Web-enabled and experience based learning

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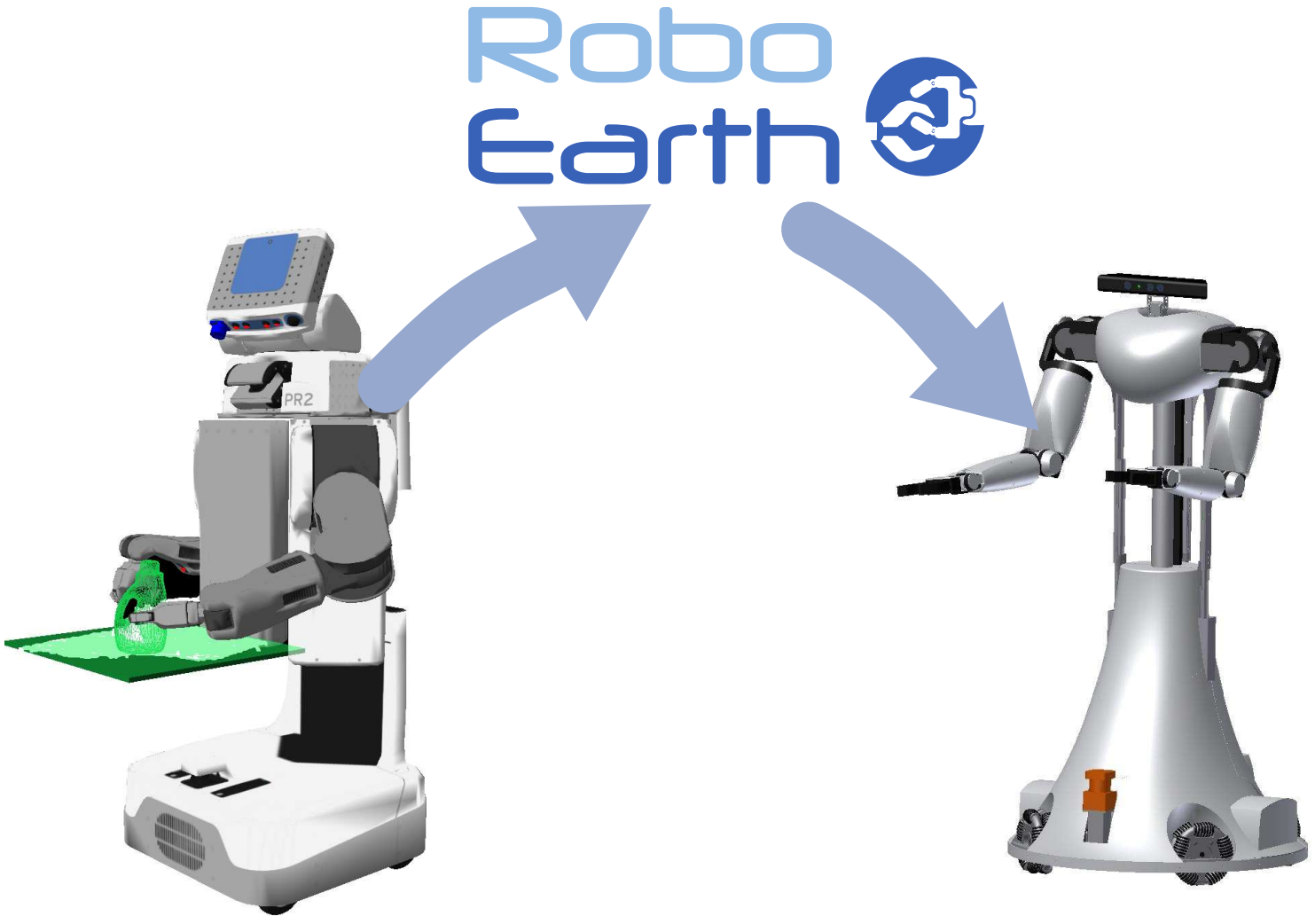
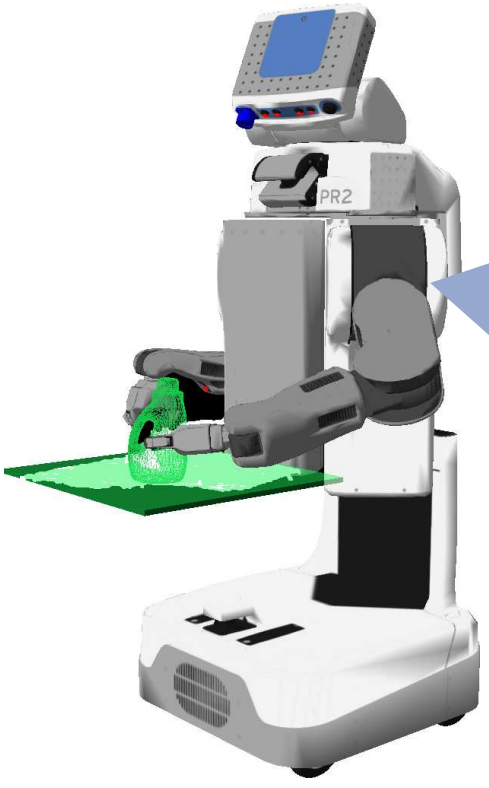
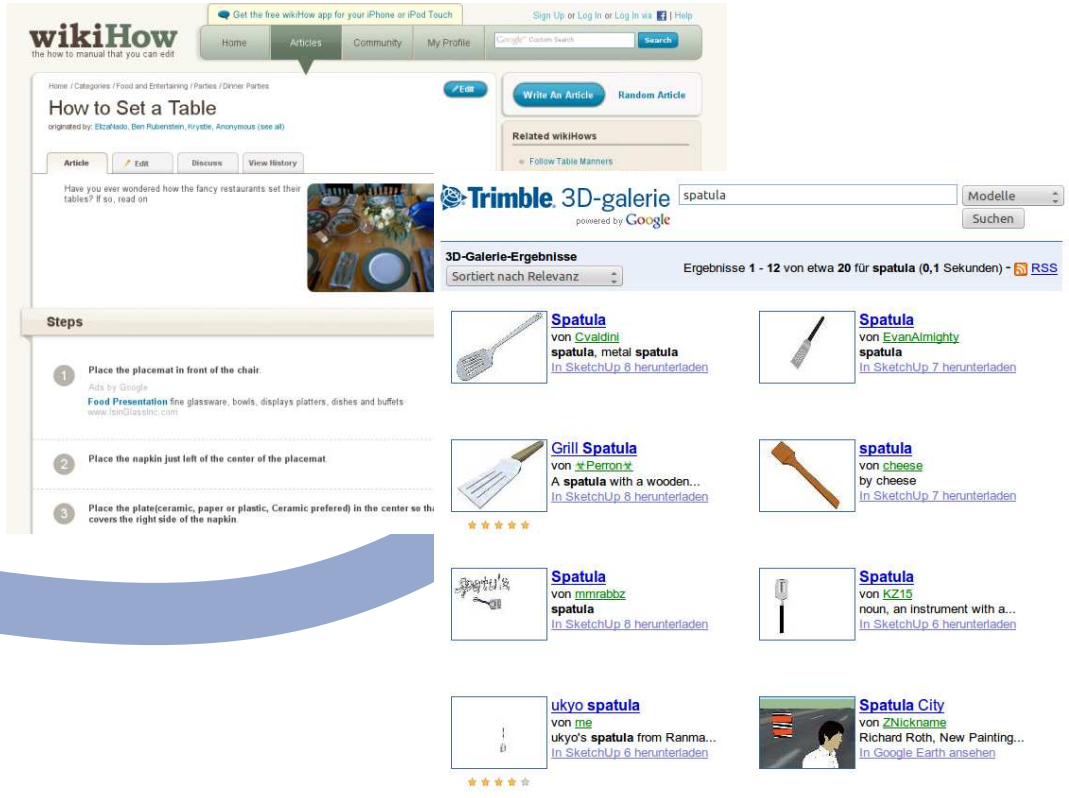
Use Case 1: Exchanging Information via the Cloud

