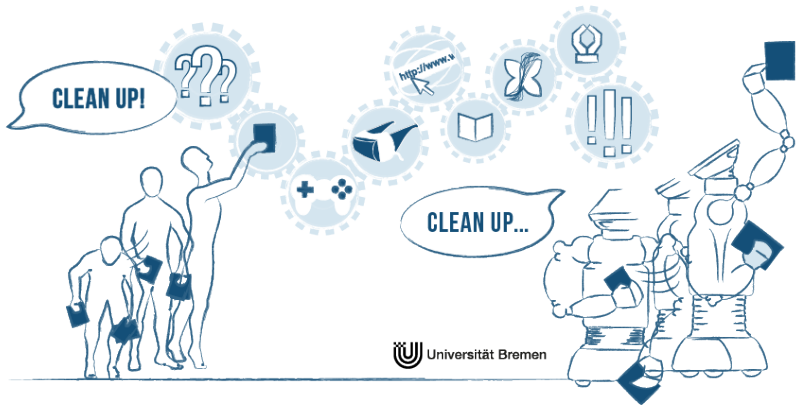


EASE - EVERYDAY ACTIVITY SCIENCE AND ENGINEERING

Michael Beetz
Kerstin Schill

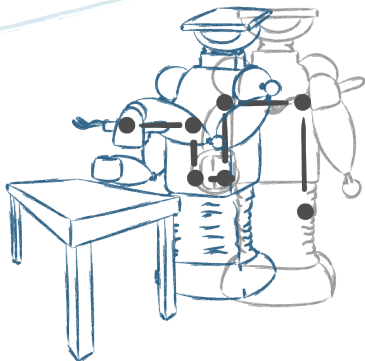


FROM

PERFORMING
A TASK

TO

MASTERING
A JOB



???



Mastering everyday activities —

Cognitive capabilities & computational problems



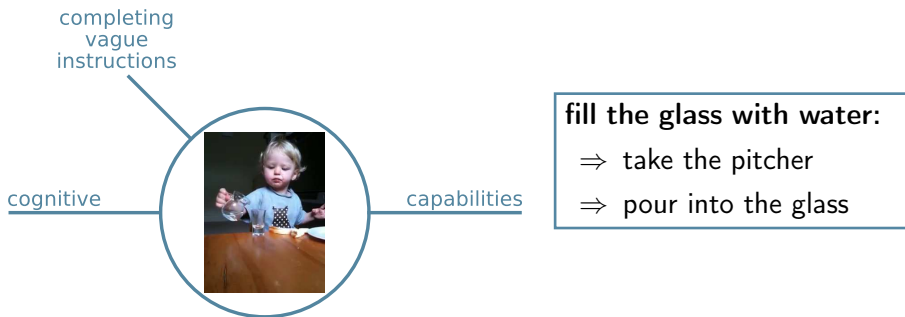
Mastering everyday activities —

Cognitive capabilities & computational problems



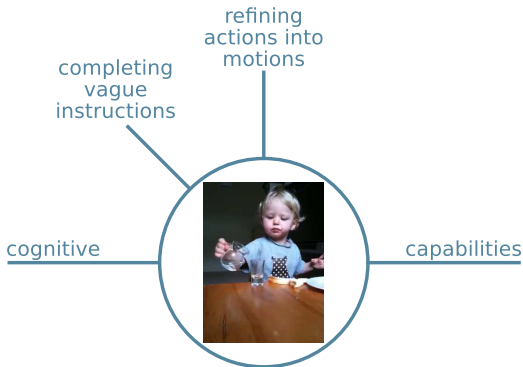
Mastering everyday activities —

Cognitive capabilities & computational problems



Mastering everyday activities —

Cognitive capabilities & computational problems

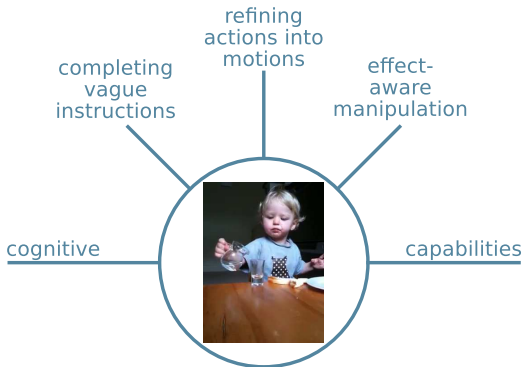


fill the glass with water:

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

Mastering everyday activities —

Cognitive capabilities & computational problems

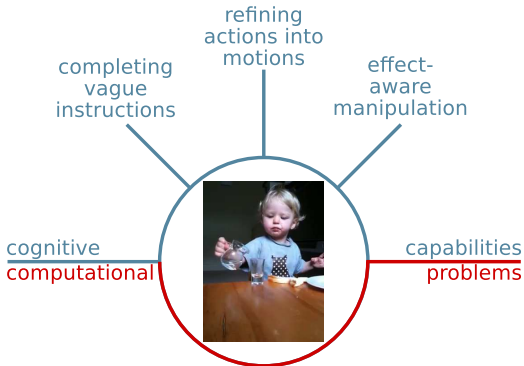


fill the glass with water:

