

# EASE - EVERYDAY ACTIVITY SCIENCE AND ENGINEERING

Michael Beetz  
Kerstin Schill



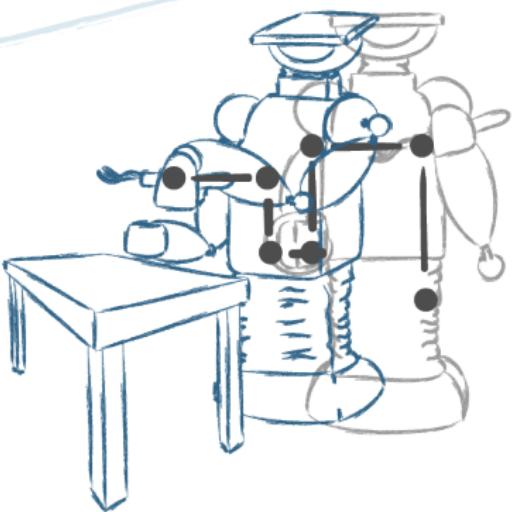
Universität Bremen

FROM

PERFORMING  
A TASK

TO

MASTERING  
A JOB



???



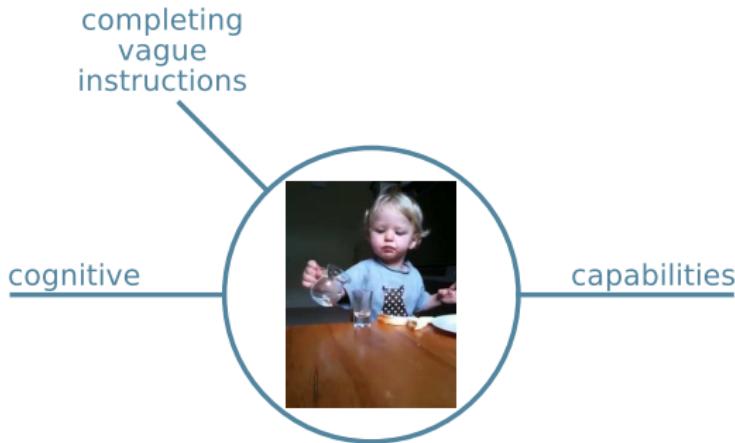
# Mastering everyday activities — Cognitive capabilities & computational problems



# Mastering everyday activities — Cognitive capabilities & computational problems



# Mastering everyday activities — Cognitive capabilities & computational problems

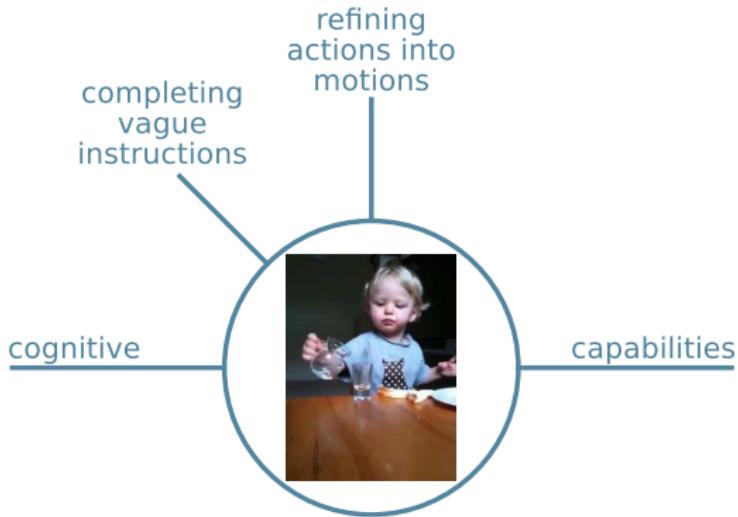


**fill the glass with water:**

- ⇒ take the pitcher
- ⇒ pour into the glass

# Mastering everyday activities —

## Cognitive capabilities & computational problems

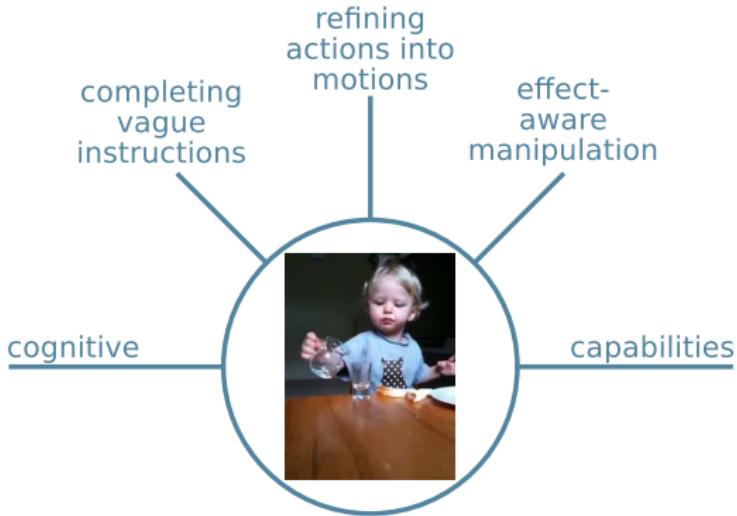


**fill the glass with water:**

- ⇒ grasp the pitcher by the handle
- ⇒ hold the pitcher upright
- ⇒ tilt the pitcher
- ⇒ ...

# Mastering everyday activities —

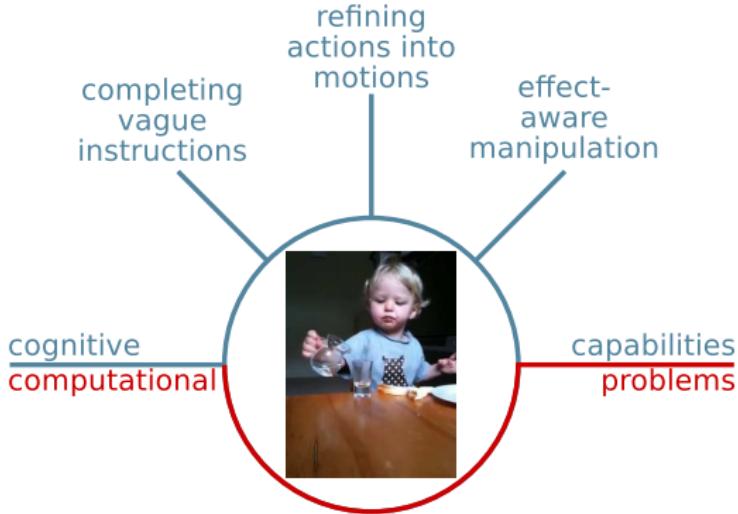
## Cognitive capabilities & computational problems



**fill the glass with water:**

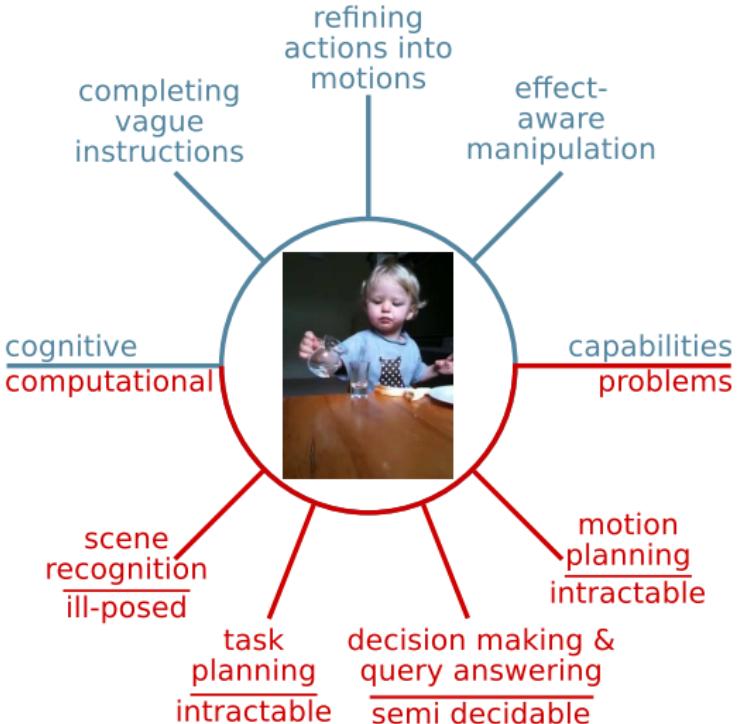
- ⇒ hold the pitcher above the glass while tilting
- ⇒ stabilize the pitcher
- ⇒ pour less than the capacity
- ⇒ ...

