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Dr. Michael Suppa I Co-Founder and CEO

EUROPEAN ROBOTICS FORUM
Brought to you by SPARC

Workshop: AppliedAI in Agile Production

Dr. Michael SUPPA, Roboception GmbH, Germany
Prof. Markus VINCZE, Technical University of Vienna, Austria

ERF 2020, Malaga, March 4th, 2020

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Agenda

16:15 Introduction by the moderators/ definition of key questions

16:25 Presentations:

Applied AI Overview: Prof. Markus Vincze, Technical University of Vienna, Austria.

Applied AI in Agile Production: Dr. Michael Suppa, Roboception GmbH, Germany.

AppliedAI from the Logistics Perspective: Dr. Maximilian Beinhofer, TGW Logistics GmbH, Austria.

AI and Human Robot Collaboration (HRC) in the Context of Reconfigurable Factories: Niki Kousi, LMS, University of Patras, Greece.

17:15 Interactive session/round table discussion of the key questions with all speakers and the audience

17:35 Conclusion for roadmapping and take-home message

17:45 End of workshop

Link to the website: http://roboception.com/erf2020

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Market Requirements

LOW-COST ROBOTS ARE THE FUTURE

- Perception and manipulation systems must be tightly coupled
- Flexible production
- Real-time requirements
- Users need intuitive and integratable robotic solutions
- Ready-to-use and easy-to-use functionality

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Agile Manufacturing

PERCEPTION IS THE KEY TECHNOLOGY FOR FLEXIBLE PRODUCTION

- In flexible and agile production, robots must be able to reliably detect and locate work pieces and human collaborators.
- In logistics, manual work is still pre-dominant due to the complexity of tasks and the variation of objects.
- Individual engineering of solutions is costly and does not scale

Agile Production

REQUIRES A FAST ADAPTATION OF A SYSTEM TO NEW ENVIRONMENTS

- Avoid approaches that require an extensive re-training of the system in changing environments
- Combination of learning and model based approaches show great potential
- Low level perception modules or front-layers in the learning approaches.
- Business models for open source software and commercial platforms including data models

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Key Questions

1. What expectations are connected to AppliedAI from a provider and customer perspective?
2. Which are major challenges and potential step changes, i.e. what is required from the solutions in order to increase flexibility in production?
3. What is the role of ecosystems in the context of AppliedAI?
4. Which business models in terms of data/software tools/platforms do you see and how do open source tools and commercial tools adapt to these models?

USE THE APP IN FOR Q&A or https://event.eur.crowdcompass.com/erf2020

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Statements

Applied AI Overview:
Prof. Markus Vincze, Technical University of Vienna, Austria.

Applied AI in Agile Production:
Dr. Michael Suppa, Roboception GmbH, Germany.

AppliedAI from the Logistics Perspective:
Dr. Maximilian Beinhofer, TGW Logistics GmbH, Austria.

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Niki Kousi, LMS, University of Patras, Greece.

Perception Group

CLOSING

Workshop Slides:
http://roboception.com/erf2020

Interest in participating in TG Perception:
michael.suppa@roboception.de

TECHNISCHE UNIVERSITÄT WIEN

Applied AI Overview

What Industry Would Like to Have

Markus Vincze
Automation and Control Institute, Technische Universität Wien
vincze@acin.tuwien.ac.at

ERF 2020, Workshop on Applied AI for Agile Production

Study with Industrial Experts

“What Do Industrial Developers and End-Users Expect from a Cognitive Robot?”

- Questionnaire of AICoR Topic Group
- ERF Workshop on AI & Robotics 2016-2019
- Interviews with selected key persons in industry

11 Functional Abilities – The Essence

Industry wants to

Teach a robot like an intern

Motivation

- Moving robots out of the lab and going into the … wild!
- Customisation & short product life cycles … need agility
- Get the robot in front of the fences
- Rapidly set-up any new production step
- Show the new task with high level instructions
- Expecting robot to keep learning

Teach a Robot like an Intern

Cognitive Abilities

- Safe, reliable, transparent
- Task learning → knowledge
- Reasoning about own capabilities

Goals specified at high level

- Robot knows about purpose

Partial Autonomy: user sets goal

- Formal limits, adapt interm. steps

Instructions

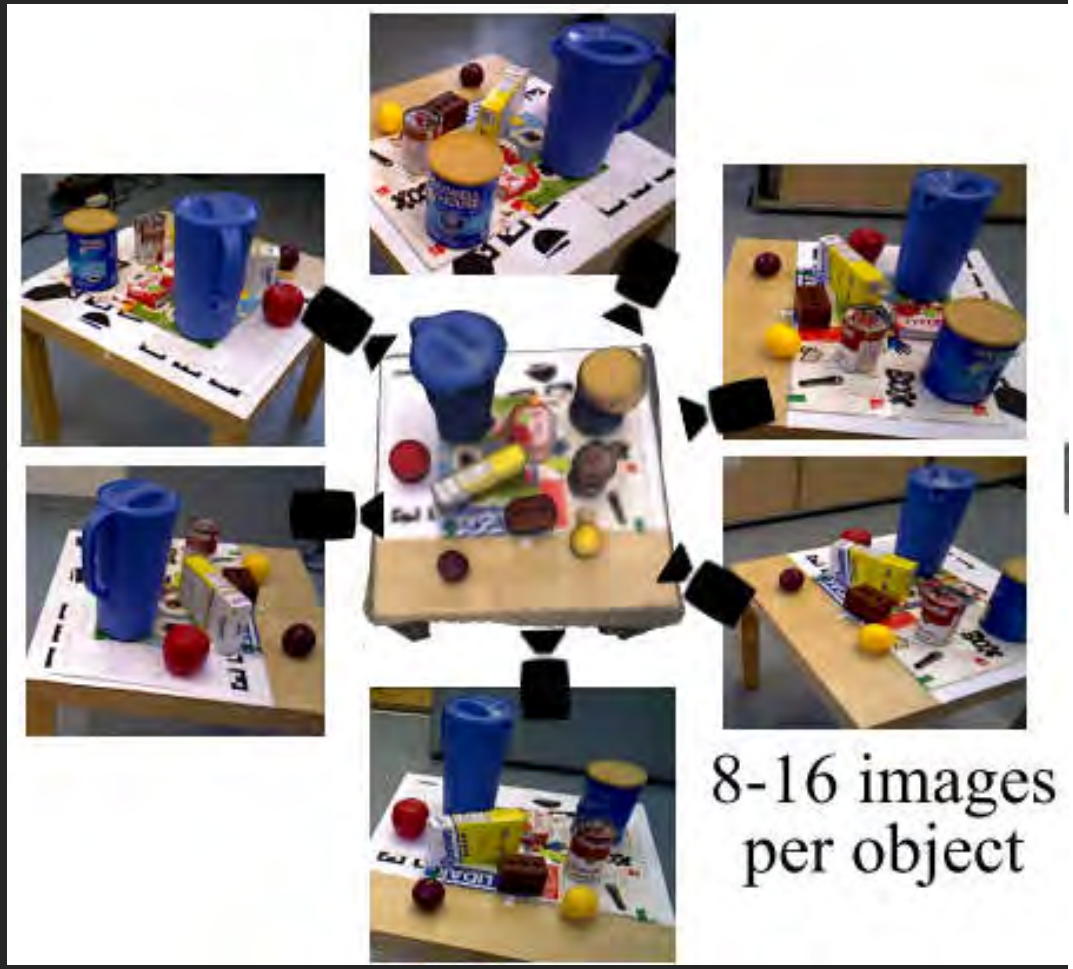
- Teaching by demonstration, learn application context