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

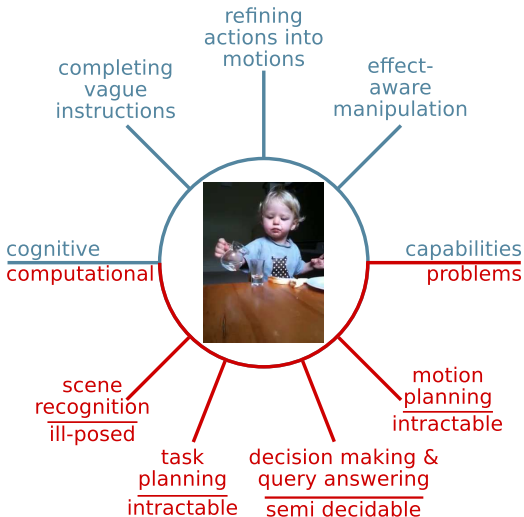
Mastering everyday activities —

Cognitive capabilities & computational problems



Mastering everyday activities —

Cognitive capabilities & computational problems



Mastering everyday activities —

The evolution of mastery

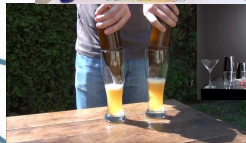
Elementary
proficiency

Mastery



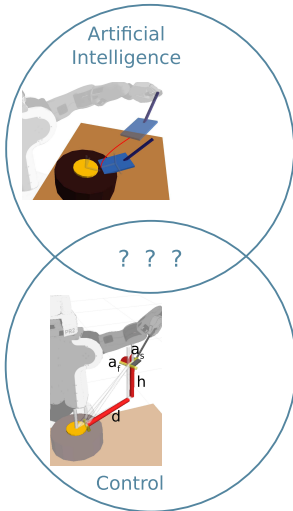
observing
reading

playing
exploring



Mastering manipulation actions —

Current state of understanding



artificial intelligence

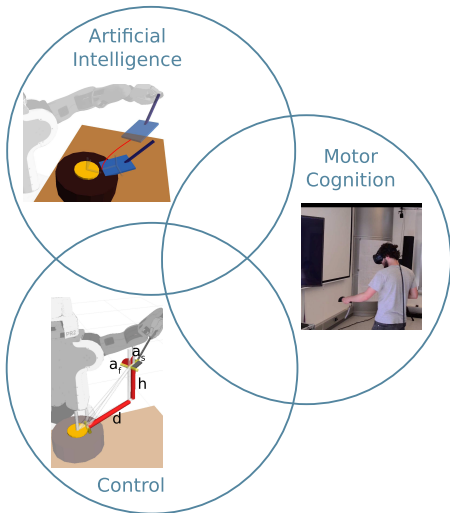
- abstract preconditions and effects suffice for mastery

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 **A**CTIVITY
SCIENCE AND **E**NGINEERING

Everyday activity

science and engineering

Everyday activity tasks are complex but common and mundane

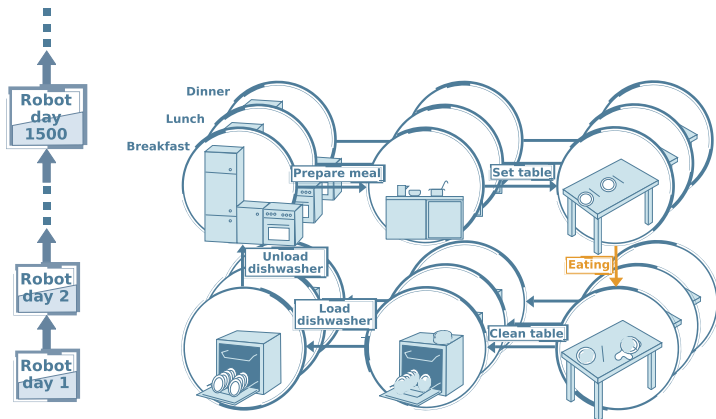
- common \implies knowledge \implies mundane
- satisficing performance¹:

$$\arg \max_{params} ExpectedUtility(action(params))$$

¹adopted from [Anderson, 1995]

Everyday activity

science and engineering

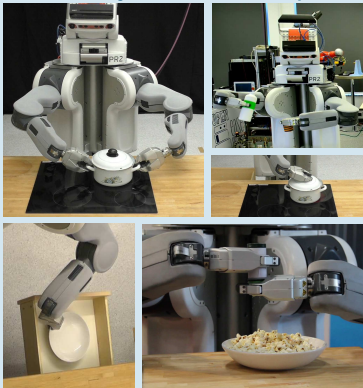


Everyday activity

science and engineering

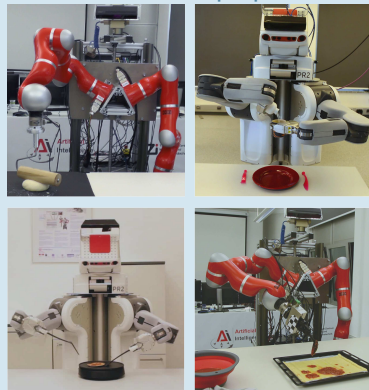
challenge 1:

