Semantics for Robots

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Tecosa 2021

Machine Perception and Interaction Lab

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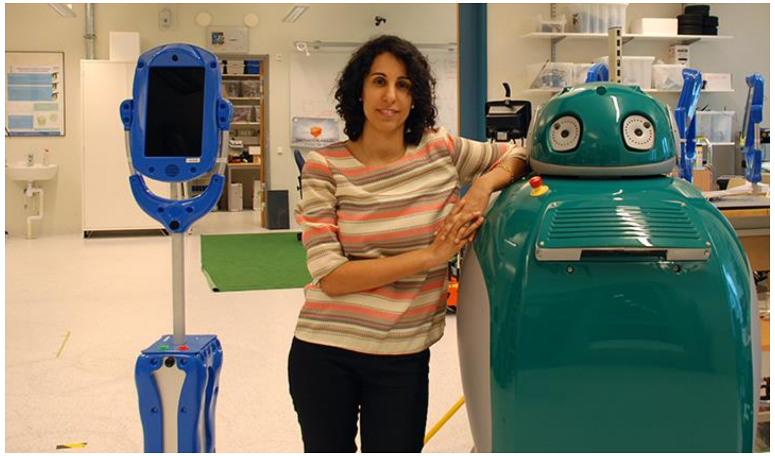
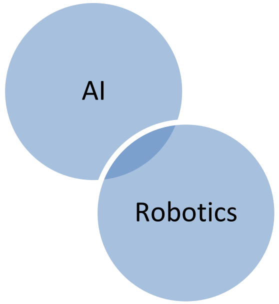
Örebro University



- **15 300** students
- **450** Ph.Ds
- **82** programs
- **980** courses
- **1 600** employees
- **880** teachers
- **135** professors
- **8** schools

Center for Applied Autonomous Sensor Systems, Örebro University

Focus on the Perceptual and Cognitive Abilities of Autonomous Systems that are developed for the service of humans



Autonomous Mobile Manipulation Lab
At the AMM lab we strive to enable mobile robots to perform complex interaction with their environment. We perform research on perception and motion synthesis for mobility and manipulation.

Cognitive Robotic Systems Lab
R&D on cognitive abilities for embedded physical systems such as robots and/or sensor systems. These cognitive abilities include: knowledge-representation, planning and scheduling, and hybrid reasoning/inference.

