roboception

2026-03-25

WORKSHOP #54:

3D Perception as a Key Enabler for AI-Based Robotics

Stavanger 2026-03-25

STAVANGER NORWAY ERF 2026 23-27 MARCH INCLUDING SIDE EVENTS

EUROPEAN ROBOTICS FORUM

eu ROBOTICS

NORCE

SINTEF

„If we were only able to provide the visual capabilities of a 2-year old, robots would quickly get a lot better.“

Rodney Brooks (2015)

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Organization

3D Perception as a Key Enabler for AI-Based Robotics

Vision of the workshop:
3D perception turns robots from blind manipulators into adaptive, data-driven collaborators in production and logistics. It enables safe interaction, robust autonomy, and scalable AI-driven services across entire value chains.

What we will focus on today

- AI-based perception of **known** objects and **unknown** objects
- From pixels and point clouds to actionable knowledge: detection, pose estimation, scene understanding, and uncertainty handling for real-world deployments.
- Integrating 3D perception with federated data ecosystems to connect edge devices, cloud services, and enterprise IT, enabling new applications and data-based business models.

Format of the workshop

- Short impulse presentations from industry and research on current capabilities and deployment experiences.
- Interactive polling and discussion of challenges, user needs, and expectations.
- Panel session on how AI-based 3D perception and federated data ecosystems unlock new services, partnerships, and revenue streams in robotics

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Agenda

3D Perception as a Key Enabler for AI-Based Robotics

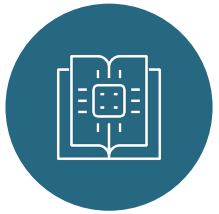
11:20	**Introduction and Definition of Key Statements / Questions** Dr. Michael Suppa, Roboception GmbH, Germany
11:25	**Insights on Pose Estimation and Grasp Prediction of Unknown Objects** Maximilian Durner, DLR, Germany
11:35	**Industrial-Grade Bin Picking: Real-World Deployment and Performance for Known Objects** Dr. Nicolas Alt, Siemens AG, Germany
11:45	**Shiny, reflective, thin – approaches and challenges for 3D perception in sheet metal** Dr. Ralph Lange, Trumpf, Germany
11:55	**The Data space: Introduction to a new way of sharing and using data collectively** Dr. Lukas Solbach, VDMA, Germany
12:05	**AI-based Perception of Seen and Unseen Objects** Dr. Michael Suppa, Roboception GmbH, Germany
12:15	**Interactive Poll Session / Round Table Discussion with the Audience**
12:35	**Closing Remarks and Take Home Messages**

ROX
Enabling AI Robotics

Key Questions

3D Perception as a Key Enabler for AI-Based Robotics

How does 3D perception enable robust AI-based robotic skills for handling known and unknown objects, while unlocking greater flexibility, autonomy, and economic value in dynamic production and logistics environments?



What are the key technical challenges and solution approaches for deploying 3D perception in real-world robotic applications such as bin-picking, kitting, and assembly?

How can federated data ecosystems improve the development, sharing, and scalability of AI perception models across different robots, factories, and applications?

Would a federated data space increase your willingness to share and jointly use data?
If not, why not?

INSIGHTS ON POSE ESTIMATION AND GRASP PREDICTION OF UNKNOWN OBJECTS

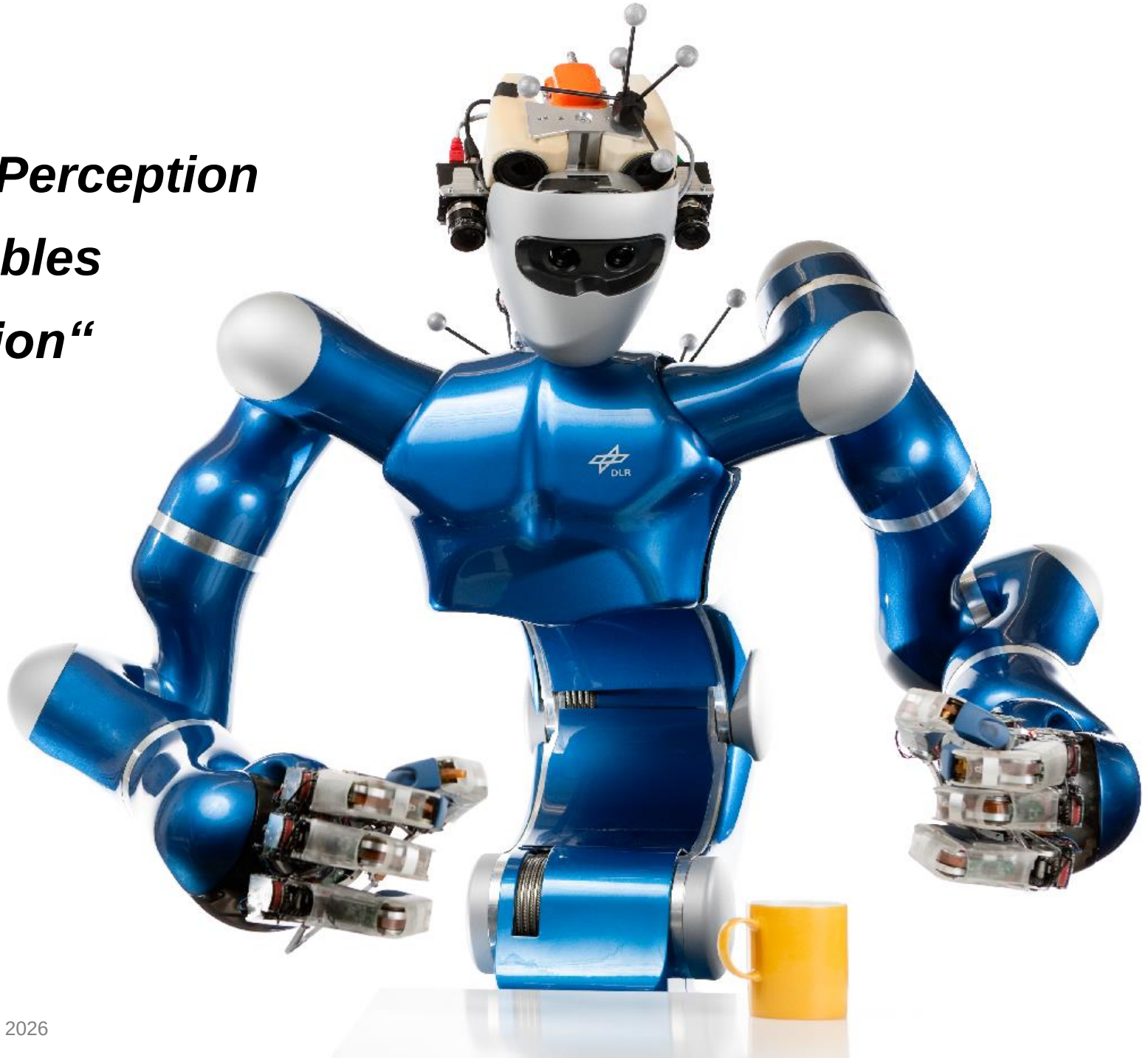
Maximilian Durner

WS#54 3D Perception as a Key Enabler for AI-Based Robotics

ERF2026
STAVANGER - NORWAY

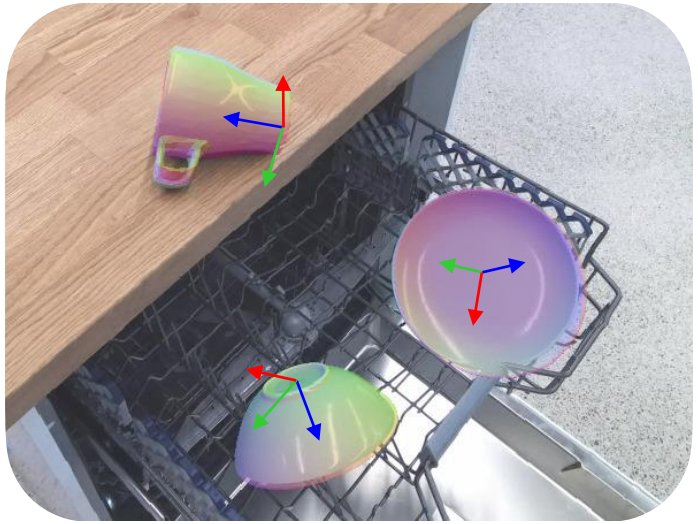
DLR

„Visual Perception that enables Interaction“

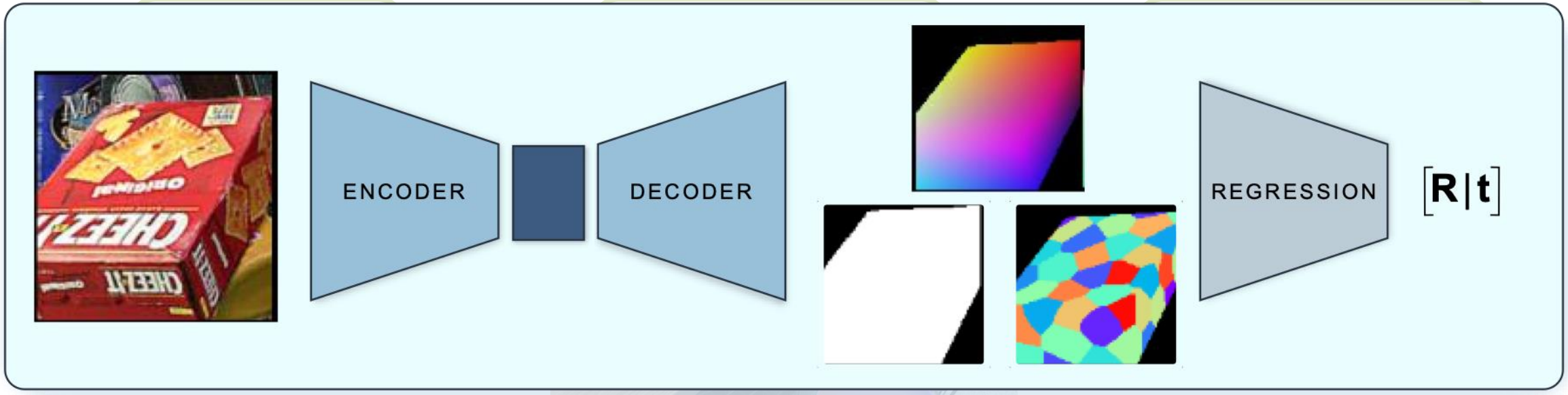


Perception system

object detector → 6D pose estimation → local refinement



Perception system

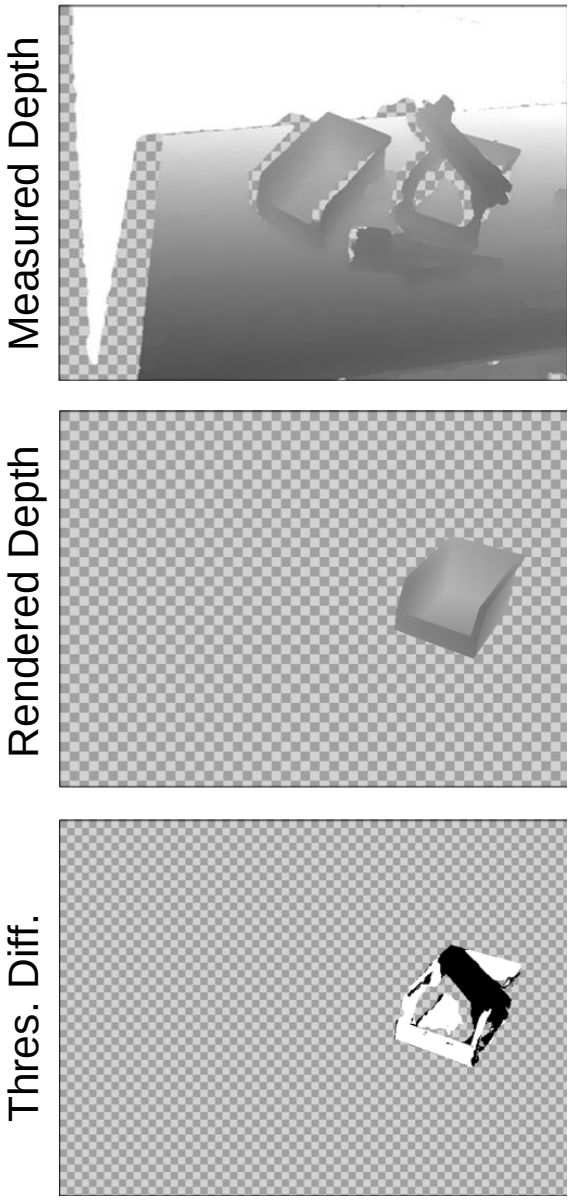


[Ulmer et al., IROS 2023]

Perception system

6D Pose estimation: Dense Correspondences

Pose Plausibility

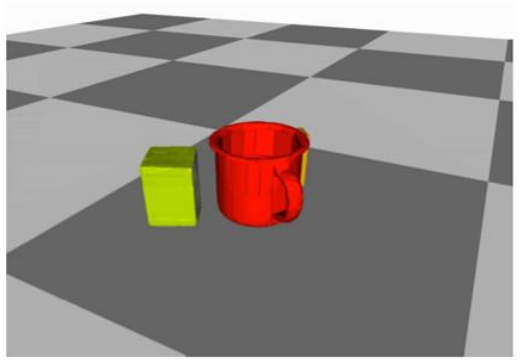


Plausibility score:

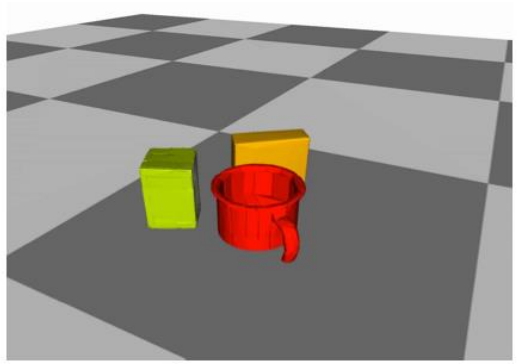
- Visual Information

[Risch et al., pending submission]

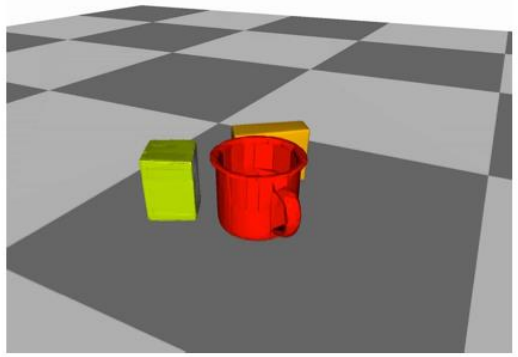
Pose Plausibility



Floating
→ Implausible



Intersecting
→ Implausible



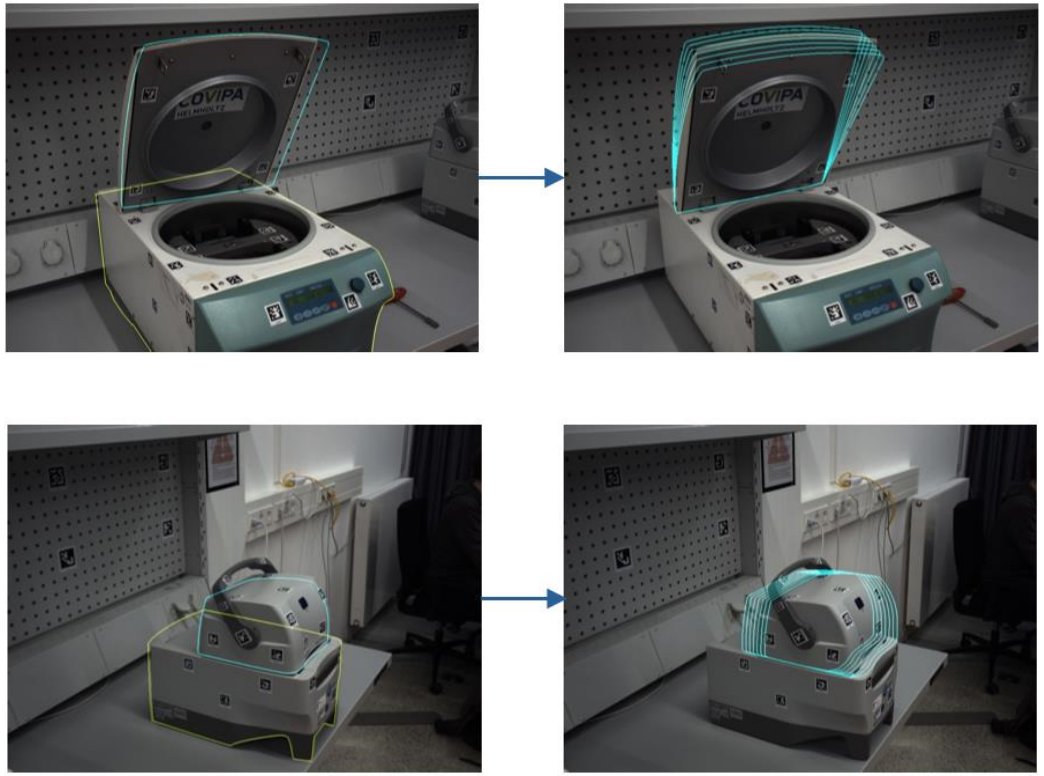
Stable
→ Plausible

Plausibility score:

- Visual Information
- Physics

[Risch et al., pending submission]

Pose Plausibility

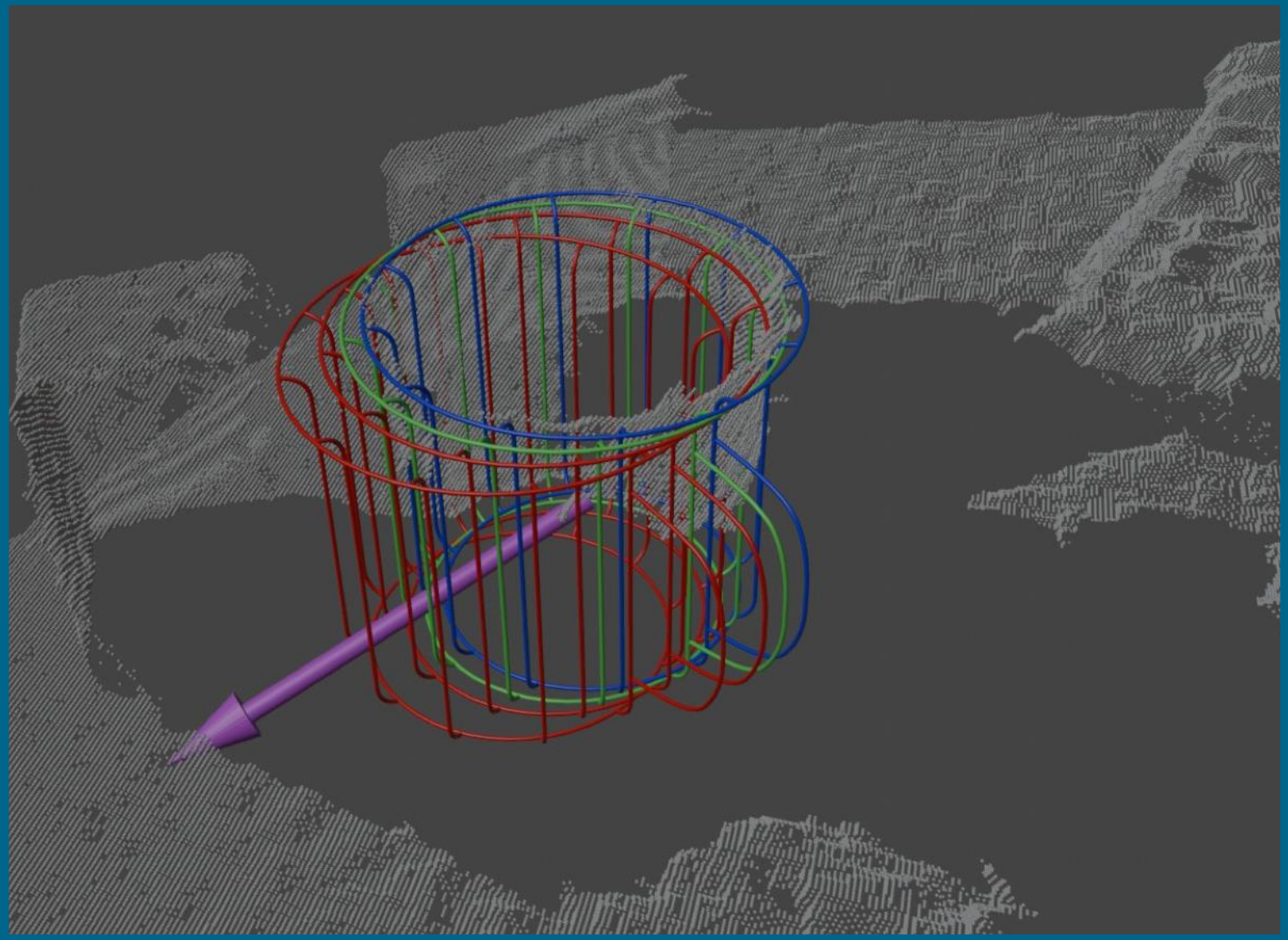


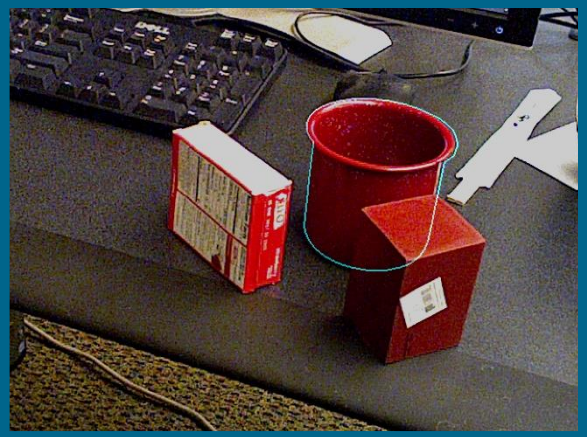
Plausibility score:

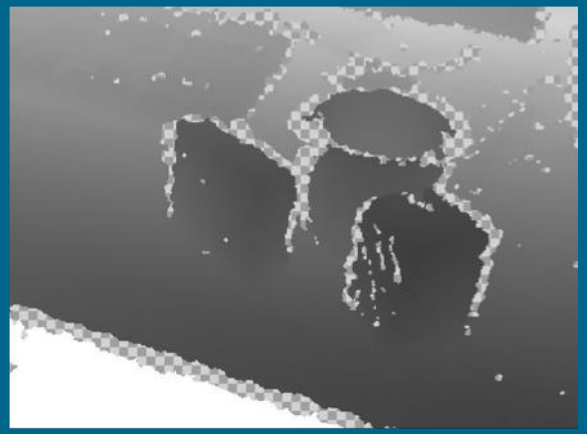
- Visual Information
- Physics
- Prior Knowledge

[Risch et al., pending submission]

Pose Plausibility

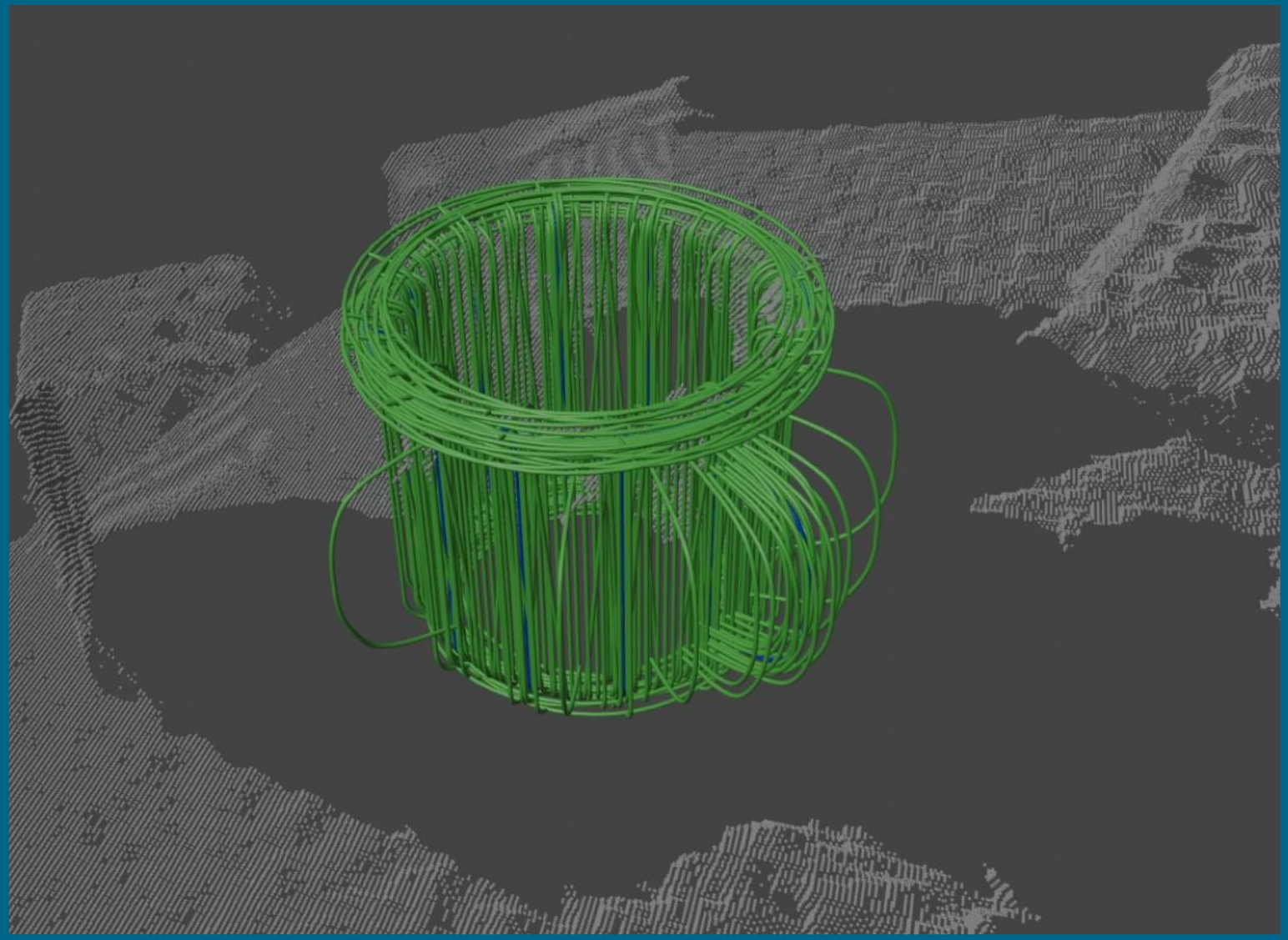


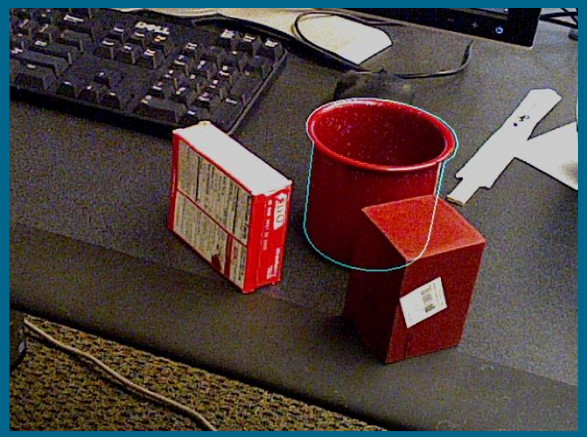


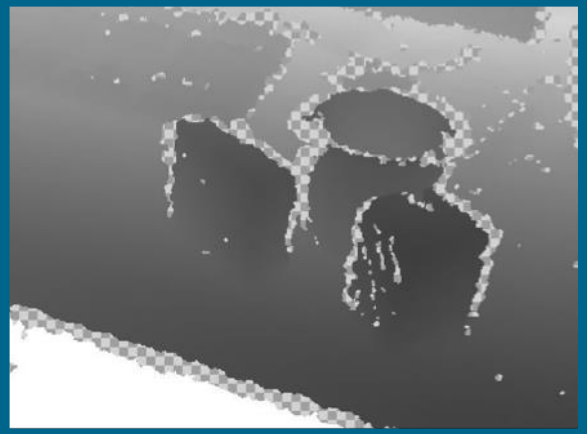


[Risch et al., pending submission]

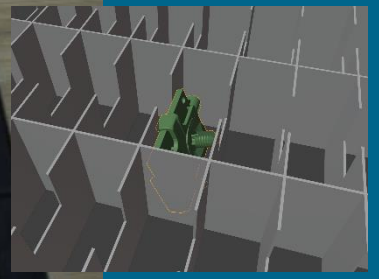
Pose Plausibility

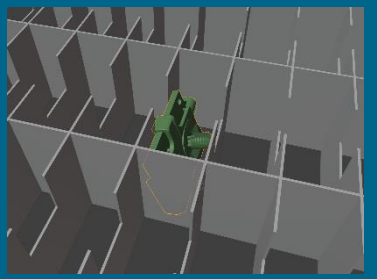


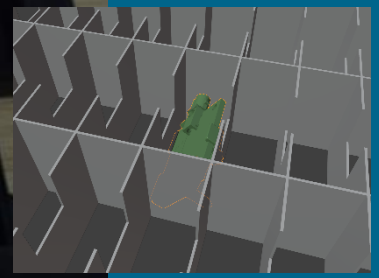


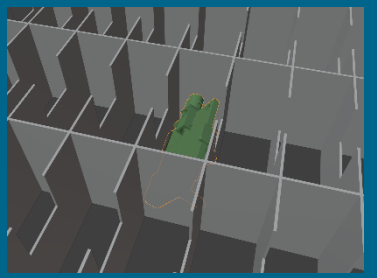


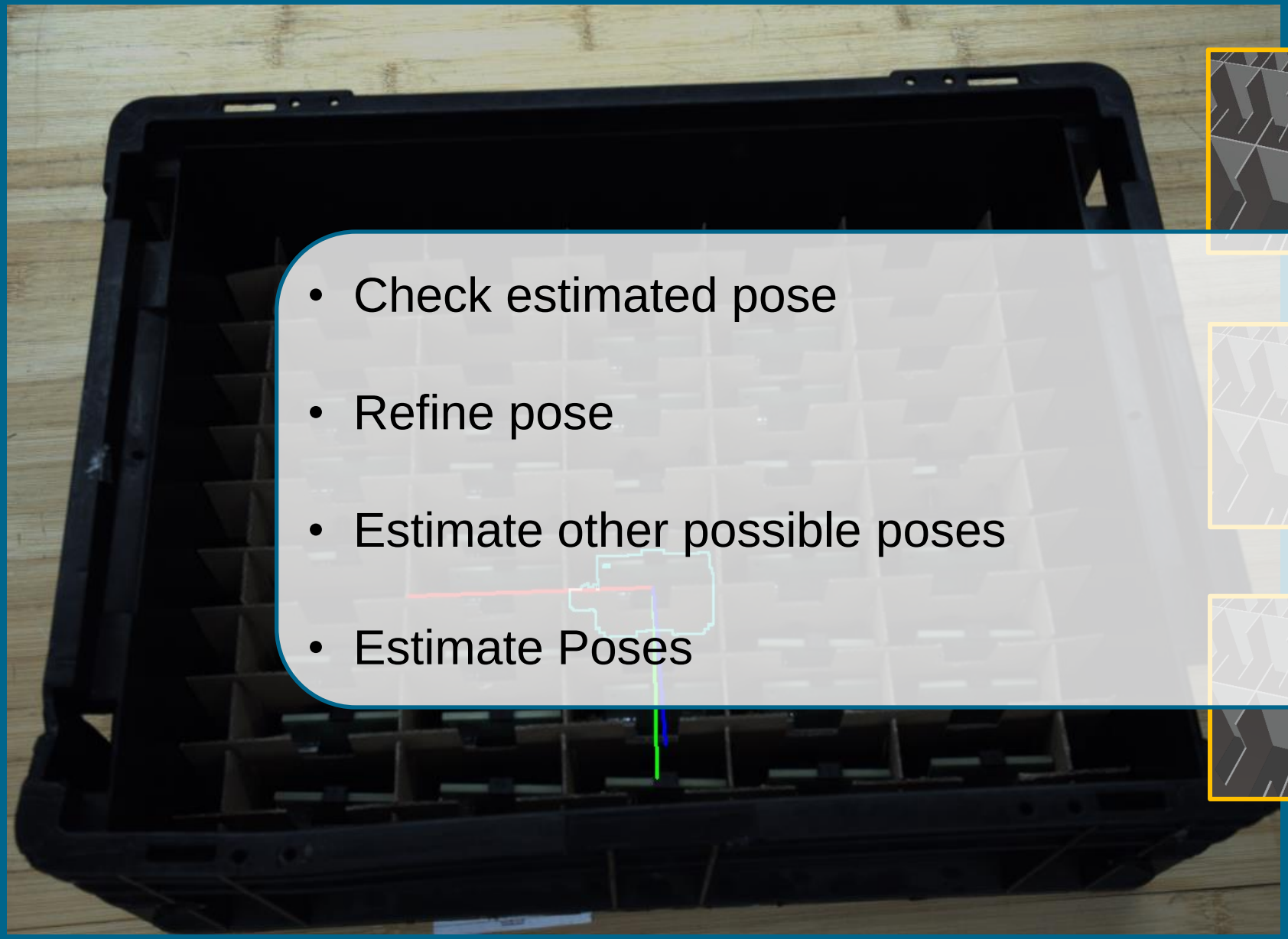
[Risch et al., pending submission]

