ReGround: Relational Symbol Grounding through Affordance Learning

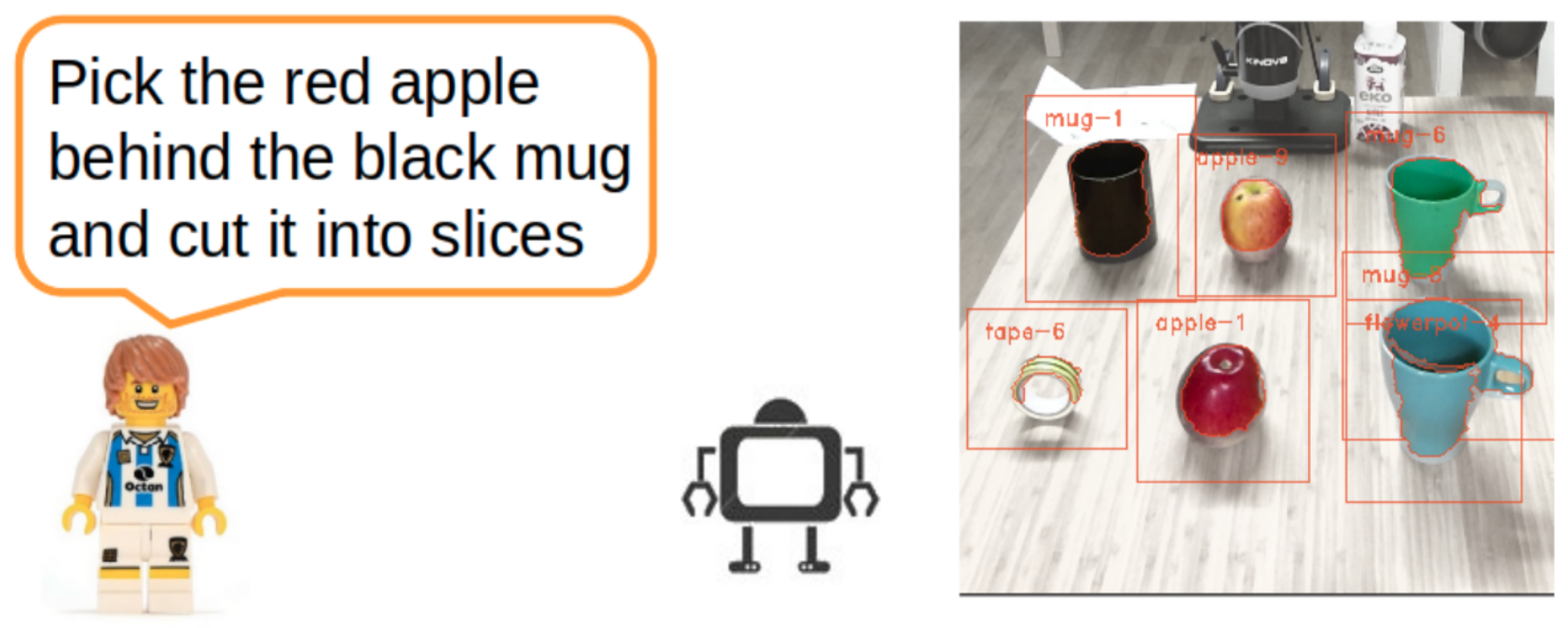
Laura Antanas[1] Ozan Arkan Can[2] Jesse Davis[1] Luc De Raedt[1] Nitesh Kumar[1] Amy Loutfi[3] Andreas Persson[3] Alessandro Saffiotti[3] Deniz Yuret[2] Pedro Zuidberg Dos Martires[1]

[1]KU Leuven

[2]Koç University

[3]Örebro University

Motivation



This requires

1. Identifying which objects “apple” and “mug” symbols refer to
2. Understanding the relation “behind”
3. Knowing that it is possible to cut an apple and how to cut it

