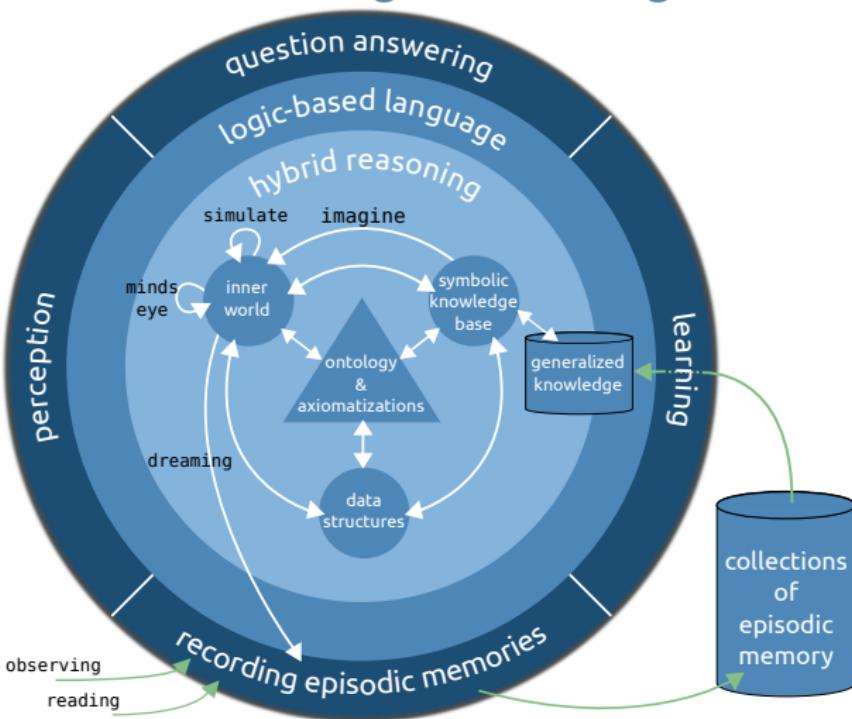


Daniel Beßler
Institute for Artificial Intelligence
Universität Bremen

27, June, 2018

KnowRob 2.0 – A Knowledge Processing Framework



Beetz et al., "KnowRob 2.0 – A 2nd Generation Knowledge Processing Framework for Cognition-enabled Robotic Agents", ICRA, 2018.

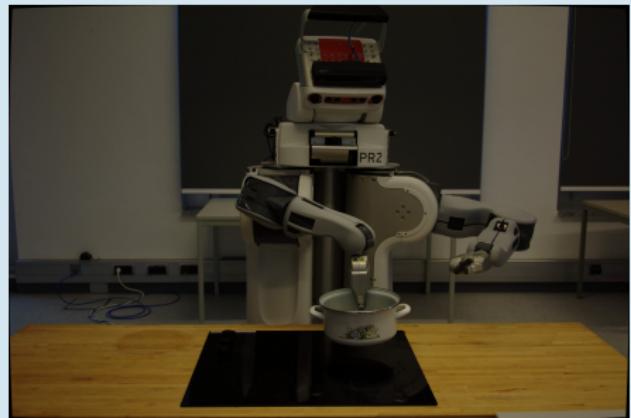


What we want

cleaning the livingroom



making popcorn



Mastering Everyday Manipulation Tasks

in the knowledge lies the power.

