Cognition-Enabled Transferable Embodied AI

Prof. Dr. Michael Beetz
AICOR Institute for Artificial Intelligence, University of Bremen

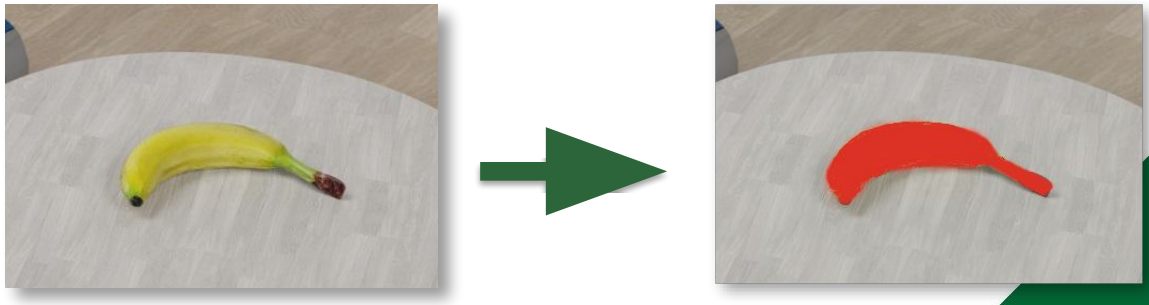
Prof. Dr. Rudolph Triebel
Leader of Dep. for Perception and Cognition, Robotics Institute, DLR
Professor for Intelligent Robot Perception, KIT

Motivation

Perception for Robotic Manipulation

Object detection

- often involves segmentation + feature extraction
- adds *semantic* information
- is a *classification* problem
- requires the appearance (color, texture) of objects



Perception for Robotic Manipulation

Object detection

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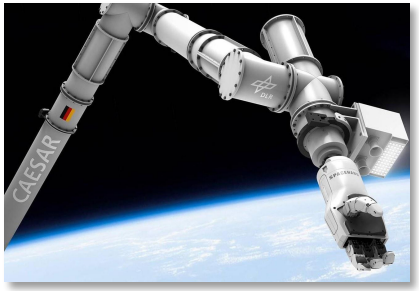
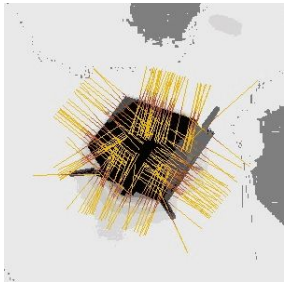
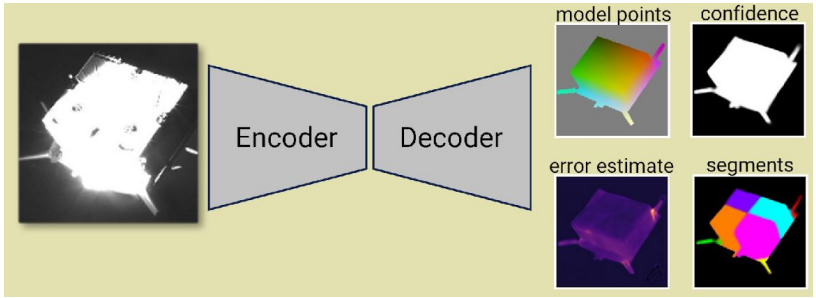
Object pose estimation

- retrieves the exact position and orientation in the camera (robot) frame
- is a *regression* problem
- *requires the exact geometry of objects* **really?**







Ulmer, Durner, Sundermeyer, Stoiber, Triebel, “6D Object Pose Estimation from Approximate 3D Models for Orbital Robotics”, IROS *2023*