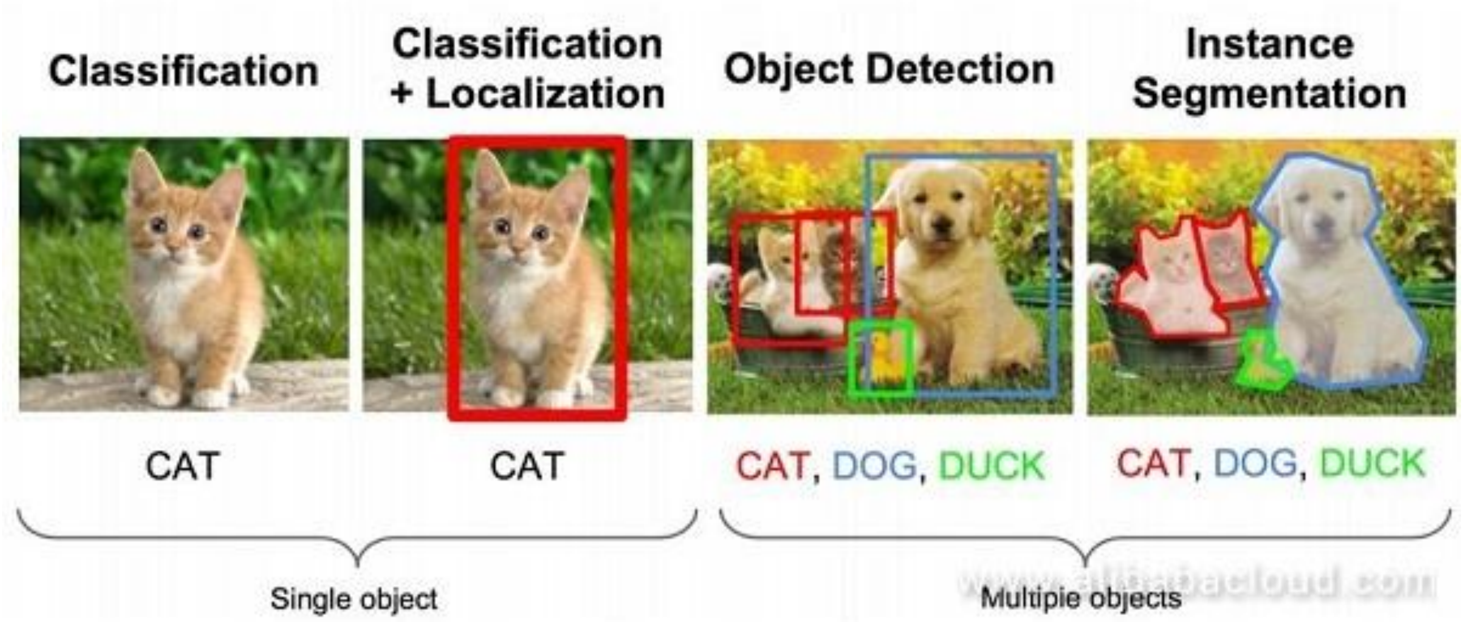
Machine Perception and Interaction Lab
R&D on sensor-based perception for intelligent systems and evaluation of the quality of interaction of systems with multi-actors. Focus on representation learning of sensor data, semantic perception and human-systems interaction including human-robot interaction.

Mobile Robots and Olfaction Lab
R&D on perception for robots: rich 3D maps (3D optical/laser data augmented with additional sensor data and semantic information); robot vision for mapping, localization and navigation (e.g.,VSLAM); and mobile robot olfaction – gas discrimination and quantification, statistical gas distribution modelling and gas source localization with mobile robots.

Multi-Robot Planning and Control Lab
R&D on automated planning and control for robots and multi-robot systems. Focus on integrated task and motion planning, coordination, hybrid reasoning about time, spac motions, resources and tasks, plan-based robot control with realistic boundary conditions, and online multi-robot planning .

Machine Perception and Interaction

Deep Learning and Perception



Deep learning has enabled rapid progress in object detection, recognition, and segmentation, but objects are much more complex than simply pixels in an image

Non-trivial view on objects

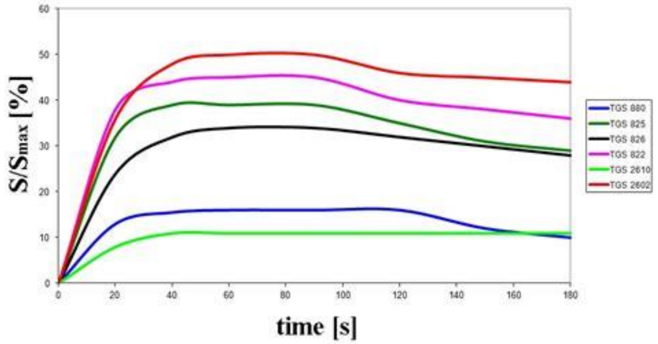
- Multiple and changing properties
- Relations and Affordances
- Deeper Semantics associated to objects
    - permanence
    - (de) composition
    - Impact their surroundings

Robots that have a deeper ”understanding” of the objects around them

Easily instruct using natural language e.g ”Pick up all the toys, Move box, find my glasses”