# Mastering everyday activities — Cognitive capabilities & computational problems



# Mastering everyday activities —

## Cognitive capabilities & computational problems



# Mastering everyday activities —

## The evolution of mastery

Elementary proficiency



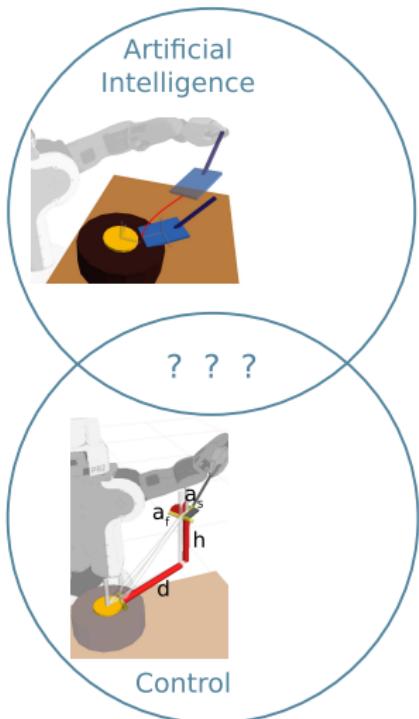
observing  
reading  
playing  
exploring

Mastery



# Mastering manipulation actions —

## Current state of understanding



### artificial intelligence

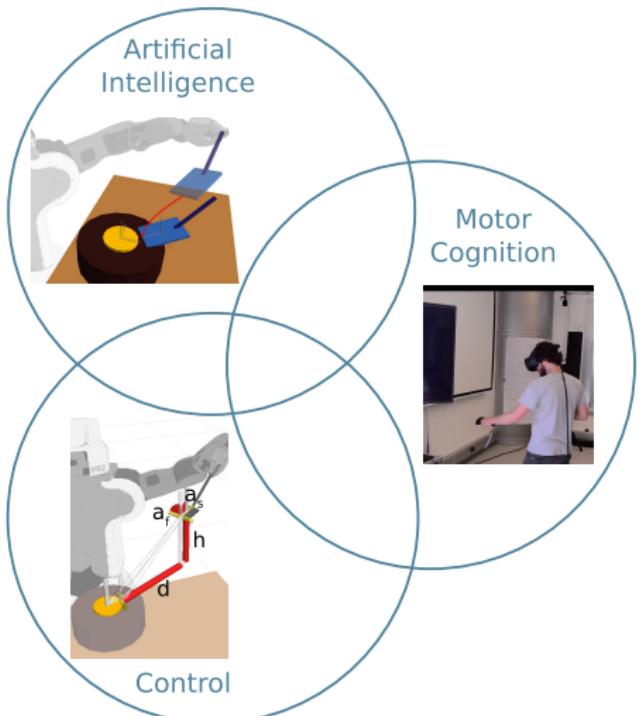
- abstract preconditions and effects suffice for mastery

### robot control

- motion constraints and objectives suffice for mastery

# Mastering manipulation actions —

Extending knowledge representation and reasoning



## motor cognition

learning, reasoning, and planning  
how to parameterize and synchronize  
motions to accomplish goals

# Open research question

Design, realization, and investigation of  
**generative information processing and control models** that can  
evolve manipulation capabilities of artificial agents from  
elementary proficiency to mastery of human-scale manipulation tasks

ease

EVERYDAY ACTIVITY  
SCIENCE AND ENGINEERING



# *Everyday activity*

science and engineering

Everyday activity tasks are complex but common and mundane

- common  $\Rightarrow$  knowledge  $\Rightarrow$  mundane
- satisficing performance<sup>1</sup>:

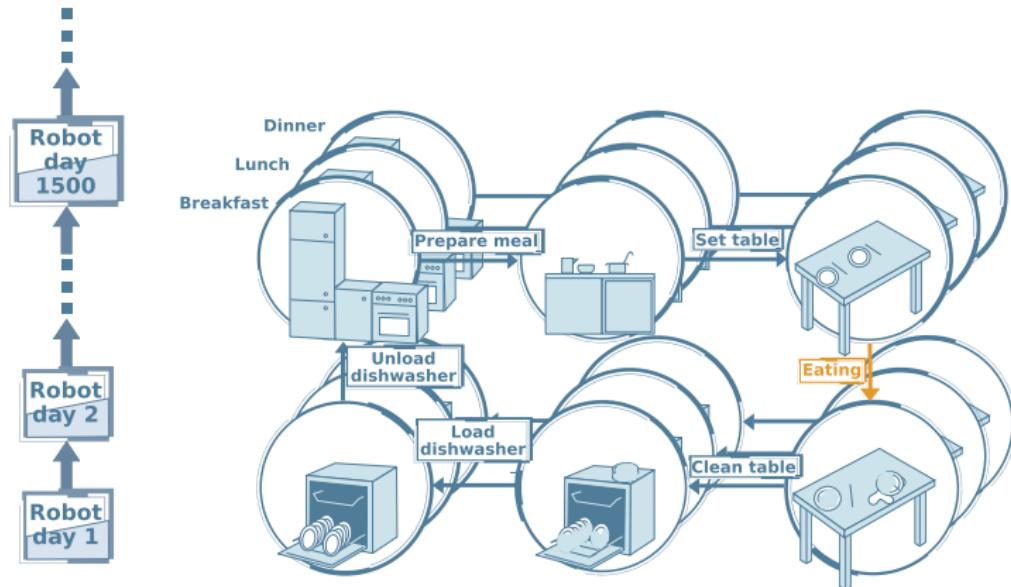
$$\arg \underset{\textit{params}}{\text{sat}} \textit{ExpectedUtility}(\textit{action}(\textit{params}))$$

---

<sup>1</sup>adopted from [Anderson, 1995]

# *Everyday activity*

## science and engineering

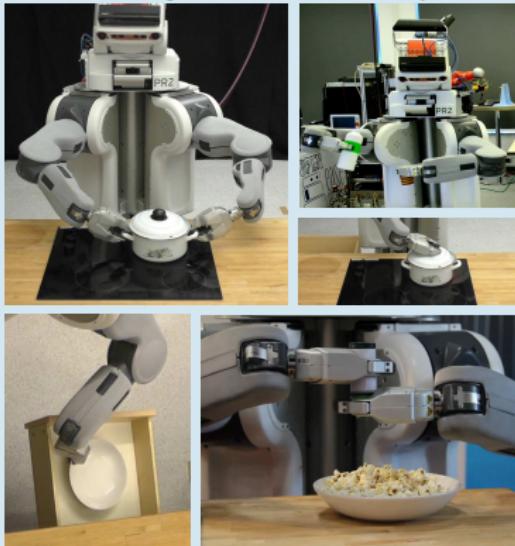


# *Everyday activity*

## science and engineering

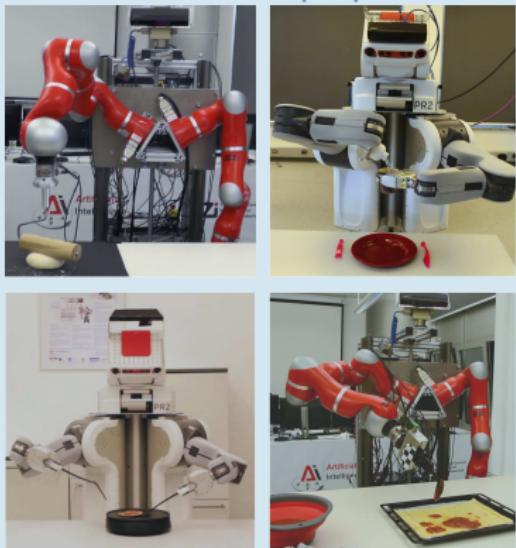
### challenge 1:

Variability of fetch and place

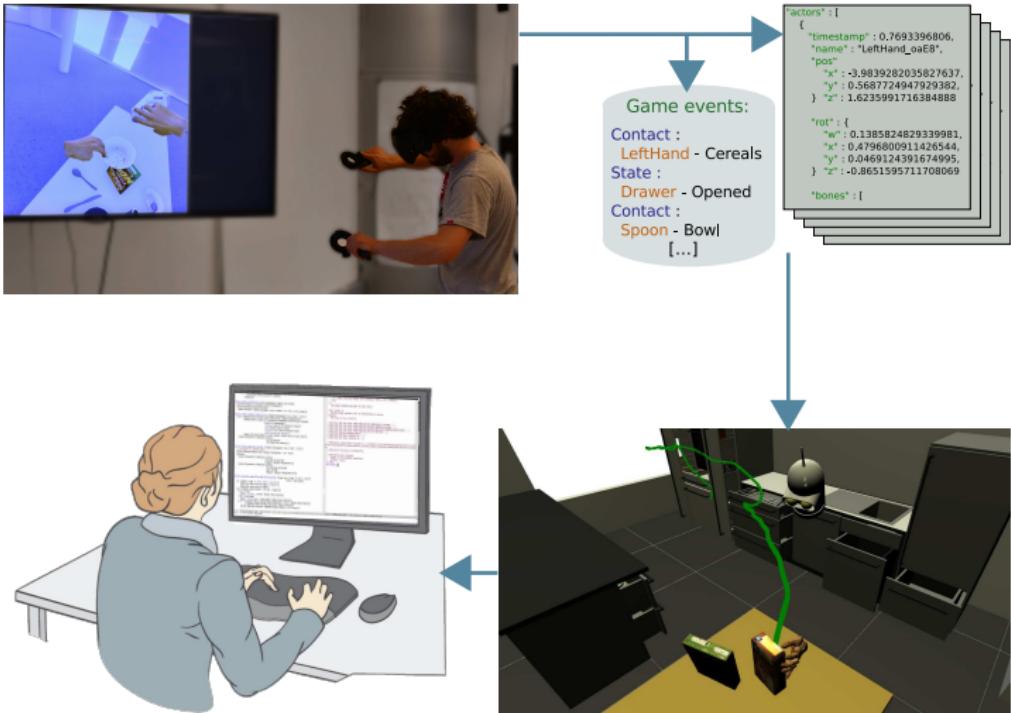


### challenge 2:

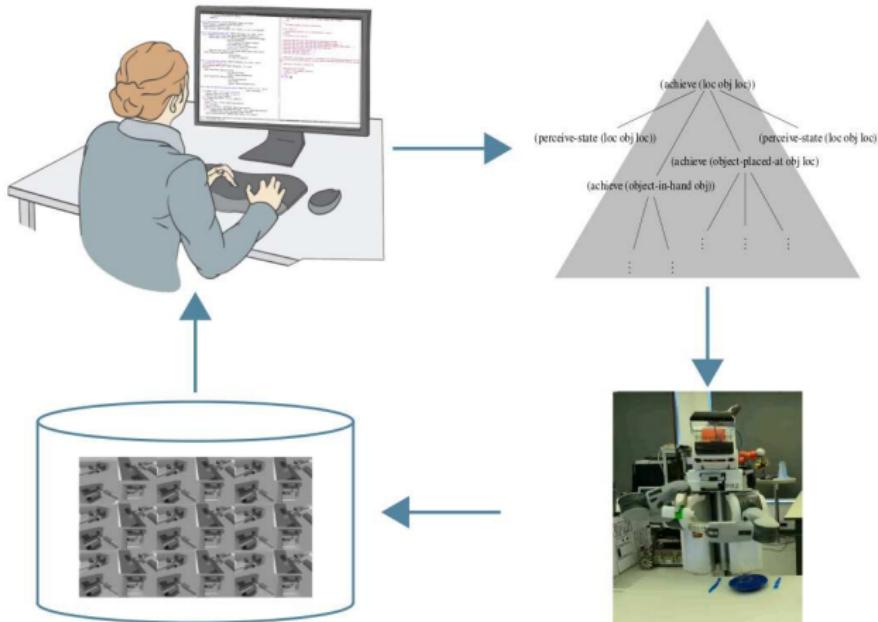
Competent, effect-directed action for meal preparation