Variability of fetch and place

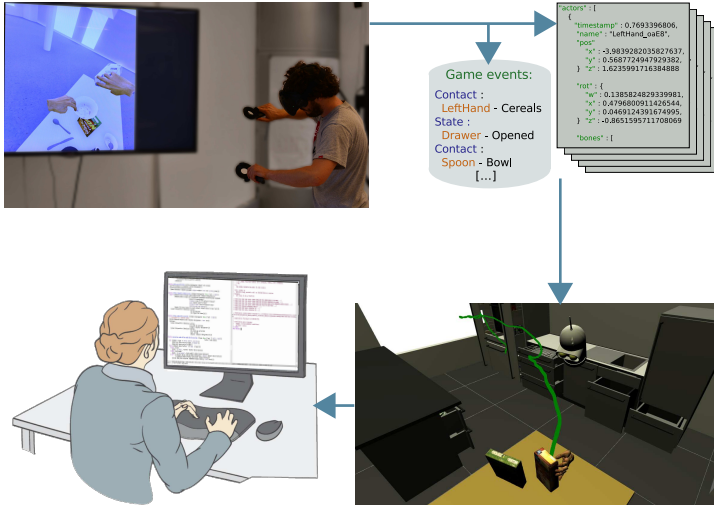


challenge 2:

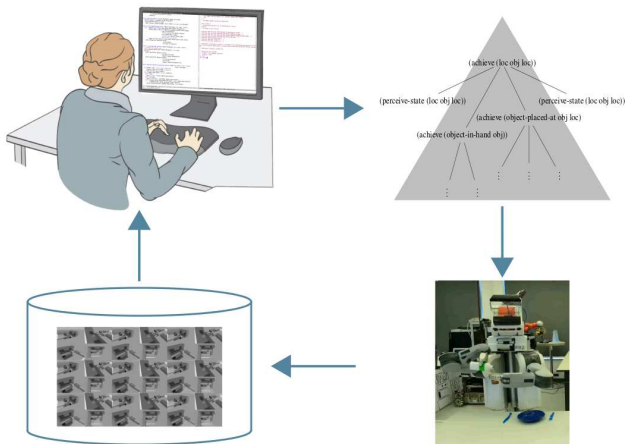
Competent, effect-directed action for meal preparation



Everyday activity *science* and engineering

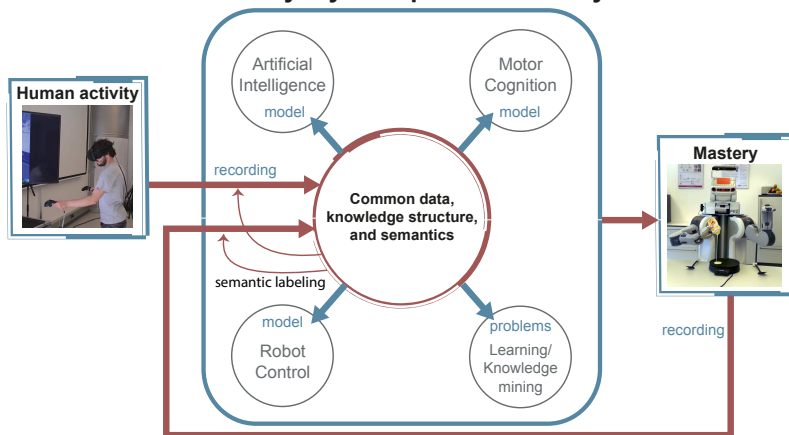


Everyday activity science and *engineering*



Envisioned research breakthrough

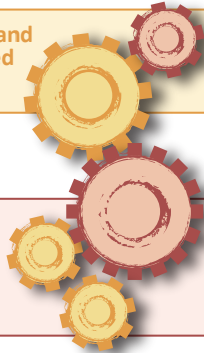
Generative model for the mastery of everyday manipulation activity



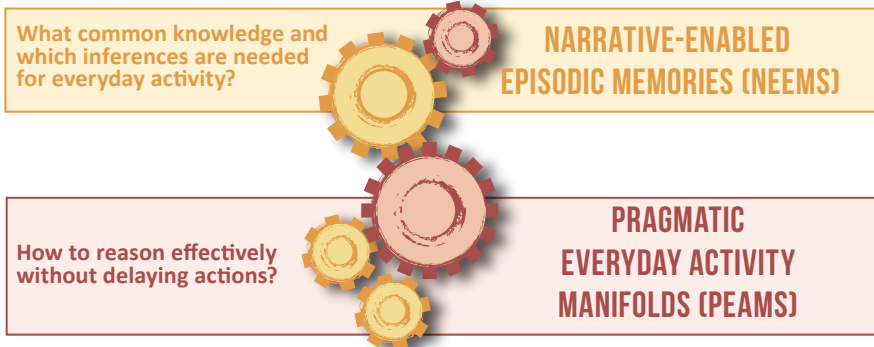
Approach

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

How to reason effectively without delaying actions?