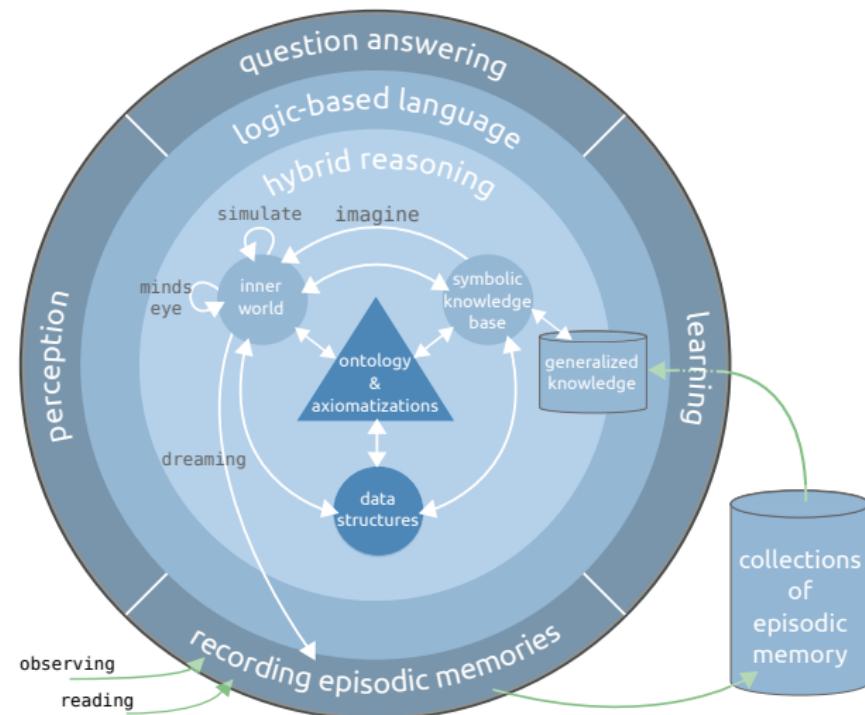
plan parameterization expected to succeed

- vague instruction (eg, add milk to the dough)
-

= knowledge required by robotic agents

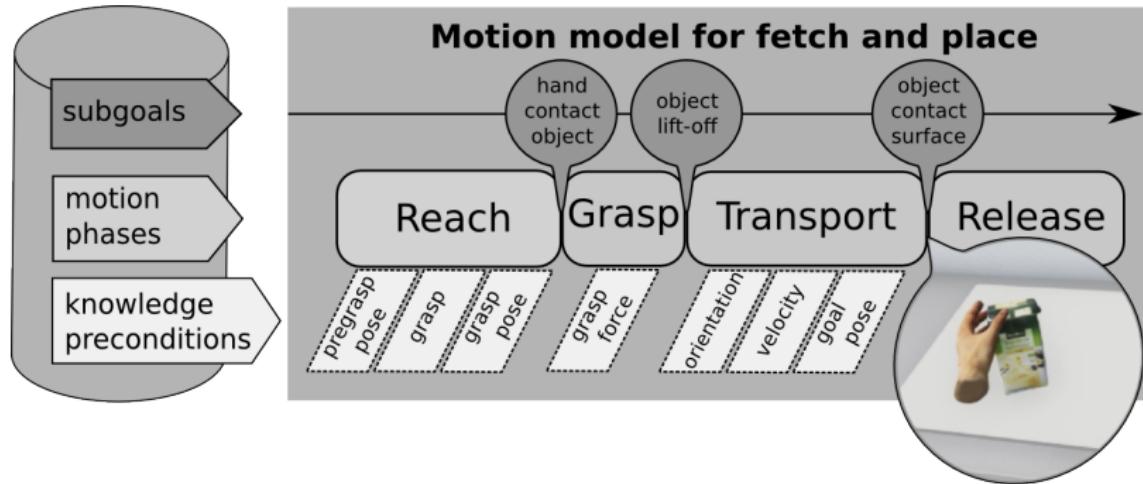
Symbolic and Sub-Symbolic Data

make control-level data knowledgeable.