Applied AI

- Missing link: Visual Perception
- E.g., learn objects

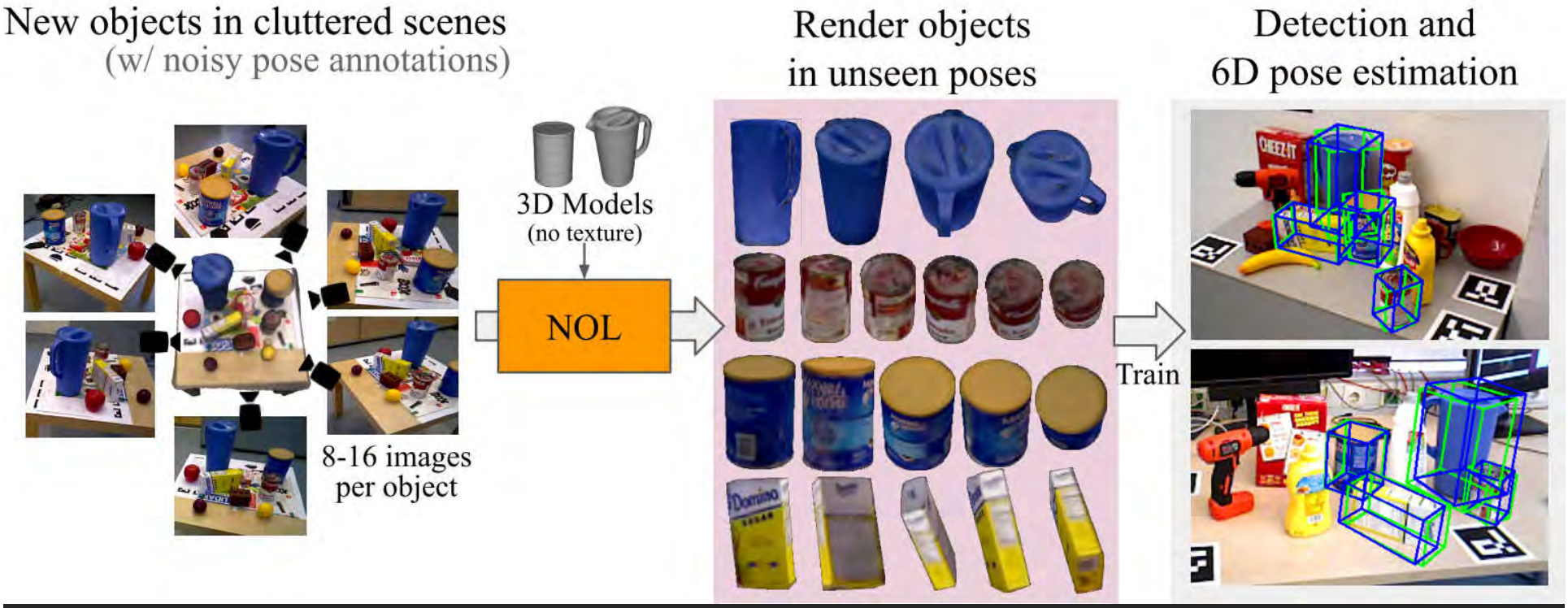
Learning Novel Objects

- Learn from a few sample views
- Create object model for training CNN
- Learn a 6DOF pose estimator