Approach



Narrative-enabled episodic memories (NEEMs)

A closer look

NEEMs = NEEM narrative + NEEM experience



goals, plans, actions, objects



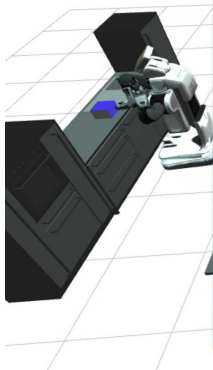
poses, object perceptions, forces



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

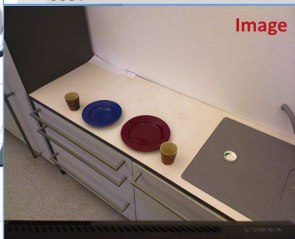
0 1 0 0

-0.7066892618451815 0 0.7075240541442478 0.11

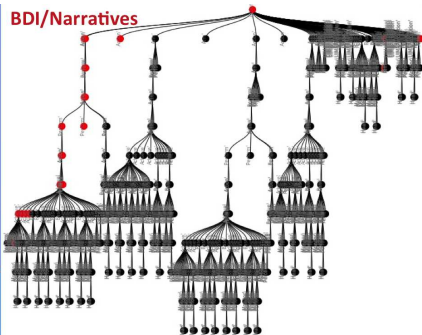
0 0 0 1

Belief State

Image



BDI/Narratives



NAVIGATE				
PERCEIVE				
GRASP		■		■
PUTDOWN				

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)

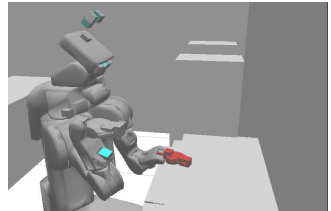
Semantic retrieval

```
?- 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 >= 2kg,  
   task-start(T, Tstart),  
   holds(pose(pr2,P), Tstart).
```



Narrative-enabled episodic memories (NEEMs)

Learning from execution

NEEMs = NEEM narrative + NEEM experience



semantic retrieval

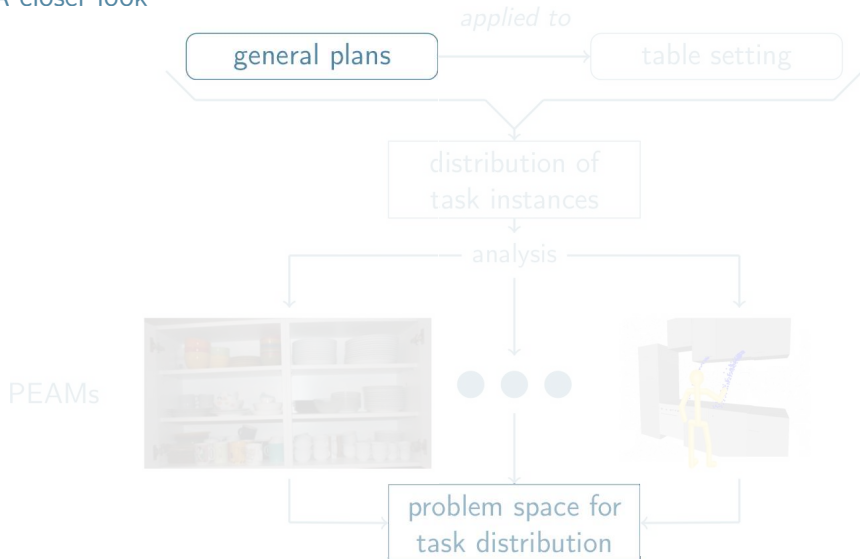


learning from
execution



Pragmatic everyday activity manifolds (PEAMs)

A closer look

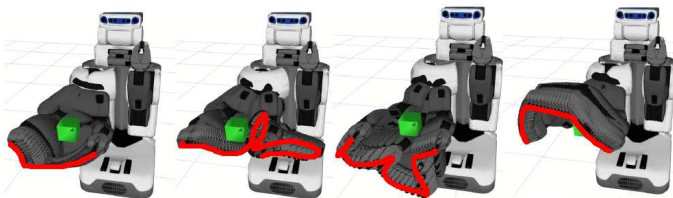
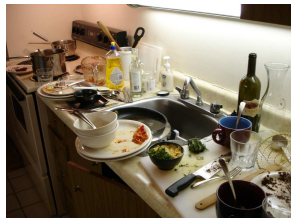


Pragmatic everyday activity manifolds (PEAMs)

A closer look

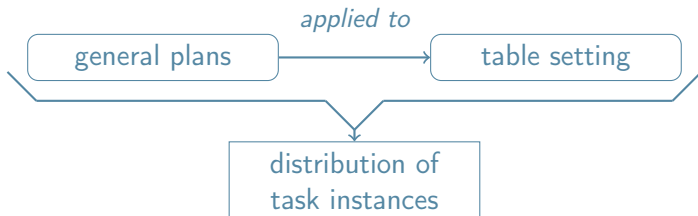
general plans

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)