Symbolic Action Representation

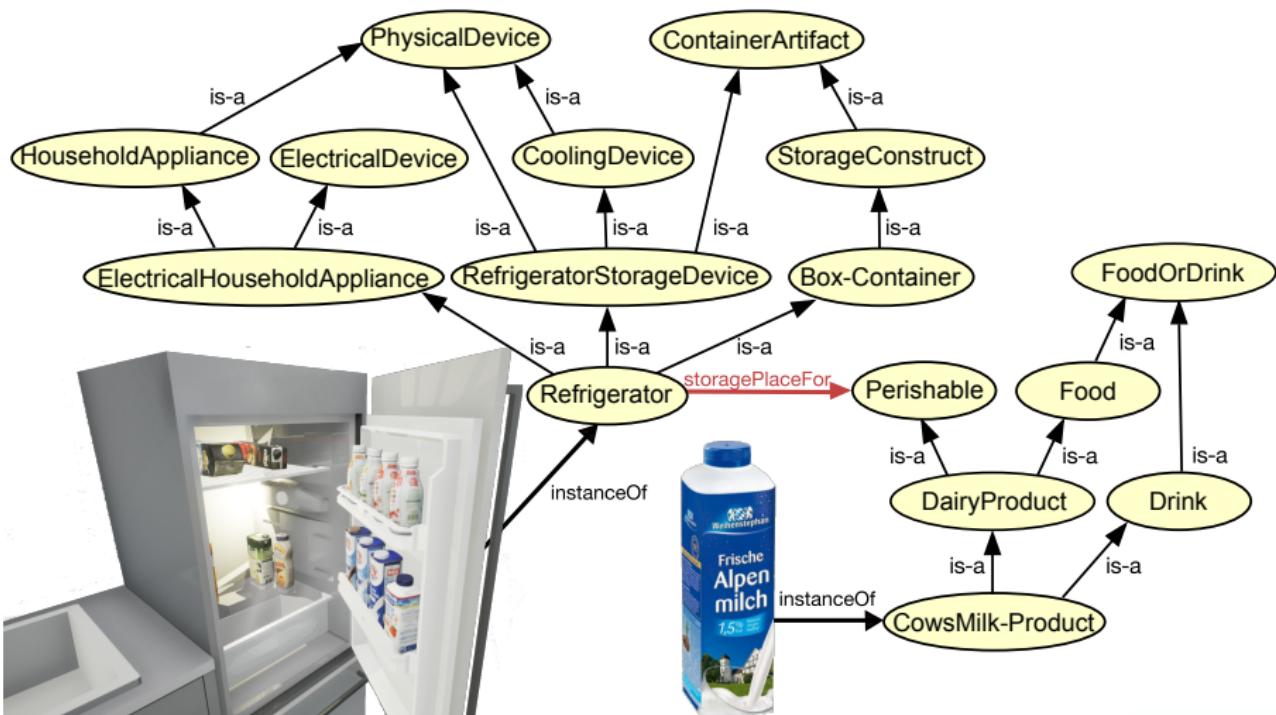
do not treat actions as black boxes.



Flanagan et al., "Control strategies in object manipulation tasks", Curr. Opin. Neurobiol. 16(6):650–659, 2006.