Main Components

1. Object anchoring from the perceptual data
2. Natural language grounding
3. Probabilistic Reasoning
4. Planning

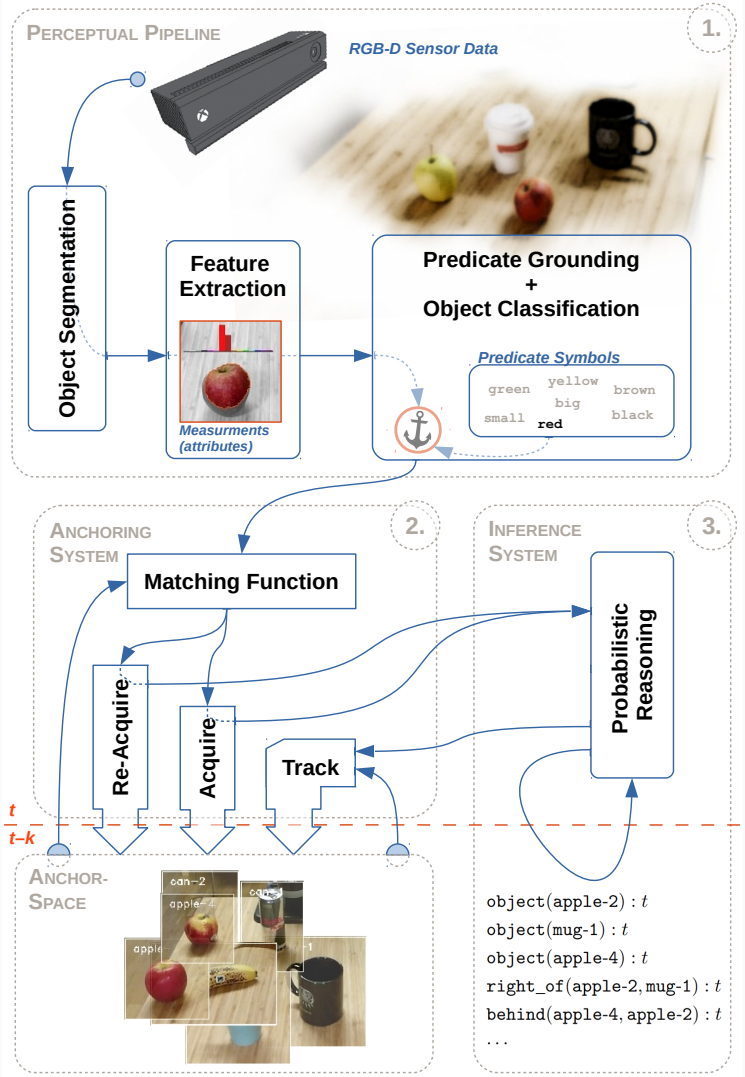
Key Goals

1. Make **language** and **vision** collaborate through **probabilistic reasoning**.
2. Make everything work together in a **relational robotics** setting.

Object Anchoring

Anchoring: Acquiring, Reacquiring, and Tracking

[Persson et al., Semantic Relational Object Tracking, IEEE Transactions on Cognitive and Developmental Systems 2019]