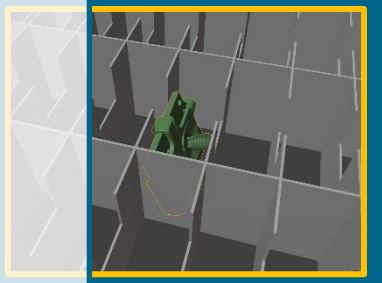


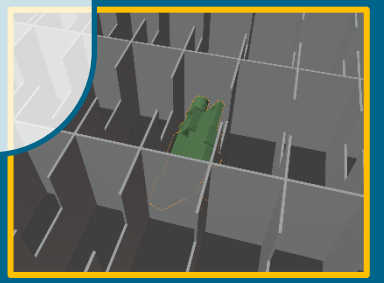






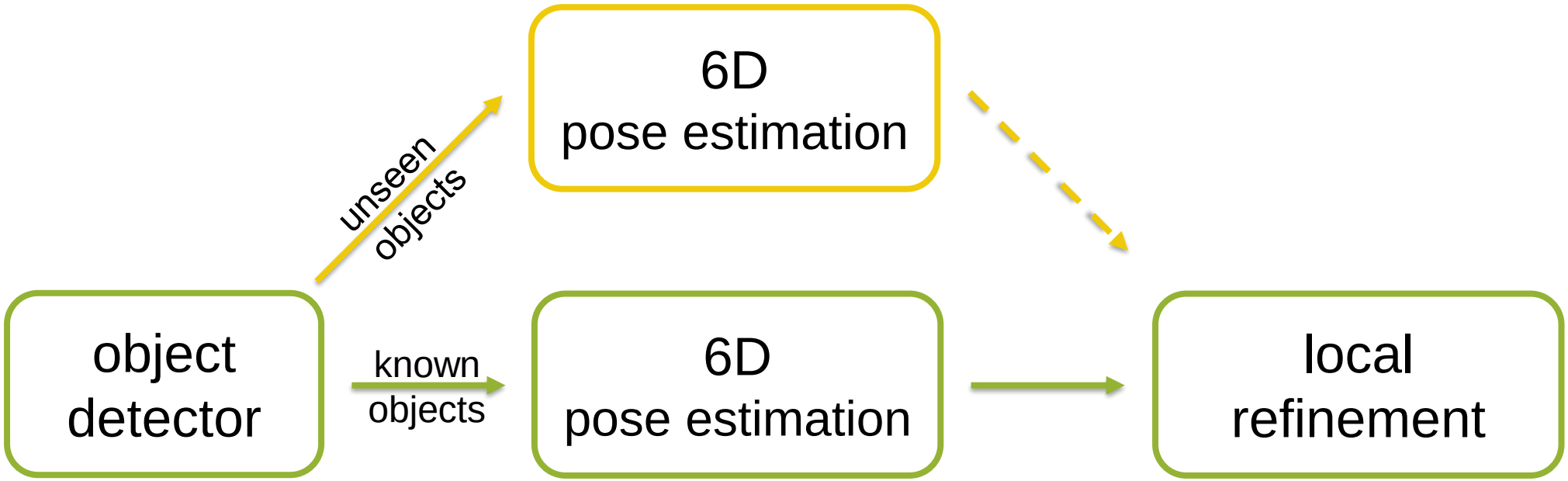


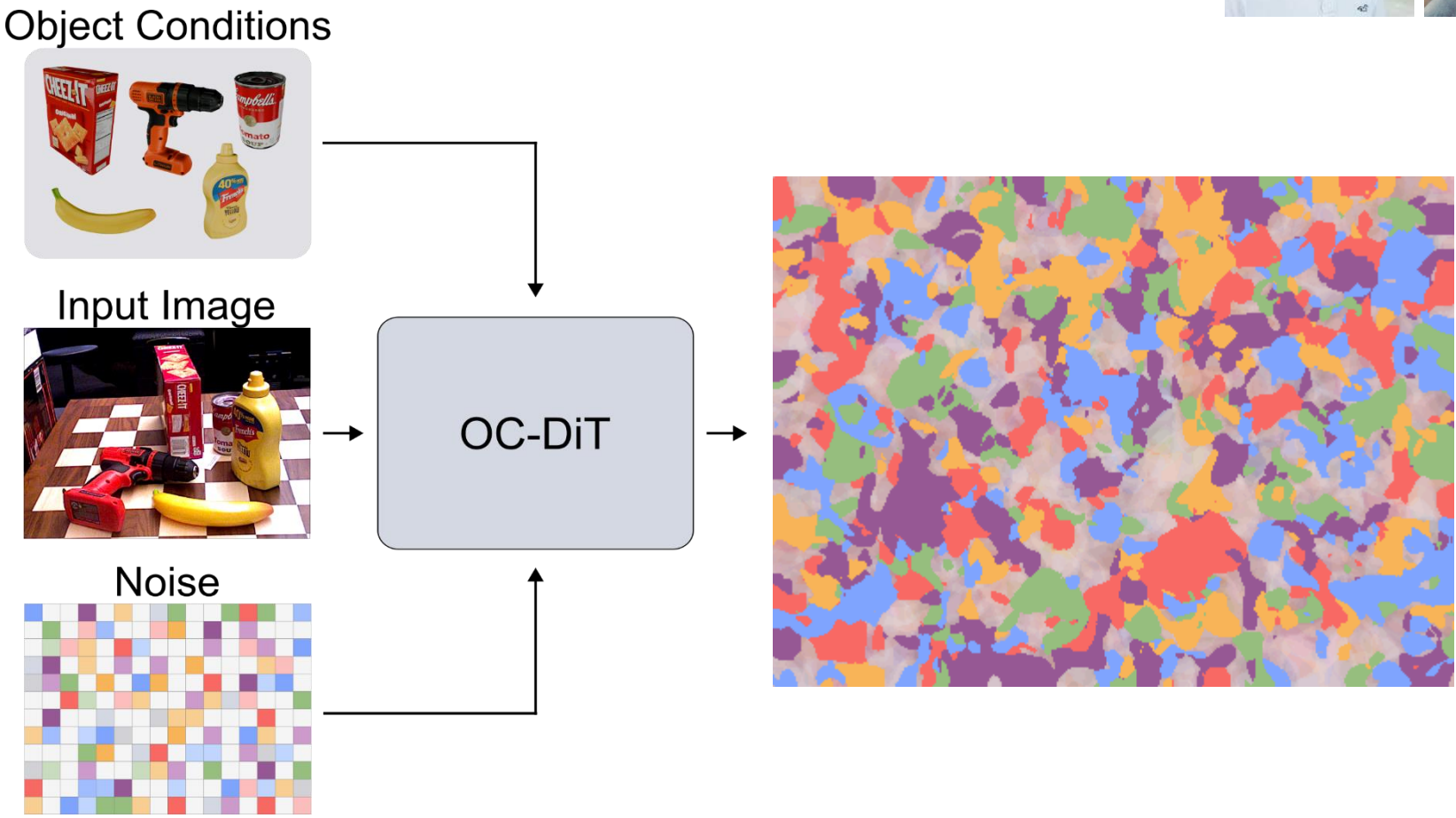


- Check estimated pose
- Refine pose
- Estimate other possible poses
- Estimate Poses

Perception system

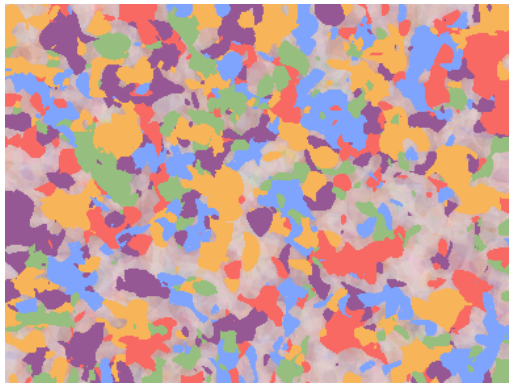
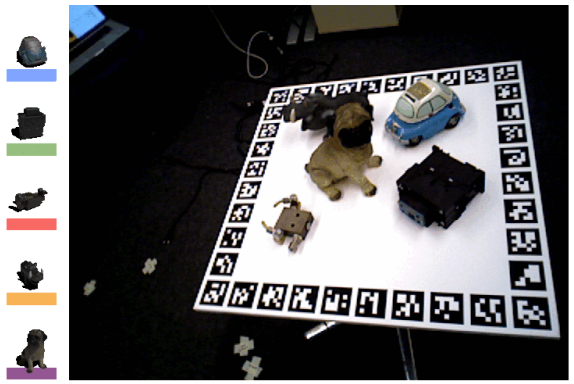


Model-based Unseen Object Detection: OC-DiT

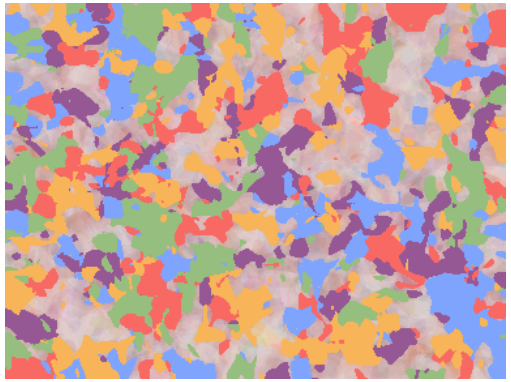



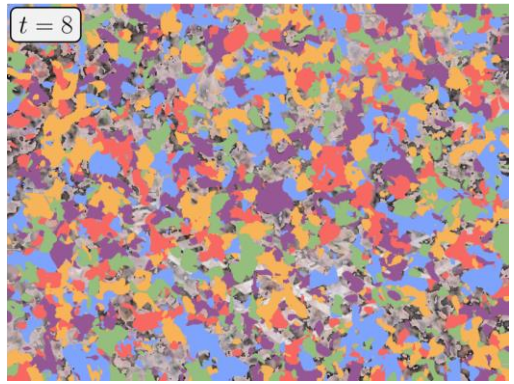
[Ulmer et al., ICCV 2025]

Model-based Unseen Object Detection: OC-DiT

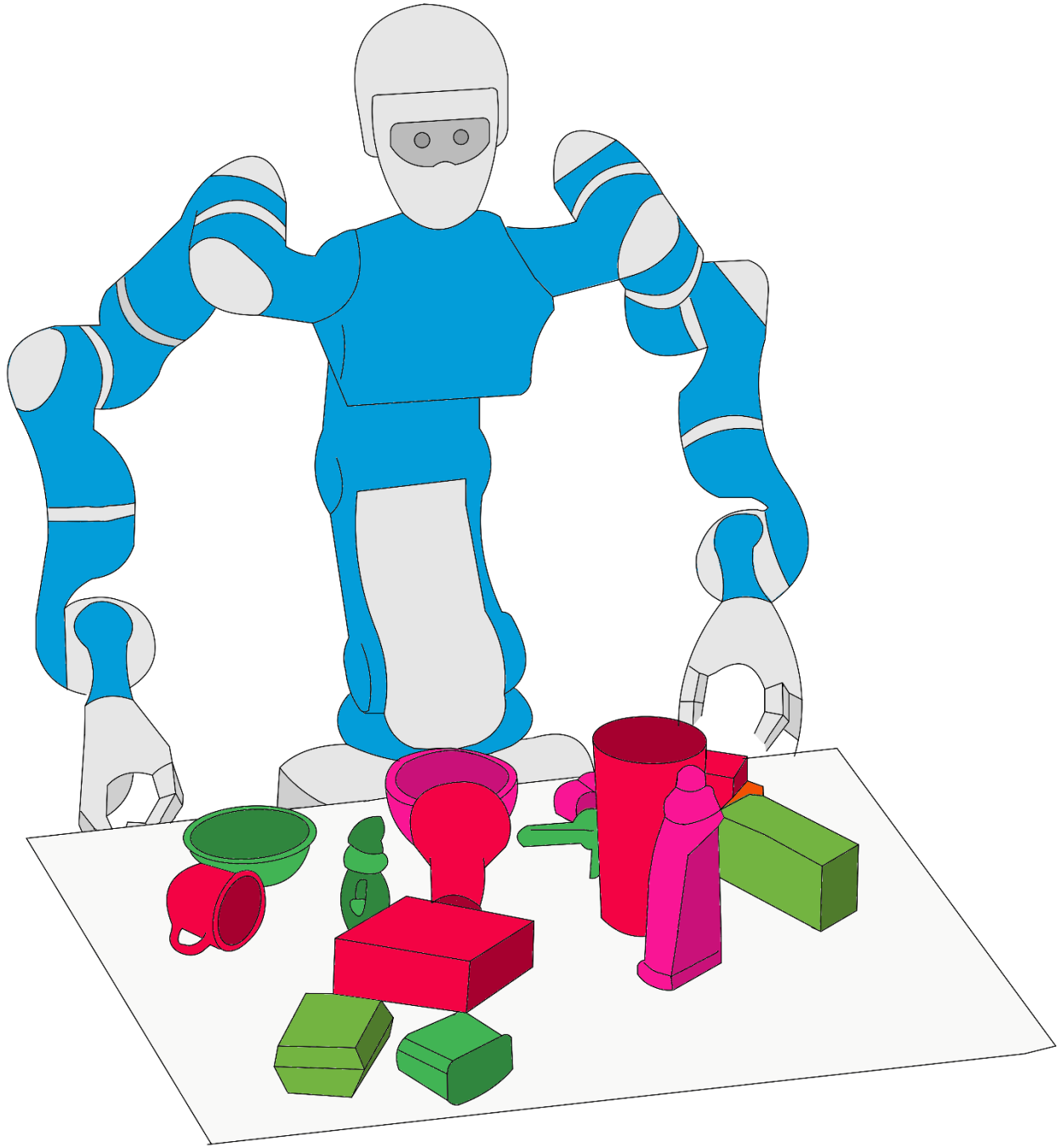










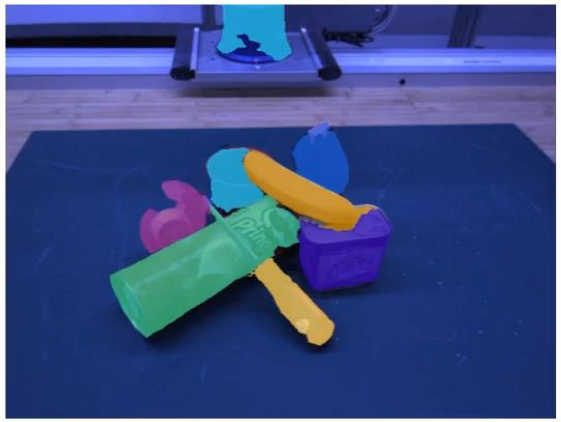
[Ulmer et al., ICCV 2025]



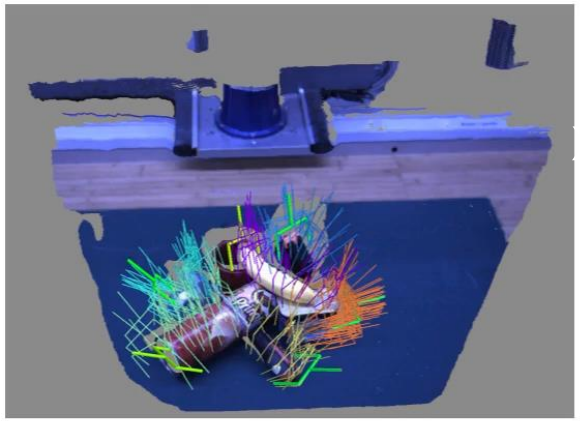
[Durner et al., IROS 2021]

[Durner et al., IROS 2021]