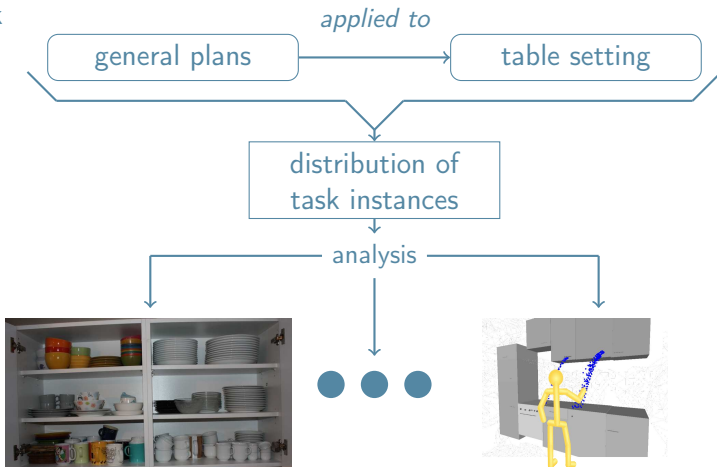
A closer look



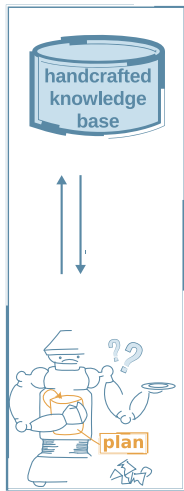
Pragmatic everyday activity manifolds (PEAMs)