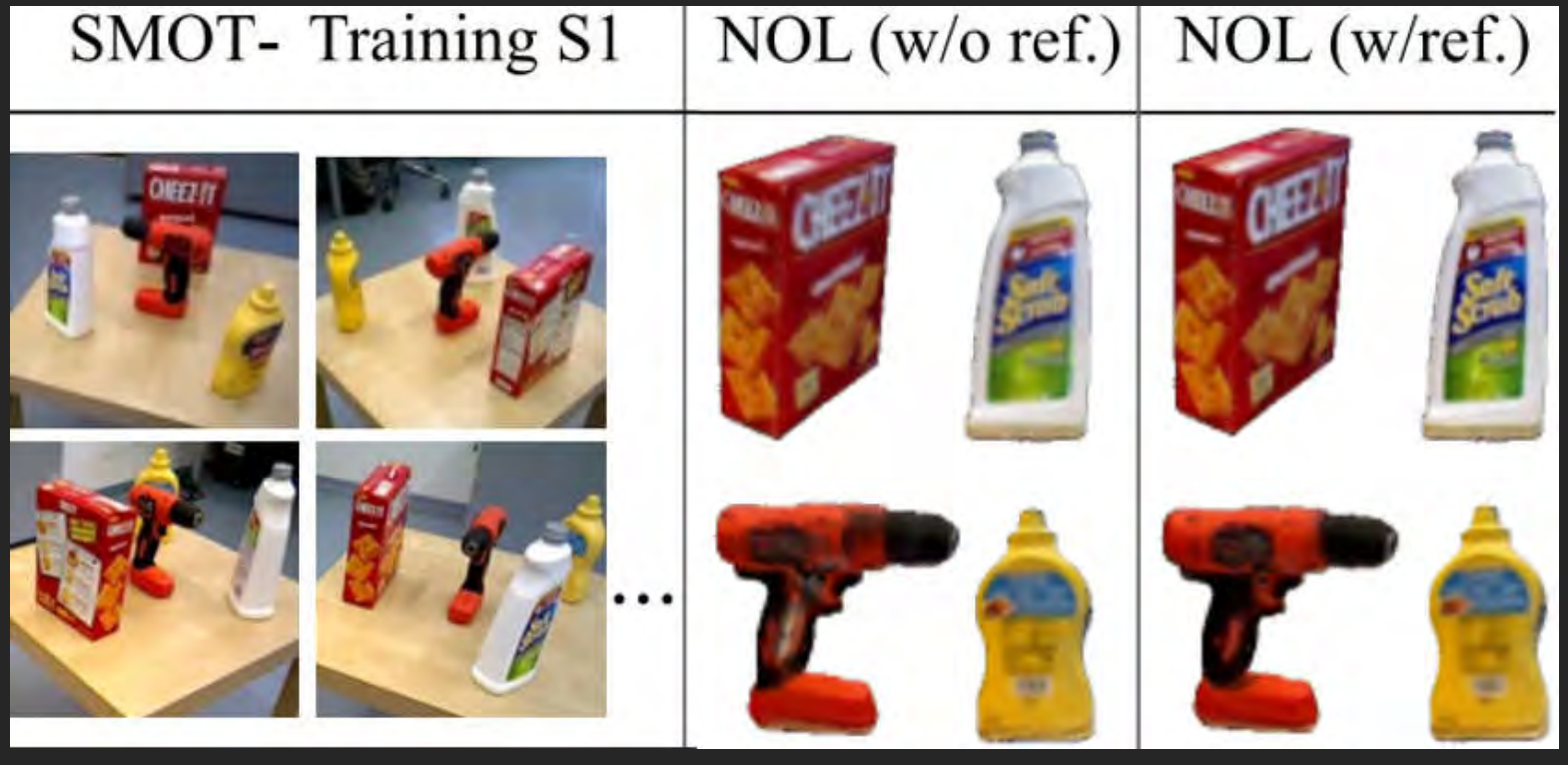
Learning Novel Objects

- Neural Object Learning (NOL)
  - Shape plus rendering texture

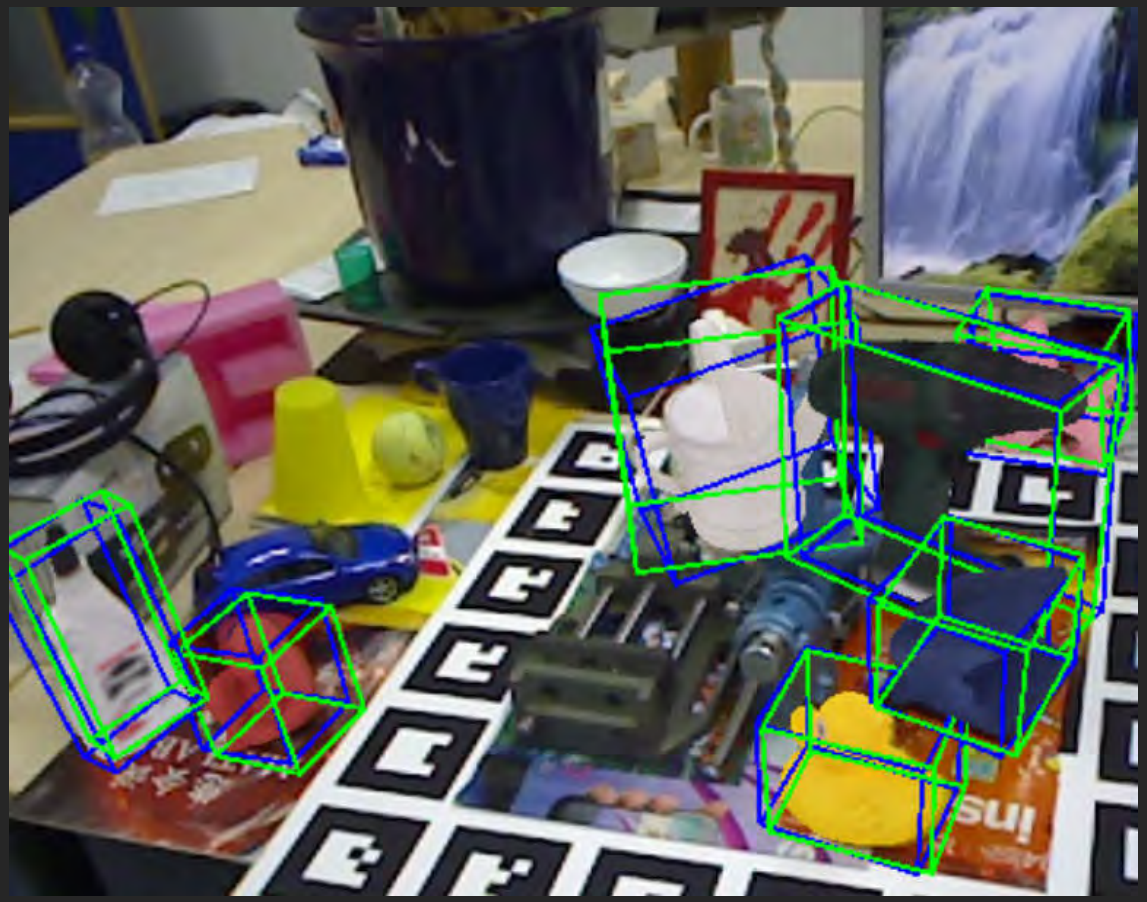


Learning Novel Object Models

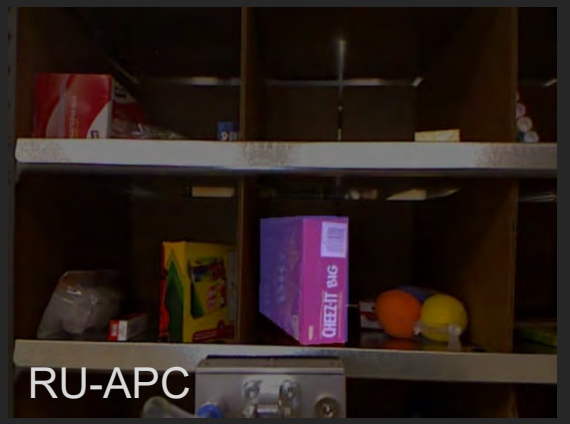
- 3D shape, closed loop
- Texture mapping, reduce illumination bias



