Mental model alignment in human-robot communication

MAYA CAKMAK
Teach robots how to understand/speak English
Teach robots how to understand/speak English
Teach humans how to understand/speak Robotese
Assumptions

Humans are smarter/more flexible than robots

Robotese is much simpler/more structured than English
Tasks

grammar, vocabulary
Spoken language
Gestures
Actions
Physical interaction

Tasks
grammar, vocabulary

Spoken language
Sounds
LEDs
Expressions
Gestures
Actions
MENTAL MODEL ALIGNMENT

Spoken language
Gestures
Actions
Physical interaction

What does the robot know?
What can the robot represent/learn?

Spoken language
Sounds
LEDs
Expressions
Gestures
Actions

Tasks
grammar, vocabulary
MENTAL MODEL ALIGNMENT

Spoken language  
Gestures  
Actions  
Physical interaction

What can the robot see?  
What can the robot understand?

Spoken language  
Sounds  
LEDs  
Expressions  
Gestures  
Actions

Tasks  
grammar, vocabulary
MENTAL MODEL ALIGNMENT

Spoken language
Gestures
Actions
Physical interaction

What does the robot mean?
What is the robot doing?

Tasks
grammar, vocabulary

Spoken language
Sounds
LEDs
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MENTAL MODEL ALIGNMENT

Spoken language
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Physical interaction

Spoken language
Sounds
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Tasks
grammar, vocabulary

How can I get the robot to do X (something useful)?
MENTAL MODEL ALIGNMENT

What can we do?

Interaction design

Explicit instruction
MENTAL MODEL ALIGNMENT

Previous work

Teaching people how to teach robots

Making robots ask questions

Crazy ideas

Robot-world goggles

Robot driving license
MENTAL MODEL ALIGNMENT

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END-USER ROBOT PROGRAMMING

[VIDEO]
MOTIVATION

ROBOT          EXPERIMENTER  USER
MOTIVATION

ROBOT    EXPERIMENTER    USER
**User Manual**

Programming PR2 by Demonstration

You can program PR2 to do what you want by creating a new skill and saving a sequence of arm poses and hand actions (open/close) into that skill. When you execute the skill, PR2 will go through these poses and actions in the order you saved them. You can keep adding poses to the skill after executing it, or clear the skill to start over.

The speech commands described below will allow you to interact with PR2 to program new skills. You can program PR2 to do what you want by creating a new skill and saving a sequence of arm poses and hand actions (open/close) into that skill. When you execute the skill, PR2 will go through these poses and actions in the order you saved them. You can keep adding poses to the skill after executing it, or clear the skill to start over.

PR2 will verbally respond to all your commands. If you do not hear a response, try repeating the command.

### COMMANDS

<table>
<thead>
<tr>
<th>COMMAND</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST MICROPHONE</td>
<td>Use this command to test if the microphone is working.</td>
</tr>
<tr>
<td>RELEASE : RIGHT ARM</td>
<td>Use these commands to release the robot's arms so you can move them around, or to make them hold a certain pose.</td>
</tr>
<tr>
<td>OPEN : RIGHT ARM</td>
<td>Use these commands to open and close the robot's hands.</td>
</tr>
<tr>
<td>CREATE SKILL</td>
<td>Use this command to create a new skill (for example “skill-1”) in its response.</td>
</tr>
<tr>
<td>SAVE POSE</td>
<td>Use this command to save PR2's current arm pose into the skill. Make sure to hold the arm in place while using this command. To make the robot open or close its hand at the saved pose as part of the skill, first use the hand action command, and then use this command, while holding the arm in place.</td>
</tr>
<tr>
<td>EXECUTE SKILL</td>
<td>Use this command to execute the current skill. PR2 will go through the poses and hand actions saved into the skill so far.</td>
</tr>
<tr>
<td>CLEAR SKILL</td>
<td>Use this command to delete all the poses and hand actions that have been saved into the skill so far.</td>
</tr>
<tr>
<td>NEXT : SKILL</td>
<td>Use these commands to switch to the next or previous skill. These commands will let you navigate through skills in the order they were programmed.</td>
</tr>
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<td>PREVIOUS : SKILL</td>
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<td>UNDO LAST COMMAND</td>
<td>Use this command after using one of the commands above, in order to undo its effect (excluding TEST MICROPHONE and EXECUTE SKILL).</td>
</tr>
</tbody>
</table>

### PROGRAMMING PR2 by Demonstration

#### Step 1: GETTING STARTED

- To make sure PR2 hears your commands, say TEST MICROPHONE and wait for its response.

