Unified Pragmatic Models for Generating and Following Instructions

Daniel Fried, Jacob Andreas, and Dan Klein
UC Berkeley
Instruction: *walk along the blue carpet and you pass two objects*
Instruction: *walk along the blue carpet and you pass two objects*
Interpreting instructions

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Interpreting instructions

Instruction: *walk along the blue carpet and you pass two objects*
Instruction: walk along the blue carpet and you pass two objects
Listener: reasoning about routes

walk along the blue carpet and you pass two objects
Listener: reasoning about routes

walk along the blue carpet and you pass two objects
Listener: reasoning about routes

walk along the blue carpet and you pass two objects
Listener: reasoning about routes

walk along the blue carpet and you pass two objects
Generated Instruction: go forward four segments to the intersection with the bare concrete hall
Speaker: reasoning about interpretation
Speaker: reasoning about interpretation

go forward four segments to the intersection with the bare concrete hall
Explicit pragmatic reasoning

Interpretation

“blue”

Frank and Goodman, 2012; Goodman and Stühlmuller, 2013; Wang et al., 2016

Generation

“The sun is in the sky”

Golland et al., 2010; Monroe and Potts, 2015; Andreas and Klein, 2016; Mao et al., 2016; ...

Both

Monroe et al. 2017

Our work
Explicit pragmatic reasoning

**Interpretation**

“blue”

- Frank and Goodman, 2012;
- Goodman and Stühlmuller, 2013;
- Wang et al., 2016

**Generation**

“The sun is in the sky”

- Golland et al., 2010;
- Monroe and Potts, 2015;
- Andreas and Klein, 2016;
- Mao et al., 2016; ...

**Both**

- Large, structured domains
- Monroe et al. 2017
- Our work
Learned models of listeners and speakers

walk along the blue carpet and you pass two objects

Both models trained independently on action sequences annotated with human instructions
Building a pragmatic listener

walk along the blue carpet and you pass two objects

Pragmatic Listener

Base Speaker
Building a pragmatic listener

walk along the blue carpet and you pass two objects

Pragmatic Listener

walk along the blue carpet and you pass two objects

Base Speaker

walk along the blue carpet and you pass two objects
Building a pragmatic listener

walk along the blue carpet and you pass two objects

Base Listener proposes

walk along the blue carpet and you pass two objects

Pragmatic Listener

Base Speaker

?
Building a pragmatic listener

walk along the blue carpet and you pass two objects

Base Listener proposes

? Base Speaker

walk along the blue carpet and you pass two objects
Building a pragmatic listener

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Base Listener proposes

Base Speaker
Building a pragmatic listener

walk along the blue carpet and you pass two objects

Base Listener proposes

Base Speaker rescores

walk along the blue carpet and you pass two objects
Building a pragmatic listener

walk along the blue carpet and you pass two objects

Base Listener proposes

Base Speaker rescores

walk along the blue carpet and you pass two objects
Building a pragmatic listener

walk along the blue carpet and you pass two objects

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Building a pragmatic listener

walk along the blue carpet and you pass two objects

Base Listener proposes

Base Speaker rescores

walk along the blue carpet and you pass two objects
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Base Listener proposes

Base Speaker rescores

walk along the blue carpet and you pass two objects
Building a pragmatic listener

walk along the blue carpet and you pass two objects

walk along the blue carpet and you pass two objects
Unified pragmatic inference

Pragmatic Listener

walk along the blue carpet ...

Base Listener → ? → Base Speaker → walk along the blue carpet ...