# Everyday activity *science* and engineering

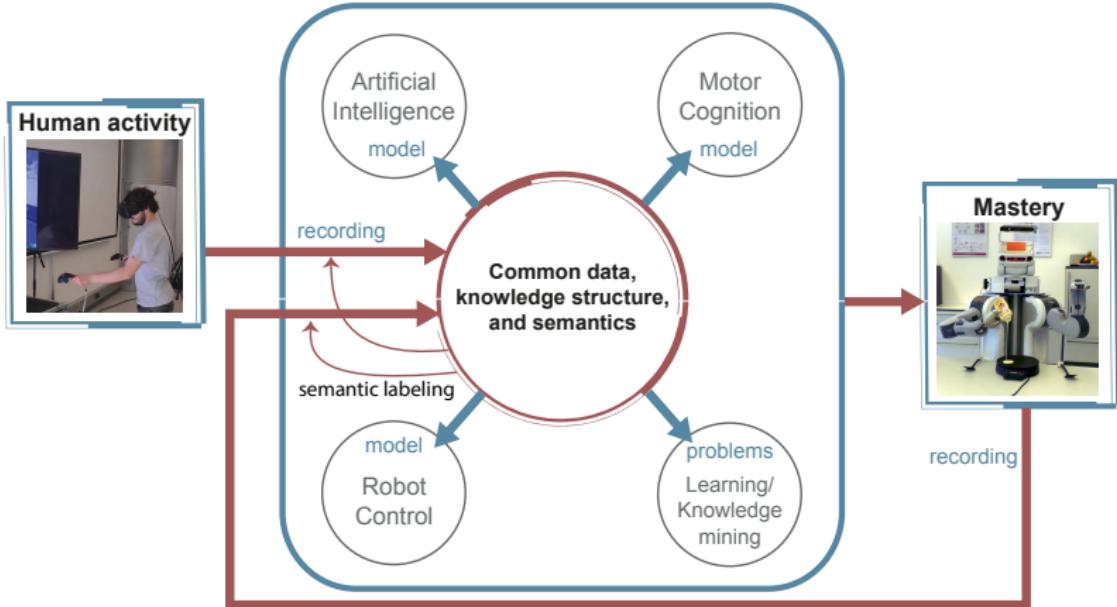


# Everyday activity science and *engineering*



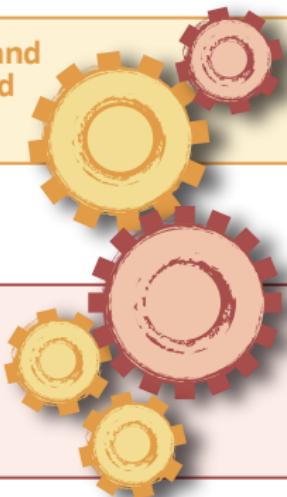
# Envisioned research breakthrough

## Generative model for the mastery of everyday manipulation activity



# Approach

What common knowledge and which inferences are needed for everyday activity?



How to reason effectively without delaying actions?

# Approach

What common knowledge and which inferences are needed for everyday activity?

**NARRATIVE-ENABLED EPISODIC MEMORIES (NEEMS)**

How to reason effectively without delaying actions?

**PRAGMATIC EVERYDAY ACTIVITY MANIFOLDS (PEAMS)**



# Narrative-enabled episodic memories (NEEMs)

## A closer look

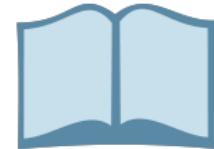
NEEMs

=

NEEM narrative

+

NEEM experience



goals, plans, ac-  
tions, objects

poses, object per-  
ceptions, forces

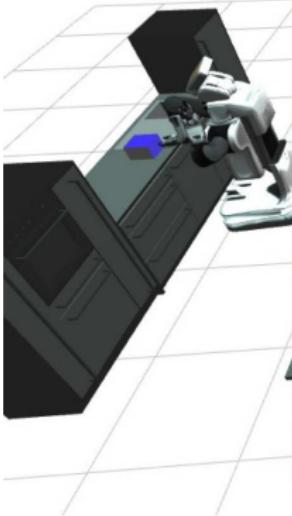


# Narrative-enabled episodic memories (NEEMs)

## Semantic retrieval

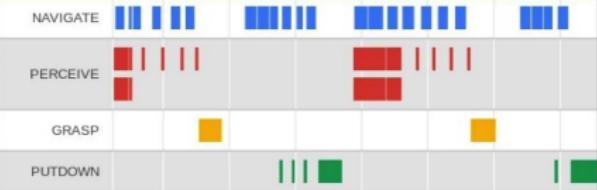
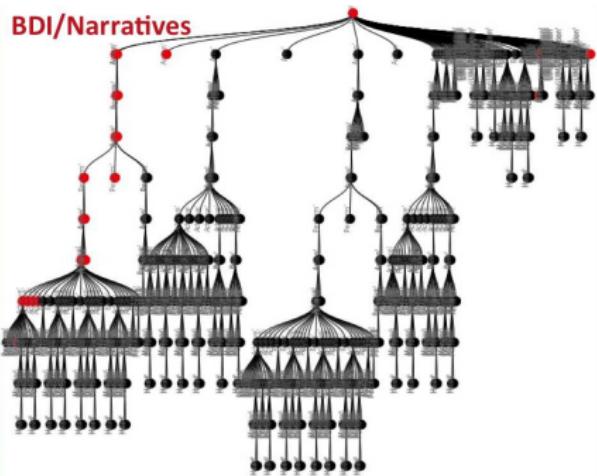
### Behavior

AT  
ON = CounterTop  
NAME = lai\_kitchen\_sink\_area\_counter\_top  
TYPE = RedMetalCup  
URDF-MODEL-FILENAME = red\_metal\_cup\_white\_speckles  
ROBOSHERLOCK-CLASS = Cup  
SHAPE = CYLINDER  
HANDLE  
TYPE = HANDLE  
GRASP-TYPE = PUSH  
AT  
POSE =  
0.7075240541442478 0 0.7066892618451815 -0.11  
0 1 0 0  
-0.7066892618451815 0 0.7075240541442478 0.11  
0 0 0 1



### Belief State

### BDI/Narratives



### Temporal Logic Representation

# Narrative-enabled episodic memories (NEEMs)

## Semantic retrieval

```
?- task(T),  
task-action(T, [an, action,  
              [type, pick-up],  
              [object-acted-on,  
               [an, object  
                 [type, pot],  
                 [weight, W]]]]),  
W >= 2kg,
```

# Narrative-enabled episodic memories (NEEMs)

## Semantic retrieval

```
?- task(T),  
task-action(T, [an, action,  
              [type, pick-up],  
              [object-acted-on,  
               [an, object  
                 [type, pot],  
                 [weight, W]]]]),  
  
W >= 2kg,  
task-start(T,Tstart),
```

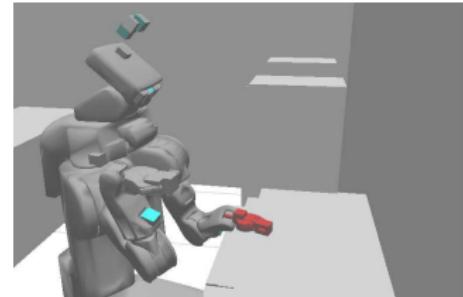
# Narrative-enabled episodic memories (NEEMs)

## Semantic retrieval

```
?- task(T),  
task-action(T, [an, action,  
              [type, pick-up],  
              [object-acted-on,  
               [an, object  
                 [type, pot],  
                 [weight, W]]]]),
```

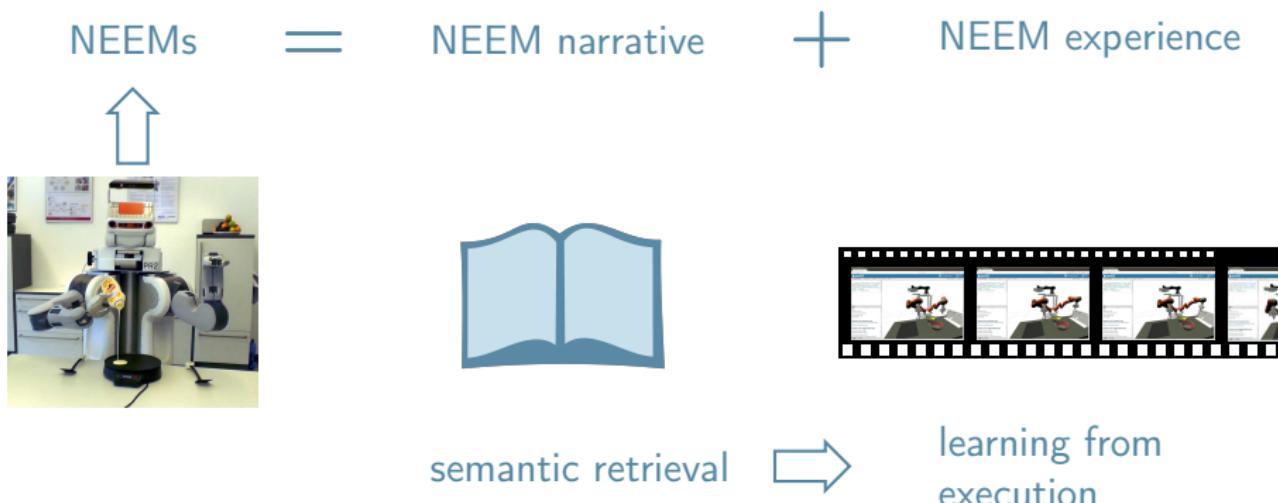
$W \geq 2\text{kg}$ ,

```
task-start(T,Tstart),  
holds(pose(pr2,P),Tstart).
```