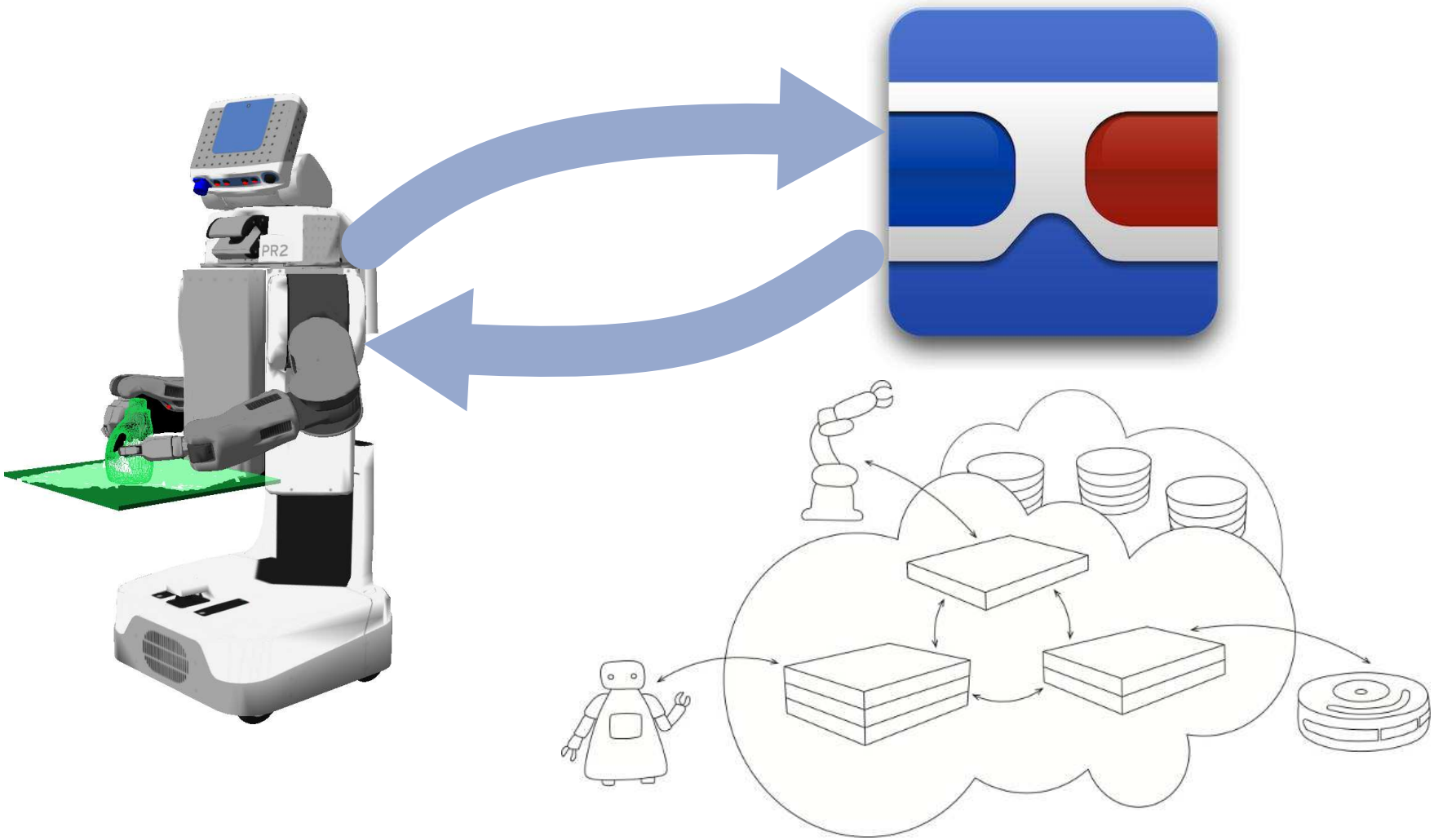


Use Case 2: Using the Cloud as Knowledge Source





Use Case 3: Outsourcing Services to the Cloud



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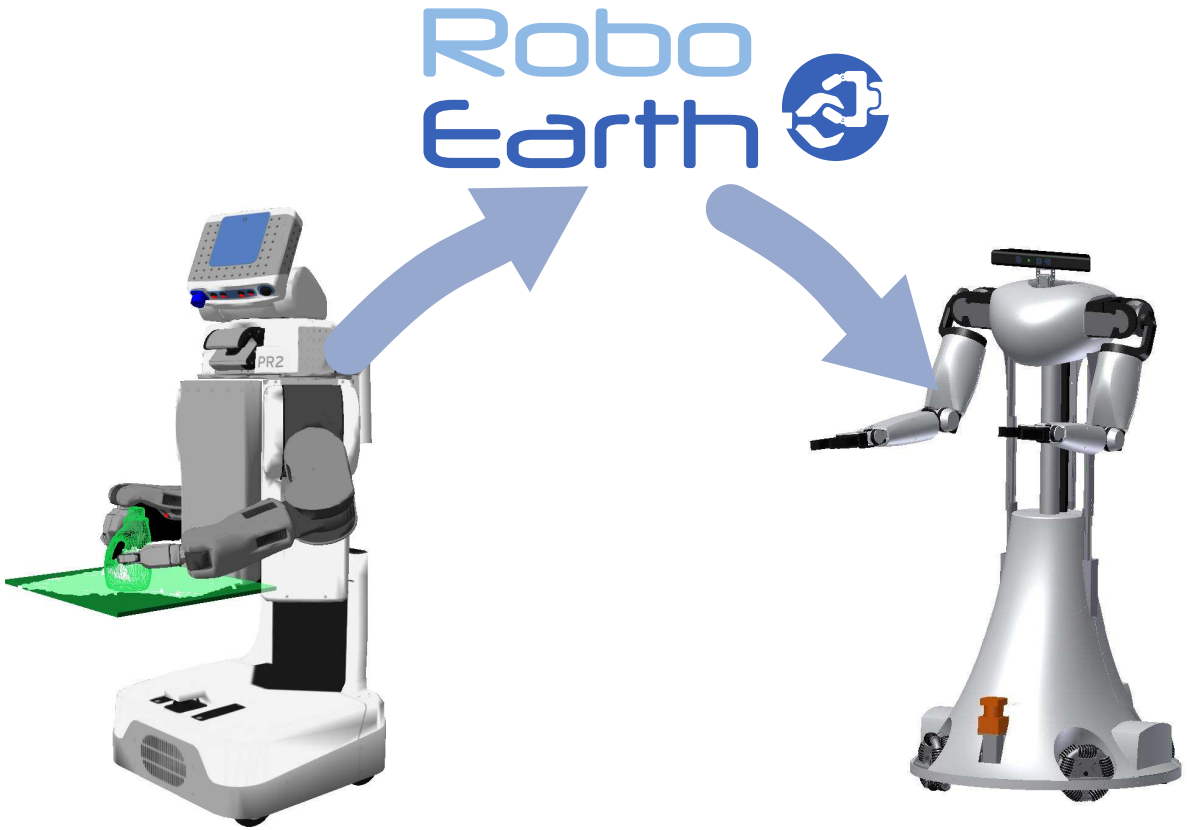
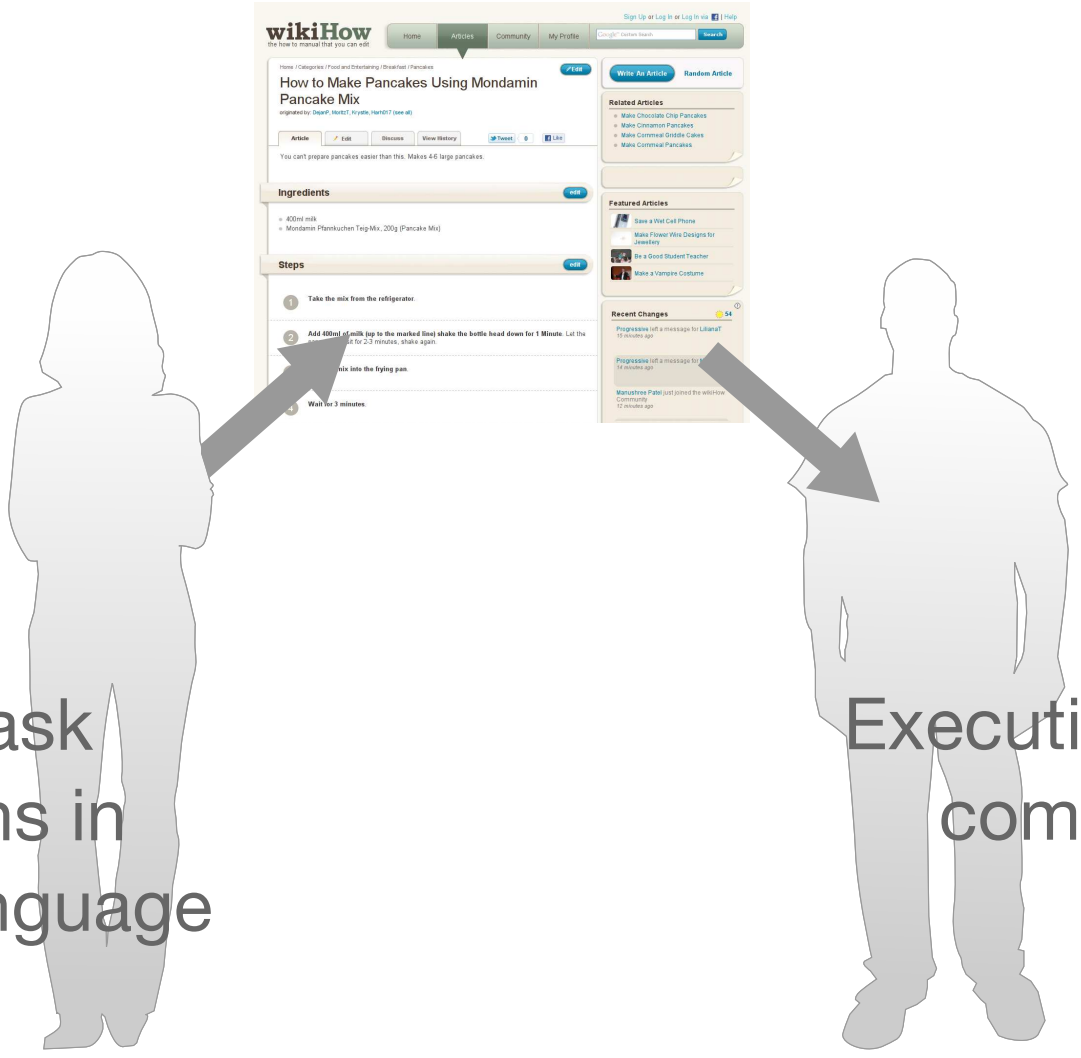


- How to represent the information to be exchanged?
- How to transfer knowledge between robots and environments?