#### Step 2: MOVING THE ARMS

- **a.** Say RELEASE RIGHT ARM.
- **b.** Grab PR2's right arm and move it around. Try to get a sense of its range of motion.
- **c.** Move the arm to a neutral pose and say HOLD RIGHT ARM while still holding the arm in place. Now let the arm go. Slightly push the arm to observe that the arm is stable.
- **d.** Repeat the same with the left arm using the commands RELEASE/HOLD LEFT ARM.

#### Step 3: USING HAND ACTIONS

- **a.** Say OPEN RIGHT HAND and observe how the right hand moves. When the hand stops moving say CLOSE RIGHT HAND.
- **b.** Repeat (a) with the left hand, but this time hold an object inside the hand before saying CLOSE LEFT HAND.

#### Step 4: PROGRAMMING A SKILL: WAVING

- **a.** Say CREATE SKILL and listen to PR2's response.
- **b.** Release PR2's right arm and move it to a waving pose. Say SAVE POSE while holding the arm in place.
- **c.** Move the arm to a different pose slightly to the right of the first pose. Say SAVE POSE while holding the arm in place.
- **d.** Save a third pose slightly to the left of the first pose.
- **e.** Let PR2's arm go and say EXECUTE SKILL. Observe the skill playing out.

#### Step 5: ADDING A HAND ACTION TO THE SKILL

- **a.** Release the right arm and move it to a neutral pose. Say OPEN RIGHT HAND and then SAVE POSE. Make sure to hold the arm still while saying both commands.
- **b.** Execute the skill to observe the added hand action at the end of the waving skill.

#### Step 6: DELETING A POSE AND CLEARING A SKILL

- **a.** Add a dummy pose to the skill. Then say UNDO LAST COMMAND to PR2's response.
- **b.** Say CLEAR SKILL, listen to PR2's response, and then try to execute the skill.
- **c.** Add new poses into the skill to make PR2 wave with the left arm, and execute the skill.

#### Step 7: NAVIGATING SKILLS

- **a.** Say CREATE SKILL and listen to PR2's response.
- **b.** Say PREVIOUS SKILL and listen to PR2's response.
- **c.** Say NEXT SKILL and listen to PR2's response.
- **d.** Say NEXT SKILL again and listen to PR2's response.
User Manual

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OPEN | Use these commands to open and close the robot’s hands.
CREATE SKILL | Use this command to create a new skill. PR2 indicates the name of the skill (for example “skill-1”) in its response.
SAVE POSE | Use this command to save PR2’s current arm pose into the skill. Make sure to hold the arm in place while using this command.
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### Tutorial

Programming PR2 by Demonstration

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HOW WE FAILED

Superstition/inefficiency

[VIDEO]

Functional ignorance

[VIDEO]
HOW WE FAILED

Superstition/inefficiency

[VIDEO]

Functional ignorance

[VIDEO]
HOW WE FAILED

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[VIDEO]

Functional ignorance

[VIDEO]
MENTAL MODEL ALIGNMENT

Previous work

Teaching people how to teach robots

* Making robots ask questions

Crazy ideas

Robot-world goggles

Robot driving license
MOTIVATION

Existing tools assume good teachers...
Existing tools assume **good teachers**...

- large number of demos
- variance in demos
- smooth/consistent demos
MOTIVATION

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... **everyday users** are not!

- inaccurate mental model
- limited time, patience, attention, memory
MOTIVATION

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**CHALLENGE:** **BETTER DEMONSTRATIONS, FASTER!**
SIMPLE QUESTIONS

[VIDEO]
COMPLEX QUESTIONS

[VIDEO]
BEGINNER IN ROBOTESE
BEGINNER IN ROBOTESE

[VIDEO]
MENTAL MODEL ALIGNMENT

Previous work

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SEEING WHAT THE ROBOT SEES

[VIDEO]
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HOW MUCH DO WE NEED TO TEACH?

Buy and start using

Pass a test before being allowed to use
HOW MUCH DO WE NEED TO TEACH?

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Pass a test before being allowed to use
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