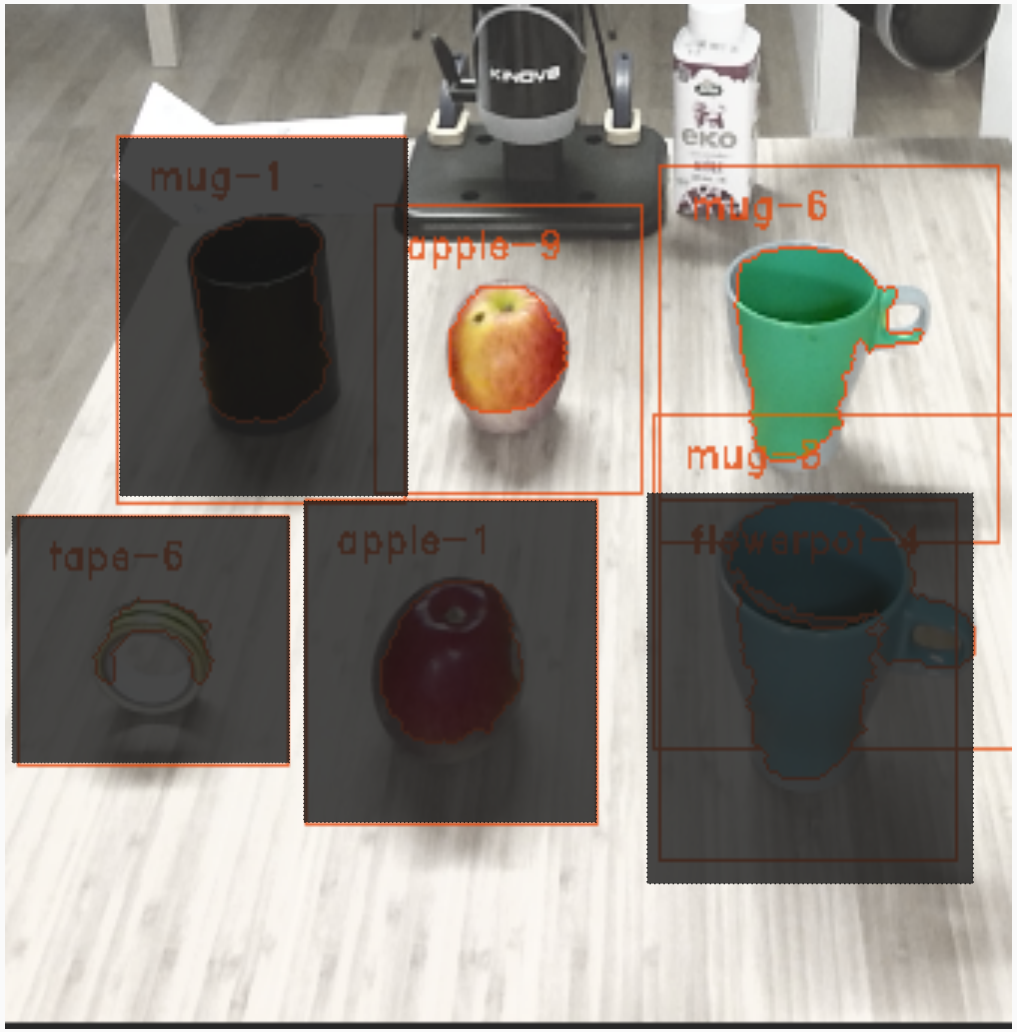


Demo

Language grounding

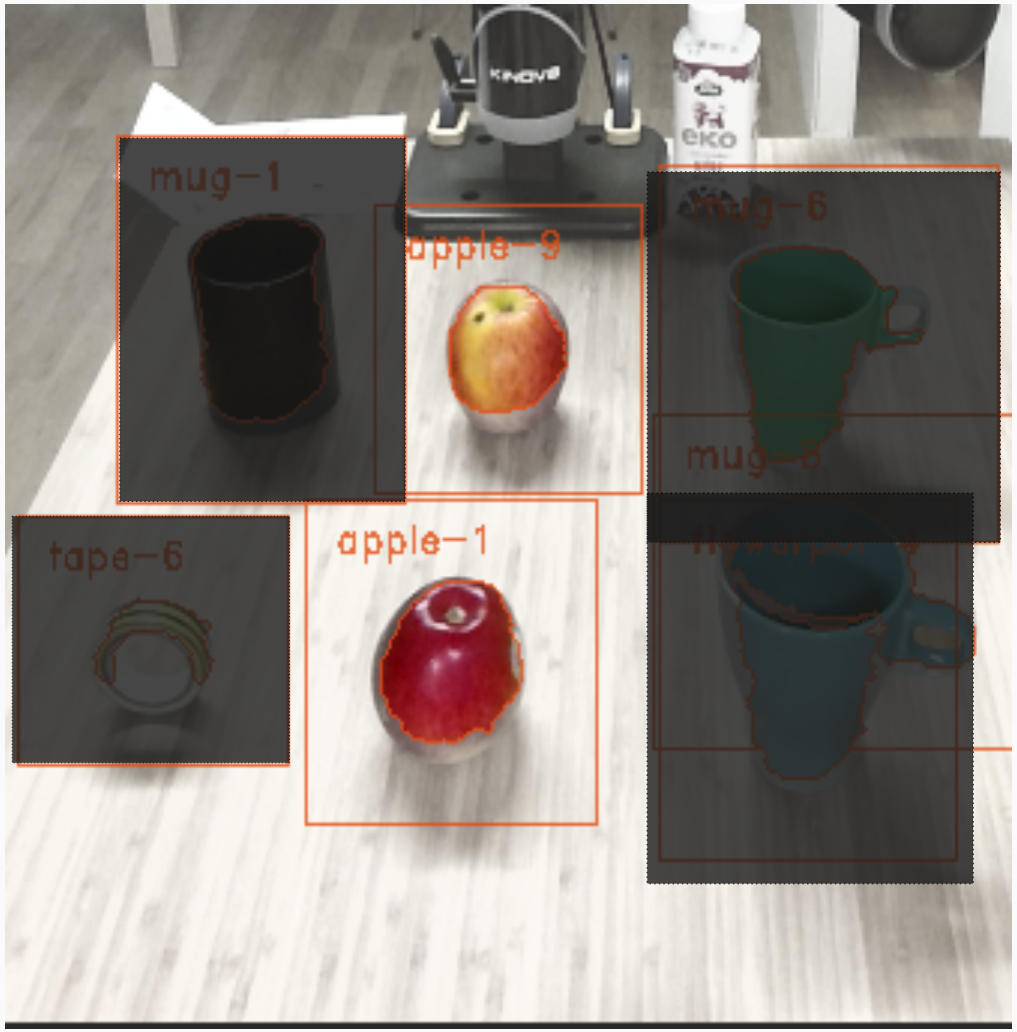
Language grounding as attention control