Pix2Pose: Learning Pose Estimation



YCB-video



RU-APC

[Park, ICCV 2019, 6DPose Estimation: winner on YCB and Amazon Dataset]

6DOF Object Pose Estimation

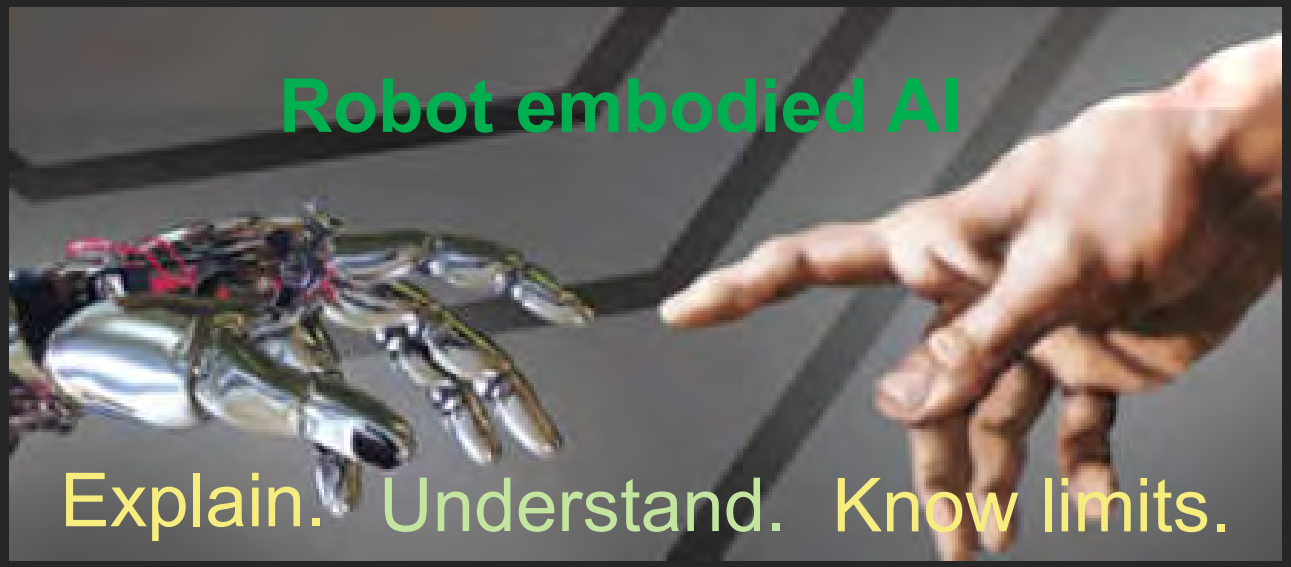
- How to learn from few examples?
  - CAD + a few real images
- How to cope with symmetry?
  - Explicitly model symmetry: transformer loss

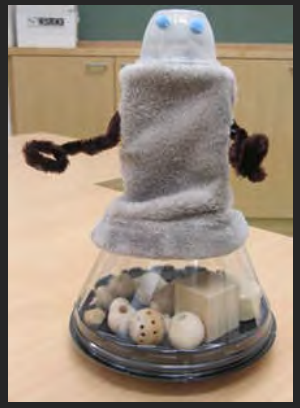
Pix2Pose

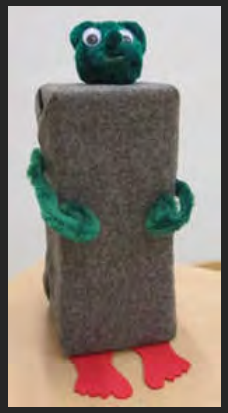
- Predicting pixel-wise 3D coordinates of objects
- Learning from
  - non-textured 3D models and
  - a limited number of real images