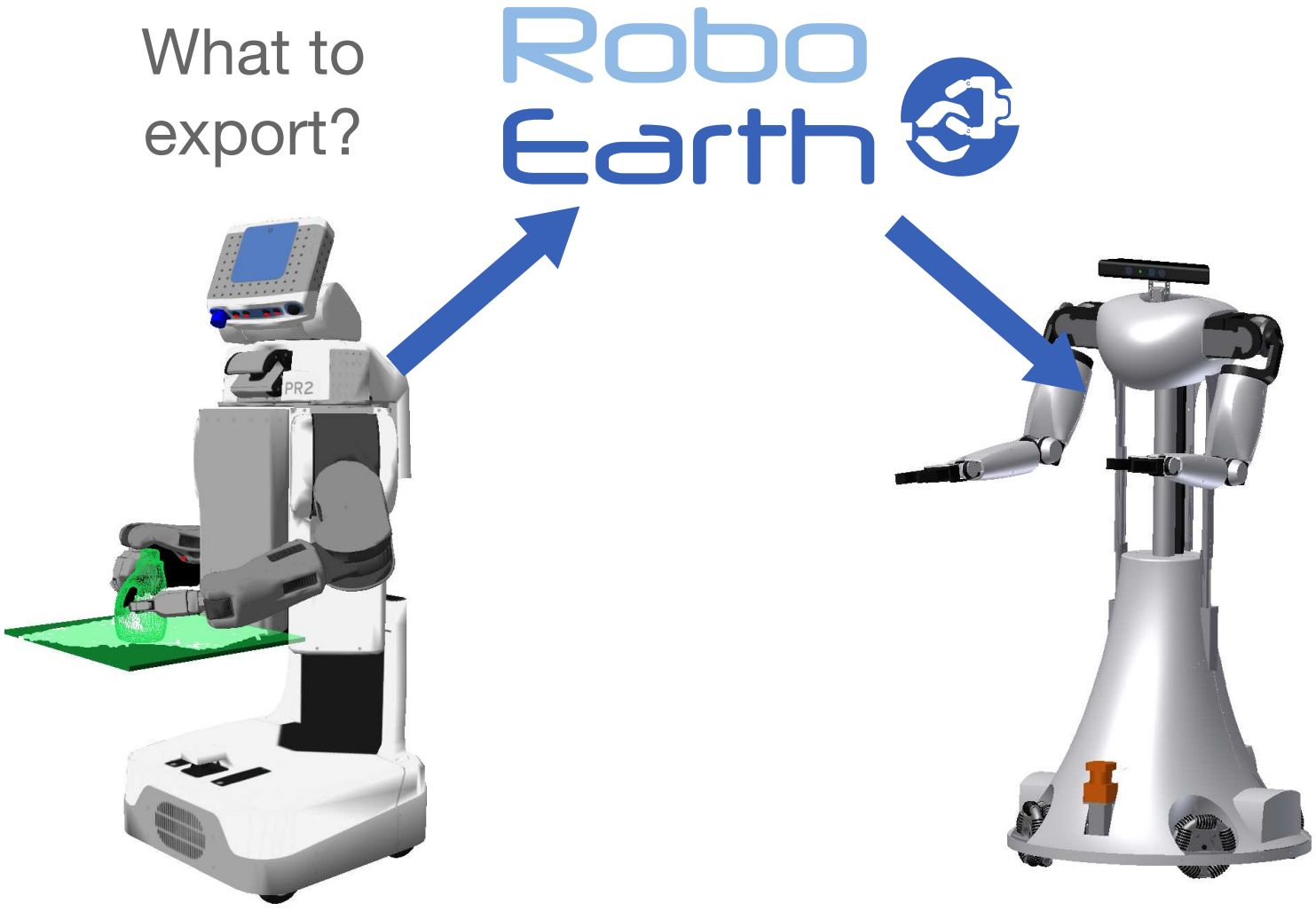
Information exchange among humans



Informal task instructions in natural language

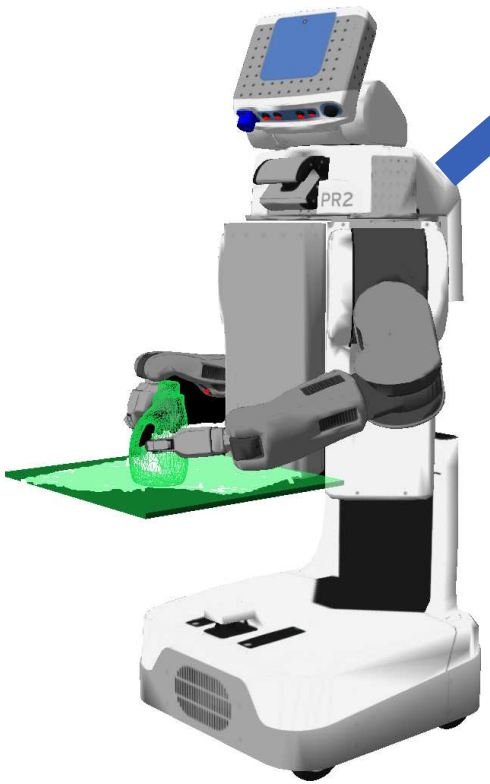
Execution requires common-sense knowledge

Information exchange among robots



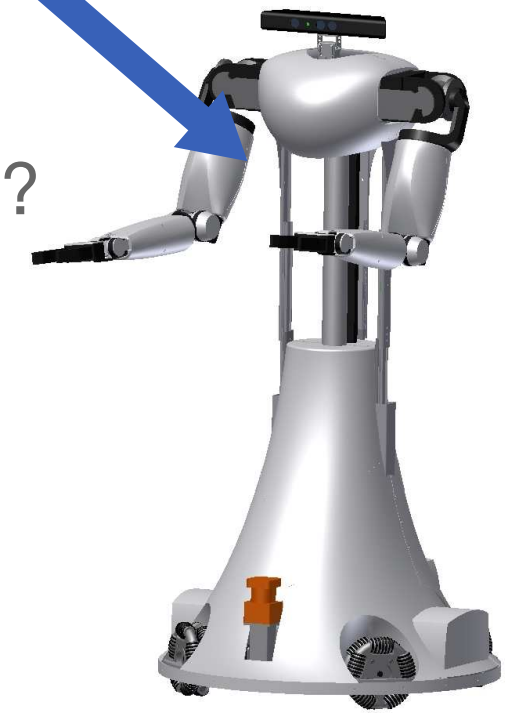
Information exchange among robots

What to export?



Robo Earth

How to represent information?

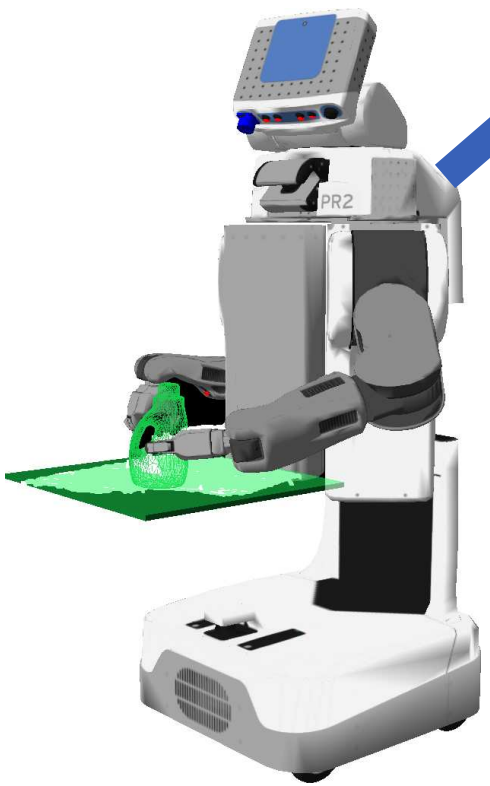


Information exchange among robots

What to export?

How to represent information?

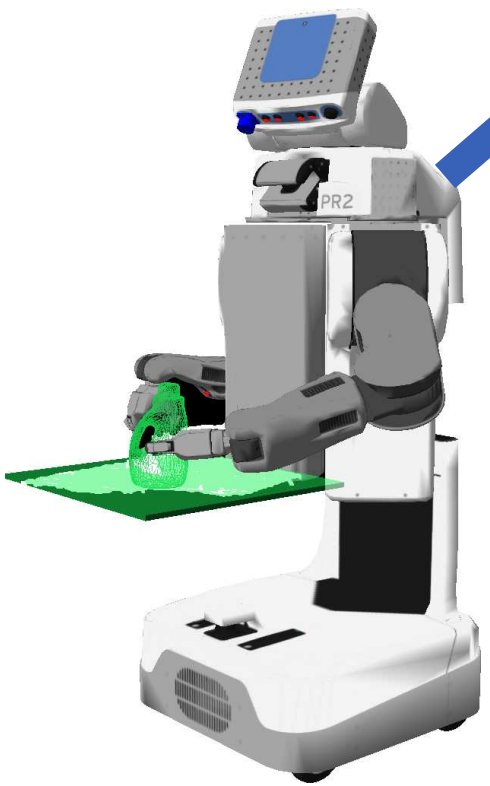
How to find information?



Information exchange among robots

What to export?

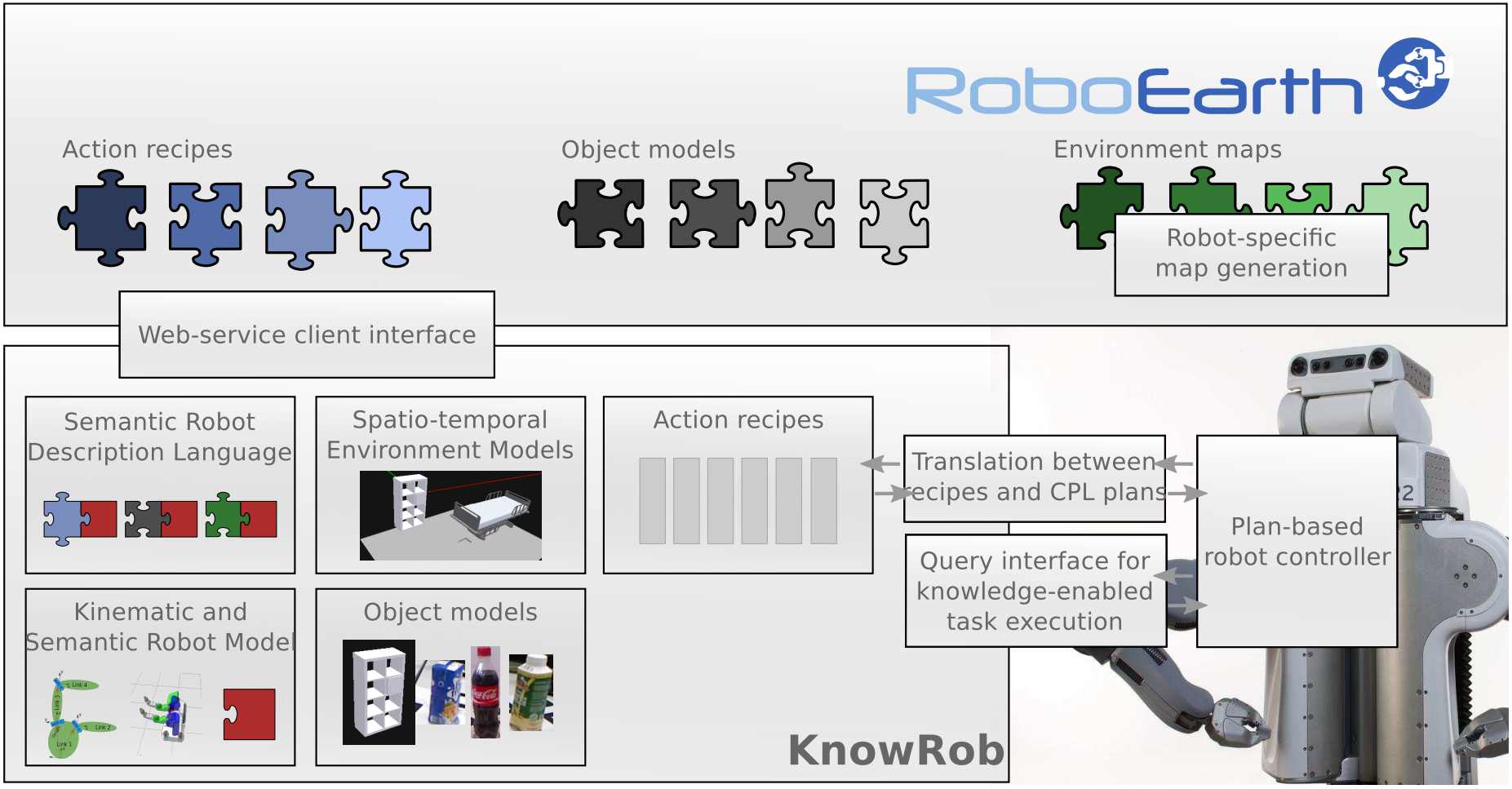
How to find information?



How to represent information?

How to execute?