pick up the apple to the right of the black mug



Language grounding as attention control

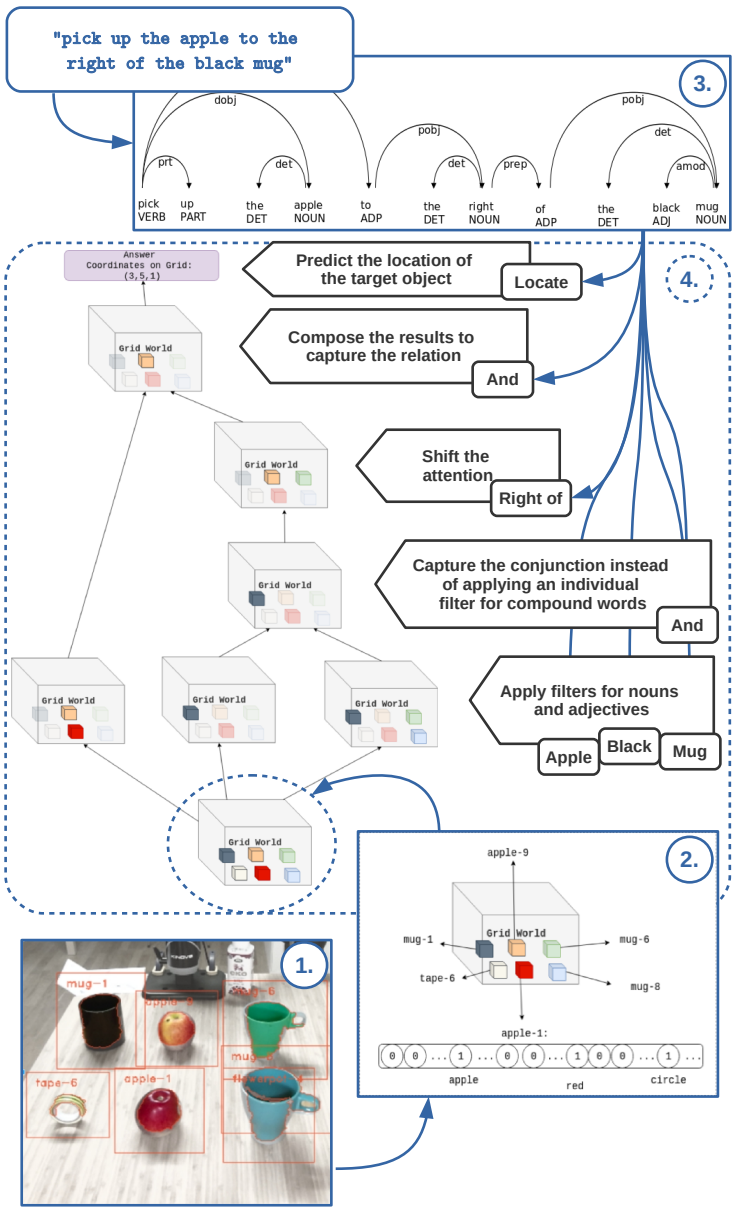
pick up the apple to the right of the black mug