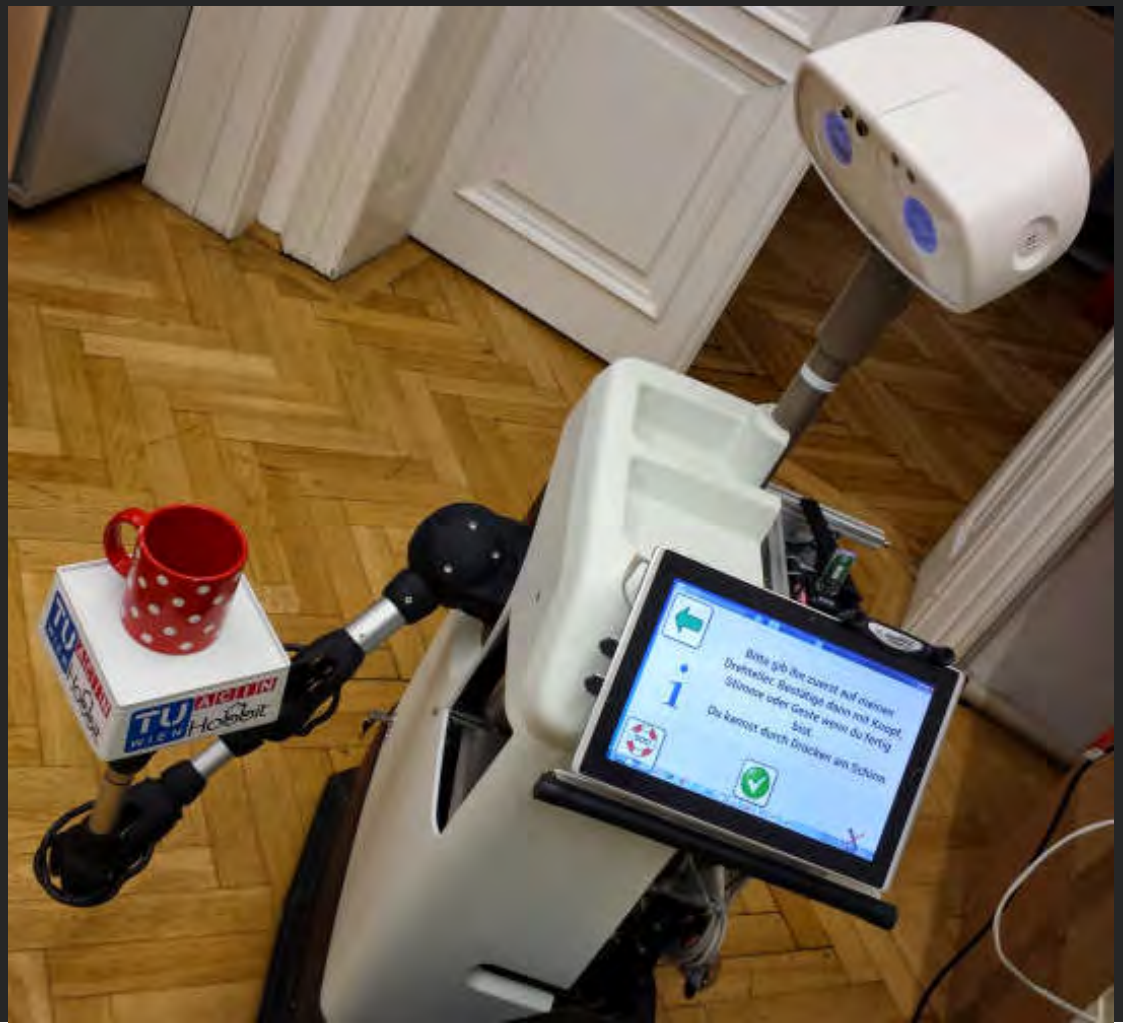
Teach a Robot Like an Intern

- Industry needs to respond to faster product cycles
- Easily and rapidly learn new task in a domain
- Perception: novel objects, scene context, user interactions
- Show task with objects, explanation, domain knowledge









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AUTOMATION & CONTROL INSTITUTE
INSTITUT FÜR AUTOMATISIERUNGS- & REGELUNGSTECHNIK

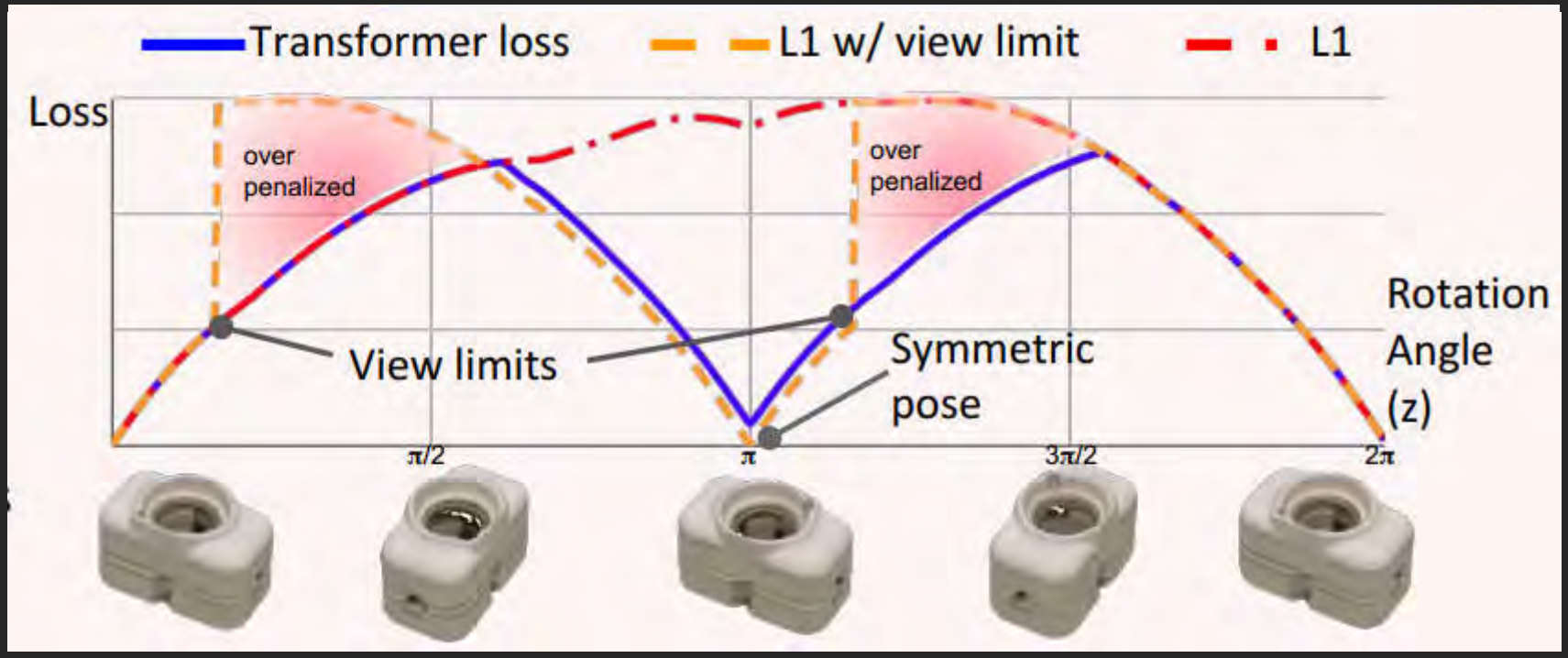
HOBBIT – The Mutual Care Robot

Fall Prevention and Robot Helper

- Demographic challenge
  - Increasing age, highest risk: fall
  - 6% health costs; leave home
- Robot for fall prevention/detection
  - *Clean up floor, keep track of things*
  - Socially connected, stay active, entertainment
- 18 test persons, 3 weeks in A, S, GR
  - 75-88 years old, living alone, moderate impairments
  - Very high acceptance 87%; rent 77%
  - 83% want full robot with arm