Perception pipeline

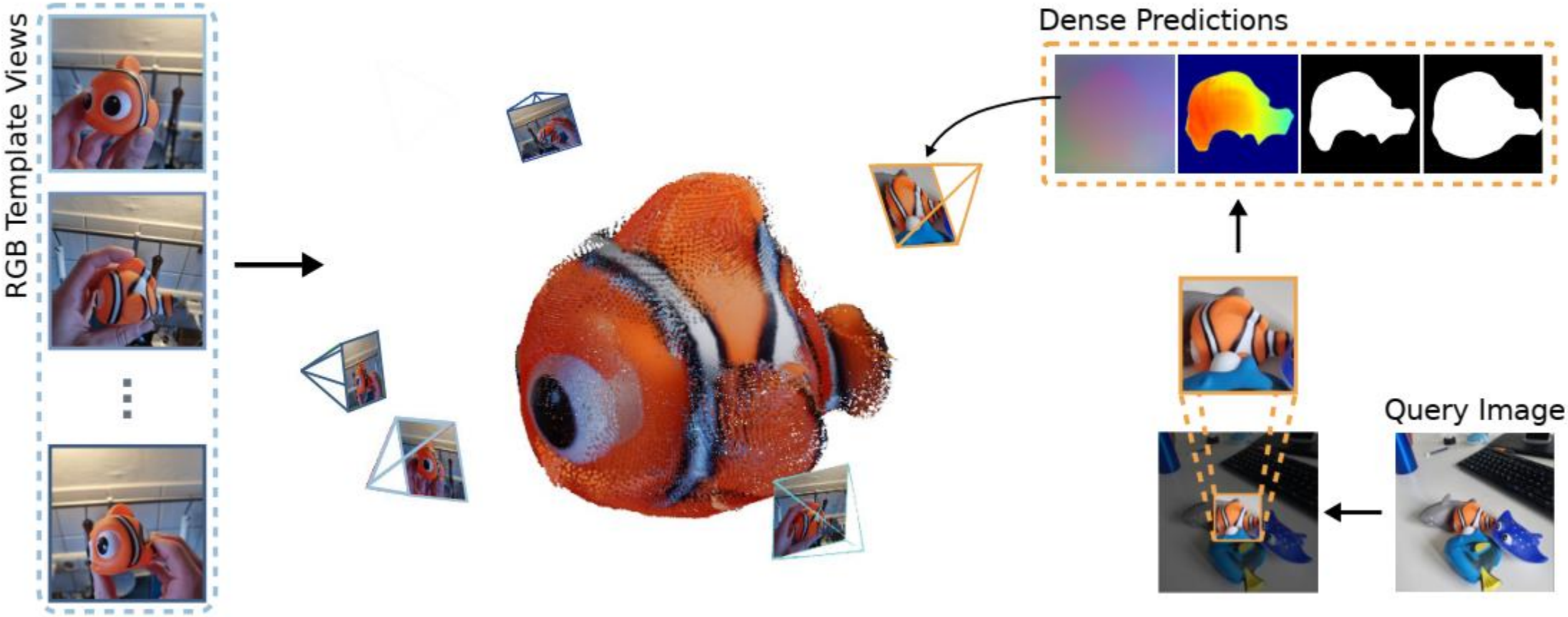


instance masks



6D grasp estimation

Object Perception

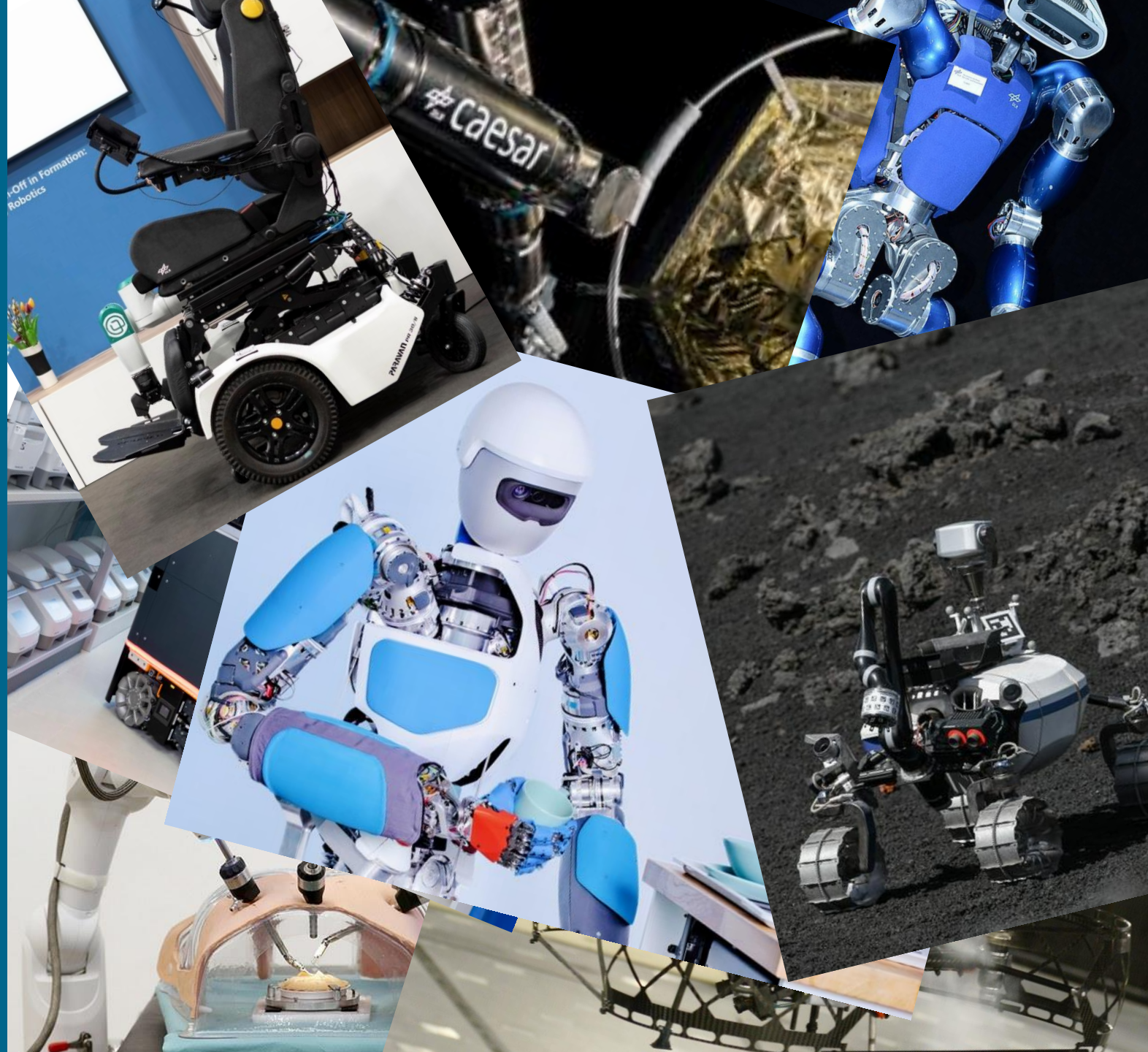
[Jung et al., 3DV 2026]

Take Aways

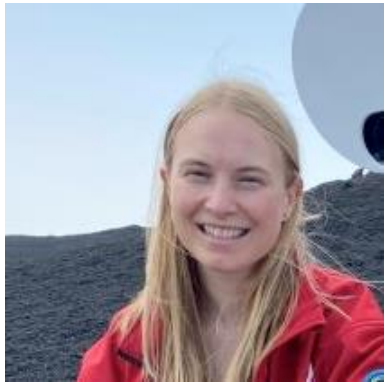
- Qualitative synthetic data
- Exploit Robotic Perception
- Precision vs. Flexibility

Outlook

- Articulated, Deformable Objects
- Category- / Semantic-Level
- Multi-Modality



Max Ulmer



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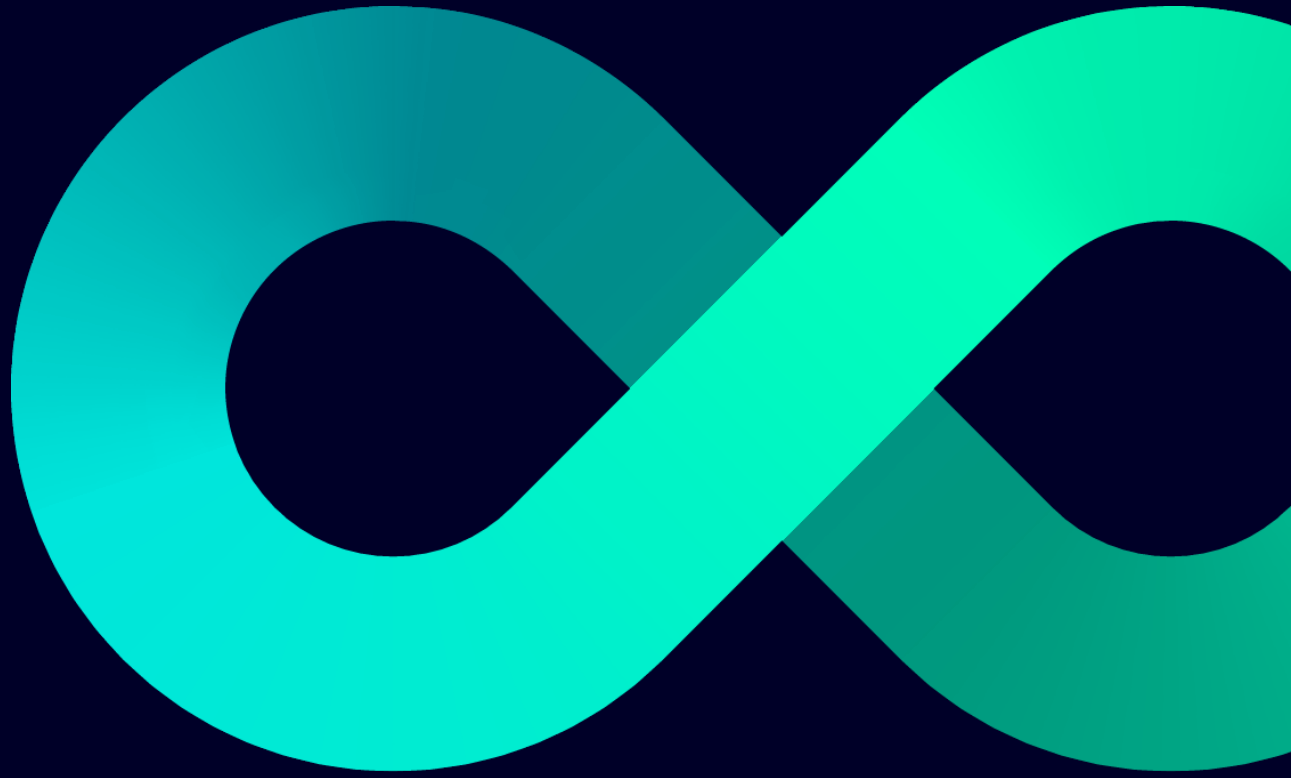
Industrial-Grade Bin Picking: Real-World Deployments

Dr.-Ing. Nicolas Alt



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Introduction

From **manual work** or
hardware-defined part feeding…

… to **software-defined**, **flexible** and
cost efficient automation

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Bin Picking - Dimensions of classification

Object model

Unknown ↔ Known

Sensor

2D camera ↔ 3D / depth

Ingoing placement

Structured ↔ Random

Outgoing pose

Undefined ↔ Defined

Object surface

Diffuse ↔ Reflective / transparent

Object appearance

Textured ↔ Textureless, few edges

Lighting

Controlled ↔ Uncontrolled

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Bin Picking for known objects - Evolution

- Evolution of pose estimation methods
- “Classical” approaches:
  Limitations (lighting, object types, etc.) lead to disappointed customers

Feature-based ("Classical")	AI-based, per object	AI-based, generic	Future: General robotic models?
• e.g. PPF, SIFT (2D), 2D template matching • Match observation to model	• End-to-end pose estimation • Train per object	• No re-training for new object • Foundation models	• VLAs and beyond • End-to-end robotics task • No more category “bin picking”?

Pipeline: Synthetic-only training

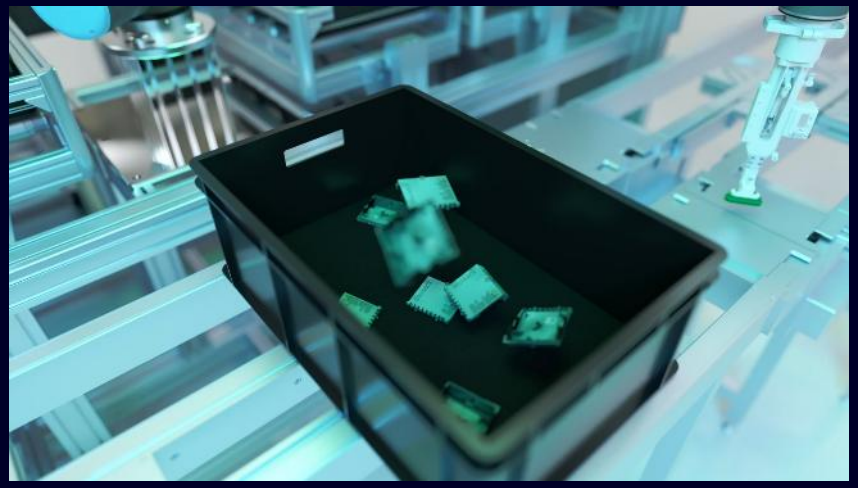
1 Synthetic data generation

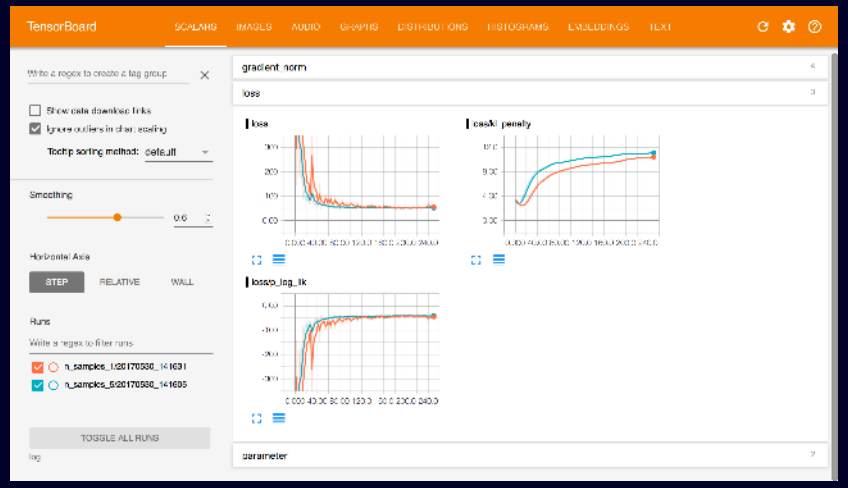
- Physical simulation of characteristic scenes
- Generation of images
- Ground truth for training

2 Training of Neural Network

- Training for 6D pose estimation
- Using RGB & Depth
- Cloud / On premise

3 Deployment on the robot





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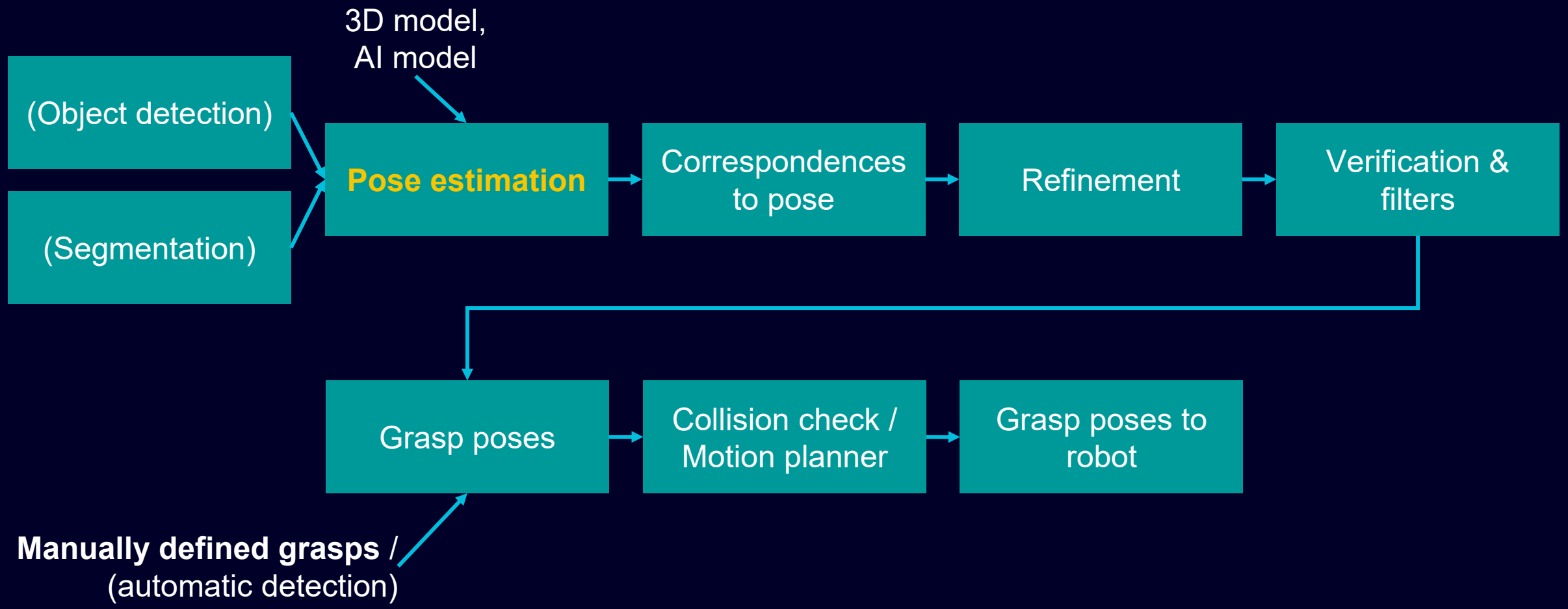
Pipeline: Inference (example)