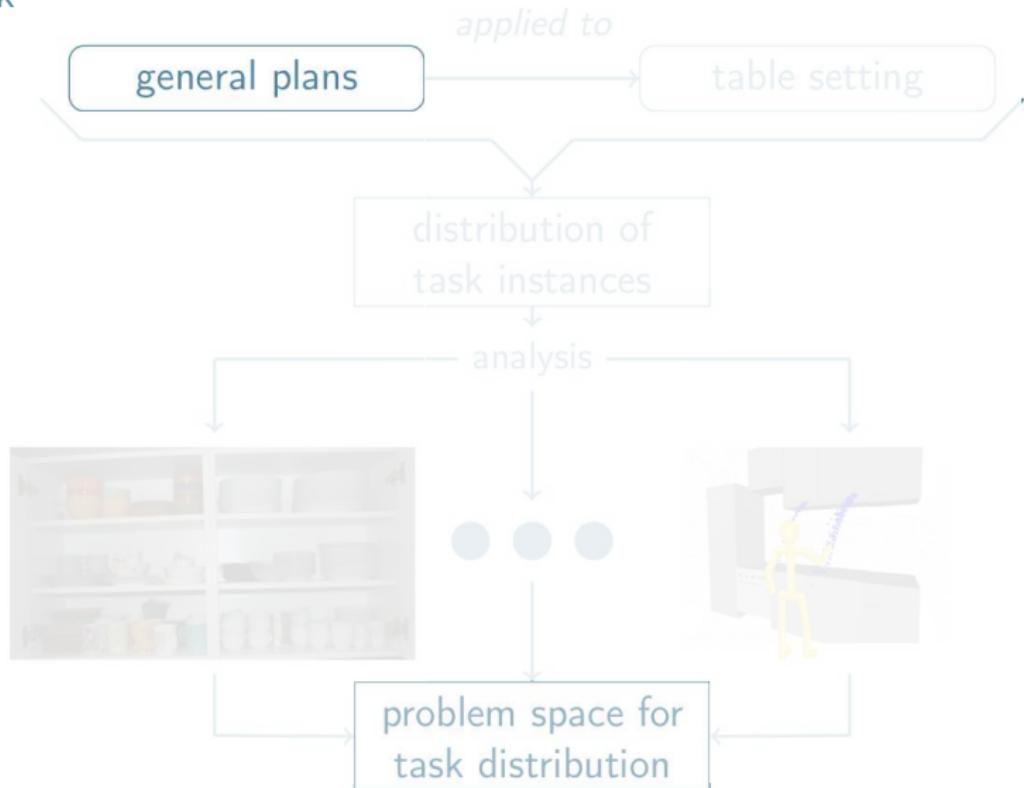
# Narrative-enabled episodic memories (NEEMs)

## Learning from execution



# Pragmatic everyday activity manifolds (PEAMs)

## A closer look

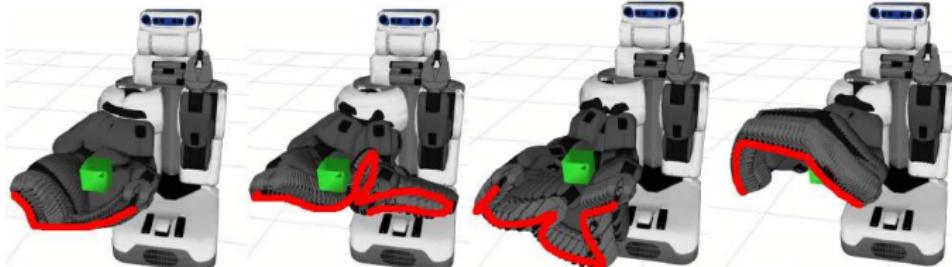


# Pragmatic everyday activity manifolds (PEAMs)

## A closer look

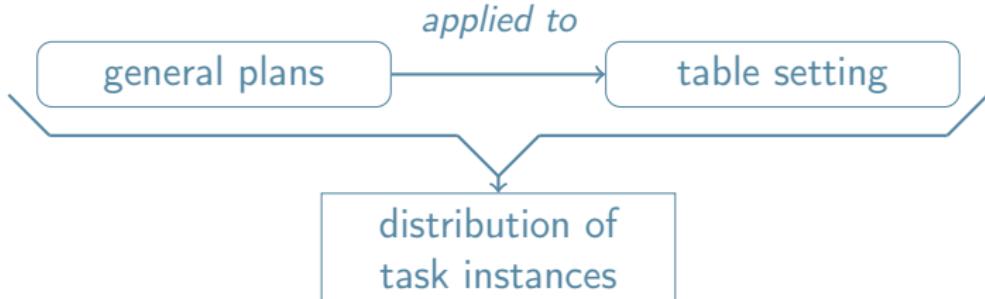
general plans

**Plan:** fetch & place  
go-to(a place  
(visible Object))  
detect-&-localize(Object)  
let Grasp-Pose  $\leftarrow$  appropriate-grasp(Object)  
reach(Grasp-Pose)



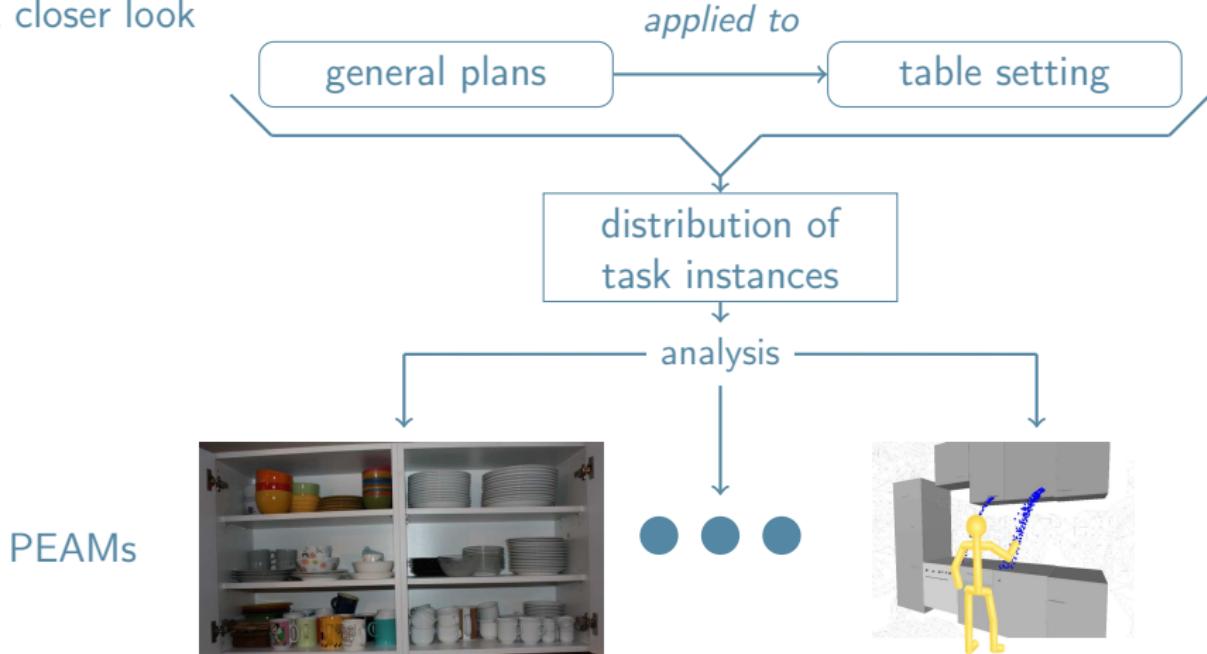
# Pragmatic everyday activity manifolds (PEAMs)

## A closer look



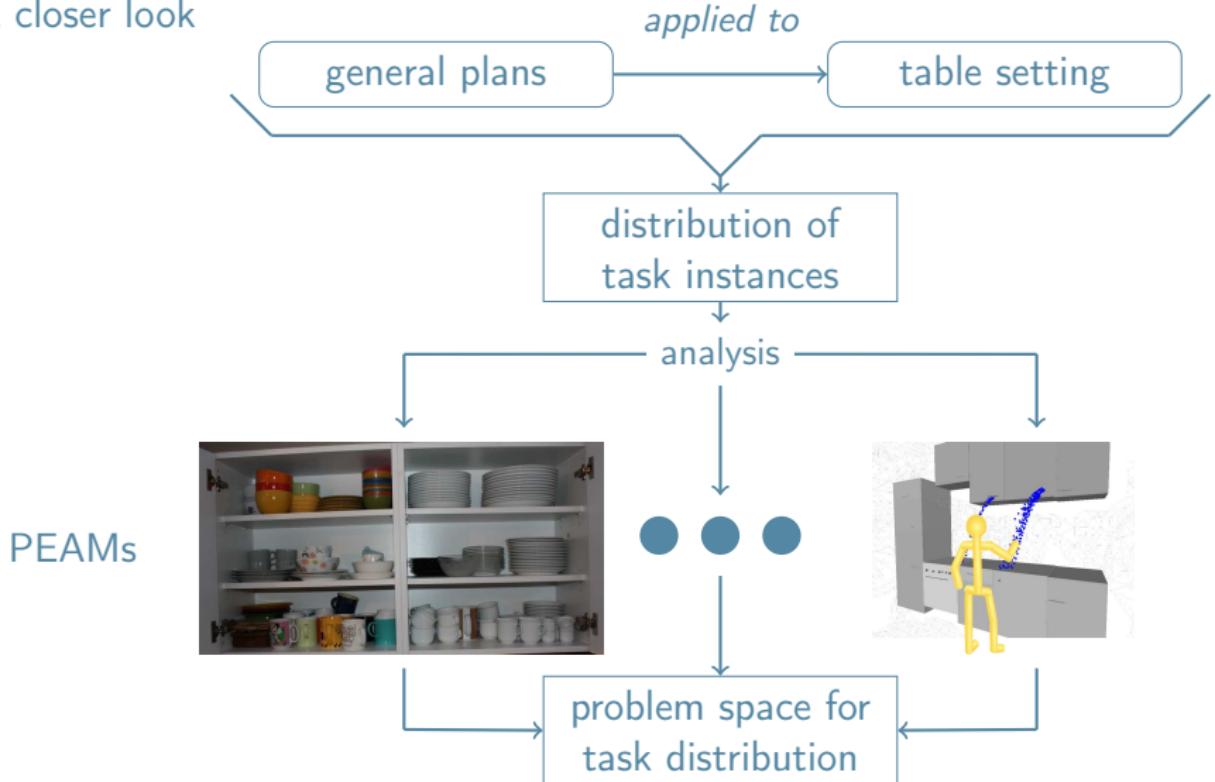
# Pragmatic everyday activity manifolds (PEAMs)