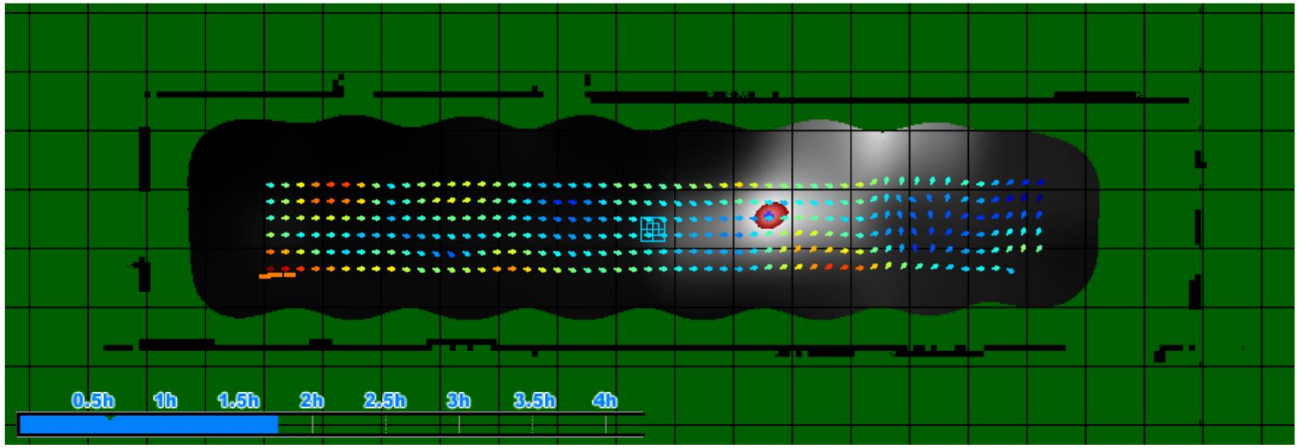
- Enable better mechanisms for action and interaction
  - Permit understanding of the meaning of observations
  - Infer beyond what can be measured
  - Handling of complex tasks
  - Shared understanding

My own interest in the subject - olfaction



E-nose@Malaga university

” A rose by any other name would smell just as sweet” . (Romeo&Juliet, Shakespeare)



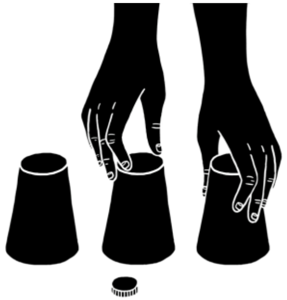
Loutfi et. al, Object Recognition a new application for smelling robots. Rob. and Aut. Systems. 2005

In Gas Distribution mapping often the highest measured concentration of an odour is not co-located at the source.

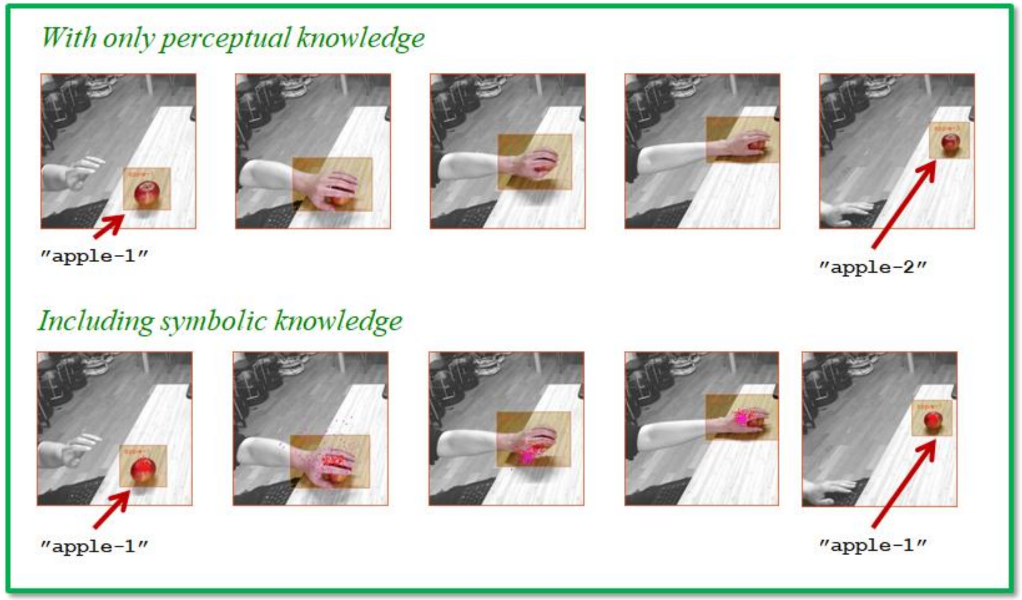
Three examples of semantics for robots (projects)