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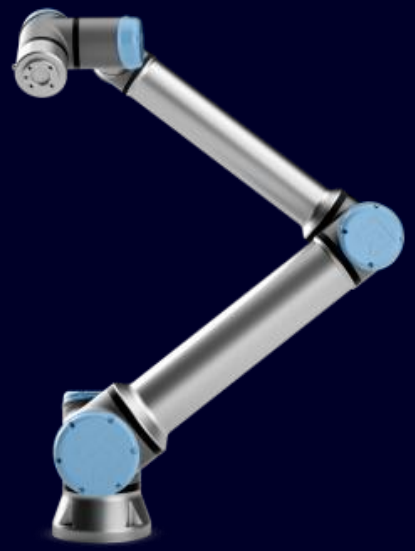
Components

Depth Camera

Gripper

Robot arm



IPC

PLC

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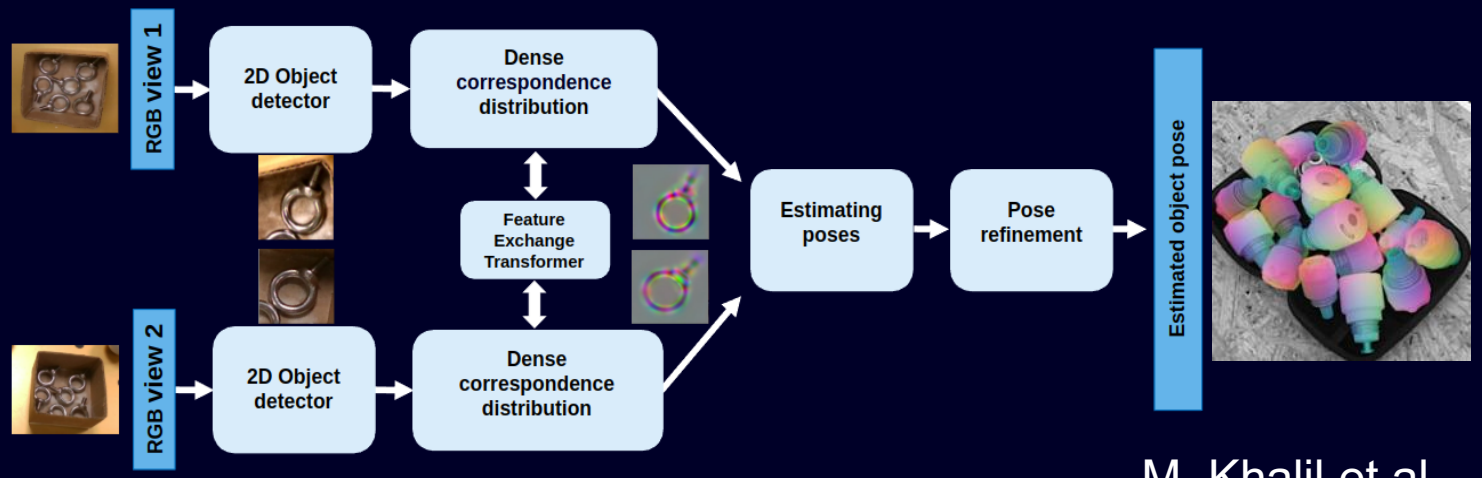
Multiview Surfemb Pose Estimator

- Feature Exchange Transformer (FET)
- Early multi-view fusion
- Improved accuracy in challenging bin-picking scenes
- Achieves state-of-the-art performance,
  tested on the ROBI dataset using only RGB input



M. Khalil et al.,
ICRA 2025

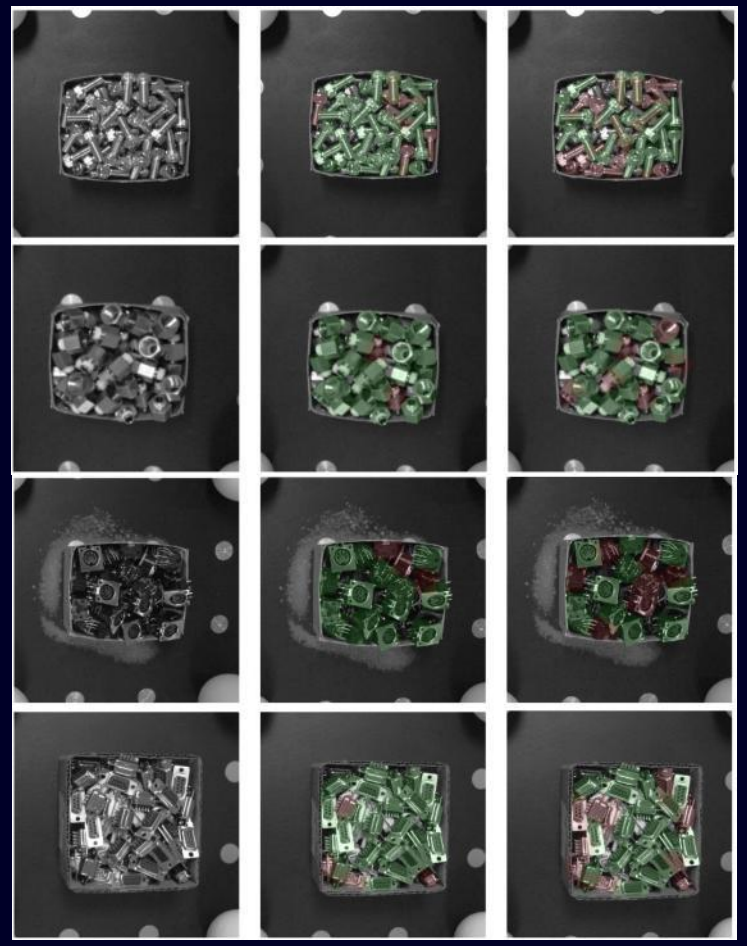


Image Ours Baseline

Correct poses (green) vs incorrect (red) under 5°/2 mm thresholds.

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Results on ROBI dataset

Camera	No.Views	Method	Detections	Modality	Zigzag	Screw	Gear	Eye Bolt	Tube Fitting	DIN	D-SUB
Realsense (1280 × 720)	4	MV-Optimization [17]	YOLO [28]	RGB	78.6	67.1	75.0	79.4	77.9	-	-
		CosyPose [13]	MaskRCNN [29]	RGBD	71.4	62.9	77.8	58.8	64.7	-	-
		Ours	YOLO [28]	RGB	**91.3**	**94.3**	**100**	**92.7**	**98.2**	**93.4**	**80.5**
		EpiSurfEmb [1]	GT	RGB	89.7	93.4	99.8	81.8	95.0	96.6	**86.9**
		Ours	GT	RGB	**93.6**	**99.1**	**100**	**99.1**	**99.3**	**97.8**	84.4
	8	MV-Optimization [17]	YOLO [28]	RGB	89.3	81.4	86.1	91.1	85.2	-	-
		CosyPose [13]	MaskRCNN [29]	RGBD	78.6	84.3	83.3	91.1	76.5	-	-
		Ours	YOLO [28]	RGB	**93.7**	**96.2**	**100**	**94.8**	**98.6**	**97.0**	**82.4**
Ensenso (1280 × 1024)	4	MV-Optimization [17]	YOLO [28]	RGB	82.7	64.9	81.5	78.4	86.1	-	-
		CosyPose [13]	MaskRCNN [29]	RGBD	75.8	66.1	83.9	77.0	80.8	-	-
		Ours	YOLO [28]	RGB	**98.0**	**97.1**	**99.7**	**98.3**	**97.4**	**92.2**	**81.2**
		EpiSurfEmb [1]	GT	RGB	98.0	94.7	99.7	97.3	93.9	94.8	**86.4**
		Ours	GT	RGB	**98.7**	**99.7**	**100**	**99.0**	**99.3**	**96.8**	84.1
	8	MV-Optimization [17]	YOLO [28]	RGB	94.8	67.8	86.4	83.8	88.7	-	-
		CosyPose [13]	MaskRCNN [29]	RGBD	89.7	75.3	85.2	87.8	86.7	-	-
		MV-Keypoints [15]	MaskRCNN [29]	RGBD	98.5	96.2	86.0	96.8	87.0	70.7	31.3
		Ours	YOLO [28]	RGB	**98.8**	**98.5**	**99.8**	**99.0**	**98.1**	**95.0**	**82.8**

TABLE I

ADD(-S) OBJECT RECALL (< 10% OF OBJECT DIAMETER)

Zigzag

Screw

Eye Bolt

Tube Fitting

D-SUB

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ERF 2026 – Workshop #54: 3D Perception as a Key Enabler for AI-Based Robotics

Shiny, reflective, thin – approaches and challenges for 3D perception in sheet metal

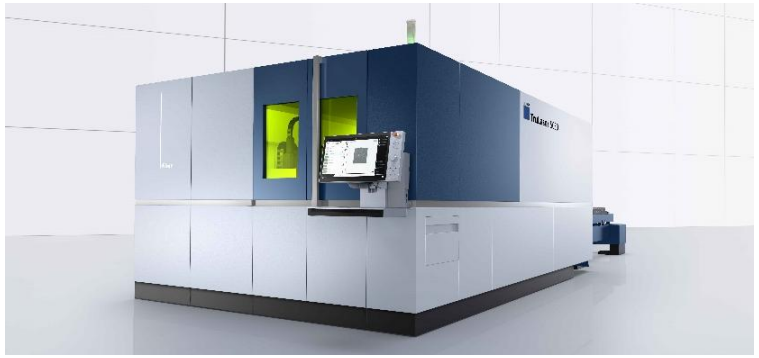
Ralph Lange, Head of Robotics at TRUMPF Machine Tools

TRUMPF

TRUMPF Machine Tools

Portfolio Overview

Machines for laser cutting



Punching and punch laser processing

Machines for bending

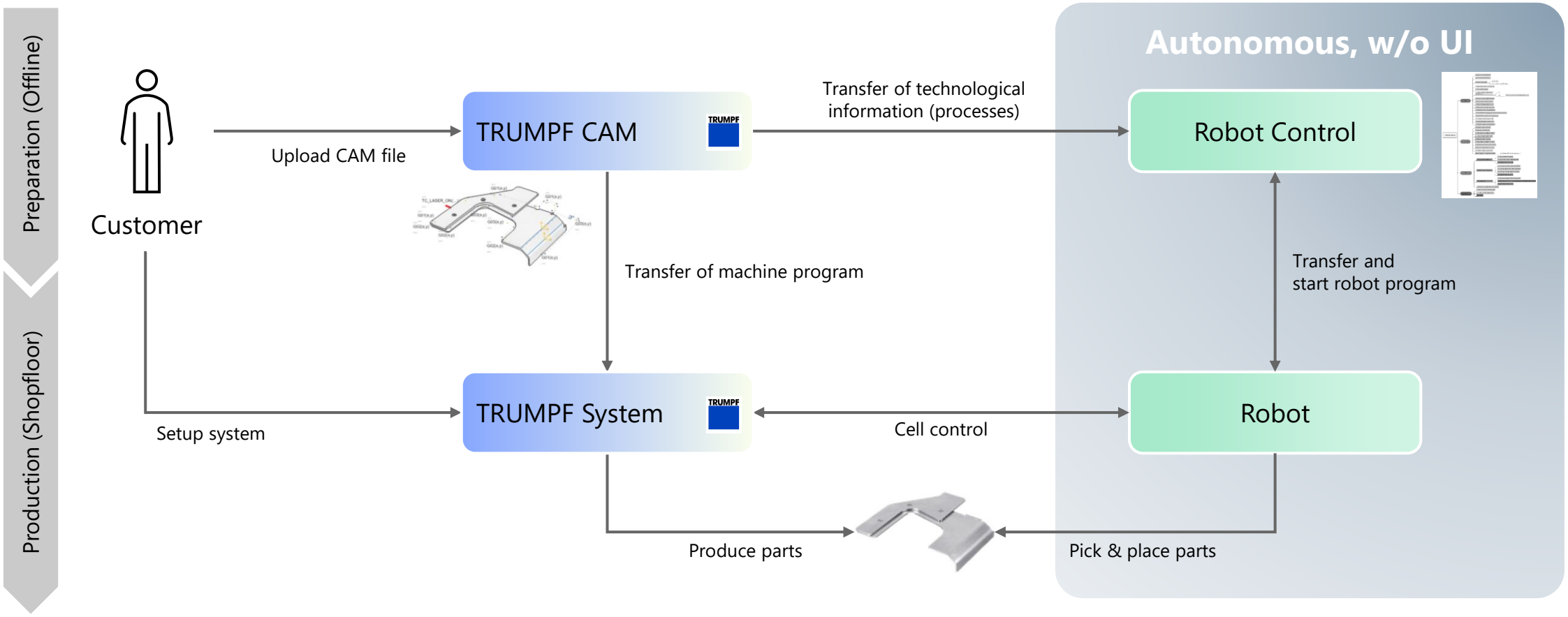
Machines for laser welding

Machines for tube processing

Solutions for a networked production

Autonomous, AI-based Robotics as Enabler for Automation at SMEs

High-level approach



Customer uses his system in the conventional way | **New: Robotics Extension**

TRUMPF

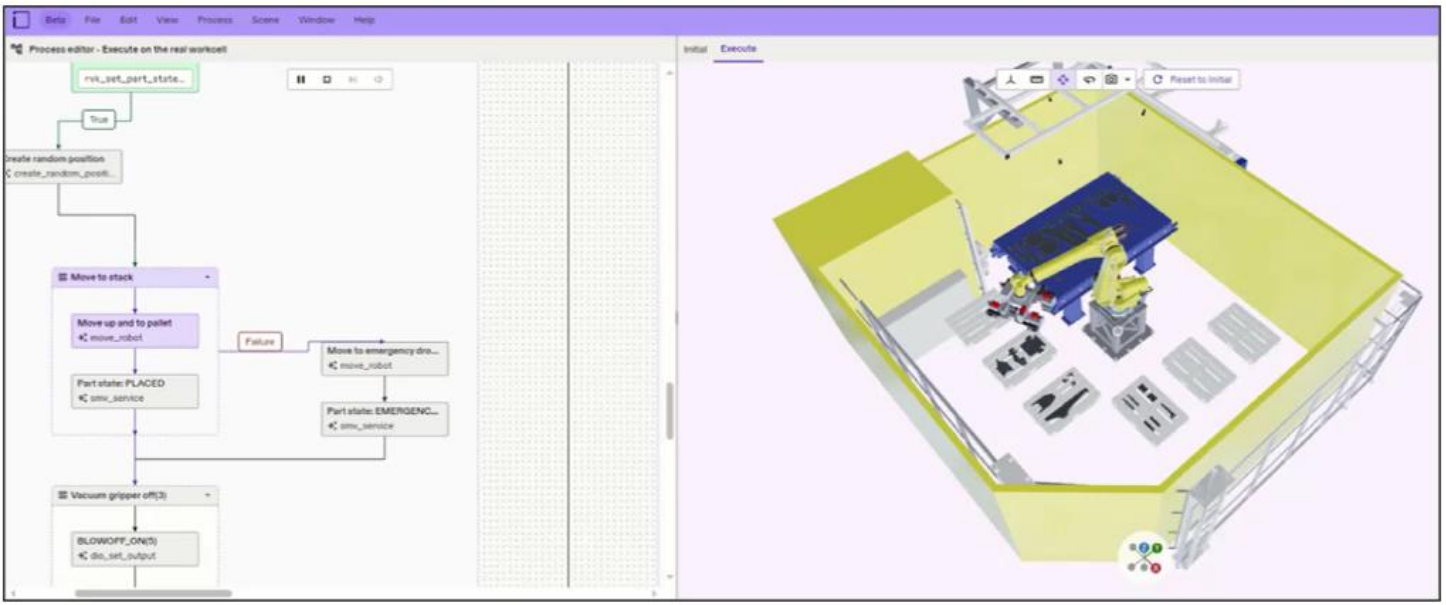
SortMaster Station and SortMaster Vision