A closer look

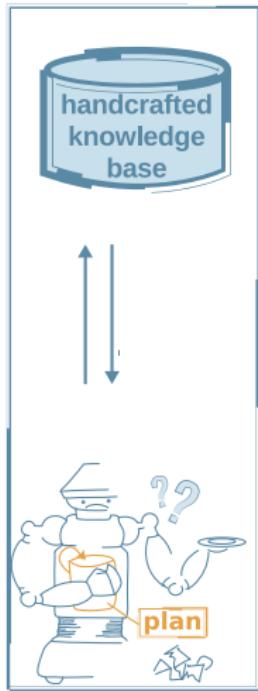


# Pragmatic everyday activity manifolds (PEAMs)

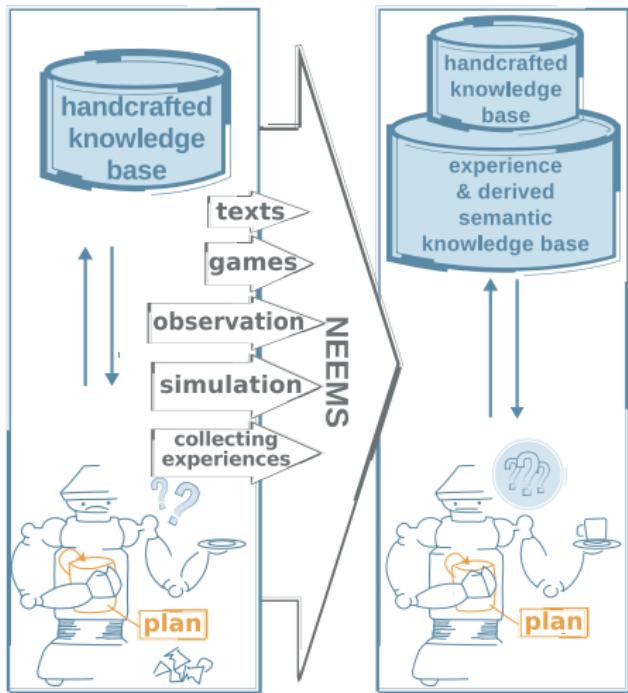
A closer look



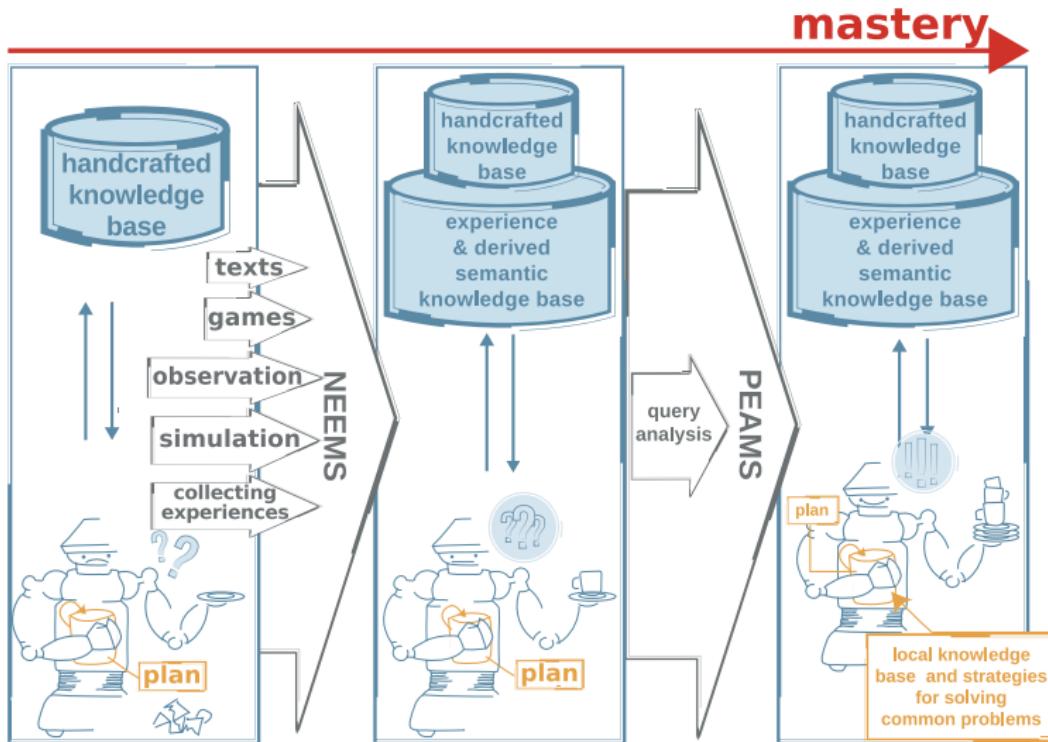
# EASE Evolution of Mastery



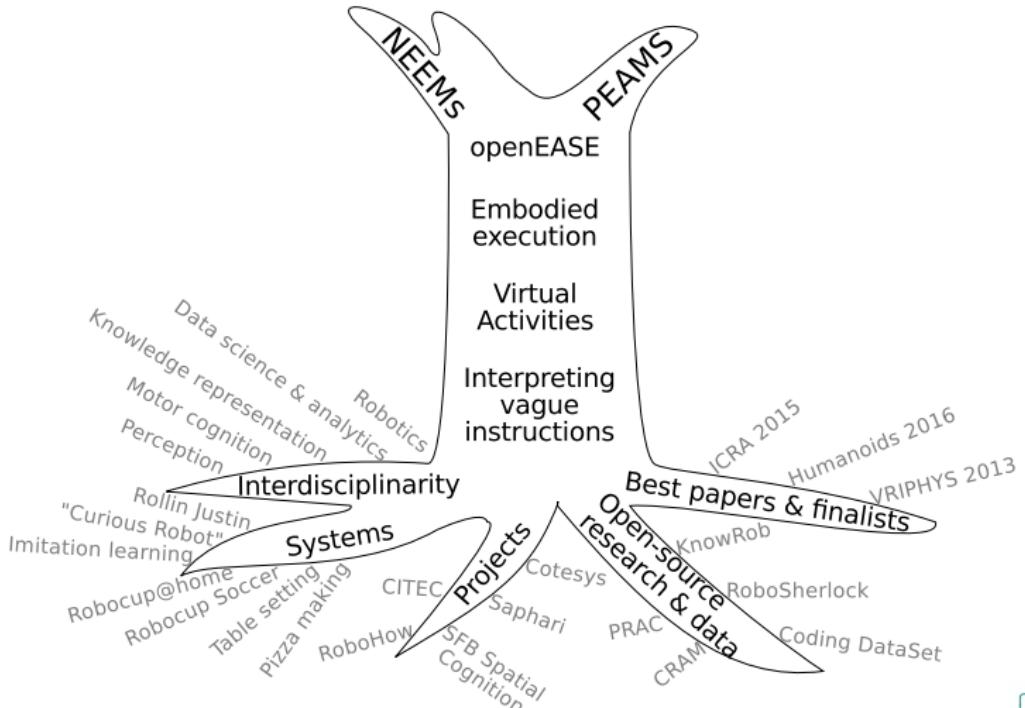
# EASE Evolution of Mastery



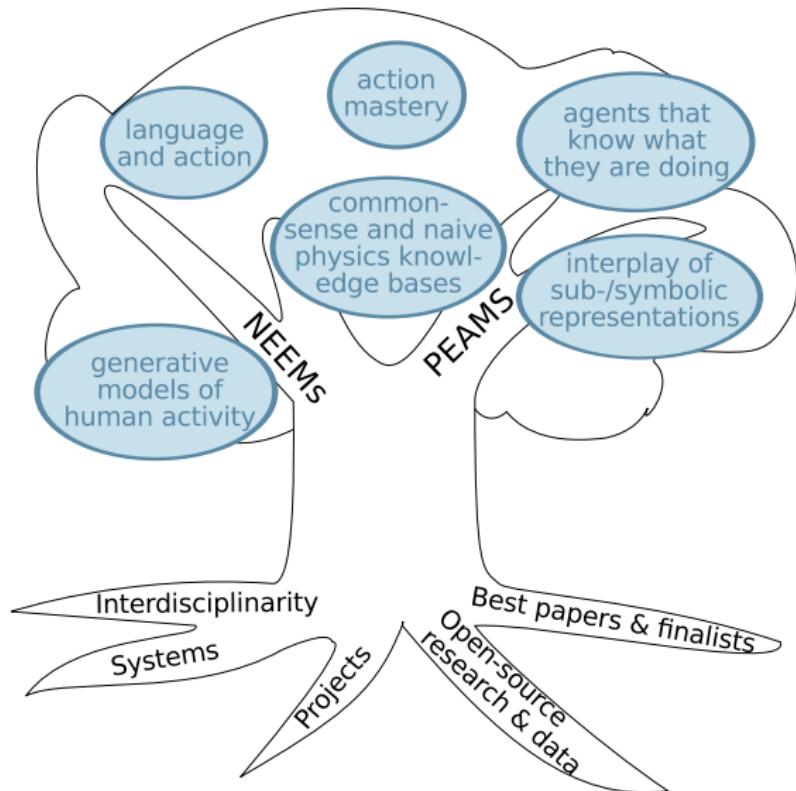
# EASE Evolution of Mastery



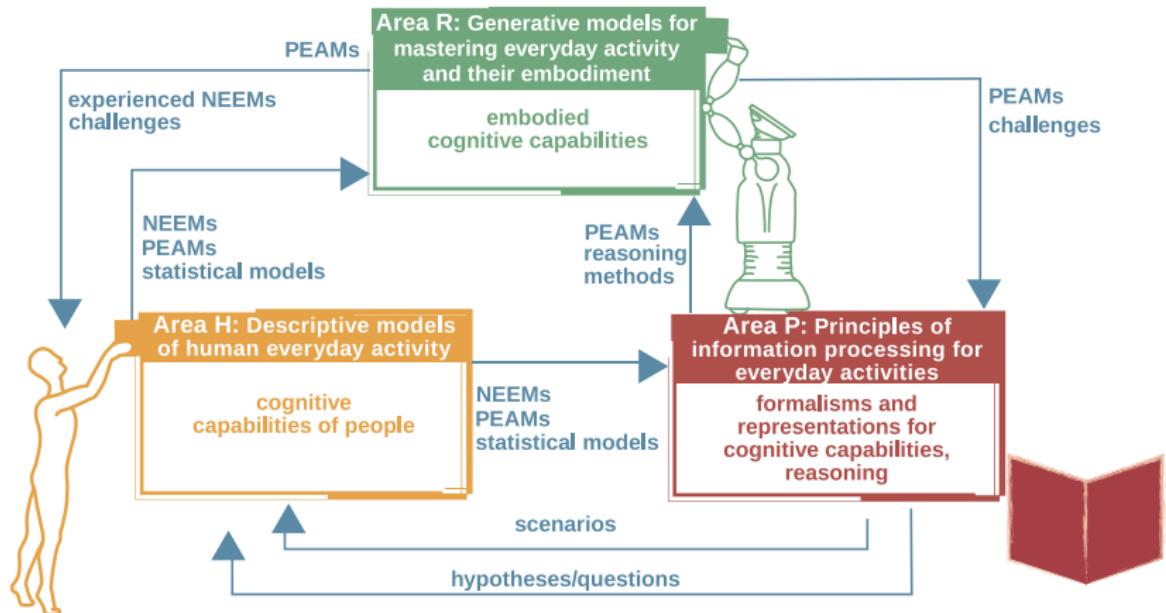
# EASE – The unique starting point



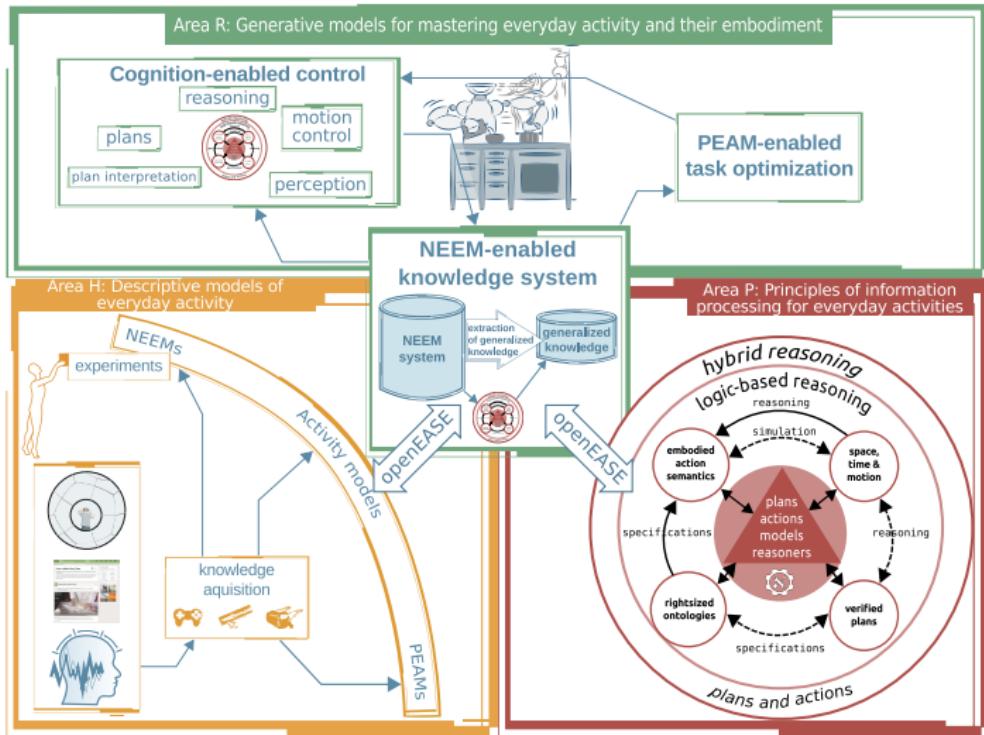
# EASE — Where we are going



# Research plan 1st phase (1)

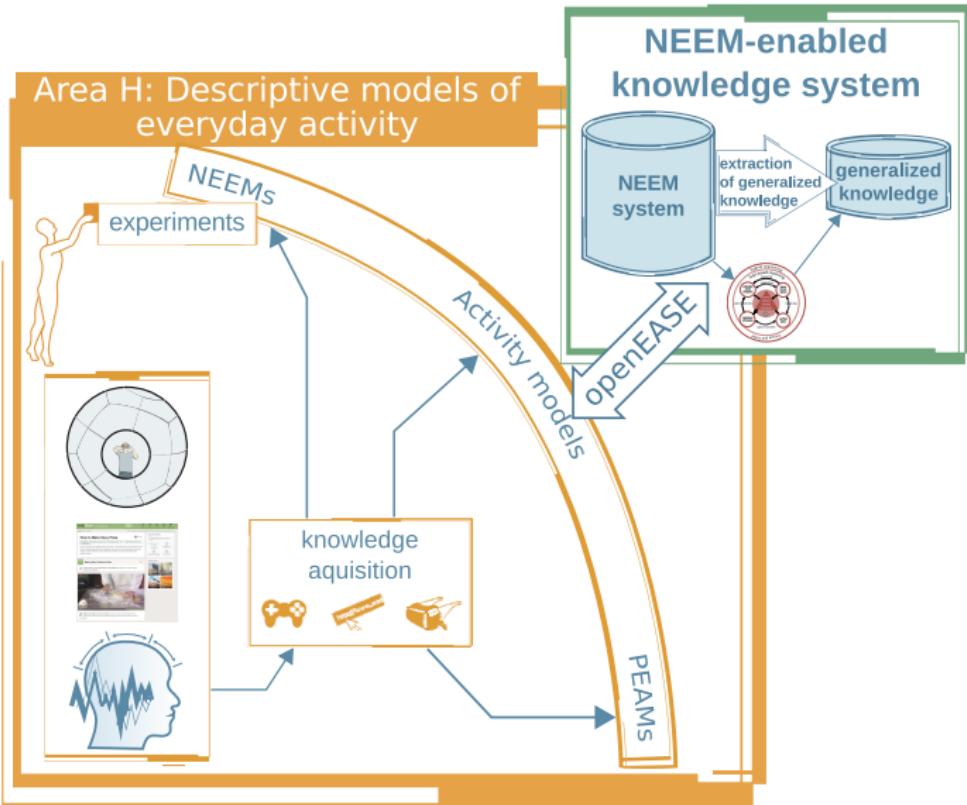


# Research plan 1st phase (2)



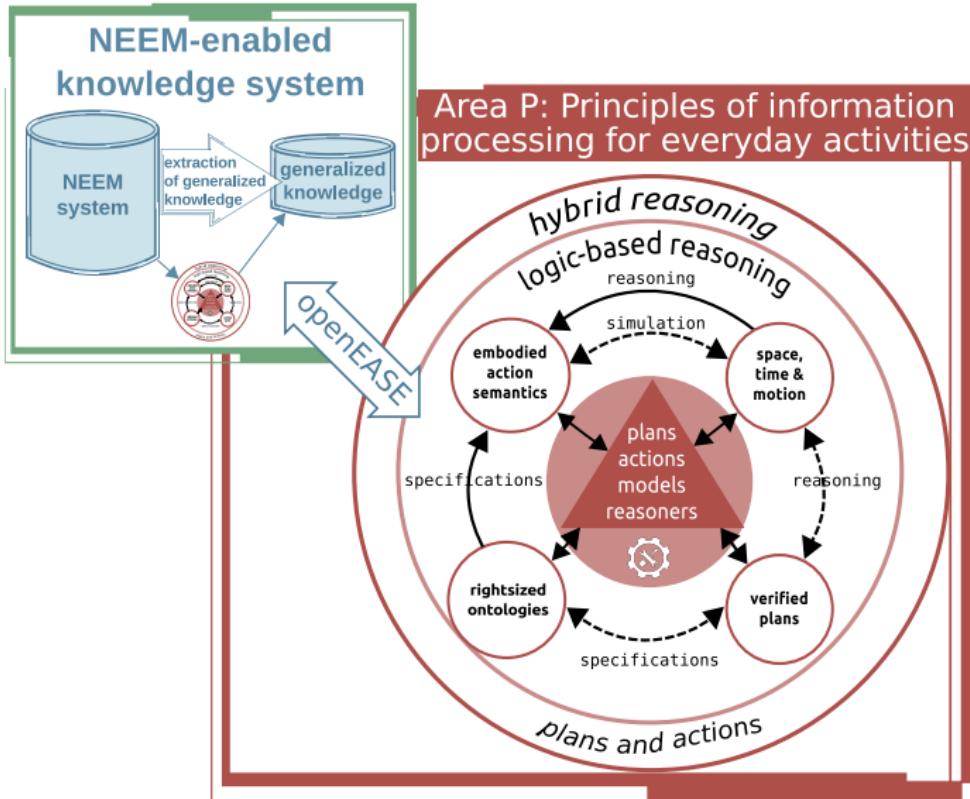
# Research plan 1st phase

## Area H



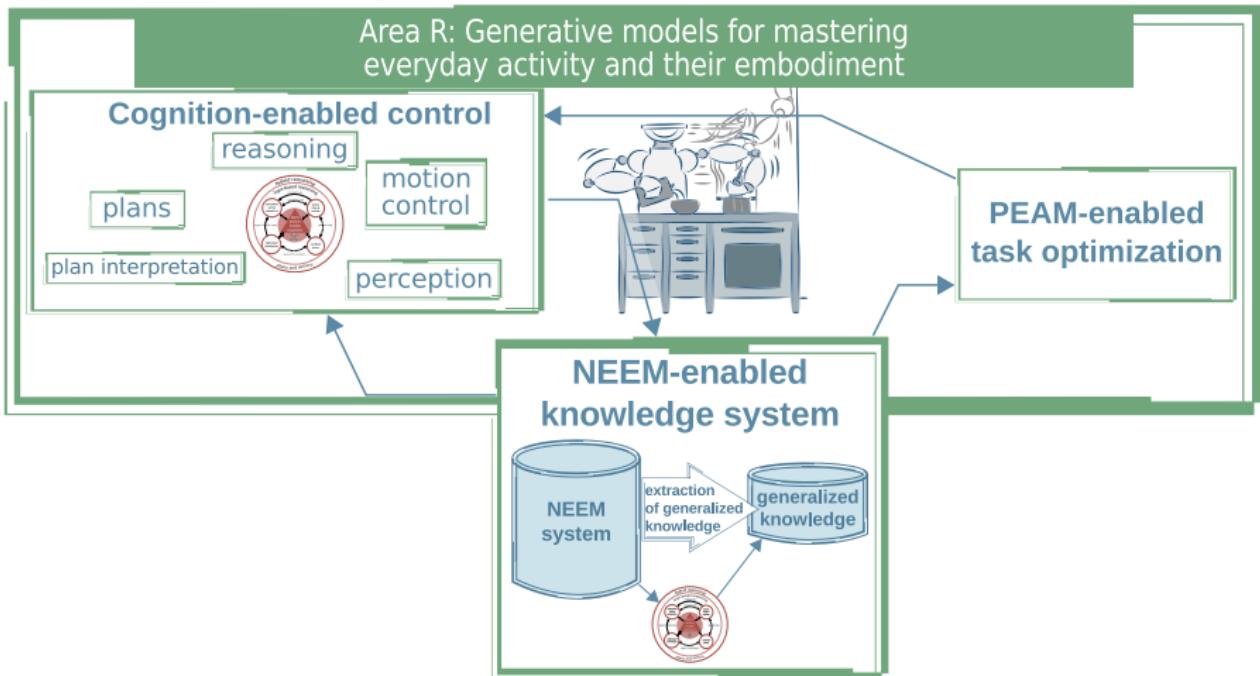
# Research plan 1st phase

Area P

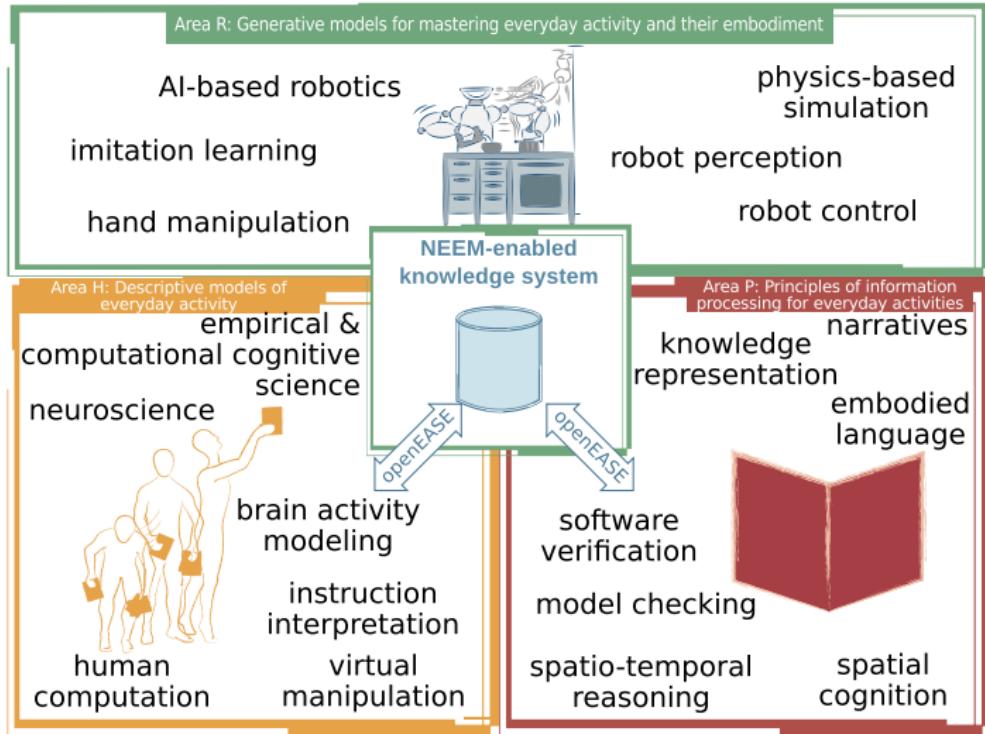