Robot Helper at Home

Pix2Pose – Handling Symmetries



- Avoid penalizing the prediction for symmetric poses

AI and Robotics

- Increasing importance of AI, complementary nature of AI and cognitive robotics
  - AI provides the platforms, tools, and techniques for constructing cognitive systems
- Cognitive robotics depends on
  - Strength of the AI foundation as well as
  - Insights from cognitive science on human-robot interaction

The 11 Industrial Priorities

- 1. Safe, reliable, transparent operation
- 2. High-level instruction and context-aware task execution
- 3. Knowledge acquisition and generalization (continuously)
- 4. Adaptive planning (recognizing and handling errors, gracefully and effectively) (within set limits)
- 5. Personalized interaction
- 6. Self-assessment (reason about their own capabilities)
- 7. Learning from demonstration
- 8. Evaluating the safety of actions
- 9. Development and self-optimization
- 10. Knowledge transfer (to other robots, connect to IoT env.)
- 11. Communicating intentions and collaborative action

ROCK eu²

Interviews with selected key persons in industry

- Tim Guhl, KUKA Systems GmbH (*) 2/8/2016
- Patrick Courtney, Tec-Communication (*) 2/8/2016
- Rich Walker, Shadow Robot Company (*) 23/8/2016
- Maja Rudinac, Robot Care Systems (*) 30/8/2016
- Slawomir Sander, KUKA Systems GmbH () 30/8/2016
- David Ball, Bosch () 30/8/2016
- Andrew Graham, OC Robotics () 7/9/2016
- Mauricio Calva, Chevron (*) 12/9/2016
- Amit Kumar Pandey, Softbank Robotics (*) 12/9/2016
- Ugo Cupcic, Shodaw Robot (*) 12/9/2016
- Daniel Wäppling, ABB (*) 19/9/2016
- Ekkehard Zwicker, GE Inspection Robotics (*) 19/9/2016
- Thilo Steckel, CLAAS E-Systems KGaA mbH & Co KG (*) 28/9/2016

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Applied AI in Agile Production

ROBOCEPTION GMBH

ERF Workshop on AppliedAI in Agile Production

Malaga, March 4th, 2020

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Company Profile

SENSE. REASON. ACT

Founded 03/2015 by three former employees of the Institute of Robotics and Mechatronics/ German Aerospace Center as a DLR SPIN-OFF

KUKA Deutschland GmbH
Shareholder since 08/2015

Based in MUNICH (Pasing)

17 employees (02/2020)

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Mission

Sense. Reason. Act.

Going from pixel to action using perception.

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3D Perception – Why?

"3D vision is a DISRUPTIVE TECHNOLOGY that enables robots to operate in a partially-structured environment".

IFR Annual Report on Service Robotics

"Perception was the DOMINATING FACTOR separating the winners from the rest of the field in the amazon picking challenge."

Henrik Christensen

"If we were only able to provide the VISUAL CAPABILITIES of a 2-year old child, robots would quickly get a lot better."

Rodney Brooks

Sources:
1. http://www.ifr.org/robots-create-jobs/
2. http://www.therobotreport.com/news/amazon-challenges-robotics-hot-topic-perception
3. http://www.robotics.org/content-detail.cfm/Industrial-Robotics-Industry-Insights/Intelligent-Robots-A-Feast-for-the-Senses/content_id/5530

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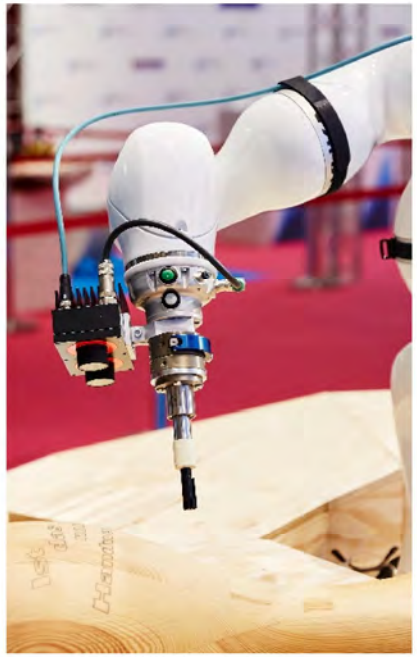

