

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.

1 Move to crate 3.

2 Possible referents: {e1,e2,e3,e4,e5,...}
I don't know what crate 3 is. What color is crate 3?

3 Crate 3 is grey.
Adding color(crate3, grey) to knowledge base

4 Possible referents: {e1,e3,e4,e7,e14,e28}
Ok, what shape is crate 3?

5 Crate 3 is wide.
Adding shape(crate3, wide) to knowledge base

6 Possible referents: {e3,e4,e14}
Ok, what symbol does crate 3 have?

7 Crate 3 has a triangle symbol.
Adding symbol(crate3, triangle) to knowledge base

8 Possible referents: {e3}
Ok, I know it. I will move to crate 3 now.
Robot moves to crate 3

9 Pickup the mechano calibrator from crate 3.

10 I can't pickup the mechano calibrator because it is locked.

11 I will teach you how to unlock crate 3.
Initiating action learning

12 Move to the code screen. Press key 1. Press key 1.
Press key 2. Press key 3. That is how you unlock crate 3.

13 Ending action learning
Ok, I know it.

14 Now unlock crate 3 and pickup the mechano calibrator.

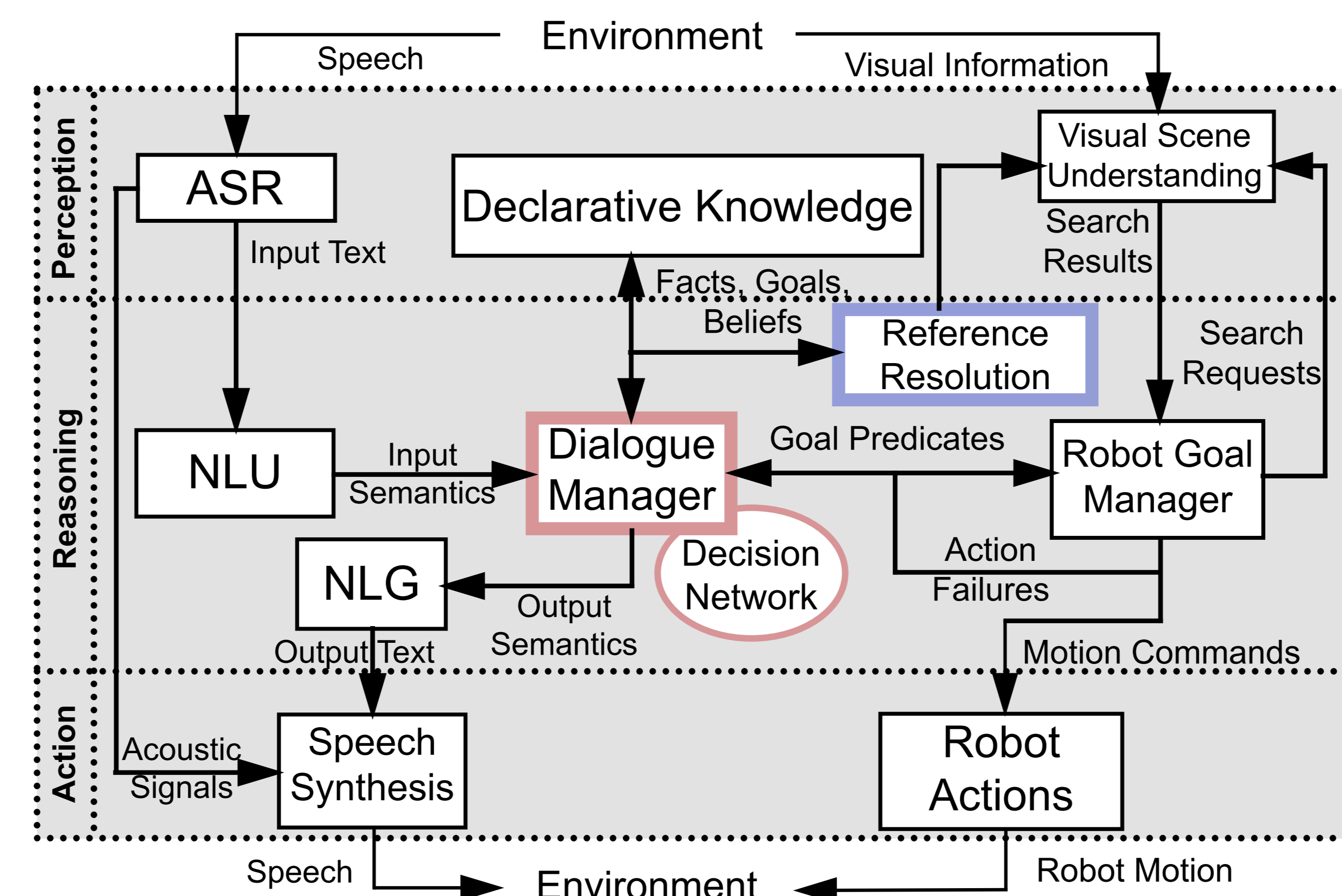
15 Ok
Robot performs procedure to unlock crate 3

16 I don't know what the mechano calibrator is.
What color is the mechano calibrator?

...