Reliable separation,
autonomous sorting!

https://www.trumpf.com/en_INT/products/machines-systems/automation/separating-and-sorting/sorting/

SortMaster Vision

Consistent use of digital twin with Intrinsic Flowstate



“Skill”-based: Organize the complexity of robotic actions into reusable SW modules

Dynamic motion planning: Real-time motion planning and collision avoidance w/o any adaptations

Transferable: Implement own skills and the know-how into the robot process

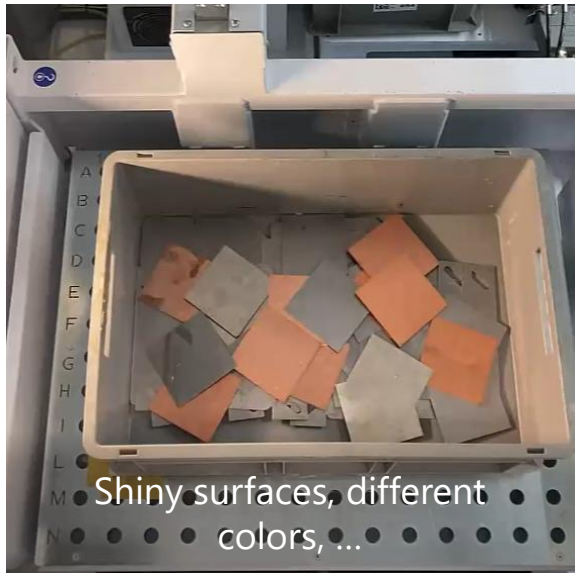
Robot-agnostic control: Intuitive control, independent of the robot OEM

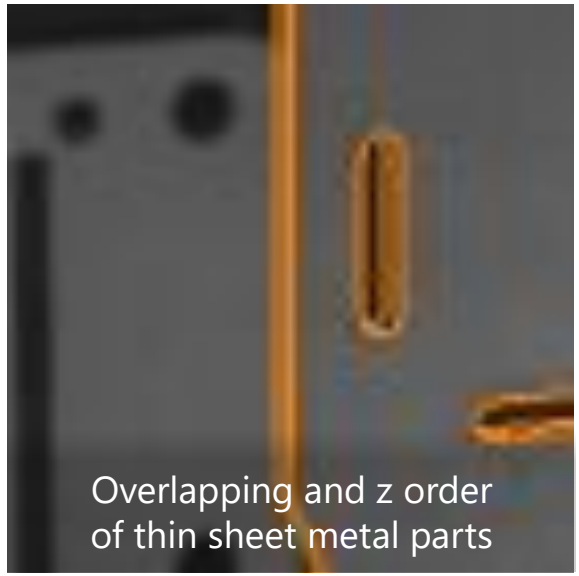
Digital Twin: Test and visualize the mission in simulation, in advance before deployment

Perception: Latest AI vision technology based on foundation models to detect and identify parts

Challenge 1: Robust Perception in Sheet Metal

… at affordable cost





➔ Very good progress on perception in sheet metal with our partner Intrinsic

Open issues:

- How to reduce size and computational complexity of models?
- Combine different aspects (identification, pose estimation, overlapping, slug piece detection) into one model or better keep them separated (maybe with shared backbone)?
- How to handle incremental updates in scene efficiently?

Challenge 2: Holistic Scene Understanding

Key for long-term autonomous operation

- Detecting unusual situations (= contingencies)
- Input for decision making about recovery procedures

Problems:

- Interior of cells may be customized
  - … even between batches or orders
- Little reference data available
- Decisions must be explainable

Idea: Include operators in maintenance of the digital twin!

Ralph Lange
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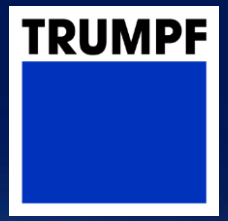

www.trumpf.com

The data space: Introduction to a new way of sharing and using data collectively

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Data Sharing

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Data Sharing – Cross-Company And Cross-Industry

- Data sharing involves transferring data to other companies or receiving data from them in order to cultivate and use it jointly.
- The greatest potential of data can be realised when combining different sources.
- However, in this day and age, it is virtually impossible for a single actor to have all the data required for comprehensive analyses at their disposal.

58 %
Benefits of data transfer unclear

47 %
Benefits of data reception unclear

61 %
Risk is greater than the benefit

74 %
All data available

N=1051, companies from industry and industry-related service providers in Germany 2023

Source: Institut der deutschen Wirtschaft, Fraunhofer-Institut für Software- und Systemtechnik ISST

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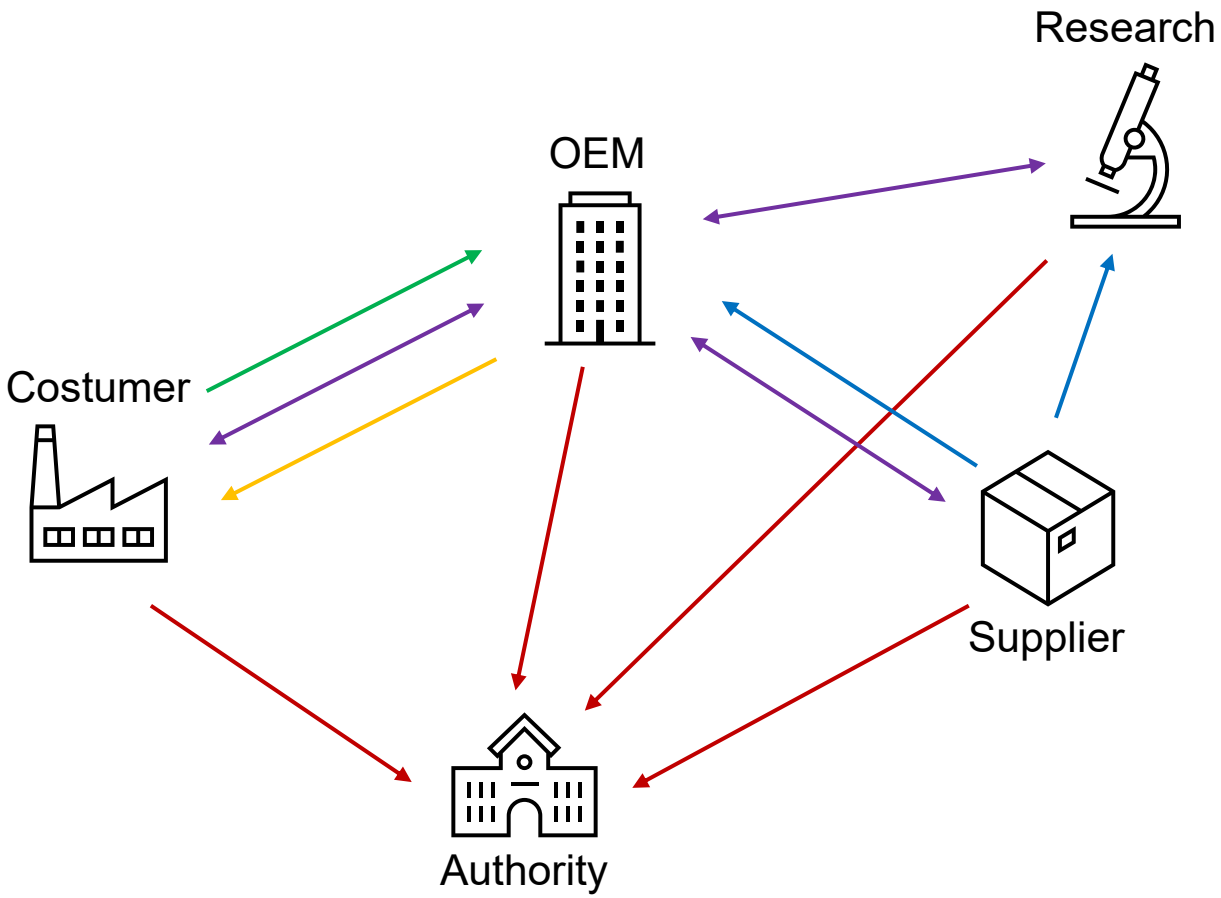
Data Sharing – Which Data to Share?



- Product data
- Production data
- Customer usage data
- Supplier data
- Research and development data
- Financial and regulatory data

Most shared

58 %

Financial data

Least shared

33 %

Research and development data

Source: Institut der deutschen Wirtschaft

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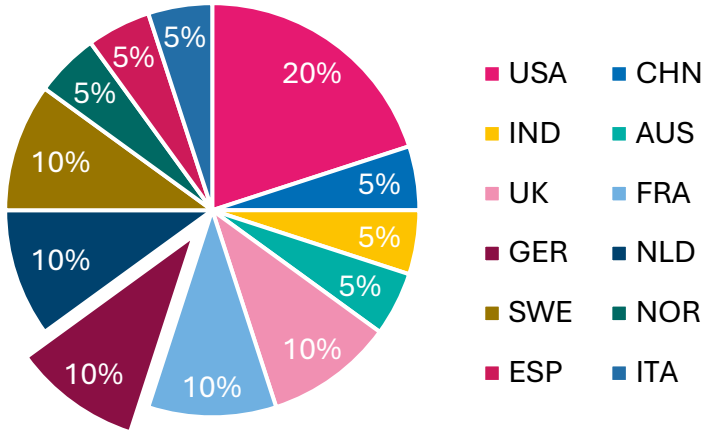
Data Sharing – Business Benefits

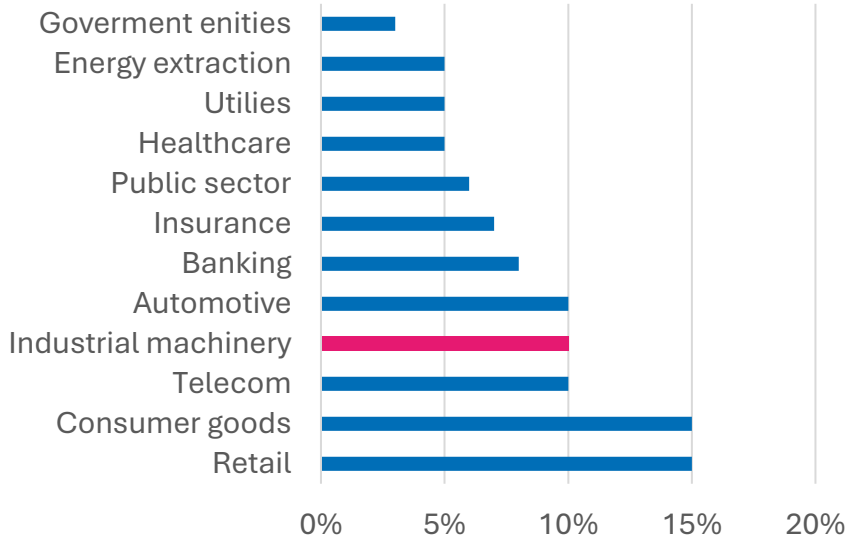
Investigated Countries

N=750



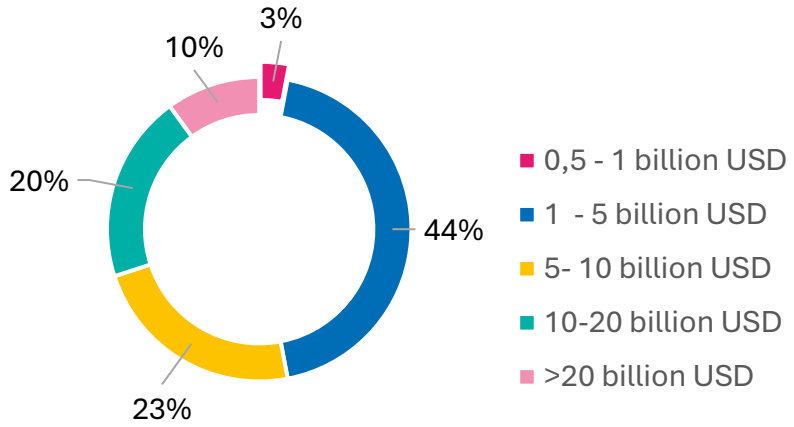
Investigated Sectors

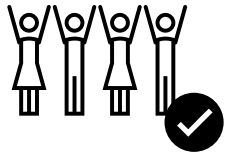
N=750



Global revenue/budgets

N=750



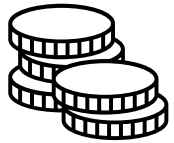


+15 %*

Customer satisfaction

+14 %*

Productivity/efficiency



-11 %*

Costs

*annually in the last 2-3 years, Source: Capgemini 2021

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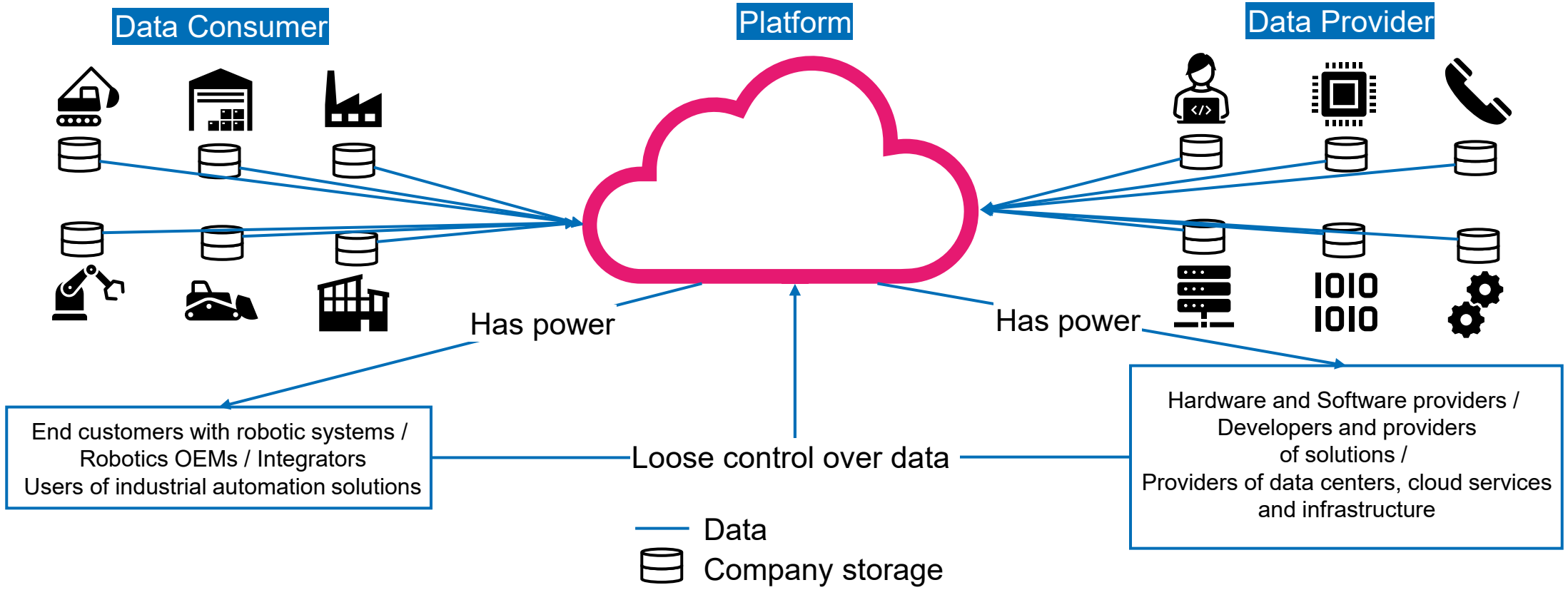
Data Sharing – Data platforms promise integration but deliver silos, dependencies and monopolization



Source: VDMA

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Data Spaces And Digital Ecosystems