- Neural-Symbolic Integration for Object Affordance Inference
- Grounded Language Learning
- Large Scale Semantic Perception for Urban Settings

How we learn to reason about objects



Same challenge for Intelligent Systems



Combine Machine Learning with Reasoning

Ball-1 (front-of ball-1 cup-1)

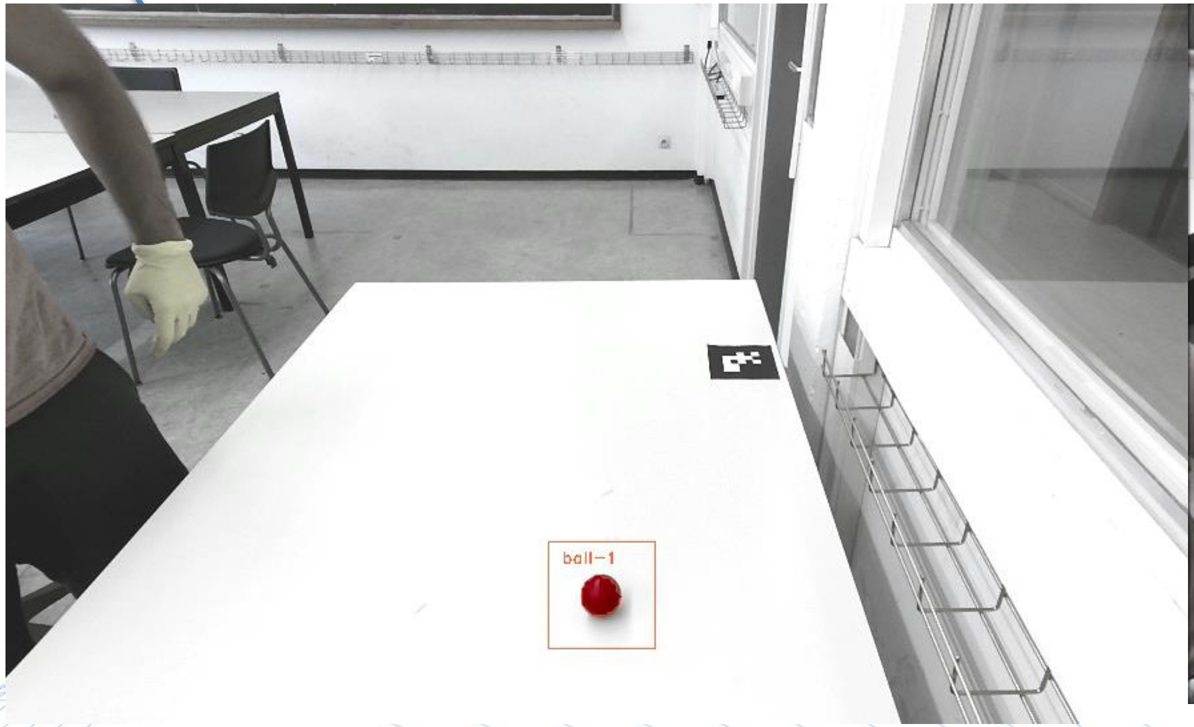
Cup-1

$$\mathtt{n} \sim \mathtt{poisson}(6).$$
$$\mathtt{pos(P)}_0 \sim \mathtt{uniform(0,N)} \leftarrow$$
$$\quad \mathtt{N} \sim= \mathtt{n}, \mathtt{between(1,N,P)}.$$
$$\mathtt{pos(P)}_{t+1} \sim \mathtt{gaussian}(\mathtt{X}+3, \Sigma) \leftarrow$$
$$\quad \mathtt{X} \sim= \mathtt{pos(P)}_t.$$