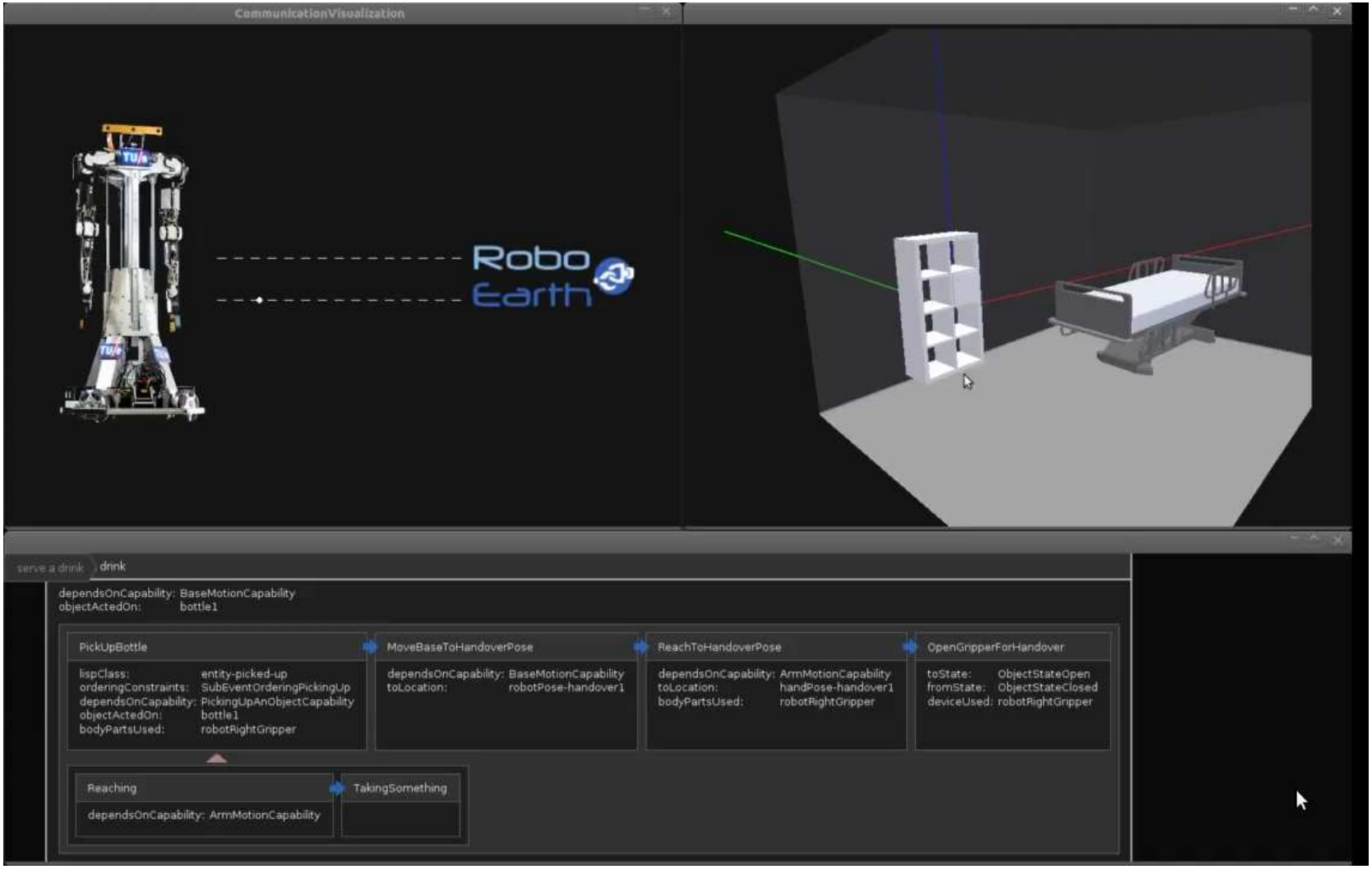
The RoboEarth system



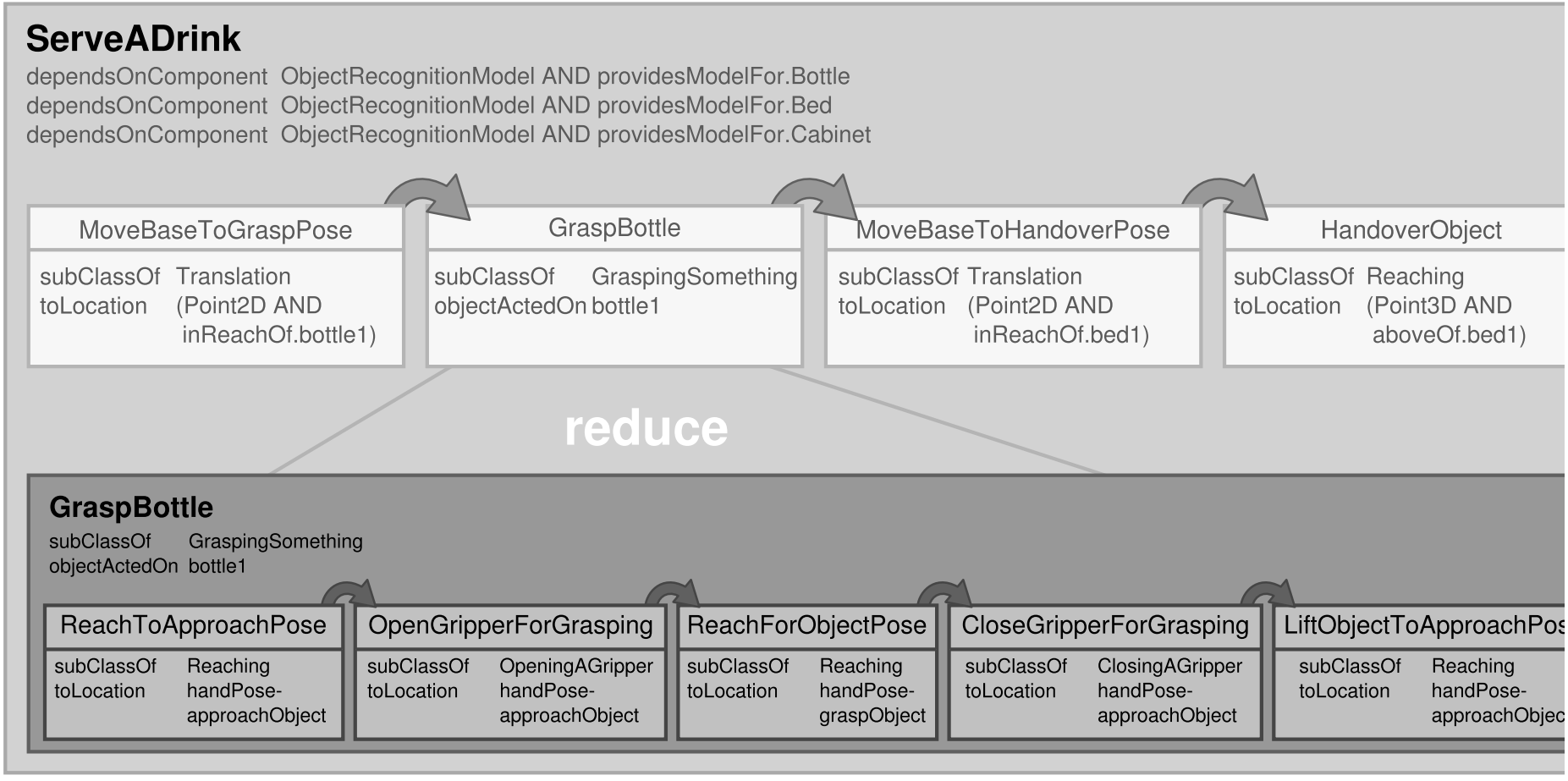
http://www.roboearth.org

[ICRA 2012]

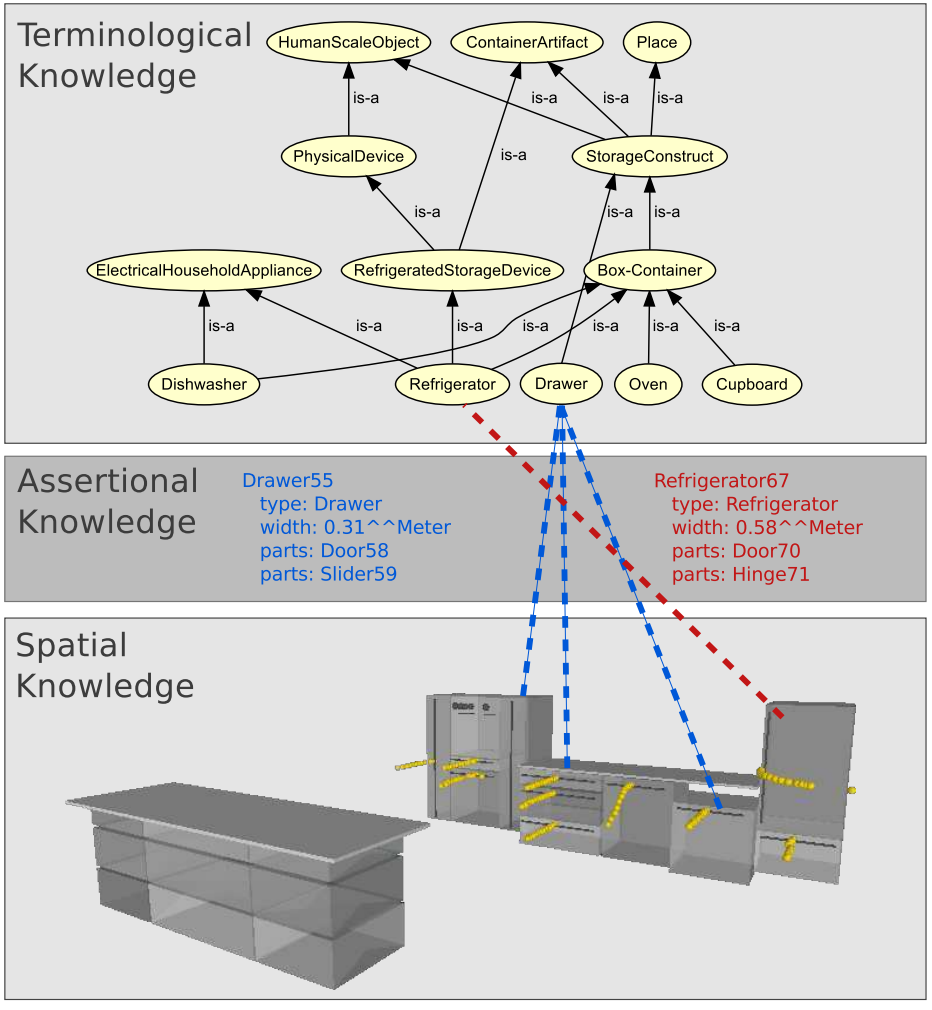
Video: Downloading recipes, objects, and maps