Language grounding as attention control

pick up the apple to the right of the black mug

Neural Module Networks

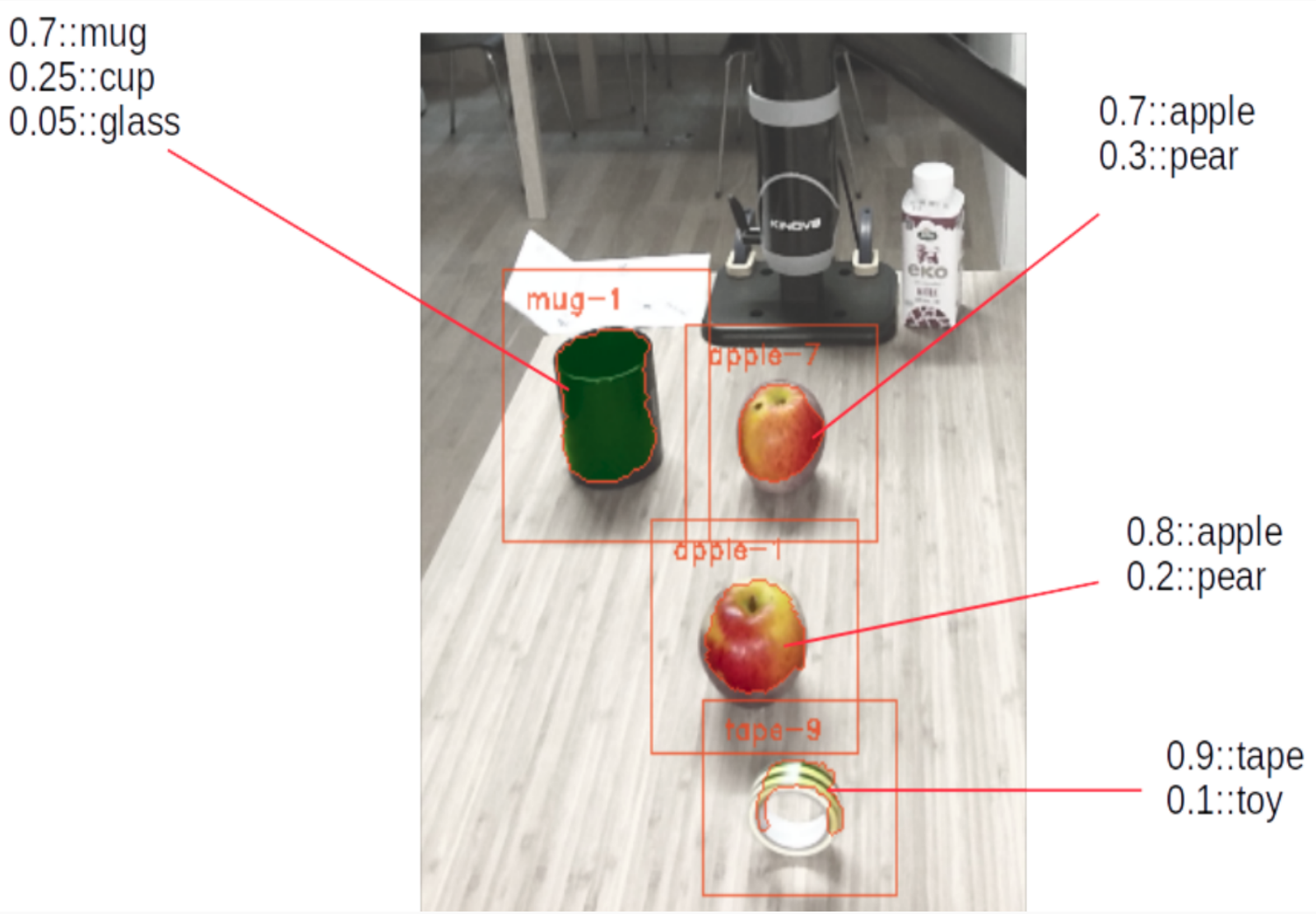


Curriculum Learning - Scenarios

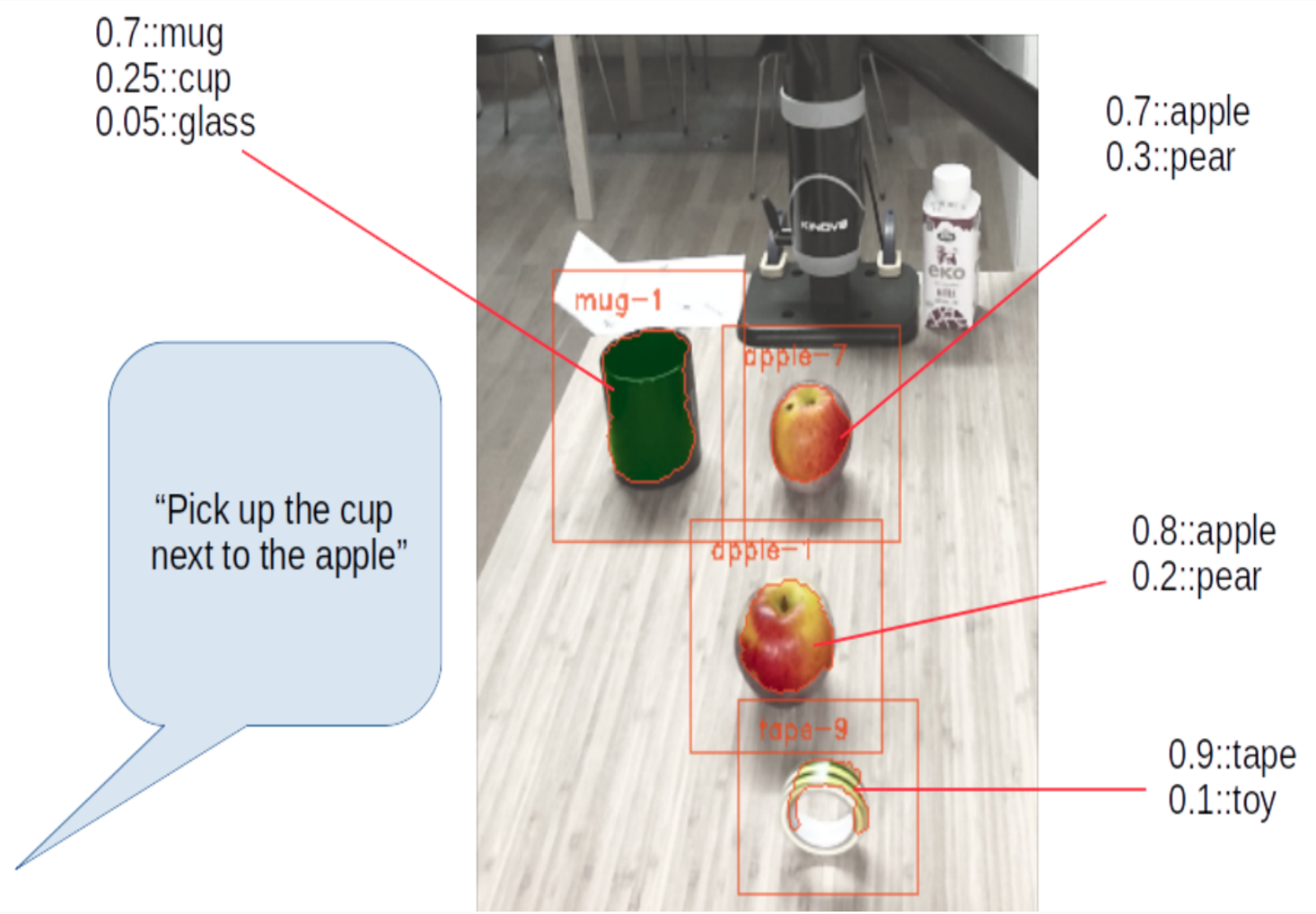
1. Using the **name** of a targeted object in the instruction is enough to localize the targeted object.
2. To solve the ambiguity, one or more discriminative **adjective(s)** are used.
3. To solve the ambiguity, the object is described with a **prepositional phrase** that utilizes a referent object.
4. To solve the ambiguity, the object is described with a **prepositional phrase** that utilizes a referent object along with necessary **adjectives**.