Symbol system

anchoring

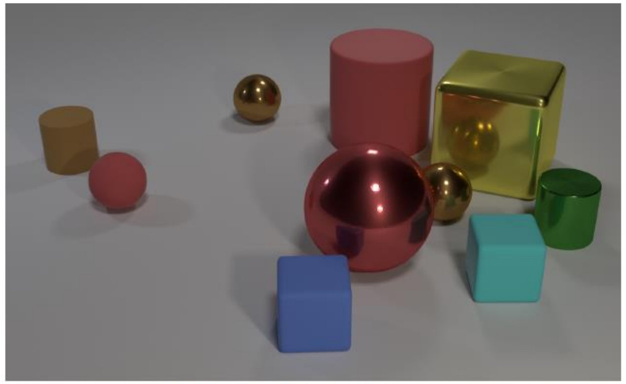
reasoning



Three examples of semantics for robots

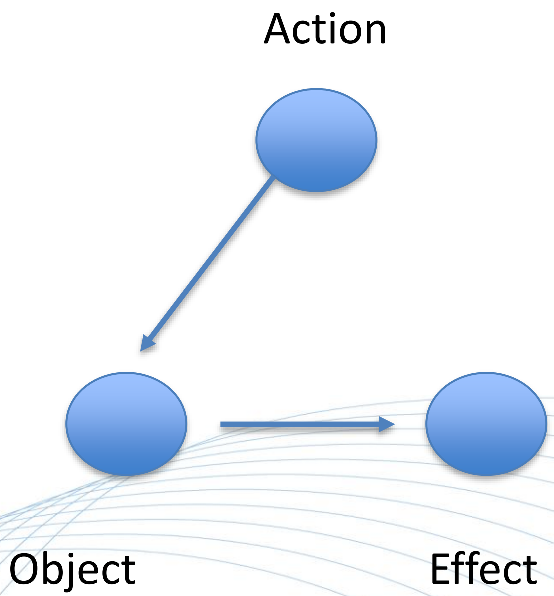
- Neural-Symbolic Integration for object inference
- Grounded Language Learning
- Large Scale Semantic Perception for Urban Settings