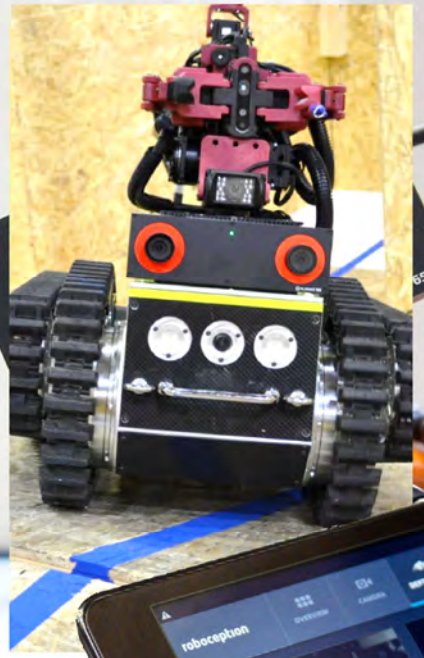

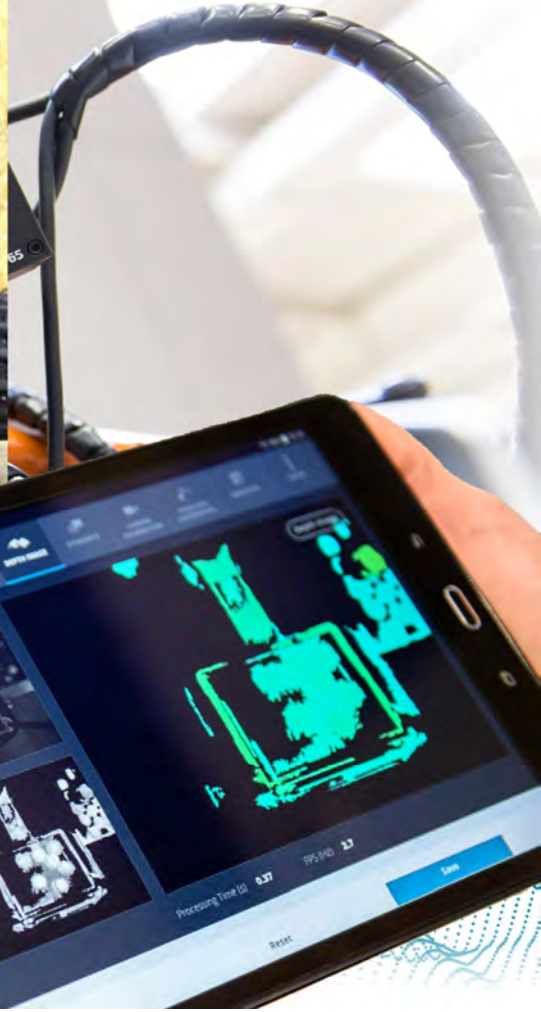

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Business Model

VERSATILE SENSORS AND INTUITIVE SOFTWARE SOLUTIONS

Hardware (sensors) incl. basic software form basis of the business, sold at highly competitive price

Business scales through add-on software

- Release of 3-4 software modules/ year
- Developments always adress a customer pain point
- Derive software products from contracted development where possible
- Pricing reflects customer's added value

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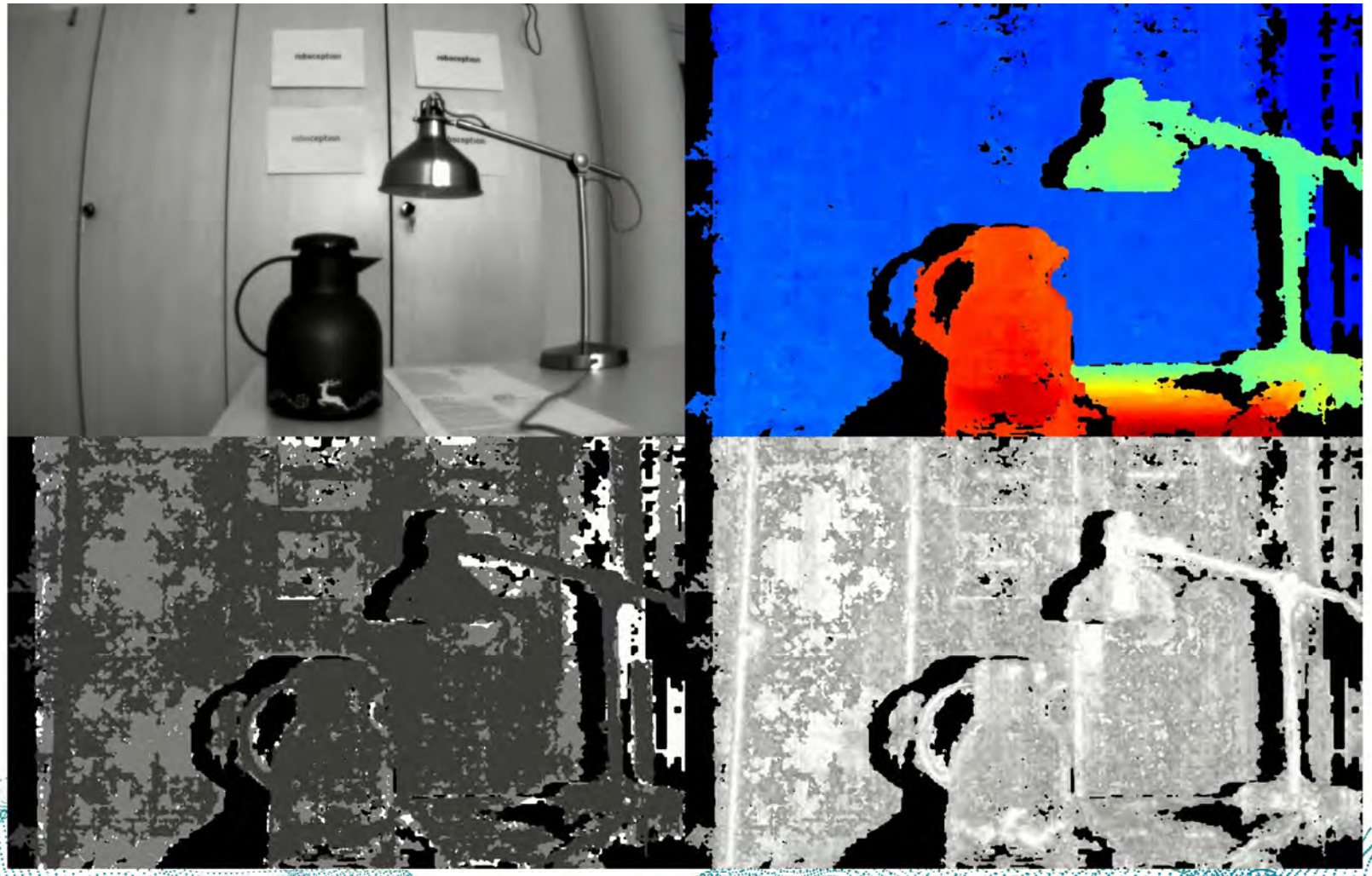
rc_visard
STEREO DATA PROCESSING RESULTS