Perception for Robotic Manipulation

Object detection

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Object pose estimation

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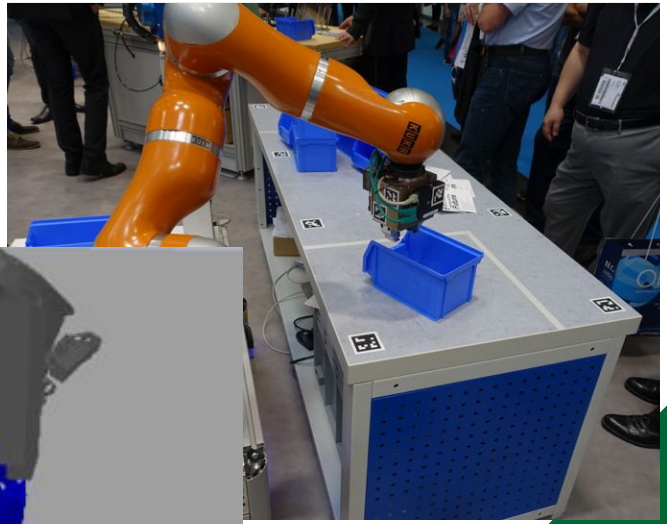
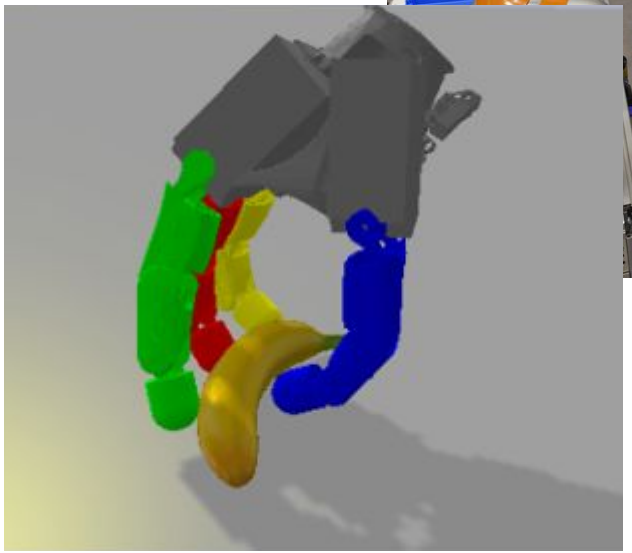
Grasp detection

- finds the pose of the robotic gripper for a grasp
- is a *regression* problem
- requires the exact geometry and kinematics of the gripper

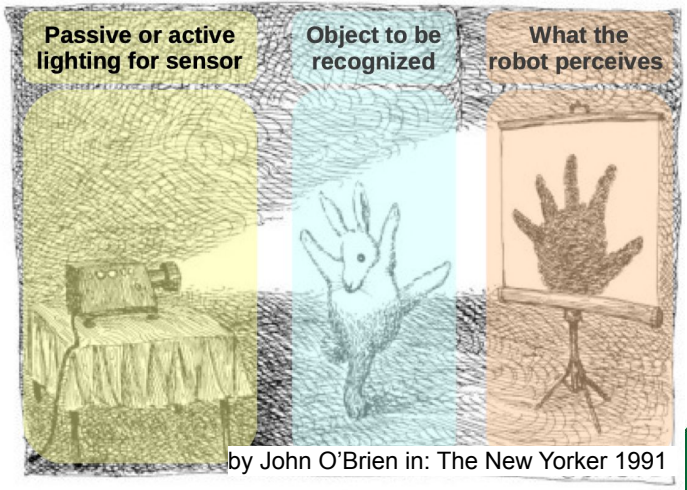




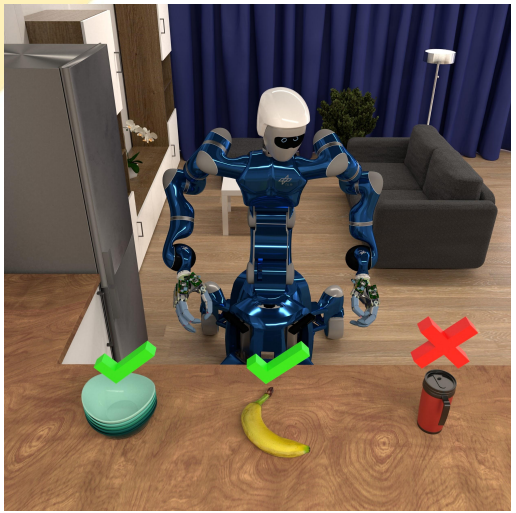
What are the Main Problems?