Resolving Inconsistencies between Language and Perception

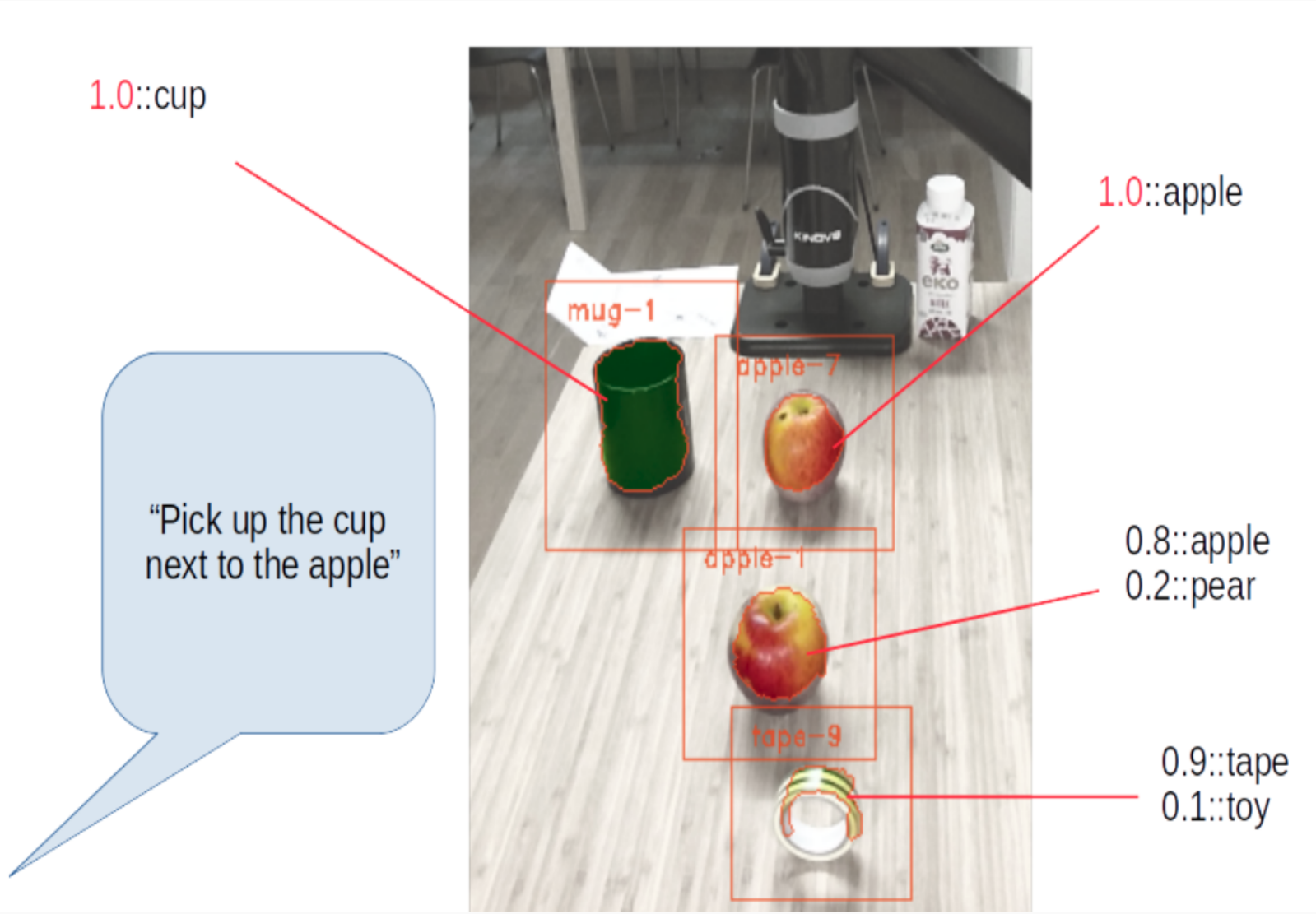
Problem


0.7::mug
0.25::cup
0.05::glass
mug-1
apple-7
apple-1
tape-9
0.7::apple
0.3::pear
0.8::apple
0.2::pear
0.9::tape
0.1::toy

Problem


0.7::mug
0.25::cup
0.05::glass
0.7::apple
0.3::pear
"Pick up the cup next to the apple"
mug-1
apple-7
apple-1
tape-9
0.8::apple
0.2::pear
0.9::tape
0.1::toy

Problem


1.0::cup
1.0::apple
mug-1
apple-7
apple-1
tape-9
0.8::apple
0.2::pear
0.9::tape
0.1::toy
"Pick up the cup next to the apple"

Solution

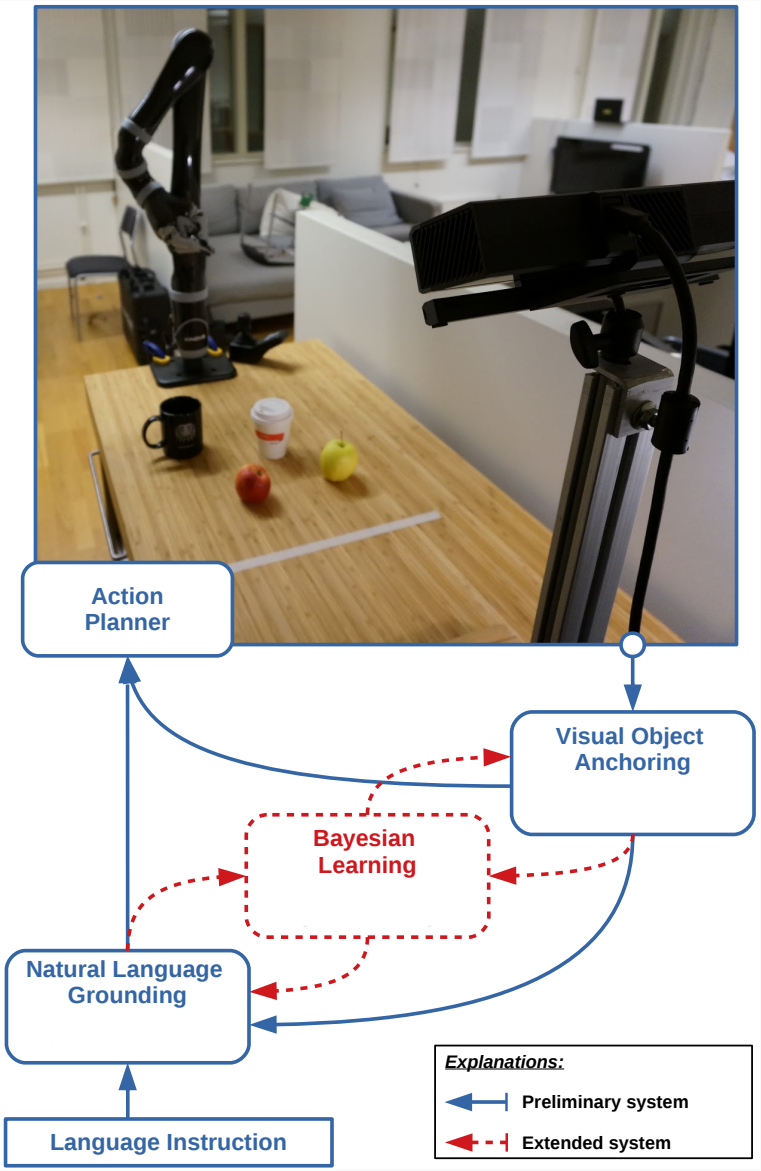
[Can et al., Learning from Implicit Information in Natural Language Instructions for Robotic Manipulations, SpLU-RoboNLP 2019]