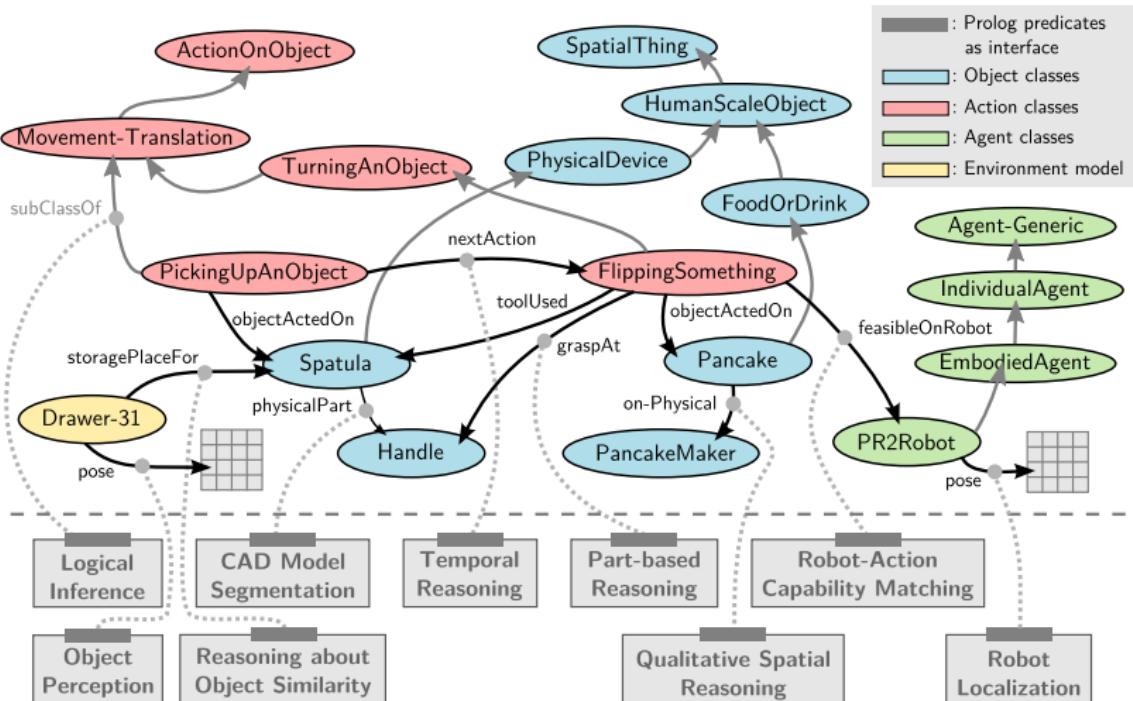
Belief State Representation

symbols grounded in perception.



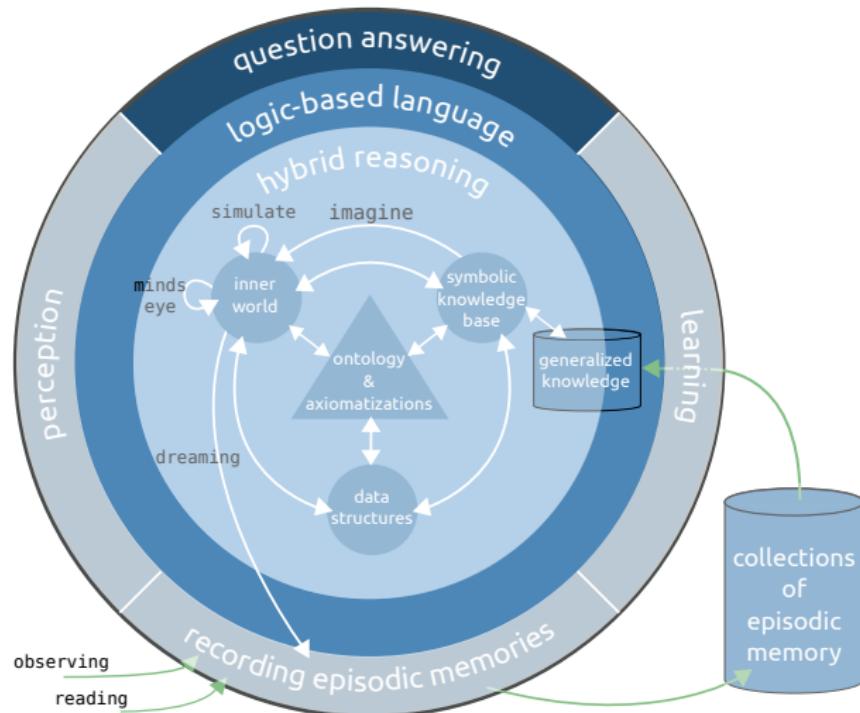
Hybrid Reasoning and Heterogeneous Data

exploit existing methods, switch formalisms where appropriate.



An Interface Layer to Robot Control Systems

unified access to heterogeneous control-level data.



Logic-based Interface Language

ontologies used as interface language.