# Research plan 1st phase

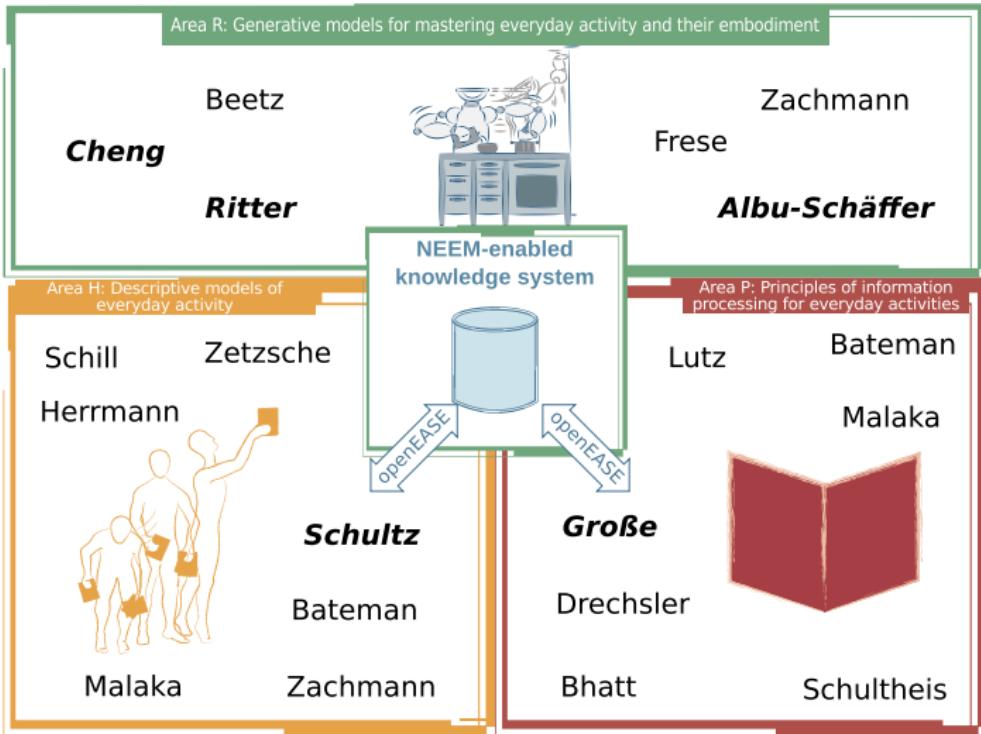
## Area R



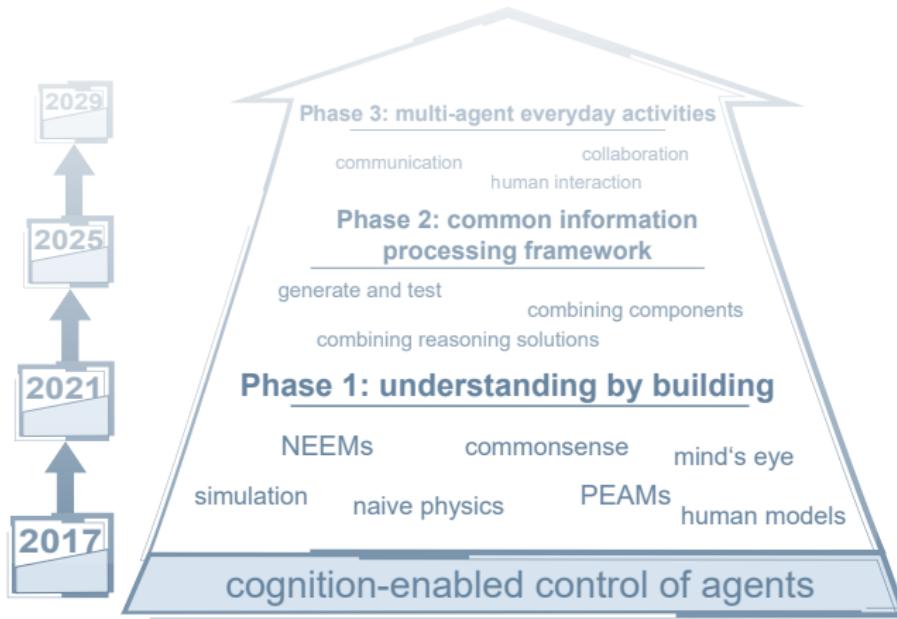
# Consortium expertise



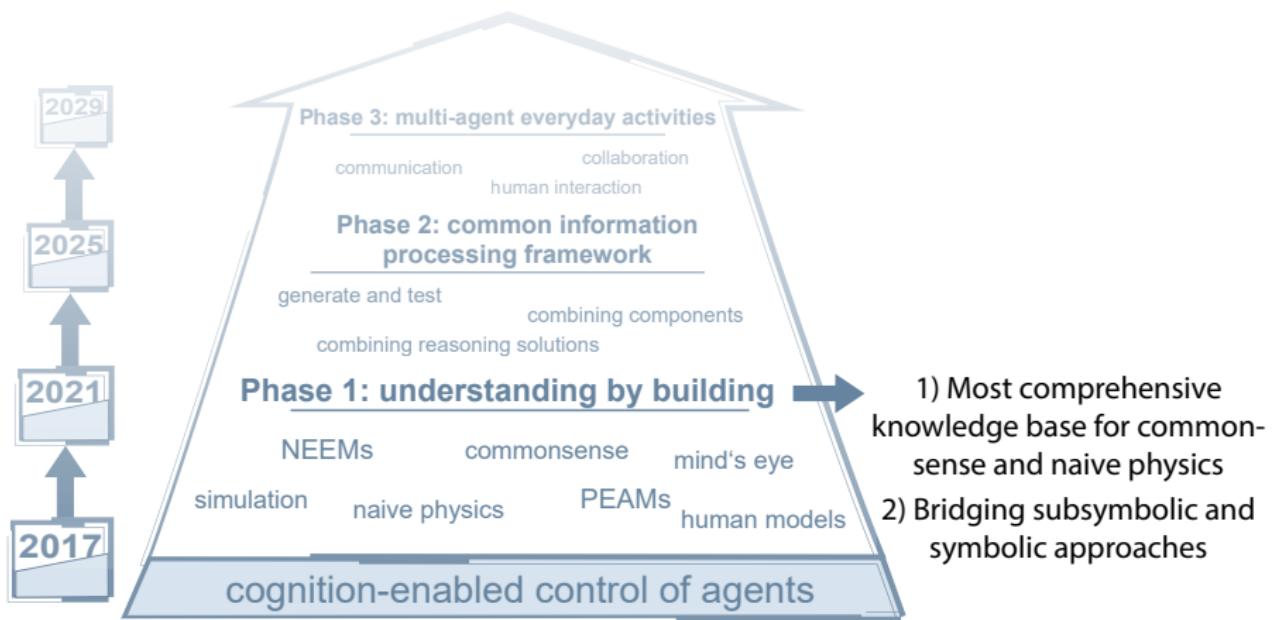
# Coverage of required expertise



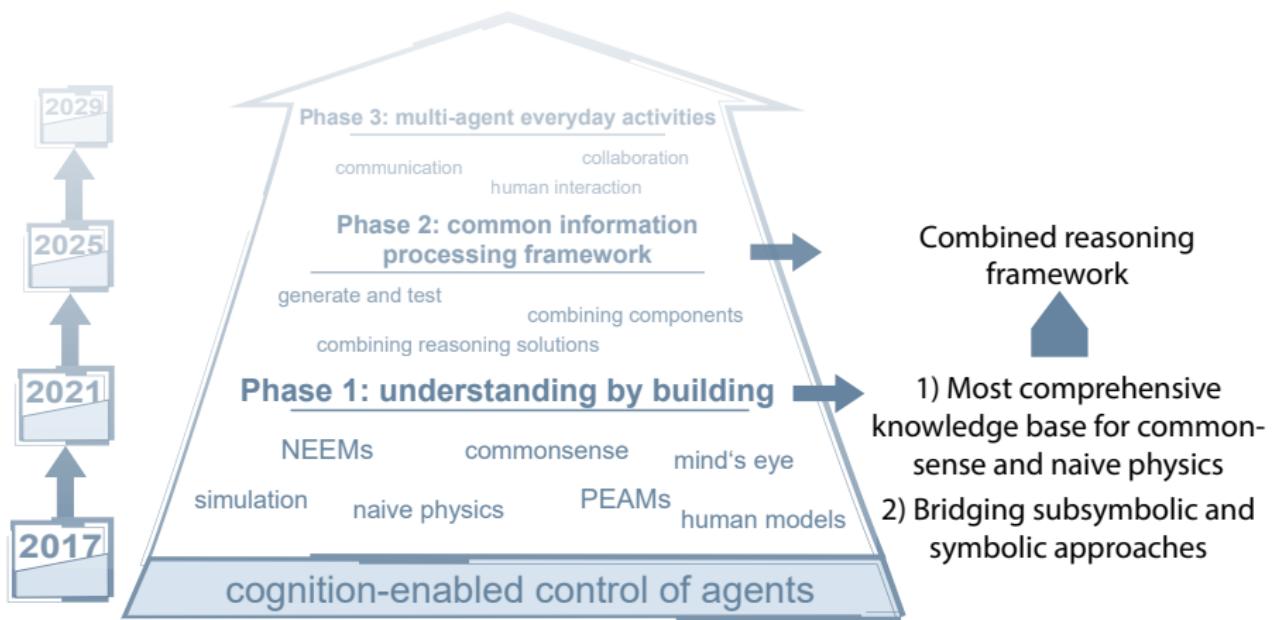
# Long-term Research Plan



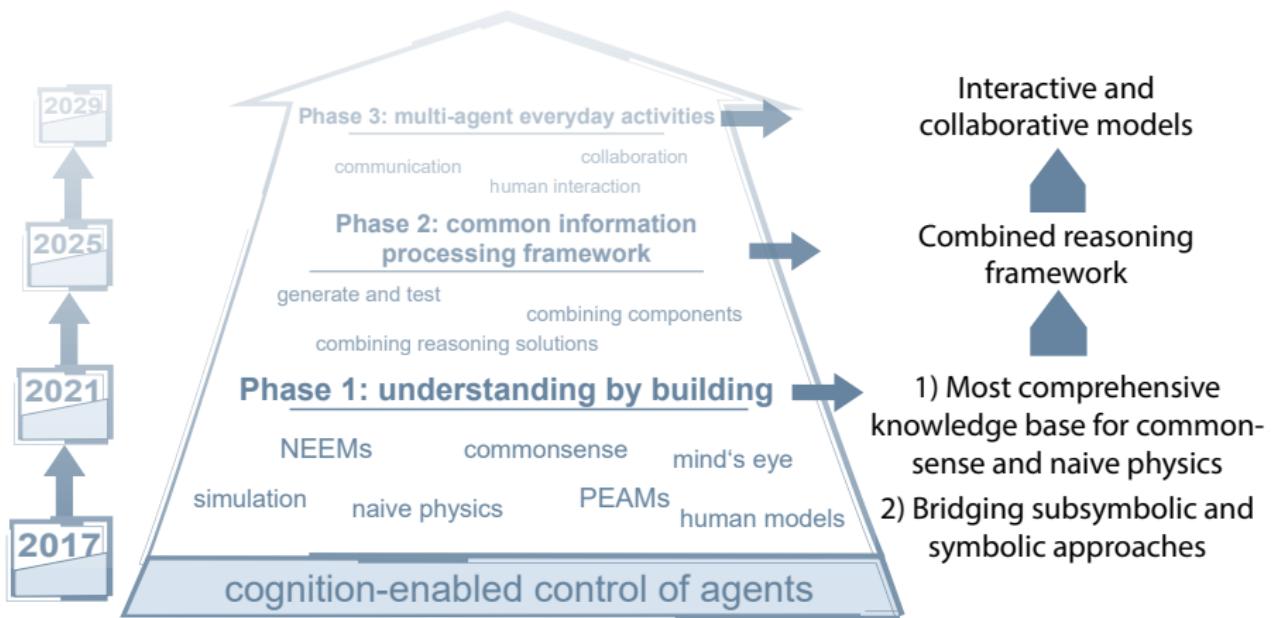
# Long-term Research Plan



# Long-term Research Plan



# Long-term Research Plan



## Leveraging competence, experience, network

"Minds, Media and Machines" high profile area at  
University of Bremen

### Assembling leading experts in

- Simulation
- Artificial Intelligence
- Linguistics
- Robot control
- Empirical and Computational Cognitive Science

### Utilizing breakthroughs in

- Analyzing and learning from big data
- Advanced robots capable of complex manipulation
- Virtual reality and simulation technology
- Artificial episodic memories linking symbolic and subsymbolic knowledge