A closer look

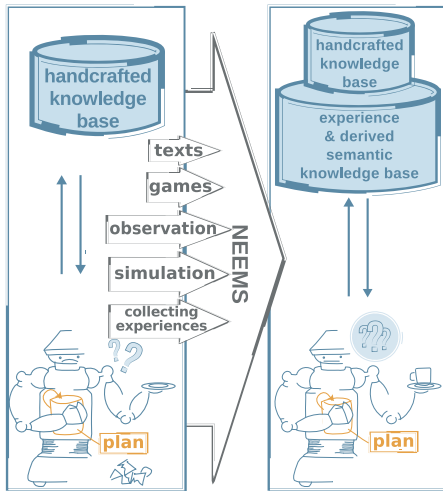
PEAMs



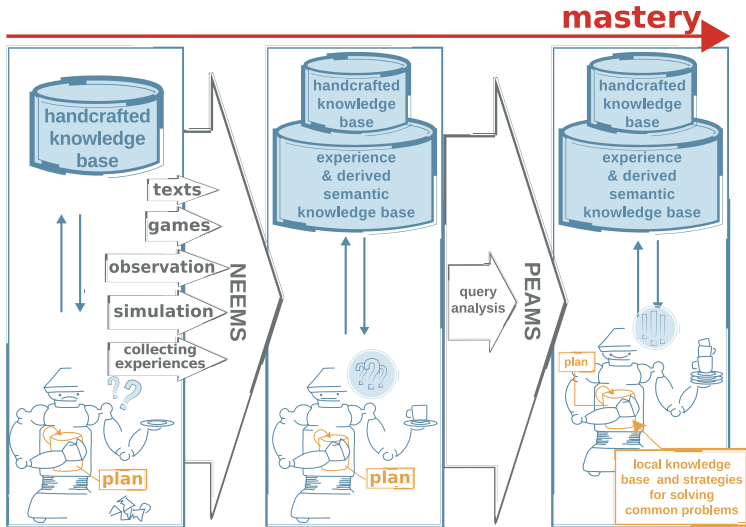
EASE Evolution of Mastery



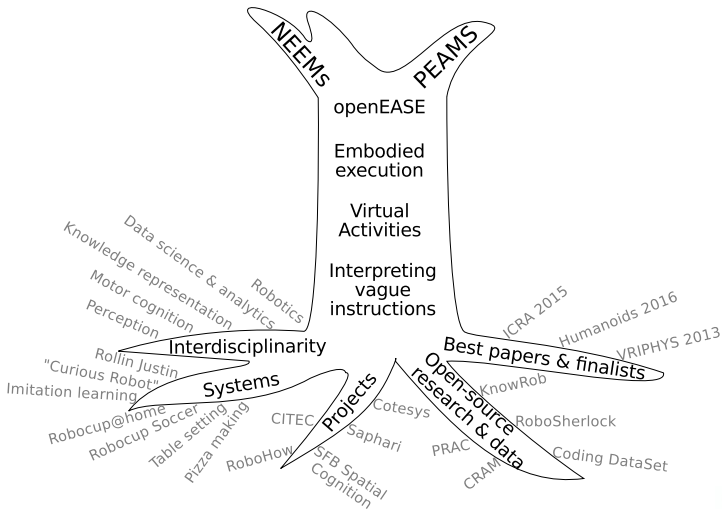
EASE Evolution of Mastery



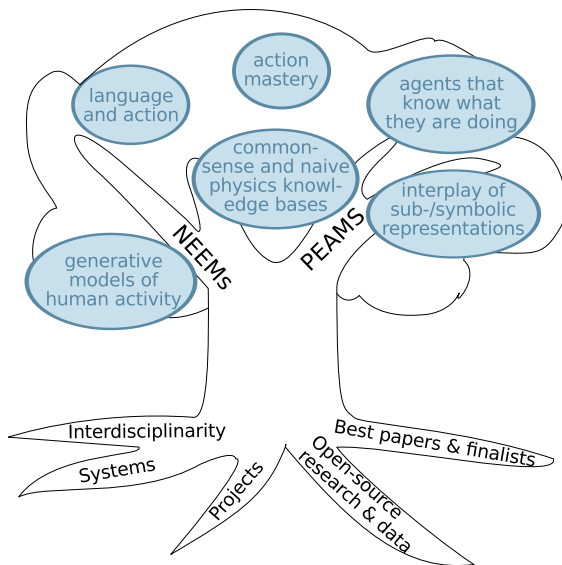
EASE Evolution of Mastery



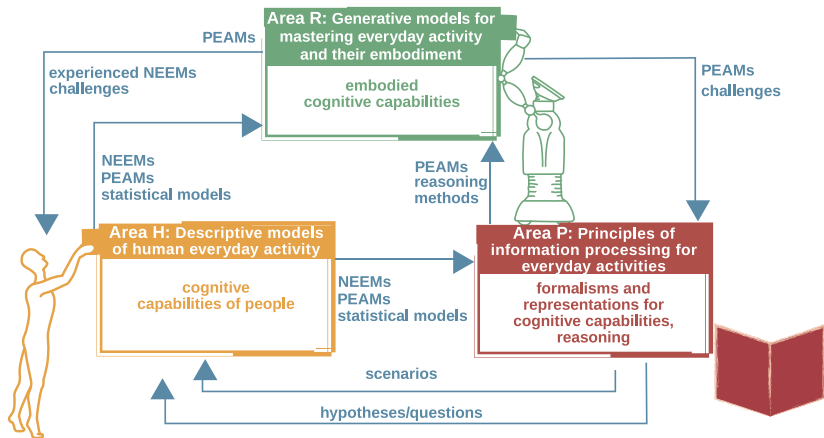
EASE – The unique starting point



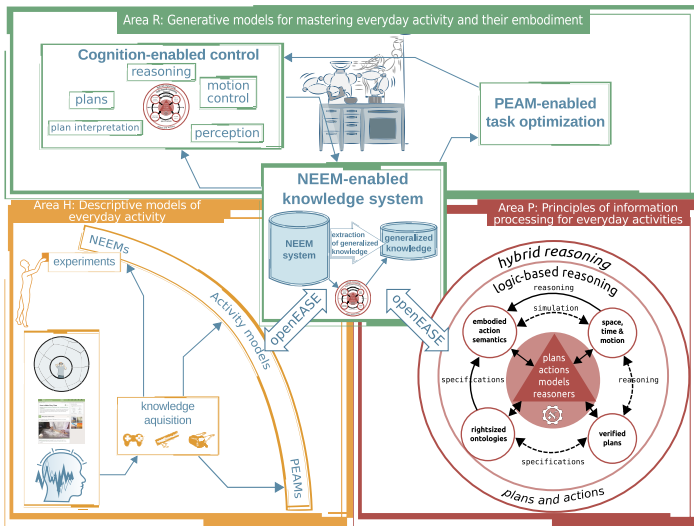
EASE — Where we are going



Research plan 1st phase (1)

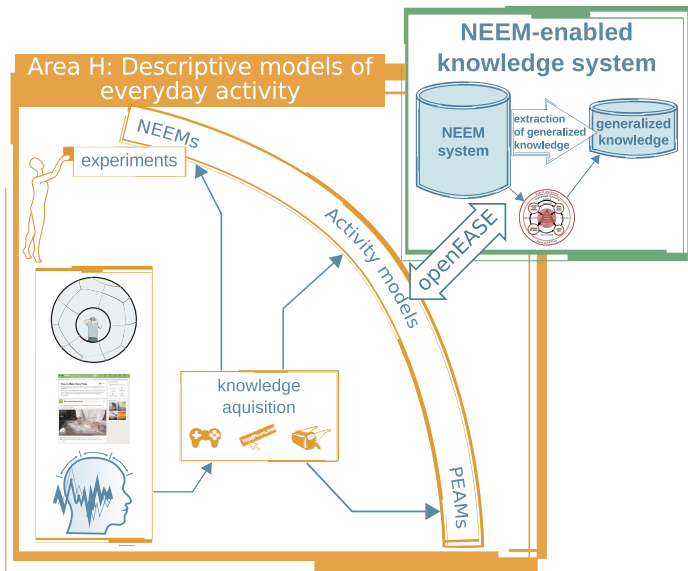


Research plan 1st phase (2)