1. $p(l)$ over the possible labels (e.g. $[0.65 : \text{apple}, 0.35 : \text{pear}]$)
2. given is a natural language instruction i and the grounding g of that instruction in the real world
3. conditional probability $p(l \mid g, i)$
4. a label configuration (or label assignment to all objects) c

Under some assumptions

$$p(l \mid g, i) = \frac{\sum_c \left(\prod_{j \in c} p(l_j)\right) p(g|c, i)}{N_c \sum_c p(g|c, i)}$$

Setup


Action Planner
Visual Object Anchoring
Bayesian Learning
Natural Language Grounding
Language Instruction
Explanations:
Preliminary system
Extended system

Demo

Future Work & Conclusions

Future Work

- Learn probabilistic rules instead of hard-coding for reasoning enhances anchoring.
- Scale-up inconsistency resolving between language instructions and anchoring.

Conclusion

- We focused on work done in collaboration between the partners
- We integrated language and vision in a **principled** way through probability calculus.
- Check out our website https://reground.cs.kuleuven.be for more materials.

Publications

2019

- Learning from Implicit Information in Natural Language Instructions for Robotic Manipulations, Ozan Arkan Can, Pedro Zuidberg Dos Martires, Andreas Persson, Julian Gaal, Amy Loutfi, Luc De Raedt, Deniz Yuret, Alessandro Saffiotti, SpLU-RoboNLP 2019
- Semantic Relational Object Tracking Andreas Persson, Pedro Zuidberg dos Martires, Amy Loutfi, and Luc De Raed IEEE Transactions on Cognitive and Developmental Systems 2019
- Exact and Approximate Weighted Model Integration with Probability Density Functions Using Knowledge Compilation Zuidberg Dos Martires, Pedro; Dries, Anton; De Raed, Luc The Thirty-Third AAAI Conference on Artificial Intelligence 2019

2018

- A new dataset and model forlearning to understand navigational instructions Ozan Arkan Can, Deniz Yuret arXiv:preprint 2018 DeepProbLog: Neural Probabilistic Logic Programming
- Robin Manhaeve, Sebastijan Dumančić, Angelika Kimmig, Thomas Demeester, Luc De Raedt Thirty-second Conference on Neural Information Processing Systems 2018 Reactive Probabilistic Programming
- Zuidberg Dos Martires, Pedro; Dumancic, Sebastijan The 1st International Conference on Probabilistic Programming 2018
- Knowledge Compilation with Continuous Random Variables and its Application in Hybrid Probabilistic Logic Programming Zuidberg Dos Martires, Pedro Miguel Dries, Anton ; De Raedt, Luc Eighth International Workshop on Statistical Relational AI 2018

2017

- Relational affordance learning for task-dependent robot grasping Laura Antanas, Anton Dries, Plinio Moreno, Luc De Raedt Presented at the Inductive Logic Programming Conference in France 2017
- The role of nonverbal behavior during book reading on language development Sarıçimen İlkim, Ölmez, B., Başçı, A., Akhavan, N., Aktan-Erciyes, Göksun, T. Poster presented at the Budapest Conference on Cognitive Development in Budapest, Hungary 2017
- Relational Symbol Grounding through Affordance Learning. An Overview of the ReGround Project Laura Antanas, Ozan Arkan Can, Jesse Davis, Luc De Raedt, Amy Loutfi, Andreas Persson, Alessandro Saffiotti, Emre Unal, Deniz Yuret, Pedro Zuidberg dos Martires GLU 2017 International Workshop on Grounding Language Understanding 2017
- Planning in hybrid relational MDPs Davide Nitti, Vaishak Belle, Tinne De Laet, Luc De Raedt Machine Learning vol:106 issue:12 pages:1905-1932 2017

Publications

2016

- Probabilistic logic programming for hybrid relational domains Davide Nitti, Tinne De Laet, Luc De Raedt Machine Learning, 103:3, pp. 307 - 449, Springer, 2016. 2016
- Knet:beginning deep learning with 100 lines of Julia Deniz Yuret Machine Learning Systems Workshop at NIPS 2016 2016 Learning Actions to Improve the Perceptual Anchoring of Objects.
- Andreas Persson, Martin Längkvist, Amy Loutfi Front. Robot. AI 2016 Learning the Structure of Dynamic Hybrid Relational Models
- Davide Nitti, Irma Ravkic, Jesse Davis, Luc De Raedt Proceedings of the 22nd European Conference on Artificial Intelligence (ECAI 2016) 2016