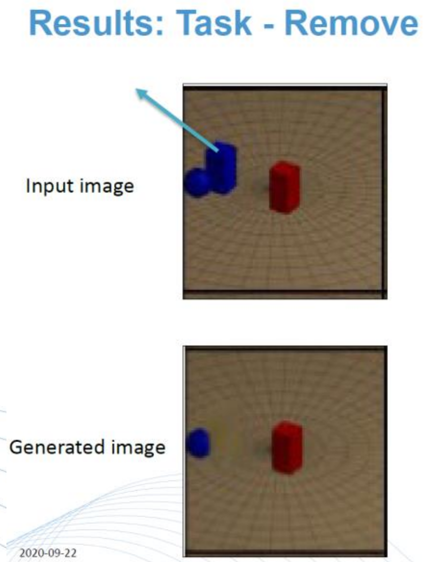
Grounded Language Learning

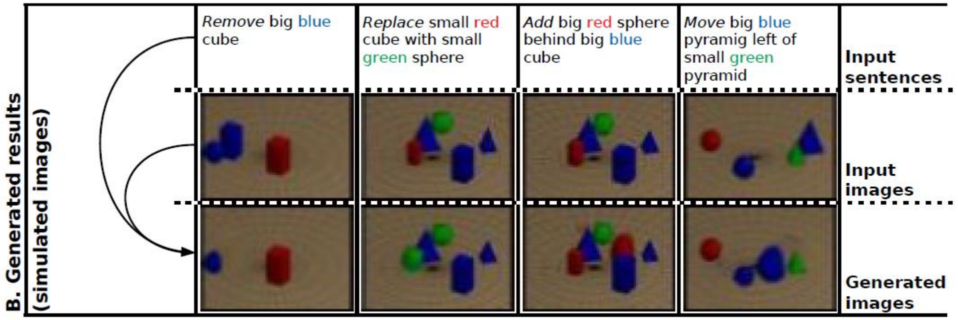


Q: Are there an equal number of large things and metal spheres? **Q:** What size is the cylinder that is left of the brown metal thing that is left of the big sphere? **Q:** There is a sphere with the same size as the metal cube; is it made of the same material as the small red sphere? **Q:** How many objects are either small cylinders or metal things?

Johnson, Justin, et al. "Clevr: A diagnostic dataset for compositional language and elementary visual reasoning." *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. 2017.



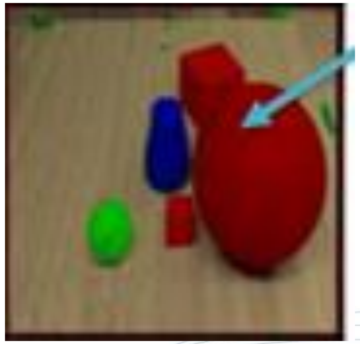




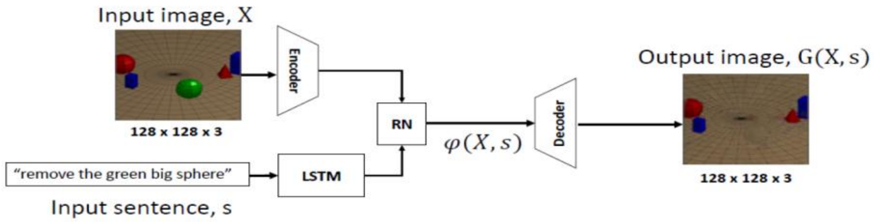
Grounded Language Learning

Transfer learning to Real Robot

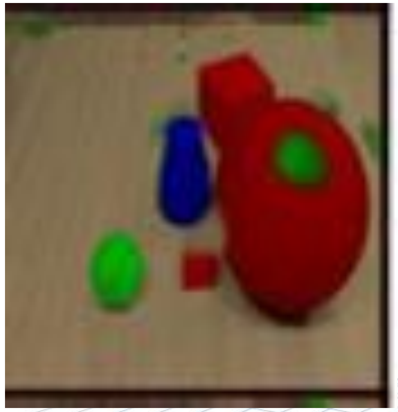
Perform action with novel objects and visualise the output



Input



1 → 2: **move** the red small cube left of red big sphere
2 → 3: **remove** the blue big pyramid
3 → 4: **replace** the green small cube with a blue big pyramid
4 → 5: **add** a green small cube on top of red big sphere



Generated Output

Three examples of semantics for robots

- Neural-Symbolic Integration for object inference
- Grounded Language Learning
- Large Scale Semantic Perception for Urban Settings