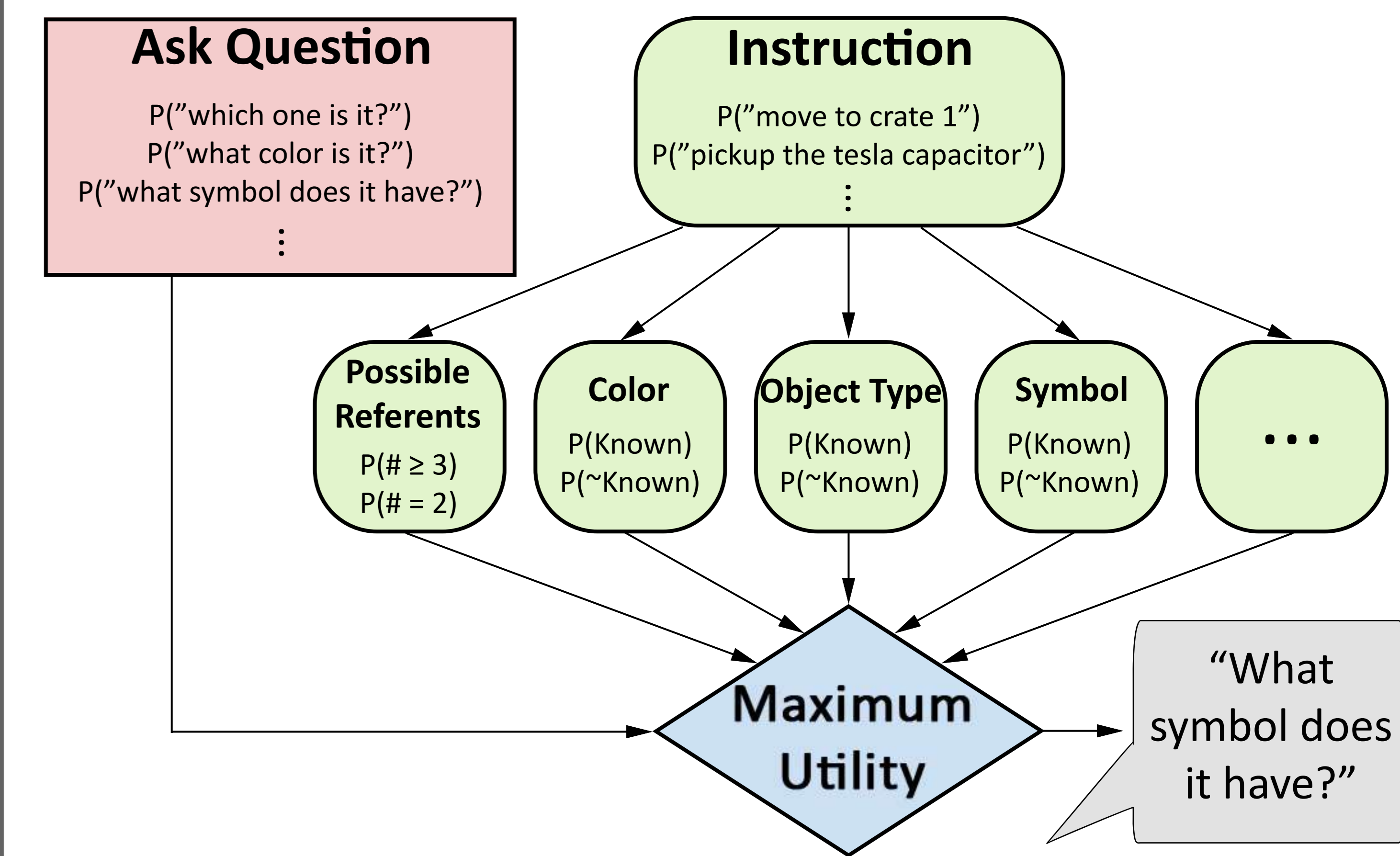
Cognitive Robotic Architecture: We extend a configuration of the DIARC architecture.

- 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.

| | Human (N=10) | Robot (N=1) |
|---------------|--------------|-------------|
| # Questions | 31 | 55 |
| Question Eff. | 1.72 | 2.29 |
| Accuracy | 0.77 | 1.00 |

Decision Network Code & HuRDL Corpus