Action recipes



Semantic map representation



Abstract knowledge about object classes

Object instances and component hierarchy

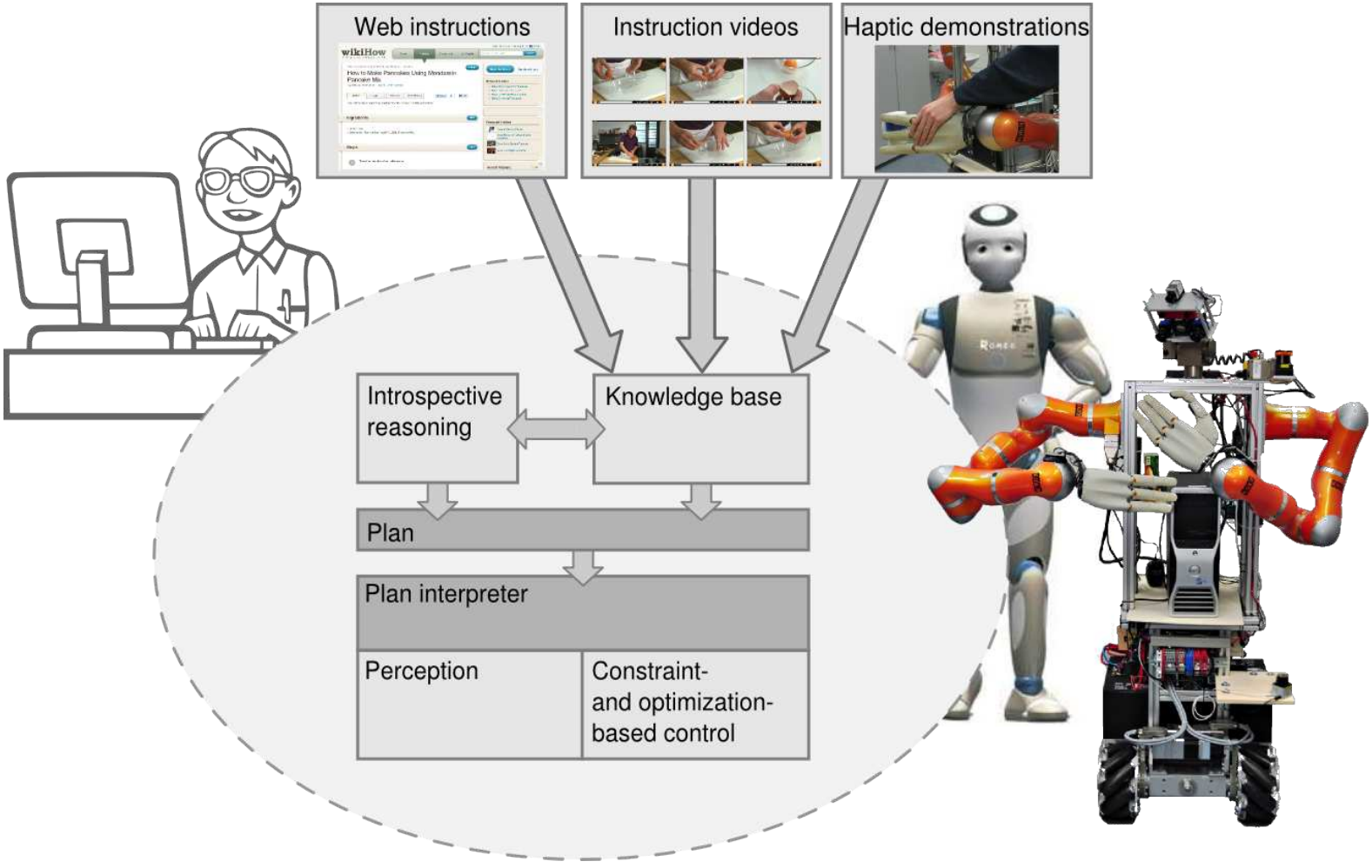
Poses in the environment and their changes over time

Related: TBOX/SBOX, Galindo et al (RAS 2008)

Use Case 2: Using the Cloud as Knowledge Source

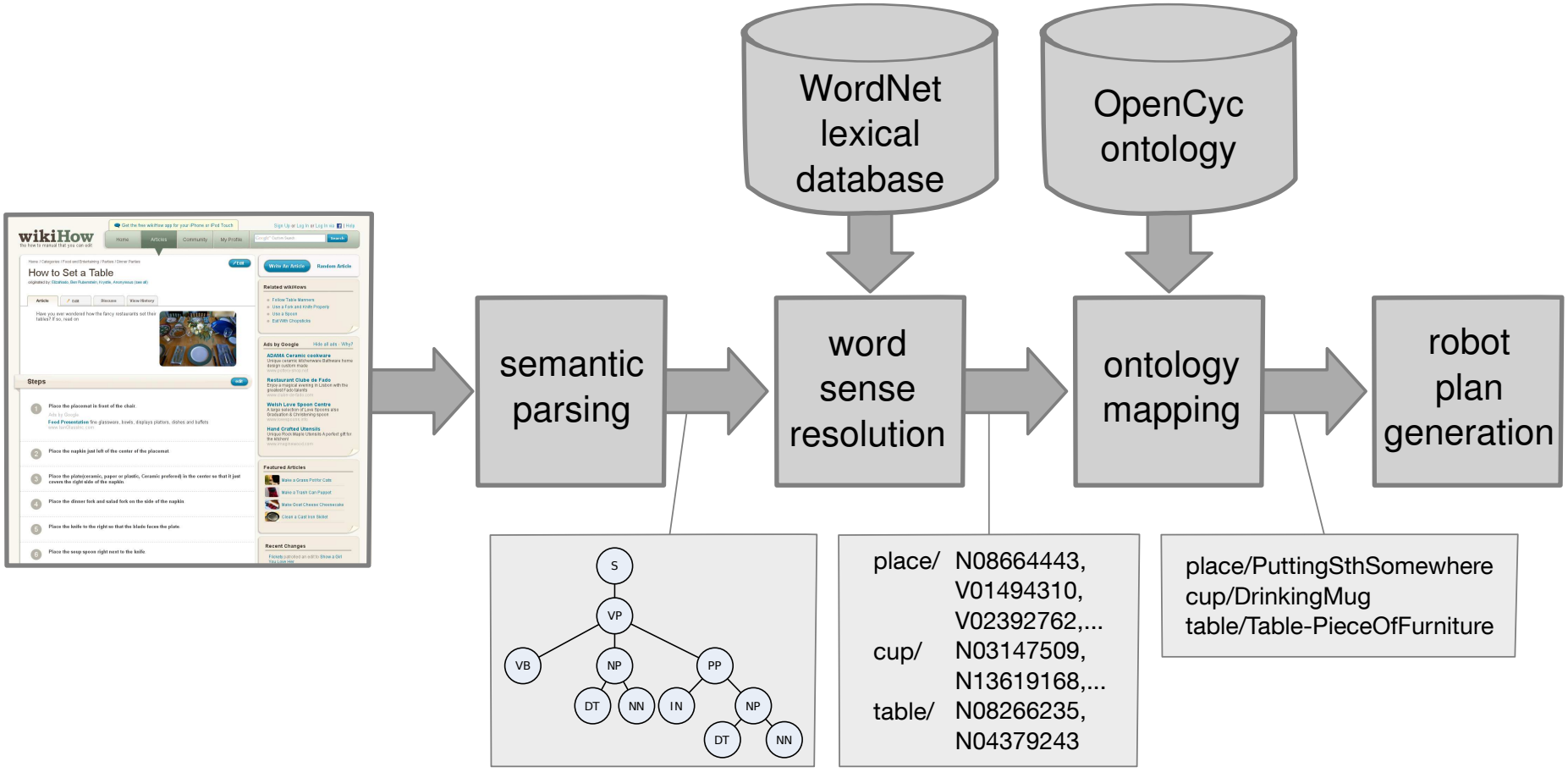
- How to identify and fill gaps in the downloaded information?
- How to make the abstract information executable?

The RoboHow Project



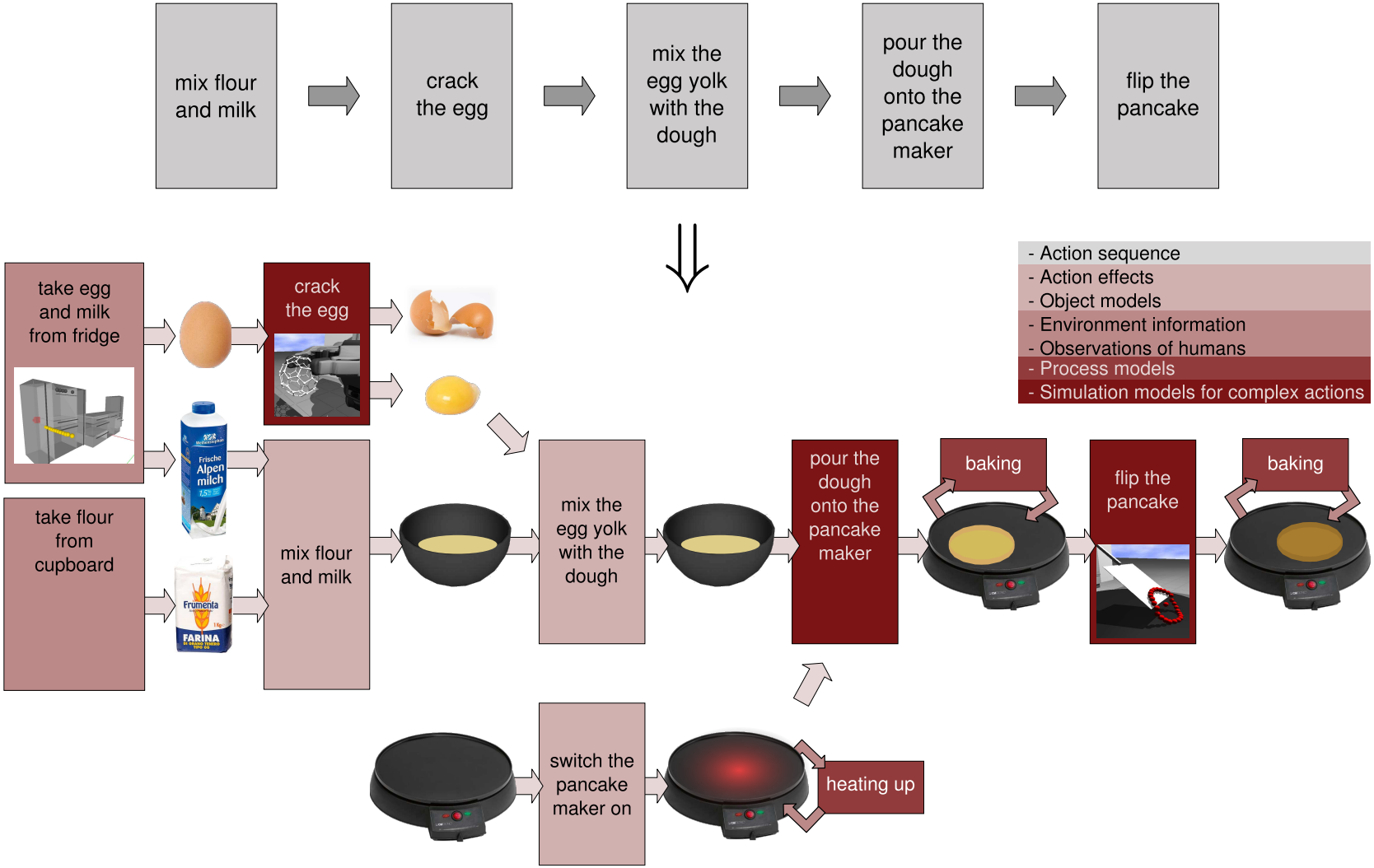
http://www.robohow.eu

Task instructions from the WWW



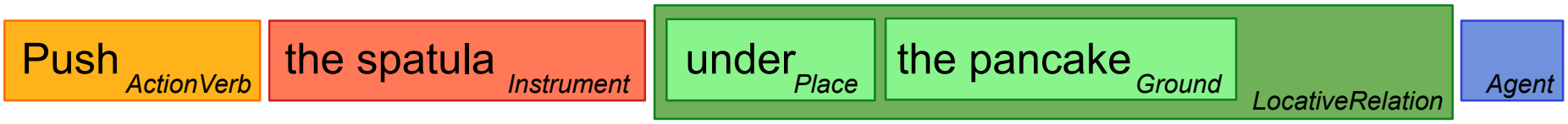
Understanding and Executing Instructions for Everyday Manipulation Tasks from the World Wide Web. Moritz Tenorth, Daniel Nyga and Michael Beetz. ICRA 2010