Large Scale Semantic Perception

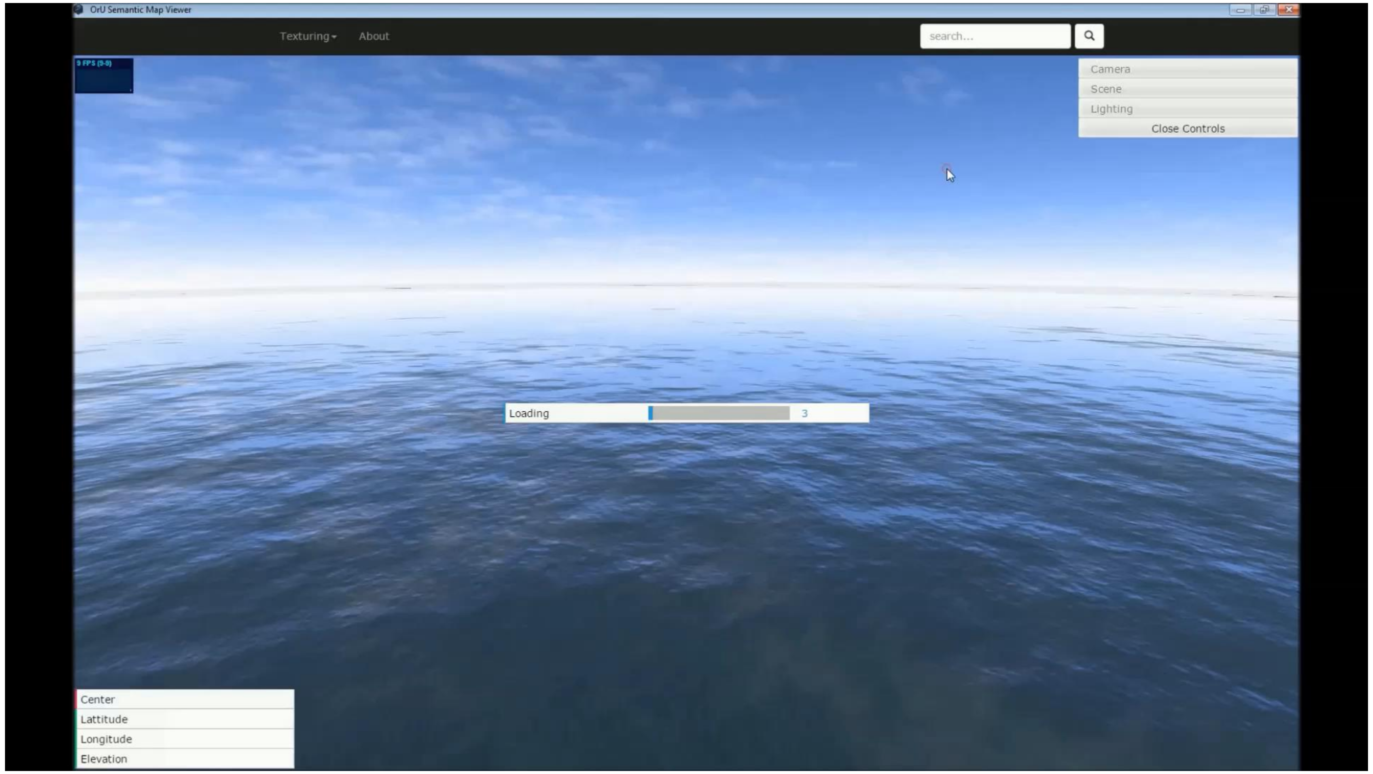
SAAB

VRICON

Goal: Automatically augment sattelite imagery with annotations about objects, functions, and relations to enable 1) users to query the map 2) improve the recognition of objects and entities with 100.000's of objects