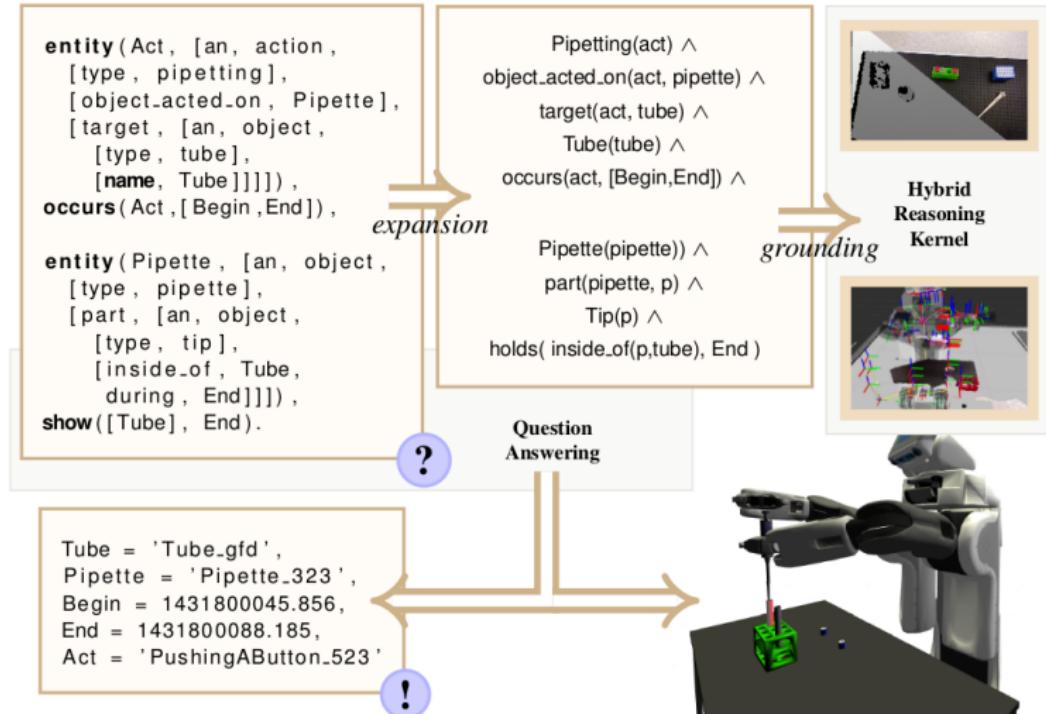
Predicate	Description
$holds(P(S,O), I)$	Relation $P(S, O)$ holds during I .
$occurs(S, I)$	Situation S occurs during I .
$entity(E, D)$	Entity E is subsumed by the partial description D .
$show(S, I)$	Visualize thing S at instant I .

Query

```
? entity(Act, [an, action,  
[type, grasping],  
[object, [an, object,  
[type, spoon],  
[name, Spoon]  
]]]),  
occurs(Act, [A,B]),  
holds(ontop(  
Spoon, Table), A),  
entity(Table,  
[an, object,  
[type, table]])),  
show(Spoon, A).
```

Question Answering Interface

symbols grounded in hybrid reasoning kernel.

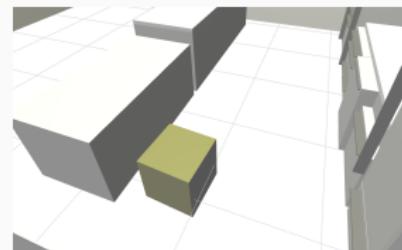


Example: “Where did the robot stand during put-down?”

Query

```
entity(Tsk, [an, action,  
[type, putting-down-an-object],  
[performed-by, [a, robot,  
[part, [an object,  
[type, mobile-base],  
[name, Base]]]]]),  
occurs(Tsk, [_, End]),  
entity(Base, [an, object,  
[pose, Pose, during, End]]),  
show(cube(mobile-base), [pose(Pose)]).
```

?



!

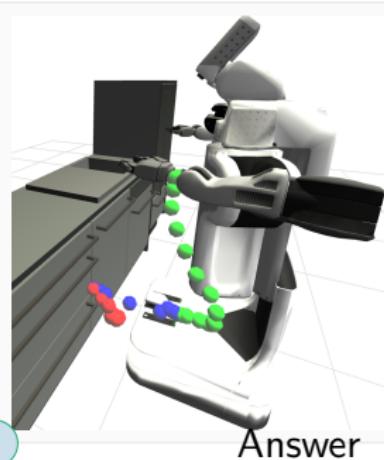
```
Tsk = log:'PuttingDownAnObject_0',  
Base = robot:'MobileBase_pr2',  
Pose = pose([TX,TY,TZ], [RW,RX,RY,RZ]),  
End = 1396512613.0.
```

Answer

Example: “What motions did the robot perform to close a drawer?”

