Expanding the Scope of Tasks that Rosie can Learn

Aaron Mininger
University of Michigan
Interactive Task Learning

Design agents that can learn new tasks from scratch through natural forms of interaction
Situated Interactive Instruction

Situated
Instruction happens in a shared environment

Interactive
Both the instructor and agent engage in dialog

Instruction
Agent learns primarily through natural language
Task Domains
Learning Tasks

What is the goal?

The goal is that the cup is on the table.

Pick up the cup.

Put the cup on the table.

Move the cup to the table.
Task Learning Characteristics

- Fast and Efficient
  Learn quickly from few examples
Task Learning Characteristics

- **Fast and Efficient**
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- **Effective Generalization**
  Generalize from one example to many variations
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  Build upon previously learned knowledge
Task Learning Characteristics

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- **Diverse**
  Use range of techniques to cover huge task variation
Previous Work on Rosie

- Goal-Based Formulation
- Singular Actions
- Sufficient Action Modeling

Expanding Learning Diversity

- **Diverse Action Types**
  
  Physical, Communicative, Mental, Perceptive
Expanding Learning Diversity

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- Diverse Task Formulations
  Goal-Based, Procedural, Optimization, RL
Expanding Learning Diversity

■ **Diverse Action Types**
  Physical, Communicative, Mental, Perceptive

■ **Diverse Task Formulations**
  Goal-Based, Procedural, Optimization, RL

■ **Diverse Action Modifiers**
  Control Structures, Collections, Temporal
Diverse Action Types
## 20 Most Common Verbs

<table>
<thead>
<tr>
<th>be</th>
<th>take</th>
<th>tell</th>
</tr>
</thead>
<tbody>
<tr>
<td>have</td>
<td>see</td>
<td>work</td>
</tr>
<tr>
<td>do</td>
<td>come</td>
<td>call</td>
</tr>
<tr>
<td>say</td>
<td>want</td>
<td>try</td>
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<tr>
<td>go</td>
<td>look</td>
<td>ask</td>
</tr>
<tr>
<td>get</td>
<td>use</td>
<td>need</td>
</tr>
<tr>
<td>make</td>
<td>find</td>
<td>feel</td>
</tr>
<tr>
<td>know</td>
<td>give</td>
<td>become</td>
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</tbody>
</table>
Expanding Learning Diversity

- **Acting**
  - do, go, get, make, take, come, use, give, work

- **Mental**
  - think, know

- **Communicative**
  - say, tell, call, ask

- **Perceptive**
  - see, look
Diverse Action Types

Want a rich and varied set of initial actions

Each action requires:

- Proposal Knowledge
- Execution Knowledge
- Modeling Knowledge
Perceptual Actions

What is the goal?

Deliver the package to Alice

The goal is that Alice is holding the package

Pick up the package

Find Alice

Give the package to Alice

Mental Actions

- **Modifying Working Memory**
  Remember the current location as the starting location.

- **Accessing Semantic Memory**
  Think of an office of Alice.

- **Accessing Episodic Memory**
  Recall Alice in a location.

Communicative Actions

Tell Alice a message

The goal is that Alice heard the message

Ask “What is the message?”

Remember the answer as the message

Find Alice

Say the message.

<table>
<thead>
<tr>
<th>Diverse Action Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>pick up</td>
</tr>
<tr>
<td>put down</td>
</tr>
<tr>
<td>give</td>
</tr>
<tr>
<td>open</td>
</tr>
<tr>
<td>close</td>
</tr>
<tr>
<td>turn on/off</td>
</tr>
<tr>
<td>orient</td>
</tr>
<tr>
<td>turn</td>
</tr>
<tr>
<td>face</td>
</tr>
<tr>
<td>approach</td>
</tr>
<tr>
<td>go to</td>
</tr>
<tr>
<td>find</td>
</tr>
<tr>
<td>scan</td>
</tr>
<tr>
<td>explore</td>
</tr>
<tr>
<td>lead</td>
</tr>
<tr>
<td>think</td>
</tr>
<tr>
<td>recall</td>
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<td>remember</td>
</tr>
<tr>
<td>ask</td>
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<tr>
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</table>
Diverse Task Formulations
Diverse Task Formulations

How is the task represented? What learning mechanisms are used?

May depend on:

- How the task is taught
- What capabilities the agent has
- Characteristics of the task
Goal-Based Formulation

Formulate the task as achieving a goal

Use planning and search to select actions

What is the goal?

Discard the soda.

The goal is that the soda is in the garbage
Procedural Formulation

Formulate the task as following a procedure
Rely on the procedure to execute the task in the future

- Lead a tour.
- Go to the copy room.
- Say ‘Here is where you can make copies.’
- Go to the kitchen.
- Say ‘Here is where you can eat lunch.’
Compositional Formulation

Formulate the task as performing a set of subtasks

- Prepare the conference room.
- Perform the following:
  - Turn on the lights.
  - Lower the screen.
  - Put 10 water bottles on the table.
Optimization Formulation

Formulate the task as optimizing some measure

Stock the fridge with sodas.

What is the goal?

Put as many sodas in the fridge as you can.
Reinforcement Formulation

Formulate the task as an RL problem

Stock the fridge with sodas.

What is the goal?

Maximize your reward

When you put a soda in the fridge, you get a positive reward

If you take a soda out of the fridge, you get a negative reward
Diverse Action Modifiers
Diverse Action Modifiers

Modify the actions to allow more complexity

Modifiers Include:

- Groups of Objects
- Control Structures
- Temporal Modifiers
Object Groups

Handle multiple objects in a goal/task

- **Numerical Quantities**
  - Deliver 2 packages to the soar office.
  - The goal is that there are at least 4 sodas in the fridge.
Object Groups

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- **Universal Quantifiers**
  - The goal is that all cans are in the trash.
  - Stack all the blocks on the table.
Object Groups

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- **Enumeration**
  - Store each object on the table.
  - Maintain each location on this floor.
Conditional Statement

Conditionally execute a subtask

- **If Statement**
  - Example: teaching a maintenance task
  - If you are in the kitchen, stock the fridge.
  - If you are in an empty conference room, turn the lights off
Conditional Statement

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- **Whenever Statement**
  - Independent task performed when appropriate
  - Whenever you see trash, throw it away
Looping Statements

Execute a subtask multiple times

- **Until Clause**
  - The condition can be used as the action model
  - Wait until *the steak is cooked.*
Looping Statements

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- **Until Clause**
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- **While Clause**
  - Defines a 'negative' goal, which is harder to learn
  - While the table is not clear, store an object on the table.
  - Wait while the steak is uncooked.
Nuggets and Coal

Nuggets
- Allows a much larger space of tasks to be learned
- Integrated approach allows interesting combinations
- Gives more options to the instructor

Coal
- Task complexity and diversity dwarfs even these extensions
- Multiplication of buggy interactions
- Instruction is still predicted to be precise
Questions?