Completing Instructions with Qualitative Reasoning



A Unified Representation for Reasoning about Robot Actions, Processes, and their Effects on Objects. Moritz Tenorth and Michael Beetz, IROS 2012

Filling Gaps with Action-specific Knowledge Bases



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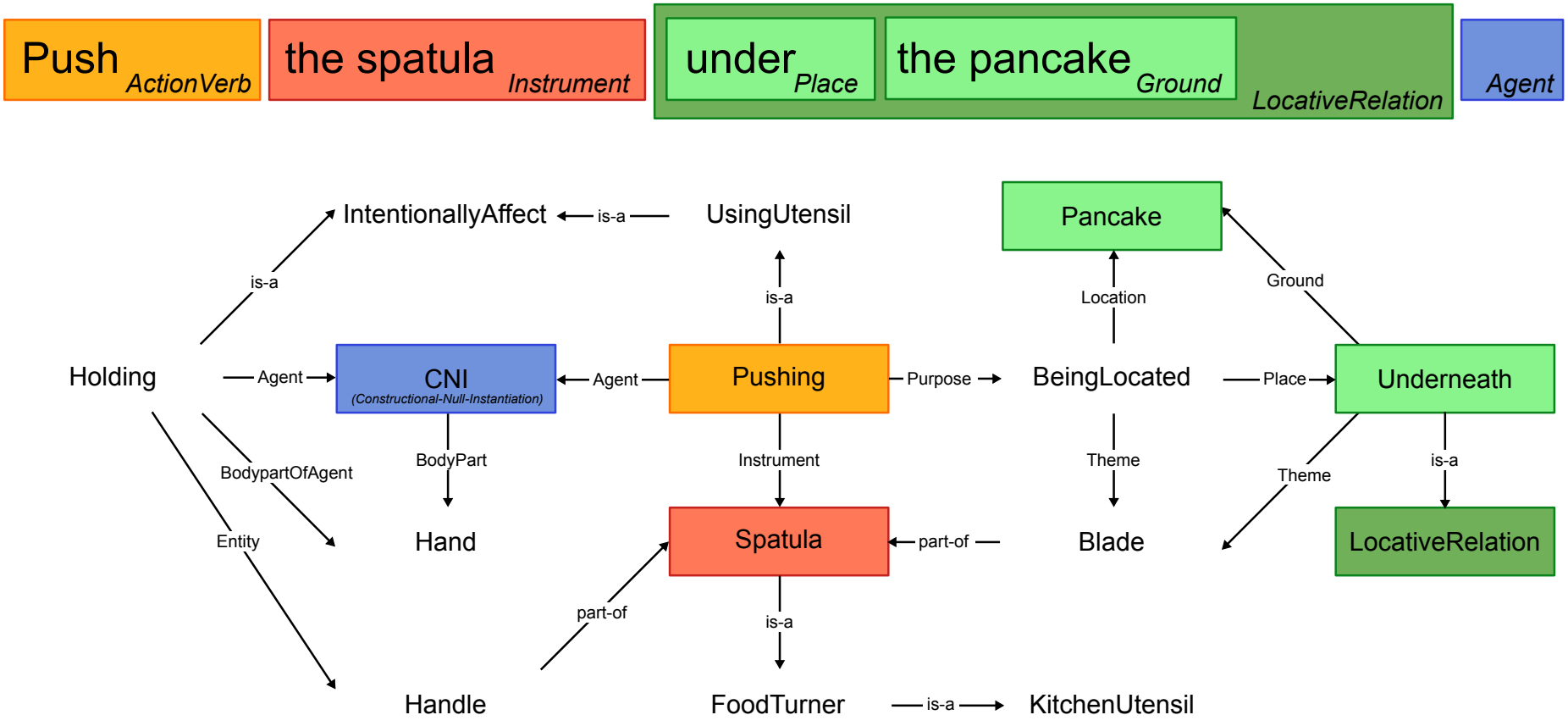
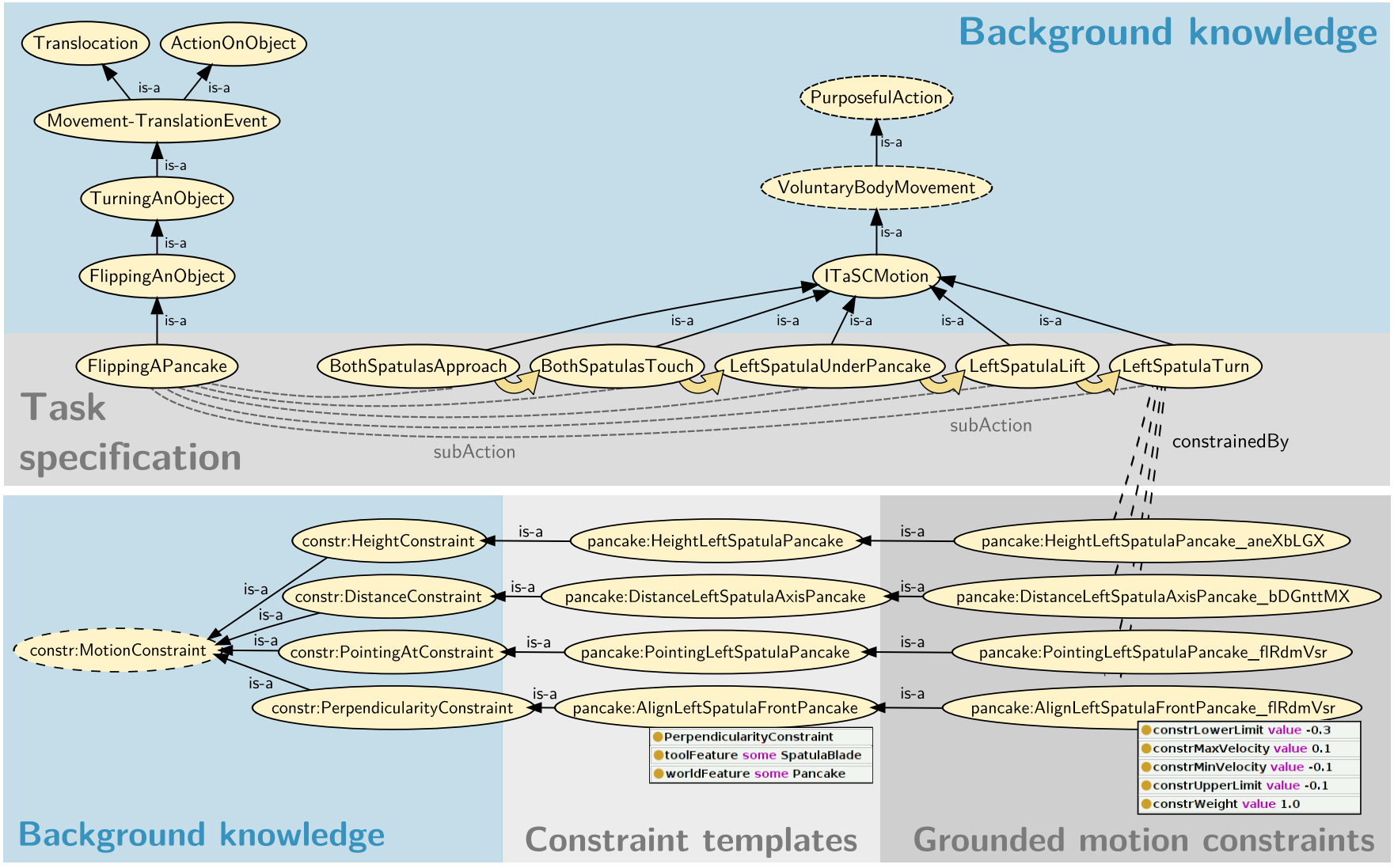
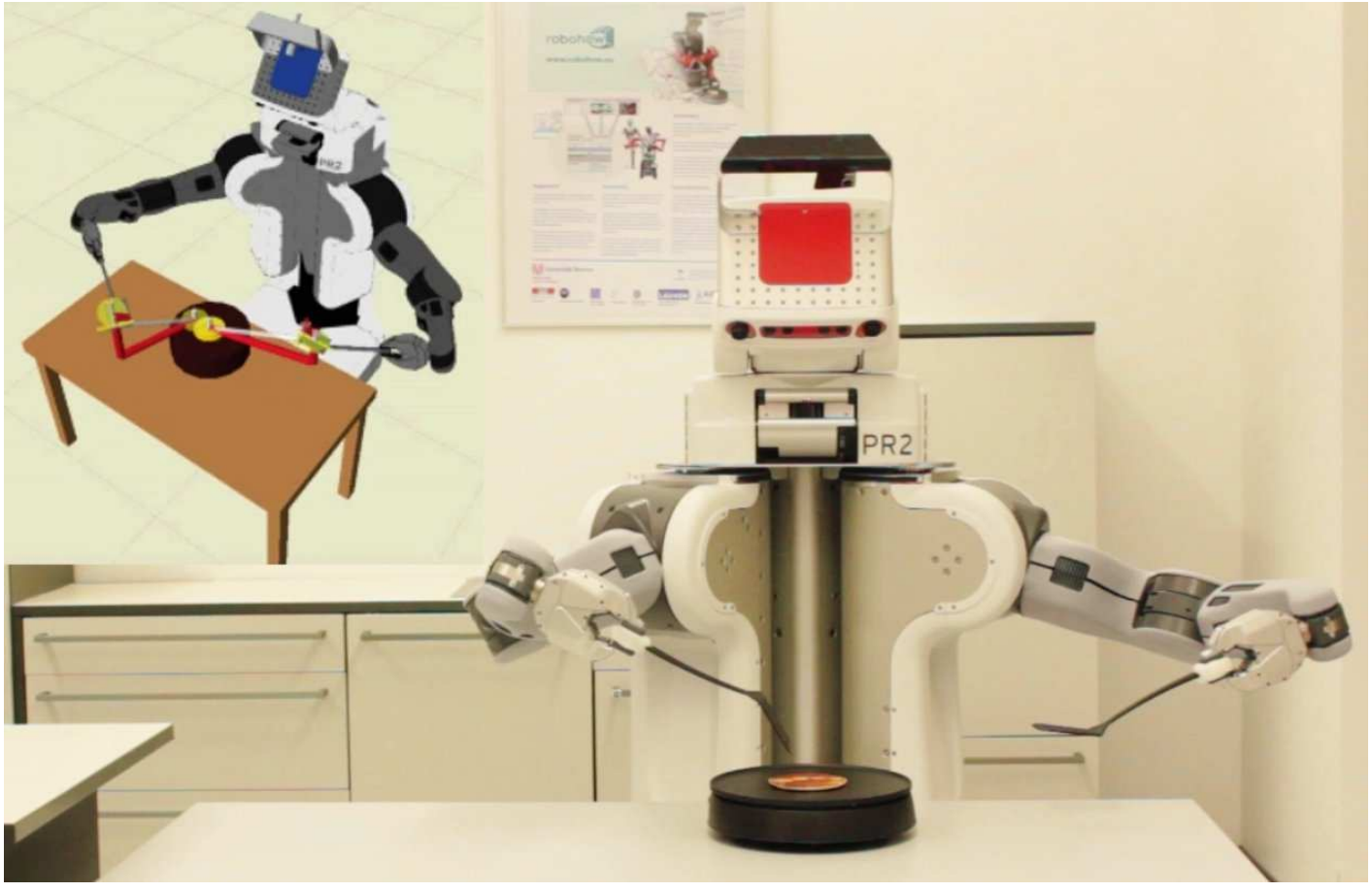


Everything Robots Always Wanted to Know about Housework (But were afraid to ask). Daniel Nyga and Michael Beetz. IROS 2012

Constraints as Symbolic Motion Description...