“Inverse” Problems

- find a plausible cause for a given effect
- e.g.: object detection, grasp detection



by John O’Brien in: The New Yorker 1991



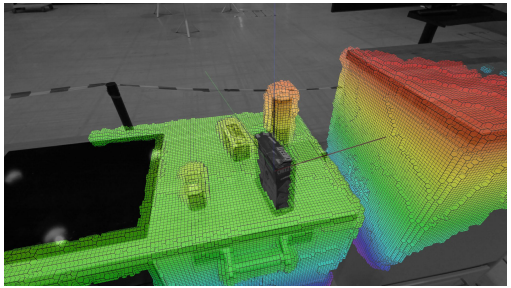
Open-world Assumption

- unknown objects can always appear
- distinguish the known from the unknown

From the Lab to the Kitchen (Part I)

Simulated training data

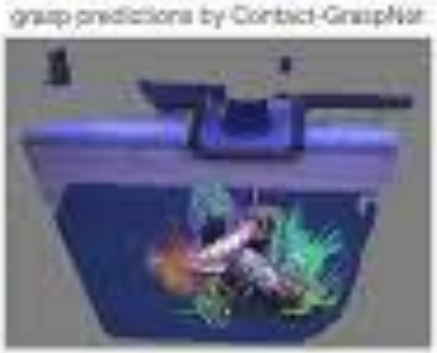
Object pose estimation
in the lab



Objects and obstacles
in the real environment

Grasping in the wild

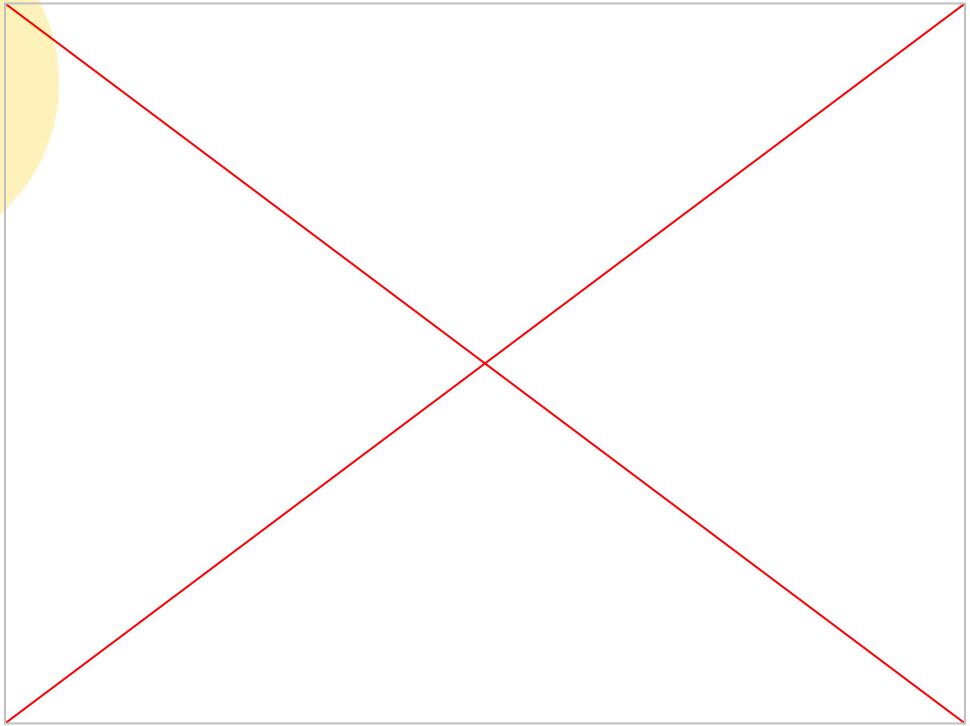
From the Lab … (Part II)



Cluttered scene

Virtual Research Building

Transfer to real world scenarios



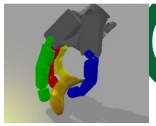
Image

Object detection

Pose estimation

$$\mathbf{x}_w = R\mathbf{x}_o + \mathbf{t}$$

Grasp detection



Are all objects of known class and known shape?

yes

Standard pipeline

no

Are all objects of some known shape?

yes

Functional grasping?

no

Direct grasp detection

yes

Infer object shape from training data

no

Is there unknown background?

yes

Treat known and unknown objects differently

Metallic objects

Thank You!