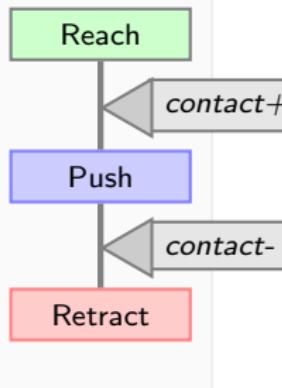
?

```
Query  
entity(Act , [an, action ,  
[type , closing_a_drawer] ,  
[part_moved , [an, object ,  
[base_link , HandBase]]]]) ,  
findall(M,  
entity(Act , [sub_motion , M]) ,  
Motions) ,  
show(Motions).
```



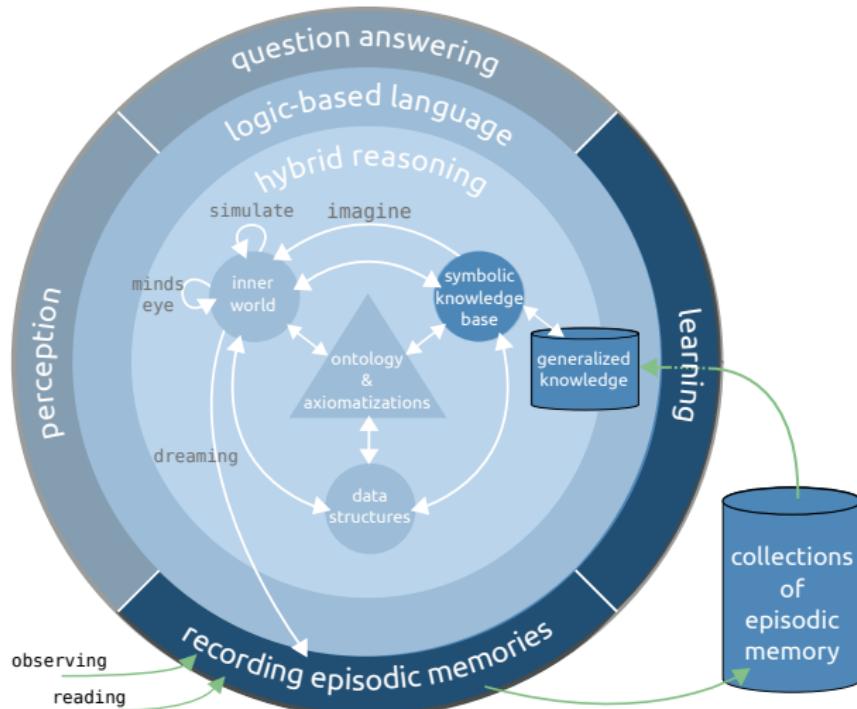
!

Answer



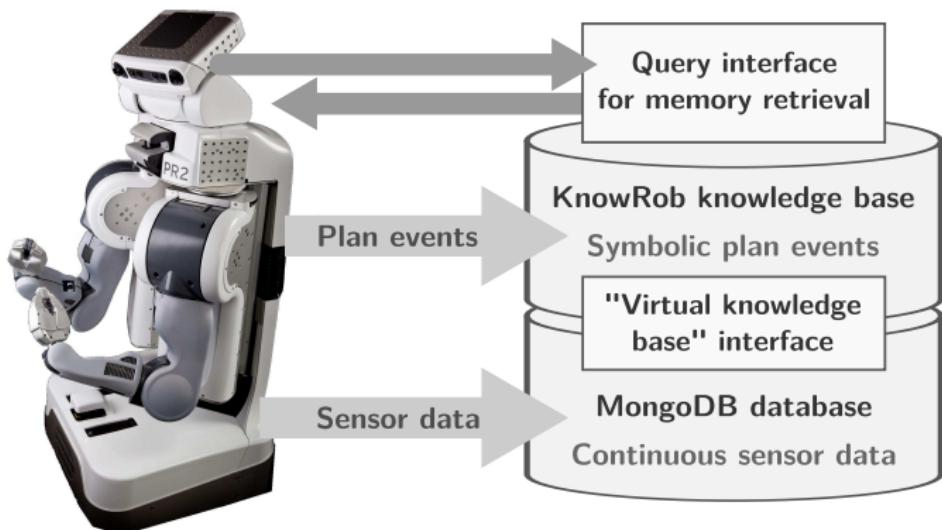
Narrative-enabled Episodic Memories (NEEMs)