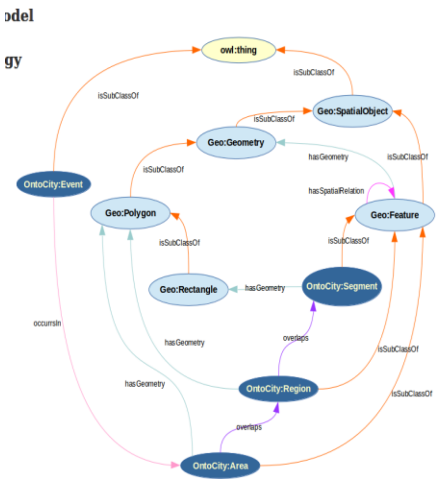
Large Scale Perception

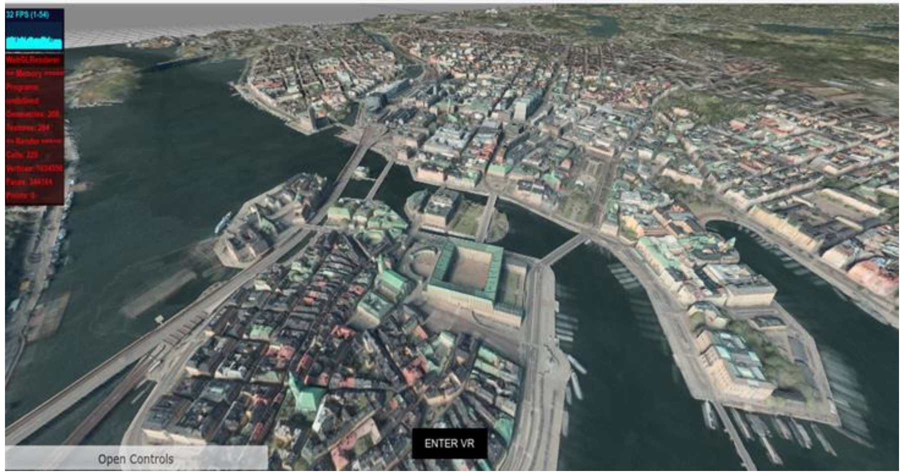
Use ML to determine each object/entity in an satellite image
Connect that information to high level representations e.g. Open Street Map

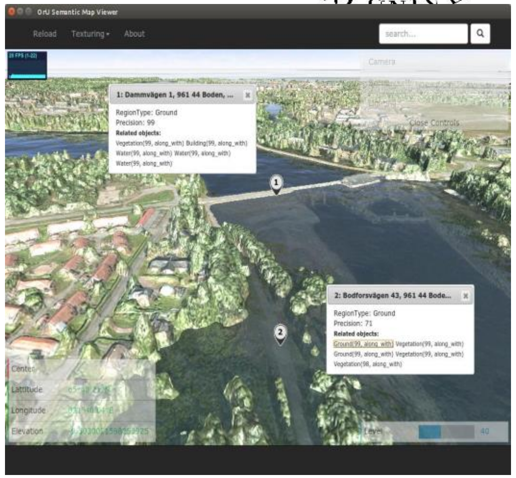


Queries for humans and robots

”Where are the shelters”







✓Since RRT is not complete, it may not find a path but it can use semantic constraints to assist it in the process.

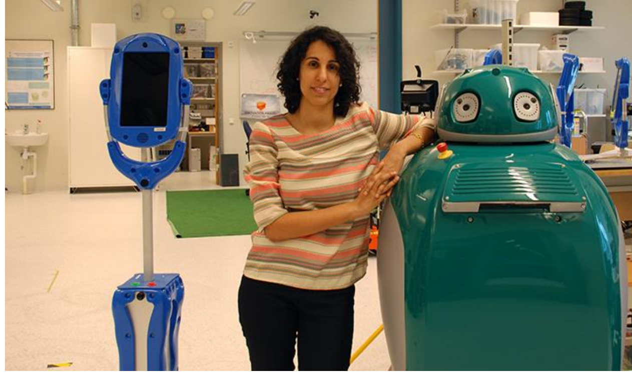
Fly to point A to B avoiding water

Robots that have a deeper ”understanding” of the objects around them

Easily instruct using natural language e.g ”Pick up all the toys, Move box, find my glasses”

- Enable better mechanisms for action and interaction
    - Permit understanding of the meaning of observations
    - Infer beyond what can be measured
    - Handling of complex tasks
    - Shared understanding
- Better AI algorithms

Thanks you for your attention



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