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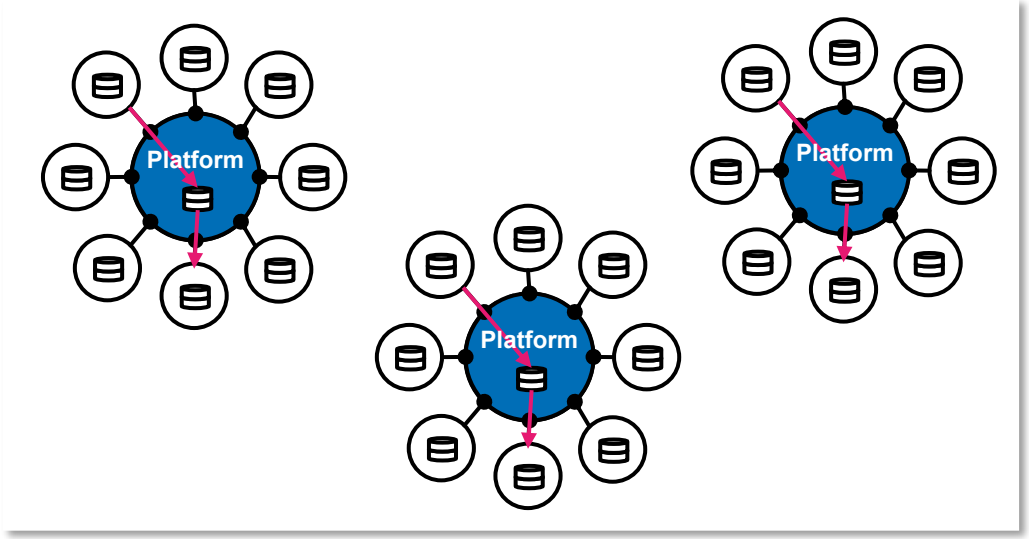
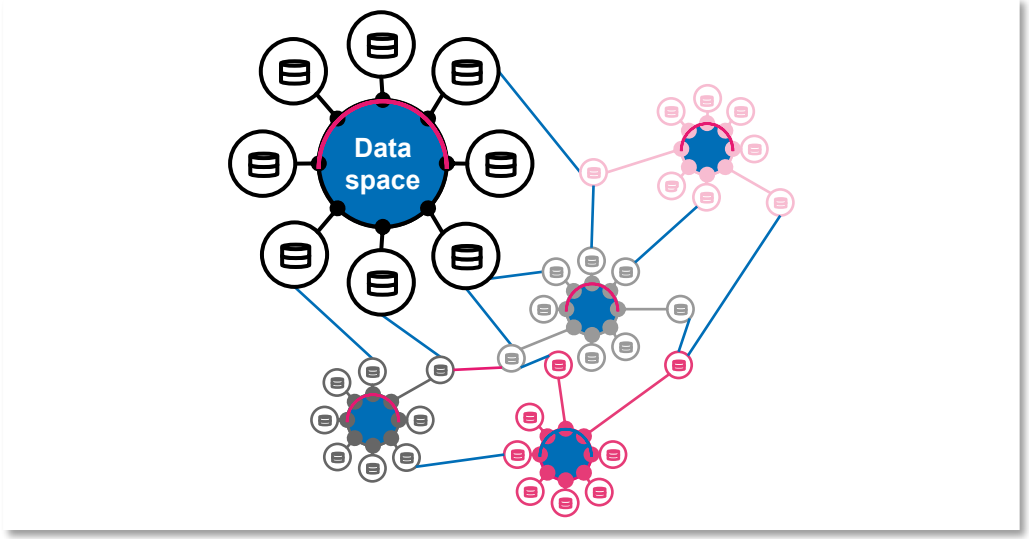
Data Spaces And Digital Ecosystems – Improving Digital Collaboration

Platform or manufacturer orientated



vs.

User orientated or interoperable



Central architecture	Decentral and federated structure
Central data storage	No central data storage , control
Silos, Lock-In, no trust, monopolies	Interoperability, sovereignty, trust

Source: VDMA

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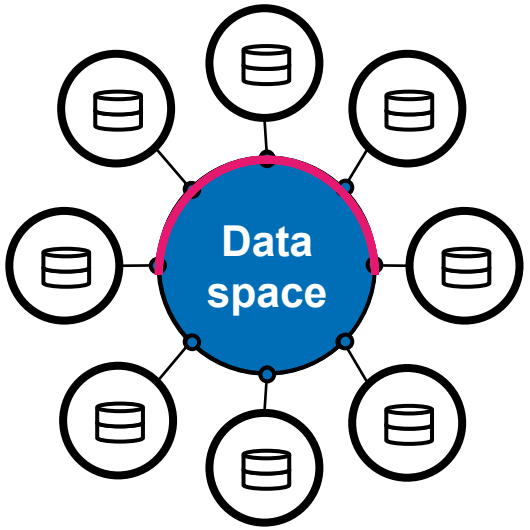
Data Spaces And Digital Ecosystems – Scalable peer-to-peer connections

A **data space** is a **trusted framework** in which **cross-industry and cross-company information** can be exchanged **automatically** and **sovereignly** in order to increase **efficiency** and **enable new value creation.**

A **clean interface** between companies through:

- **Decentralisation**
- **Data sovereignty**
- **Interoperability**
- **Shared infrastructure**
- **Market access for all companies**



Source: Scale-MX, VDMA

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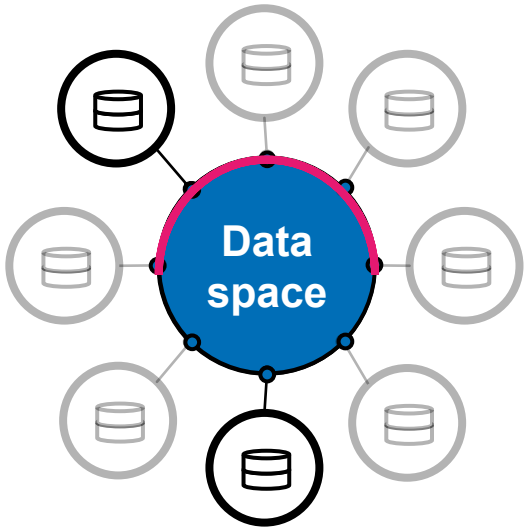

Source: Scale-MX, VDMA

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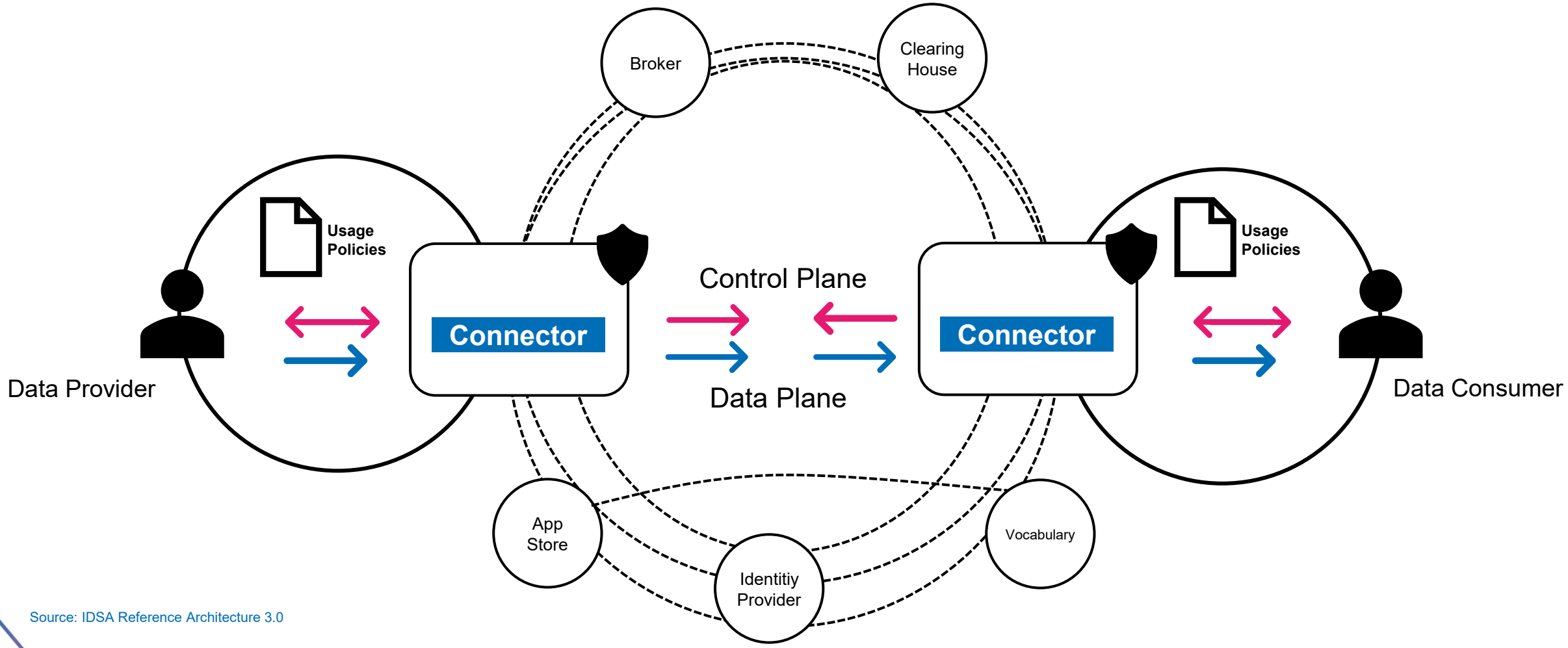
Data Spaces And Digital Ecosystems – Architecture



Source: IDSA Reference Architecture 3.0

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AI-based Perception of Seen and Unseen Objects

Dr. Michael Suppa

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Robots Need 3D Vision

WHY IMPLEMENT ROBOT VISION?

Today's robotic systems cannot handle unorganized items.

Pre-organization and standardization need (down)time, space, money.

Many existing processes are labor-intensive.

Some tasks are impossible to automate.

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Three Major Trends in Robotics

#1

GOOD DATA INSTEAD OF BIG DATA

- Generation of detection templates based on CAD data
- Simulations create realistic training data using model-knowledge

IMPLEMENTATION WITH MINIMUM EFFORT

#2

PLUG-AND-PRODUCE

- Integrators and end users can add modules on the same platform
- Smart sensors enable distribution of computing resources

SCALABLE MACHINE LEARNING PLATFORM

#3

EASE-OF-USE

- AI reduces parameterization effort for the user
- Web interfaces with wizards enable non-expert use

EASE-OF-USE FOR VISION-NEWBIES

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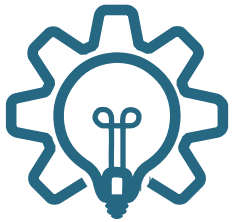
Challenge: Automation of Complex Tasks

REQUIRES CONSIDERATION OF VARIATIONS

Environment



Lighting conditions

Perspective

Objects

Material varies from shiny and transparent to translucent and black

Different sizes and distances

Application

Parameterization requires expertise

Test & implementation time

>97% availability (successful picks)

Data must cover all variations: Hard (impossible) to achieve with real data/ human input.

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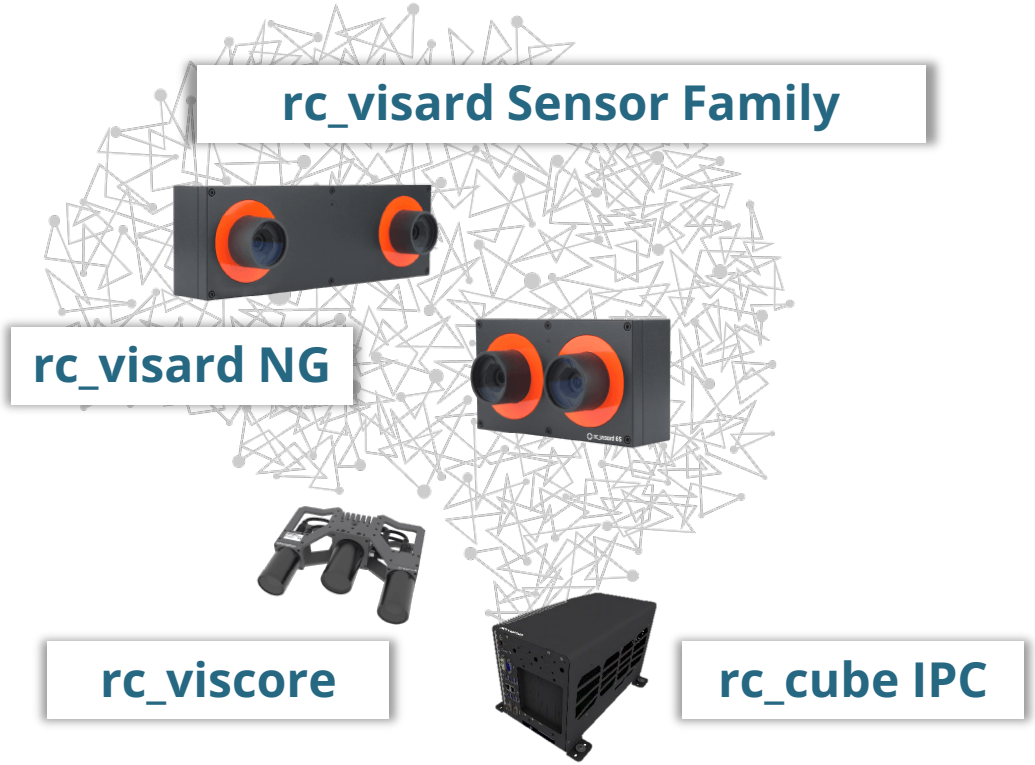
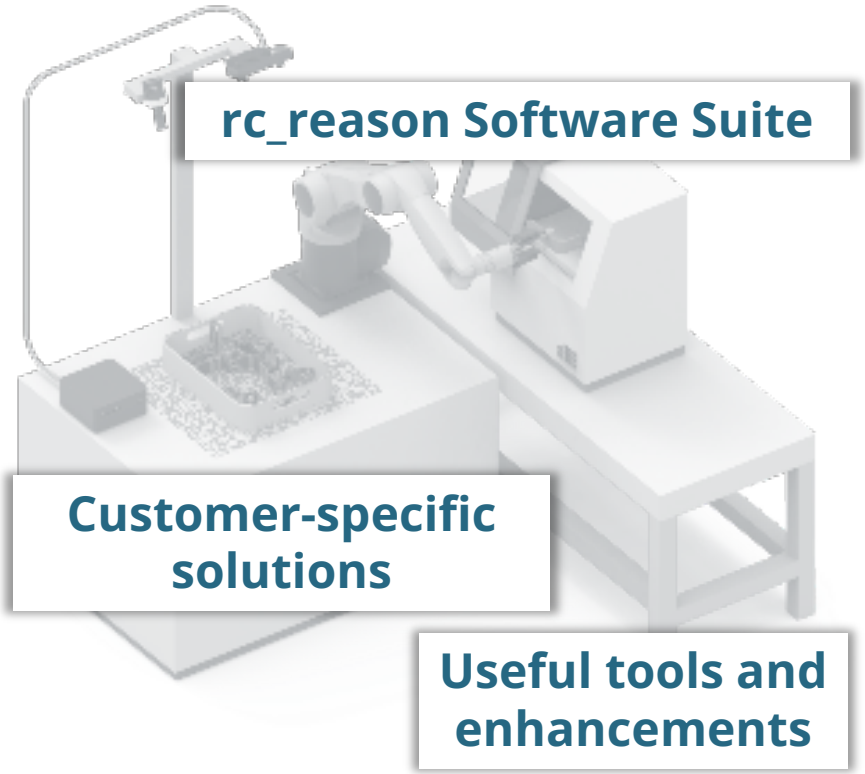
Product Portfolio