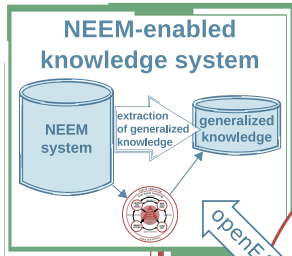
Research plan 1st phase

Area H

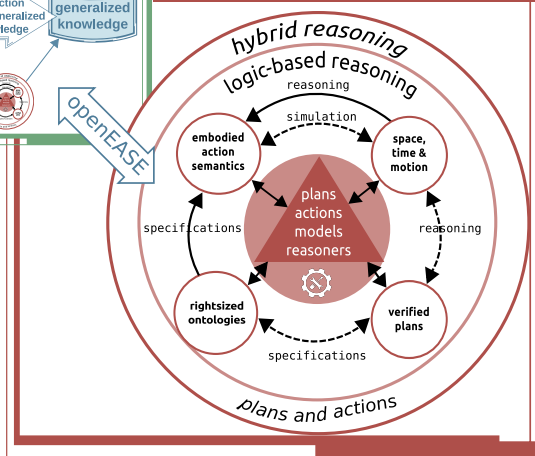


Research plan 1st phase

Area P

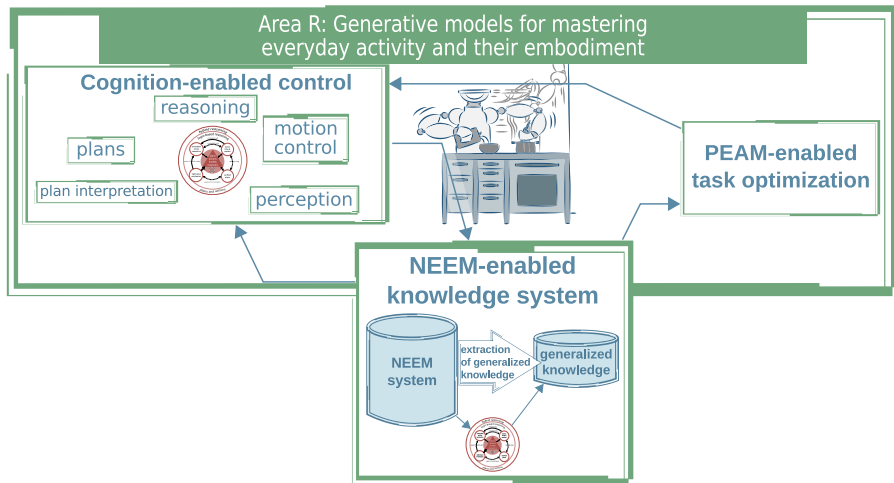


Area P: Principles of information processing for everyday activities

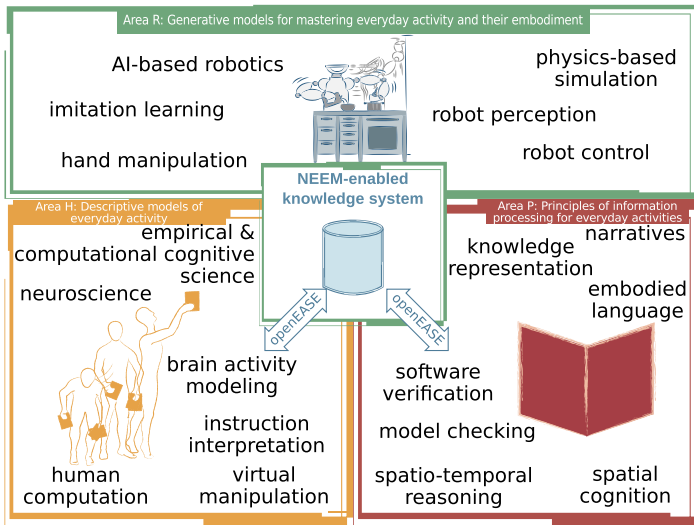


Research plan 1st phase

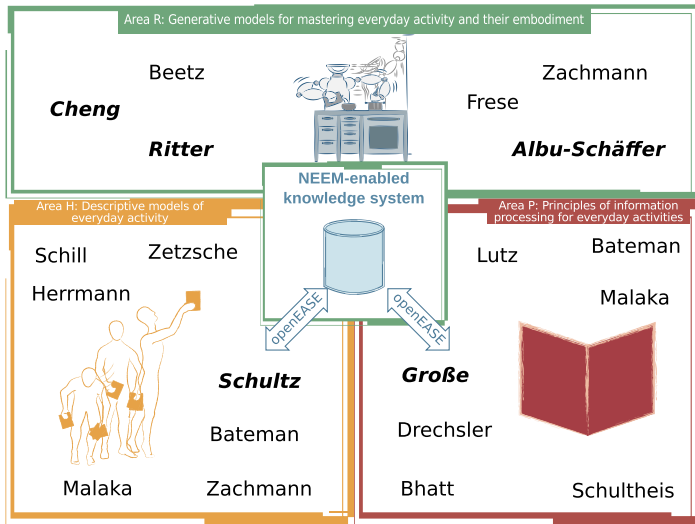
Area R



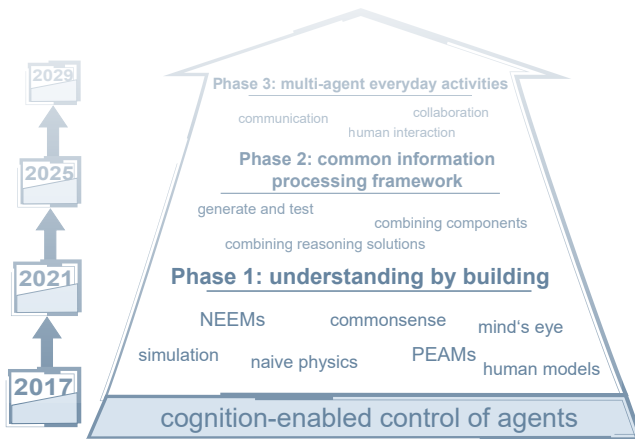
Consortium expertise



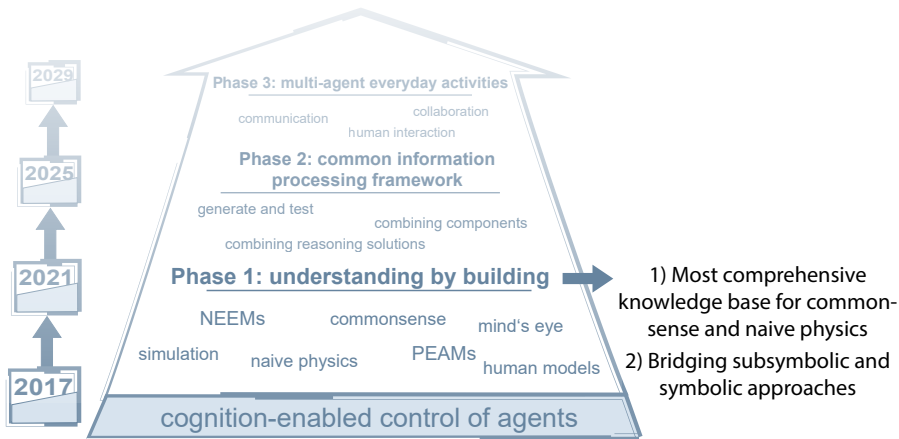
Coverage of required expertise



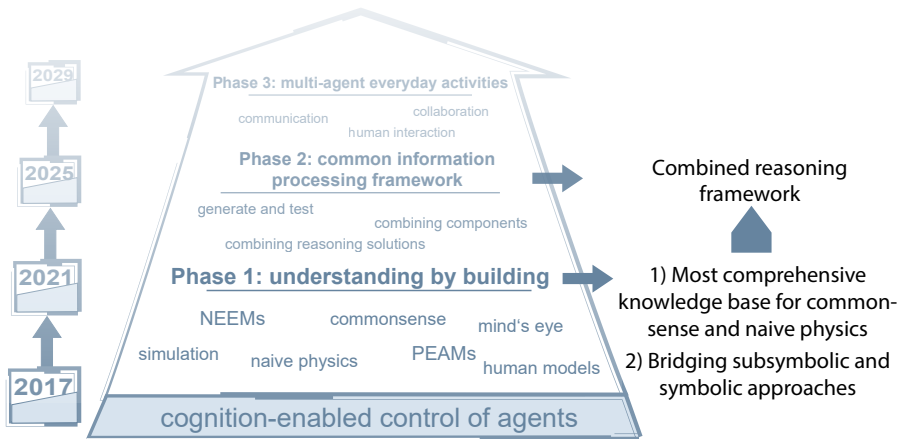
Long-term Research Plan



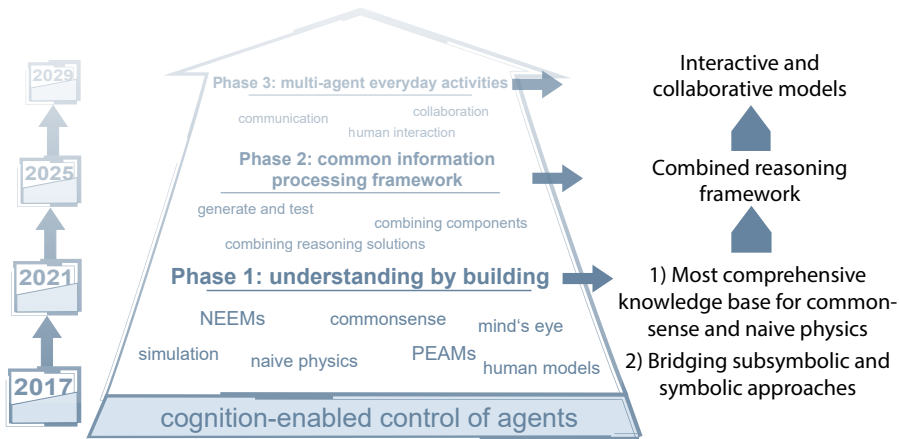
Long-term Research Plan



Long-term Research Plan



Long-term Research Plan



Generative models for the mastery of everyday activity by

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 openEASE website (open-ease.org) with several callouts highlighting key features:

- Knowledge Base Graphical User Interface**: Points to the main interface showing a 3D robot model and code snippets.
- Knowledge Base Editor**: Points to the editor interface showing code snippets.
- tutorials**, **installation guide**, **documentation**: Points to the navigation menu.
- open access to all users**: Points to the "Register" button.
- open teaching**: Points to the "Teaching" button.

The website header includes the openEASE logo, the tagline "Open Knowledge for AI-Enabled Robots", and the URL "open-ease.org". The navigation menu includes "openEASE", "Get started", "Publications", "Data&Tools", "About Us", "Sign in", and "Register". The main content area features a "Knowledge base" section with "Overview" and "Publications" links, and a "Teaching" section with a "Teaching" button.