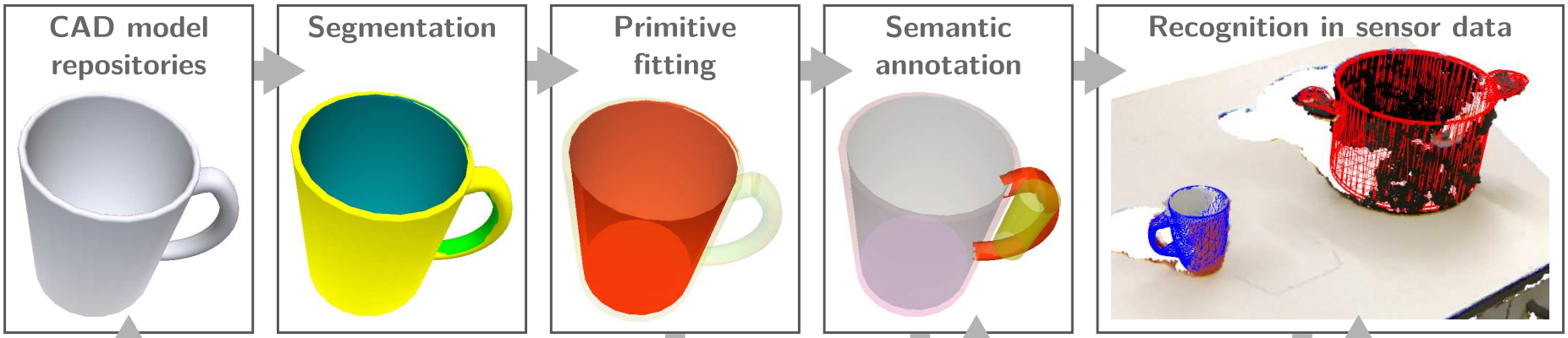


...that can also be executed



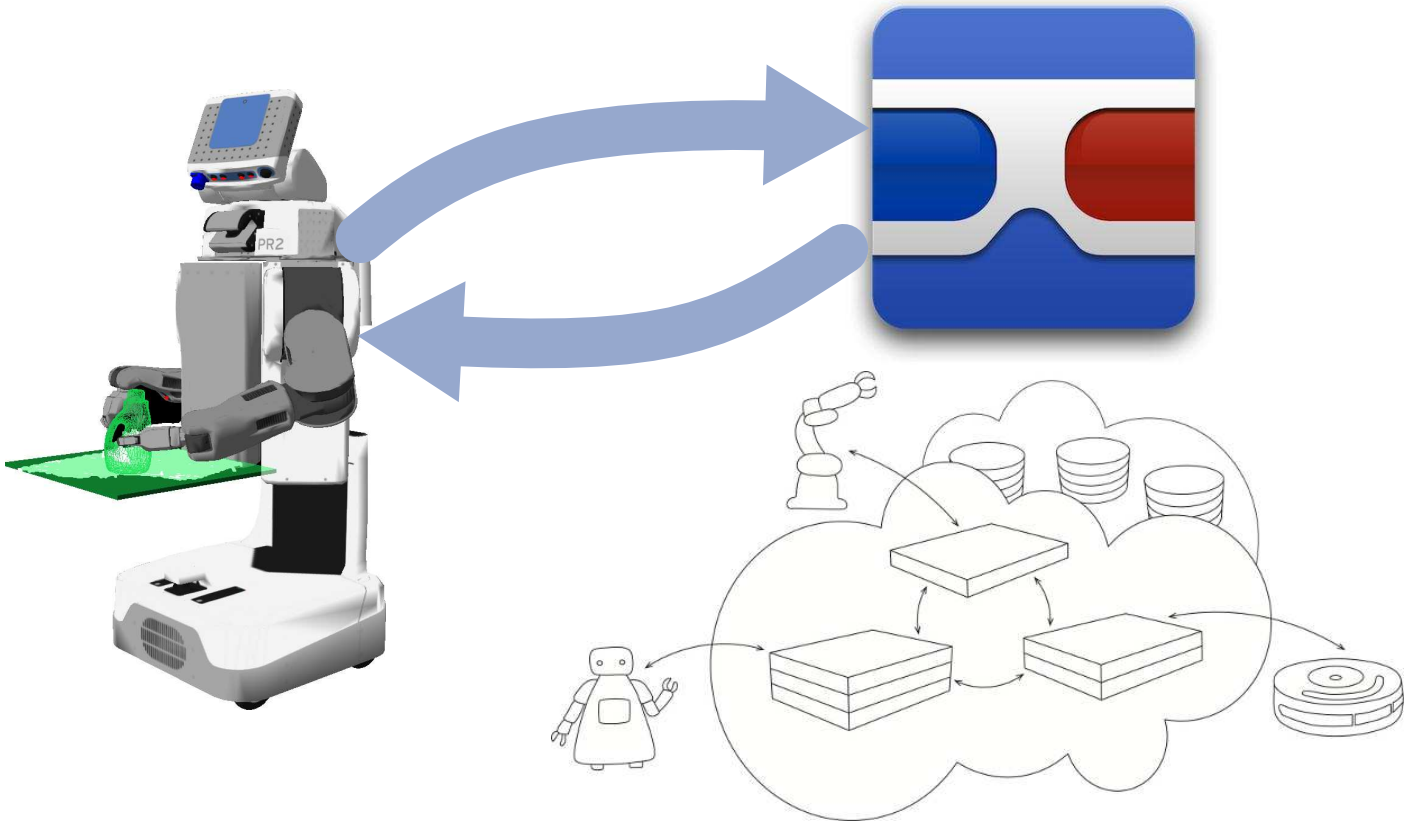
Constraint-based Movement Representation grounded in Geometric Features. Georg Bartels, Ingo Kresse and Michael Beetz. Humanoids 2013.

Grounding Action Knowledge in Object Models



Decomposing CAD Models of Objects of Daily Use and Reasoning about their Functional Parts. Moritz Tenorth, Stefan Profanter, Ferenc Balint-Benczedi and Michael Beetz. **ICRA 2014 (Talk on Wednesday)**

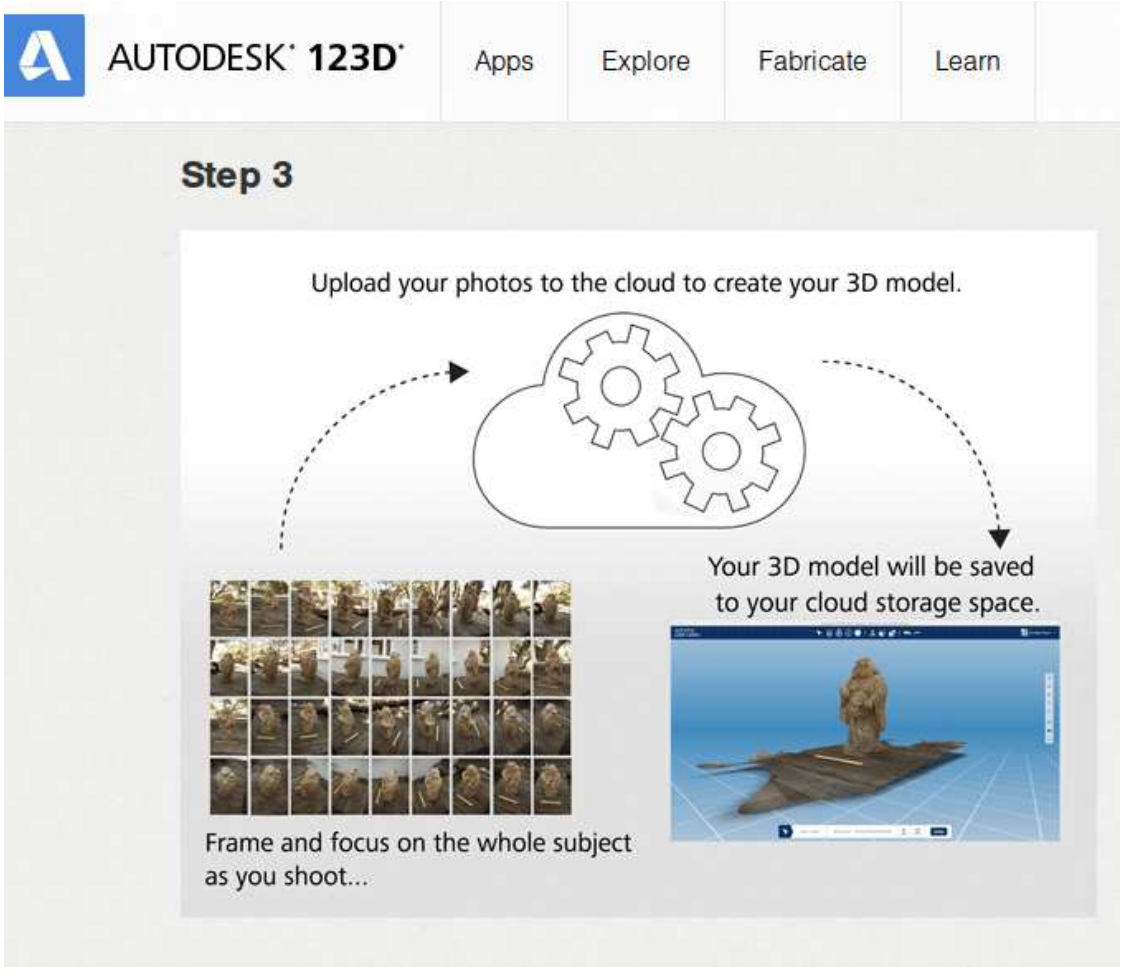
Use Case 3: Outsourcing Services to the Cloud



- How to integrate multiple complementary (cloud) services?
- How to deal with varying quality and availability?