VERSATILE SENSORS AND INTUITIVE ROBOTICS SOFTWARE

3D Stereo Vision for Your Robot



Advanced AppliedAI Software



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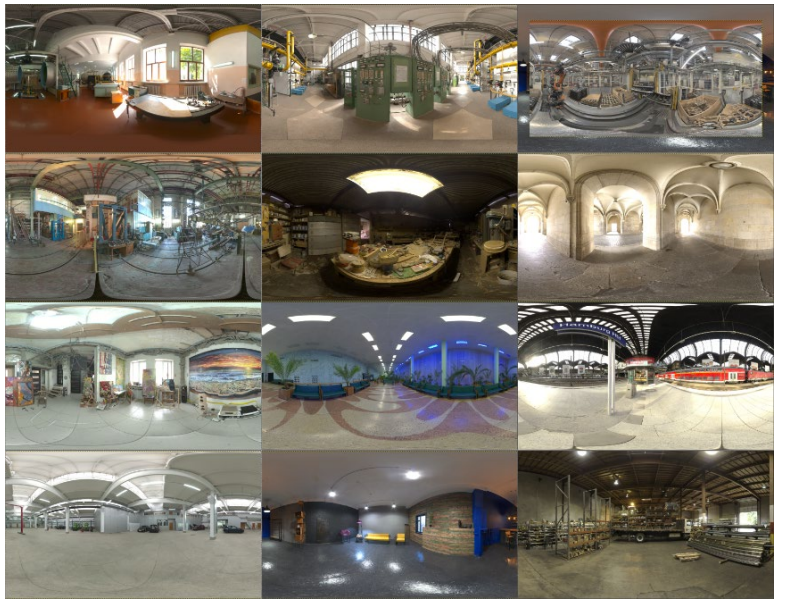
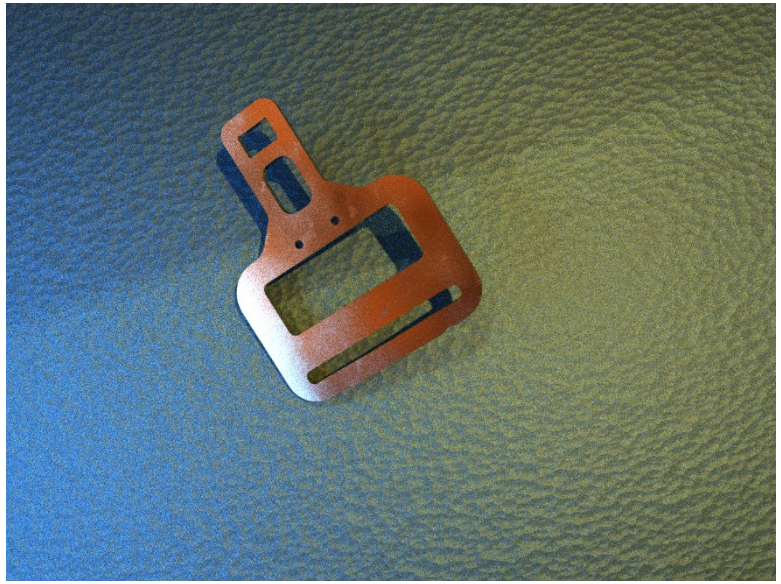
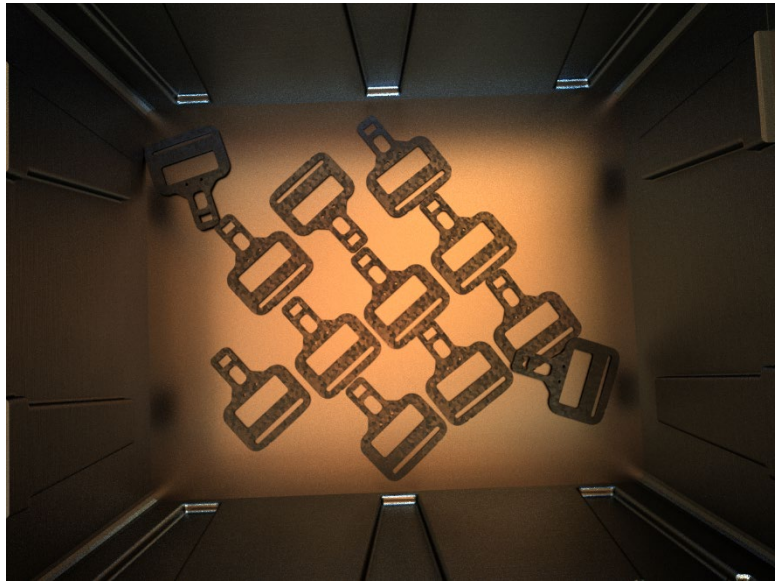
AI-Based Detection of Known Items

TRAINING WITH SYNTHETIC DATA



- Training data from a photorealistic simulation environment
- Material library, lighting simulation, CAD-models
- Support for various applications and parts
- Automated creation of templates as a cloud service





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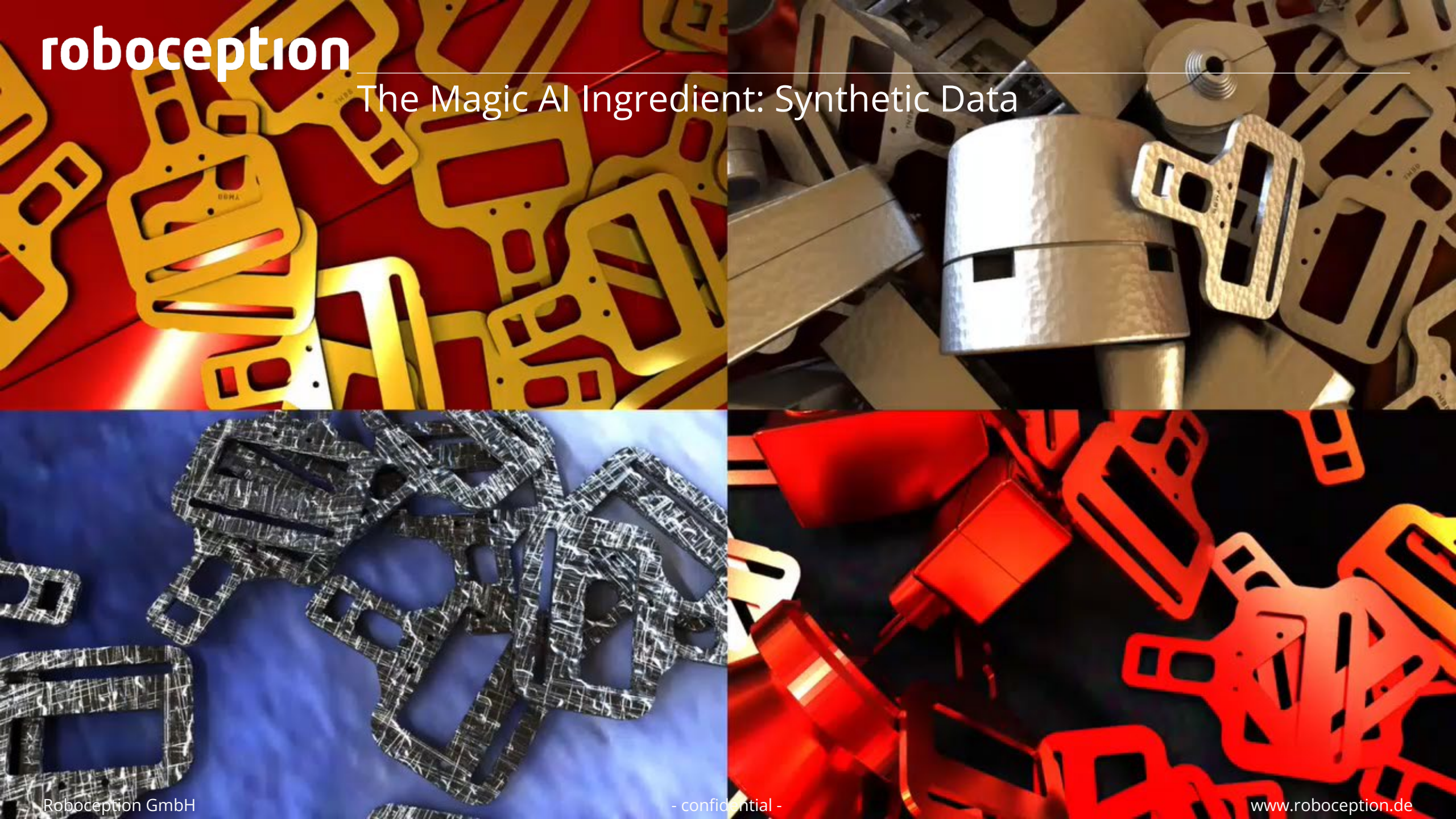
The Magic AI Ingredient: Synthetic Data



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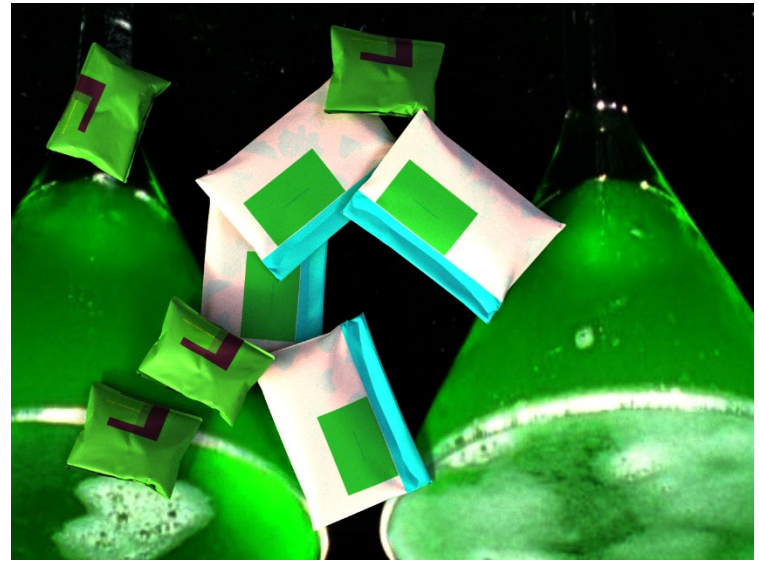
AI-based Detection of Unseen Items

TRAINING WITH SYNTHETIC DATA

- Training data from a photorealistic simulation environment
- Material, texture, lighting simulation
- Neural network per object category trained on dataset and refined with synthetic data
- Object categories allow for data and quality control



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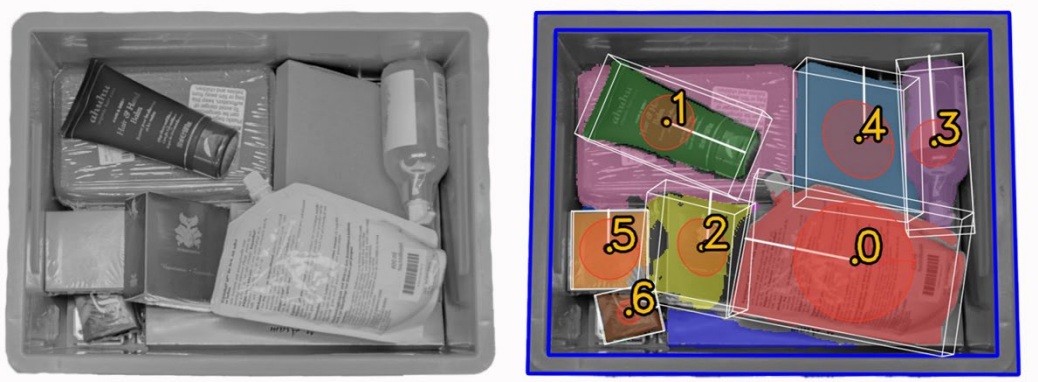
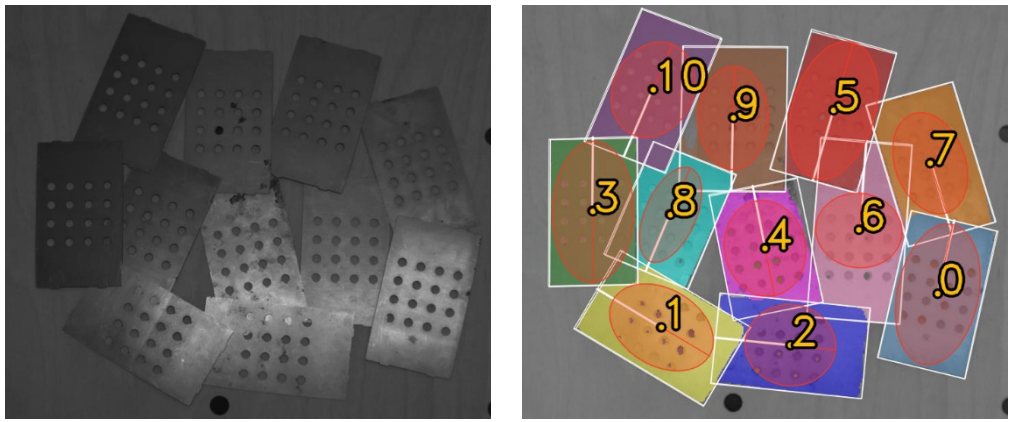
rc_reason ItemPickAI

OBJECT CATEGORIES

- Neural networks enable robust segmentation to ensure the grasp point is centered and the object's orientation is determined for proper placement
- Training is based on object categories with large image datasets
- Currently supported categories:
  - **Bag**: various volumes and fill levels
  - **Consumer Goods**: Wide range of packaged everyday items
  - **Sheet Metal**: flat metal parts of various shapes and surface qualities
- Additional categories coming soon



Object Category: Consumer Goods



Object Category: Sheet Metal

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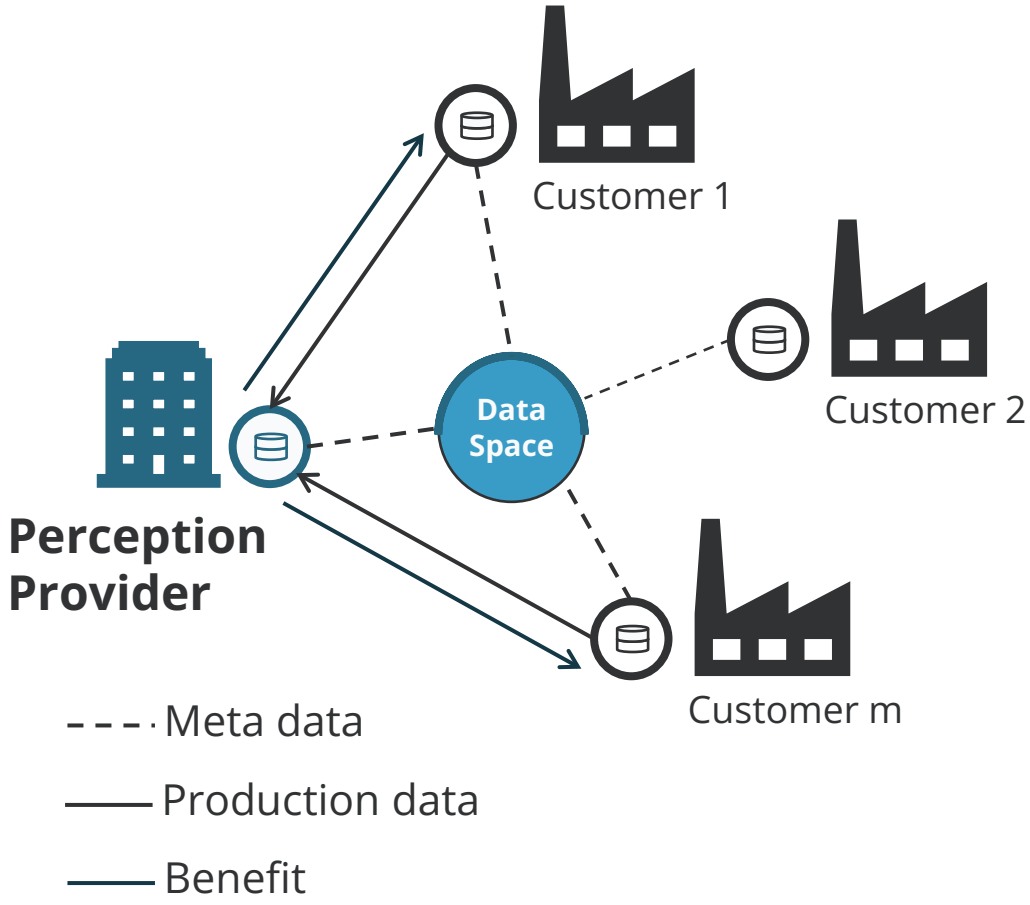
Data Spaces And Digital Ecosystems

SHARED DATA FOR PERCEPTION

Data Pooling

- Customers are free to decide whether to make data from their systems available to improve perception modules or AI models in general.
- The provider of the perception module has the option to reward users for providing data
- All customers get the improved model

Possibility to manage and further develop software modules over the entire life cycle via one interface with individual access rights



Source: VDMA

Contact

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Round Table Discussion

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Panel

Dr. Nicolas Alt
Siemens AG

Maximilian Durner
DLR

Dr. Ralph Lange
Trumpf

Dr. Lukas Solbach
VDMA

Dr. Michael Suppa
Roboception

Closing

Slides will be published on the website:
https://roboception.com/join-our-workshop-at-the-european-robotics-forum-erf-2026-in-stavanger-norway/

SMART HANDLE

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