# The EASE Collaborative Research Center

Lean, balanced, and effective management aiming at research excellence, impact, international visibility and networking, and outreach

with targeted task forces on

- promotion of young researchers
- measures to improve gender equality
- open research, data, teaching, software

# Laboratories without walls

Objective: multiply the EASE research community

- **openEASE**

UTokyo JSK,  
DLR

- **open software**

KnowRob,  
CRAM,  
RoboSherlock,  
RobCoG,  
PRAC,  
...

- **cooperations**

- **hosting visitors**

The image shows a screenshot of the [open-ease.org](http://open-ease.org) website. At the top, there's a navigation bar with links for 'openEASE', 'Get started', 'Publications', 'Data & Tools', 'About IAI', 'Sign in', and 'Register'. Below the navigation, there are three main sections highlighted with red circles:

- Knowledge Base Graphical User Interface**: A screenshot of a web-based interface showing a robotic arm interacting with a workpiece on a table. The interface includes a sidebar with navigation links like 'Home', 'About', 'Contact', 'Log in', and 'Log out'.
- tutorials**, **installation guide**, **documentation**: A list of resources available on the site.
- open access to all users**: A statement indicating that the knowledge base is accessible to everyone.

On the right side of the page, there are two more sections:

- Getting started**: A section with a 'Overview', 'Knowledge base', and 'Publications' link. It also features a thumbnail image of a person working with a robot and the text 'Acquiring everyday manipul...'.
- Teaching**: A section featuring a diagram of a robotic arm with coordinate axes and the word 'Teaching'.