very detailed stories of activities coupled with experience data.



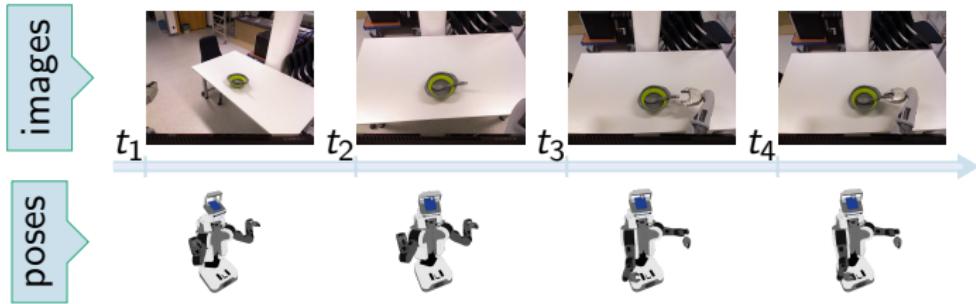
Recording Robot NEEMs

include existing data structures, no abstraction a priori.



Robot NEEMs

perfect information about intensions.



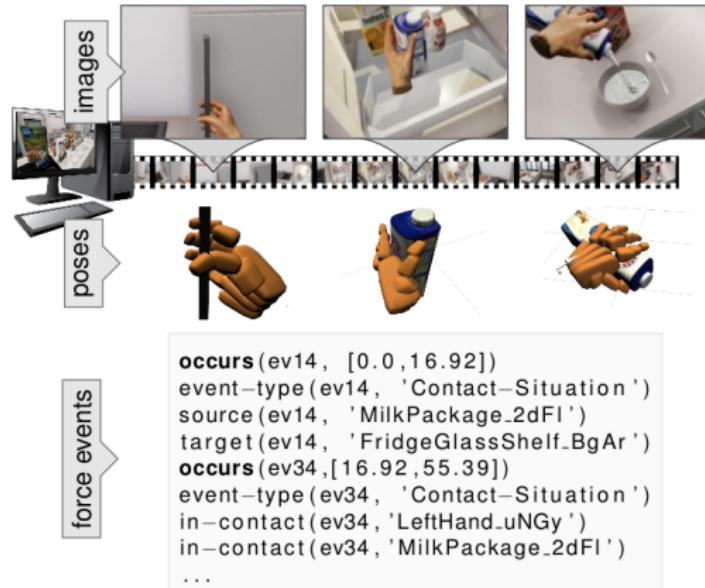
```
occurs(ev123, t2)
event-type(ev123, detect)
perception-task(ev123, obj246)
entity(obj246, [an, object, ...])
perception-result(ev123, obj345)
entity(obj345, [an, object, ...])
captured-image(ev123, img456)
image-region(obj345, reg567)
```

Assertions

!

