner)
  - Immature attention capability, don’t know where to pay attention to
  - Parental teaching helps a robot to detect significant information of the actions
Parental action demonstration

- Analyze videotaped data of parent-infant/-adult interactions
Locate attention

- Apply saliency-based attention model
Experimental comparison of saliency map

- Experimental conditions
  - Partner = infant
  - Partner = adult

- High value in saliency when the partner is infant
  - Suppressing body motion
  - Add motion to the cup
  - Long pause before start and after end of the demonstration
  - Stop and comment on action/show additional emotional facial expression
Demonstrate to robot simulation

- Program robot to look at the most salient part