123D Catch: Object Modeling

- Service for building 3D models from a set of images of an object
- Potential to massively simplify creation of new object models



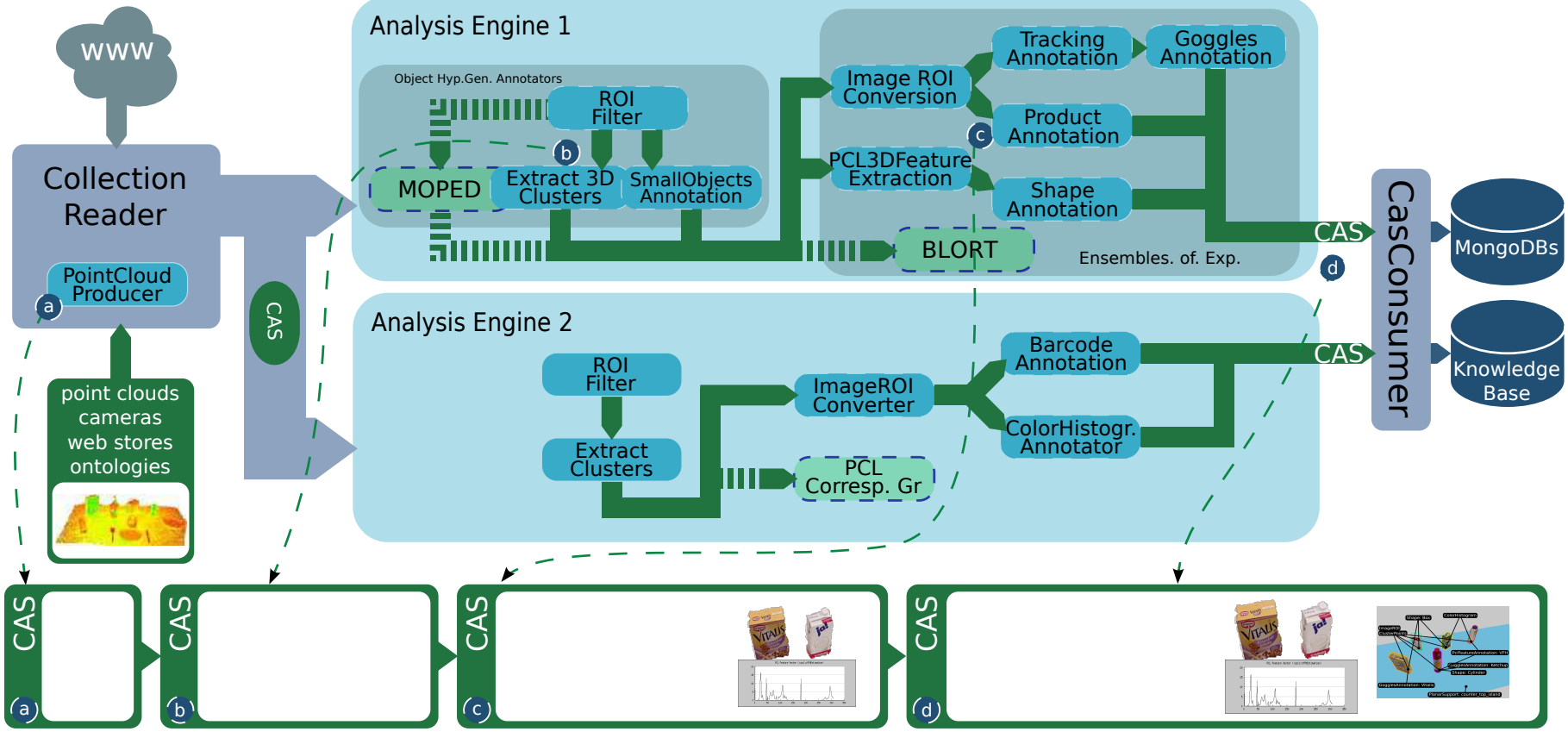
Barcoo: Barcode Recognition

- Barcode recognition in camera images
- Shows detailed information about the objects (e.g. price, comments, nutrition and health information)
- Source for detailed semantic information about objects

Google Goggles: Object Recognition

- Recognizes text, logos, barcodes, etc in camera images
- Rich semantic information about the objects
- Fast: 1-3 seconds
- Varying quality of the results depending e.g. on viewing angle

Ensemble-of-Experts Architecture for Perception



RoboSherlock: Unstructured Information Processing for Robot Perception.
M. Beetz, N. Blodow, F. Balint-Benczedi, Z. Marton, D. Nyga, F. Seidel, and C. Kerl.
Under review for IJRR.

Example: Scene Interpretation

PclFeatureAnnotation

GogglesAnnotation

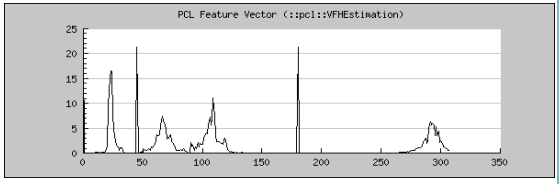
Similar Image: Hela Curry Ketchup
Bounding box: 28x53+37+110
URL:
Search More ⚓ High-Res Image ⚓ Found on Page ⚓

Text: Curry
Bounding box: 44x15+23+126
URL: Translate ⚓ Copy ⚓ Search More ⚓

ProductAnnotation

Source: GermanDeli.com
Product Name: Hela Scharfer Curry Gewürz Ketchup 400ml (Hot Curry Sauce 13.5oz)
Description:
Hela Gourmet Sauces are unique combinations of all-natural spices and seasonings. This versatile sauce adds a wonderful zesty taste to a wide variety of dishes including chicken, steak, pork and shrimp.... or even a plain hamburger. We use this curry ketchup (catsup) for our Curry Wurst! Truly an all-purpose gourmet sauce. Store on shelf and refrigerate after opening
Ingredients:
Tomato juice, sugar, dextrose, salt, curry, pepper, paprika, chilies, cloves, wine vinegar, modified starch, acidifying agent: citric acid, thickening agent: (E 412, E 413), herbs, ph-regulator: sodium lactate, flavor enhancer: E 621 monosodium glutamate
Brand: Hela
Country of Origin: Germany
Item #: 4027400168280
Rating: 5 stars
Weight/Size: 13.5oz (400ml)
Price: $5.79
Perishability: 1 (non perishable)

PclFeatureAnnotation



BarcooAnnotation

EAN / Barcode: 4000400112156
Manufacturer: Unilever

Mondamin Pfannkuch Shake
Unilever Germany
Rated 4 of 5

Google Goggles Annotator

GogglesAnnotation: Logo "Dr Oetker"

GogglesAnnotation: Product Vitalis Crunchy Choc, $8.99

Pcl Feature Annotator VFH

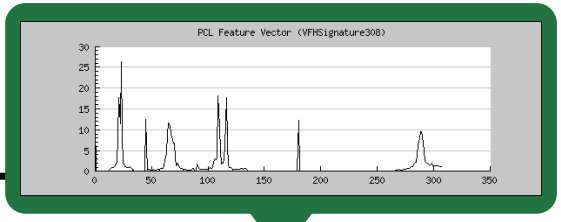
Classification Framework VFH

ClassificationAnnotation: Shape: "box" 88.9%

Combining Local Analysis with Cloud Information

Google Goggles Annotator

Pcl Feature Annotator VFH



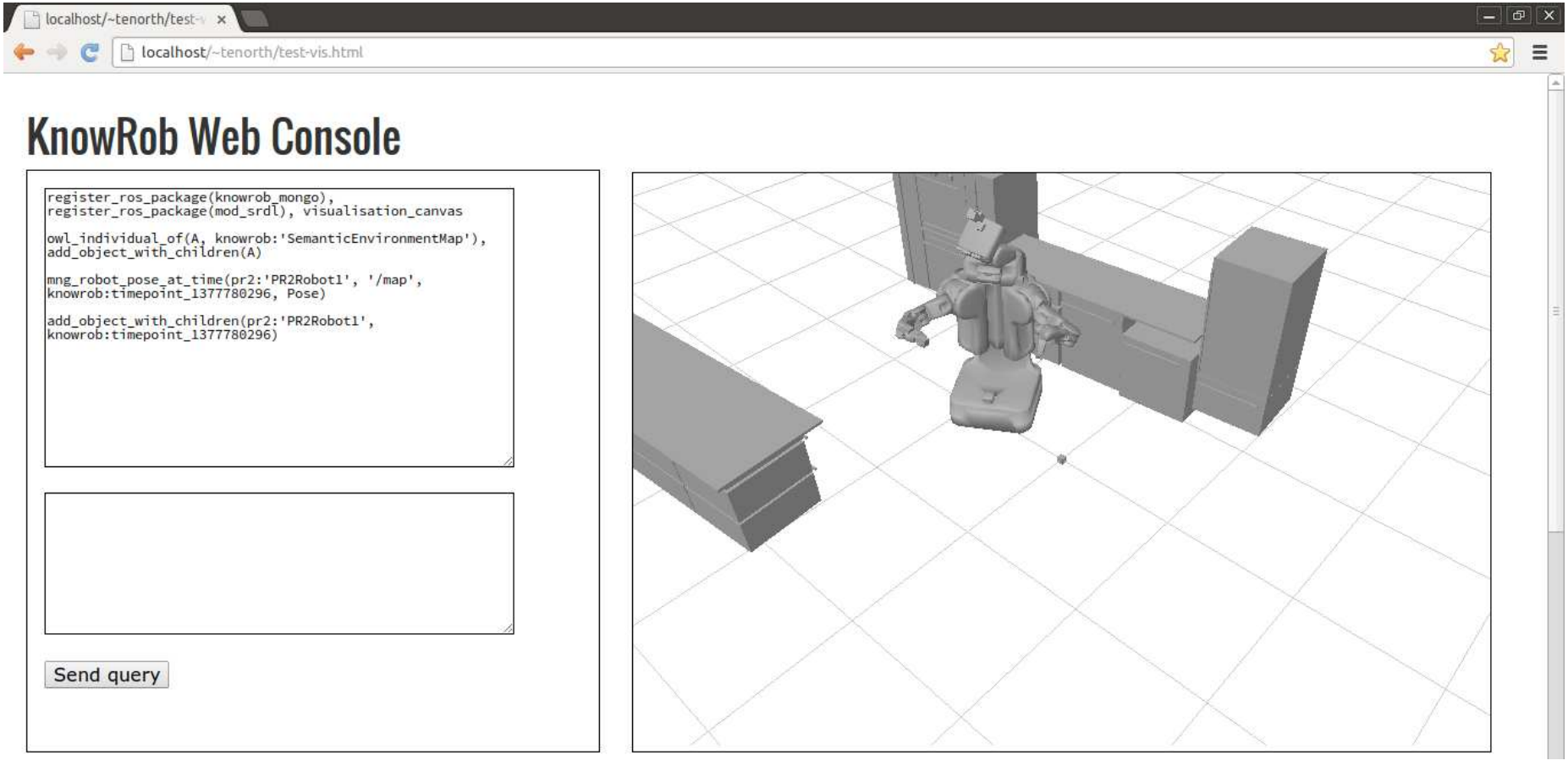
GogglesAnnotation: Logo "Dr Oetker"

Classification Framework VFH

GogglesAnnotation: Product Vitalis Crunchy Choc, $8.99

ClassificationAnnotation: Shape: "box" 88.9%

Cloud-based Robot Knowledge Base



- Ongoing work: Knowledge base and experience memory in the Cloud

Conclusions

- Cloud applications have huge potential for robots
- Interesting use cases:
  - Acquiring knowledge from the Web
  - Exchanging information via cloud-based knowledge bases
  - Offloading computation by using cloud services
- Challenges:
  - Grounding abstract Web information in perception and manipulation
  - Handling varying information quality and service availability

Thank you for your attention!

http://ai.uni-bremen.de

http://www.roboearth.org

http://www.robohow.eu