A System For Robot Concept Learning Through Situated Dialogue

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Abstract: Our system allows a robot in an unexplored environment to learn unknown concepts through back-and-forth dialogue with a human teammate.

Cognitive Robotic Architecture: We extend a configuration of the DIARC architecture.

- NLU semantic parser maps inputs to logical forms (LFs).
- Declarative Knowledge tracks object properties.
- Goal-based DM handles LFs using ‘action scripts’.
- Reference Resolution tries to map concepts to objects.
- Decision Network invoked for unknown concepts.

Decision Network Model: Automatically generates questions to reduce ambiguity and acquire concept knowledge.

- Combines Bayesian network with action/utility nodes.
- Question selected using maximum expected utility.
- Dynamically created from observed object properties.
- Scalable; uses minimally necessary subset of properties.

Evaluation: We evaluate the system’s performance in a collaborative tool organization task situated in a virtual spacecraft environment.

- 18 novel tools along 7 feature dimensions.
- Robot concept learning compared to human performance on tasks from the HuRDL corpus.
- Robot has lower question efficiency than humans but can accurately resolve every entity.

<table>
<thead>
<tr>
<th></th>
<th>Human (N=10)</th>
<th>Robot (N=1)</th>
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</thead>
<tbody>
<tr>
<td># Questions</td>
<td>31</td>
<td>55</td>
</tr>
<tr>
<td>Question Eff.</td>
<td>1.72</td>
<td>2.29</td>
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<tr>
<td>Accuracy</td>
<td>0.77</td>
<td>1.00</td>
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