Pragmatic Speaker

Base Speaker → ? → Base Listener

walk along the blue carpet ...

actions

instructions
Building a pragmatic speaker

proposes

Base Speaker
Building a pragmatic speaker

proposes

Base Speaker

walk forward past the stool

go forward four segments to the intersection with the bare concrete hall
Building a pragmatic speaker

Base Speaker proposes

walk forward past the stool

go forward four segments to the intersection with the bare concrete hall

Base Listener rescores
Building a pragmatic speaker

proposes

walk forward past the stool

go forward four segments to the intersection with the bare concrete hall

rescores

0.4
Building a pragmatic speaker

proposes

walk forward past the stool

go forward four segments to the intersection with the bare concrete hall

Base Speaker

0.4

Base Listener

rescores

0.4
Building a pragmatic speaker

- Base Speaker proposes
- Base Listener rescores

0.4 walk forward past the stool
0.8 go forward four segments to the intersection with the bare concrete hall
Building a pragmatic speaker

proposes

walk forward past the stool

go forward four segments to the intersection with the bare concrete hall

0.4

0.8
Building a pragmatic speaker

**Base Speaker** proposes:
- Go forward four segments to the intersection with the bare concrete hall
- Walk forward past the stool

**Base Listener** rescores:
- 0.4
- 0.8

Diagram:
- Speaker to Listener connections with actions and scores.
Base model implementations

Base Listener

LSTM Encoder

walk along the blue carpet ...

LSTM Decoder with Attention
Base model implementations

Base Speaker

LSTM Encoder

LSTM Decoder with Attention

walk along the blue

walk along the blue

walk along the blue
Listener tasks

SAIL navigation [MacMahon et al., 2006; Chen and Mooney, 2011]

walk along the blue carpet and you pass two objects

Sequential Context-dependent Execution (SCONE) [Long et al. 2016]

1. a red guy appears on the far left
2. then to orange’s other side
Listener results, SAIL

Model accuracy at following human instructions

- Base listener: 59.6
- Pragmatic listener: 64.4
- Artzi & Zettlemoyer: 65.3
Listener example, SAIL

Instruction

walk along the blue carpet and you pass two objects

- Base Listener
- Pragmatic Listener

✓ Pragmatic Listener
✗ Base Listener
Listener results, SCONE

Model accuracy at following human instructions

<table>
<thead>
<tr>
<th>Task</th>
<th>Base listener</th>
<th>Pragmatic listener</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alchemy</td>
<td>69.7</td>
<td>72.0</td>
</tr>
<tr>
<td>Scene</td>
<td>70.9</td>
<td>72.7</td>
</tr>
<tr>
<td>Tangrams</td>
<td>69.6</td>
<td>69.6</td>
</tr>
</tbody>
</table>
Listener example, SCONE

Instruction

*a red guy appears on the far left then to orange’s other side*

![Diagram showing the sequence of events for Base Listener and Pragmatic Listener, with the correct sequence highlighted.]
Speaker task and evaluation

Speaker produces an instruction

Speaker

walk along the wood path to the chair

Humans try to interpret it

walk along the wood path to the chair

Human direction followers (MTurk)
Speaker results

Human accuracy at following instructions from:

- Other humans
- Base speaker
- Pragmatic speaker

<table>
<thead>
<tr>
<th>Activity</th>
<th>Other humans</th>
<th>Base speaker</th>
<th>Pragmatic speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAIL</td>
<td>62.8</td>
<td>75.2</td>
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<td>Alchemy</td>
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<tr>
<td>Scene</td>
<td></td>
<td>31.3</td>
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<tr>
<td>Tangrams</td>
<td></td>
<td>60.0</td>
<td>88.0</td>
</tr>
</tbody>
</table>
Speaker example, SCONE

Base Speaker
- remove the last figure
- add it back

Pragmatic Speaker
- remove the last figure
- add it back in the 3rd position

Human
- take away the last item
- undo the last step
Real-world navigation

Matterport3D vision-and-language navigation dataset [Anderson et al., 2018]

human description: walk through the kitchen. go right into the living room and stop by the rug.

base speaker: walk past the dining room table and chairs and wait there.

pragmatic speaker: walk past the dining room table and chairs and take a right into the living room. stop once you are on the rug.
Conclusions

Unified inference for sequential interpretation and generation

Reasoning counterfactually, and about likely interpretations

Pragmatics helps for complex tasks in structured domains
Thanks!

http://github.com/dpfried/pragmatic-instructions