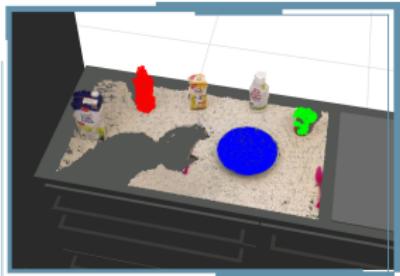
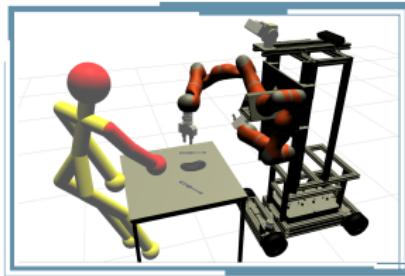
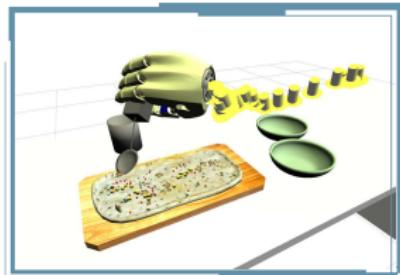
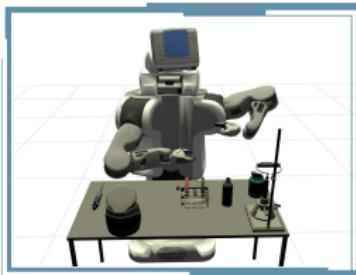
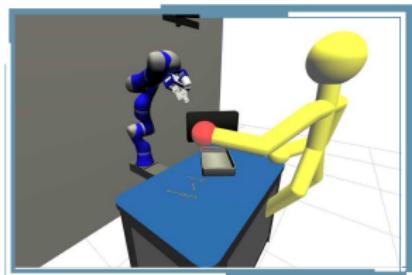
Virtual Reality NEEMs

perfect information about force dynamic events.



Collections of NEEMs

memorize to generalize.



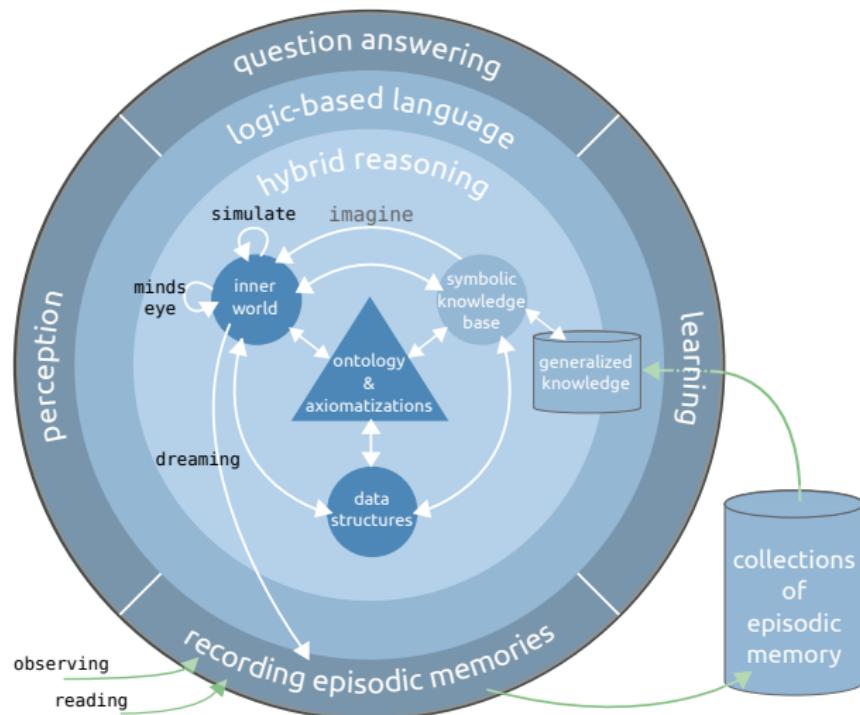
openEASE – A Knowledge Web Service for Robots for NEEM storage, analysis, and visualisation.



Beetz et al., “Open-EASE – a knowledge processing service for robots and robotics/ai researchers,”, ICRA, 2015.

Mastering Everyday Manipulation Tasks

exploit almost realistic rendering and simulation.



Almost Photo-Realistic Rendering

size, realism, detail, machine-understandable, faithful simulation.



Robot Simulation

Current State:

- Load SDF files into Unreal Engine editor
- Spawn robot into an Unreal Engine world
- Move robot and set joint velocities

Future:

- ROS interface
- Gazebo like functionalities
- Web usage



Thank you for your attention!