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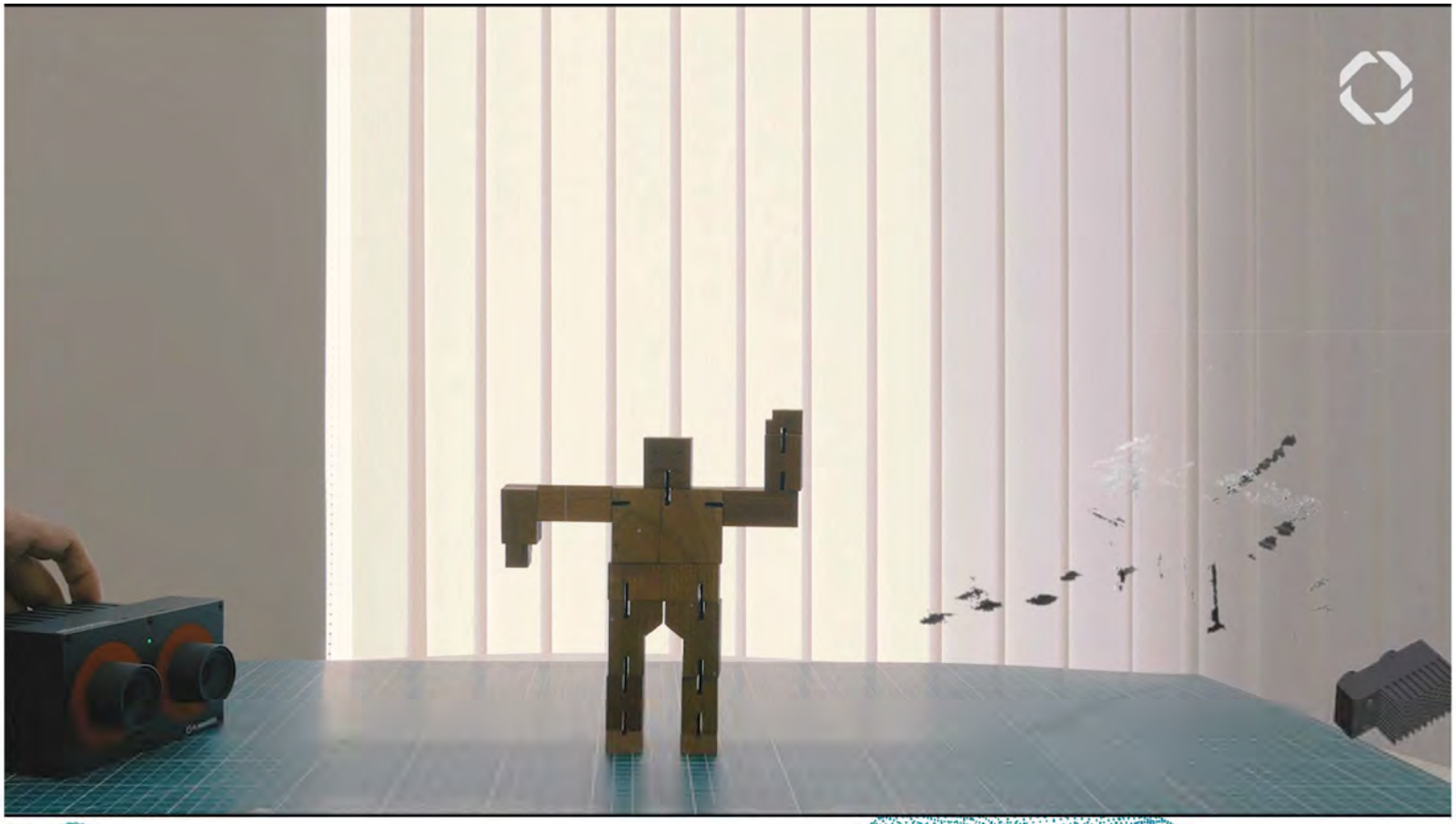
rc_visard Ego-Motion
POINT CLOUD GENERATION



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Application Domains

AGRICULTURE

crop identification, GPS-free navigation, ...

INDUSTRIAL AUTOMATION

object recognition/ handling,...

LOGISTICS

autonomous navigation, object handling,...

SERVICE ROBOTICS

area monitoring, navigation,...

HEALTH CARE

patient monitoring, people detection,...

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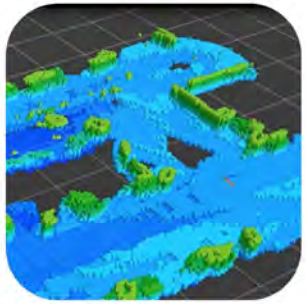
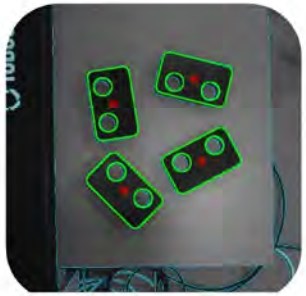
rc_reason Software Suite

ON-BOARD ENHANCEMENT OF BASIC SOFTWARE





SLAM: Precise mapping and pose estimation in 3D for a drift-free navigation

TagDetect: Identification and pose estimation of QR codes and AprilTags

ItemPick: Computation of grasp poses for suction grippers in pick-and-place applications

BoxPick: Identification of size, position and orientation of rectangular objects

SilhouetteMatch: Identification of flat objects on a plane

& MORE TO COME

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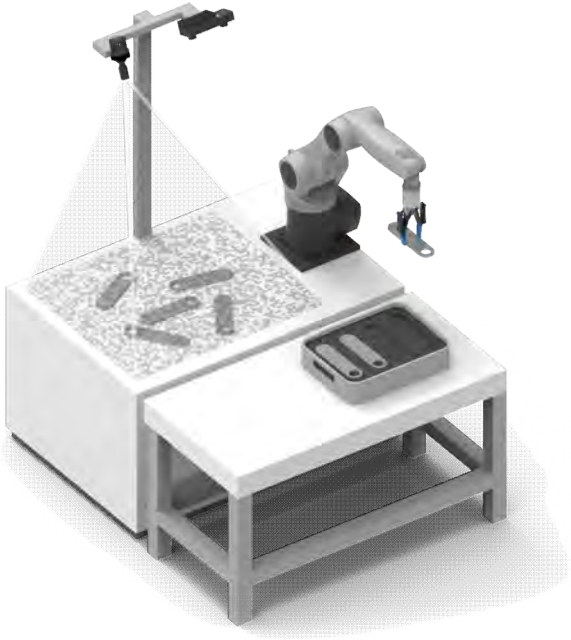
rc_reason SilhouetteMatch

FOR ROBOTIC MACHINE-TENDING APPLICATIONS

Detects position and orientation of comparatively flat objects positioned on a planar surface in unmixed scenes

- Matches the scene to a previously taught template
- 3D position and orientation is determined for each object, and grasp points can be defined on the object
- Typical applications include machine tending or emptying load carriers of several (separated) layers of objects
- Works with static and robot-mounted sensors coupled with RandomDot Projector
- On-board data processing: No external hardware required



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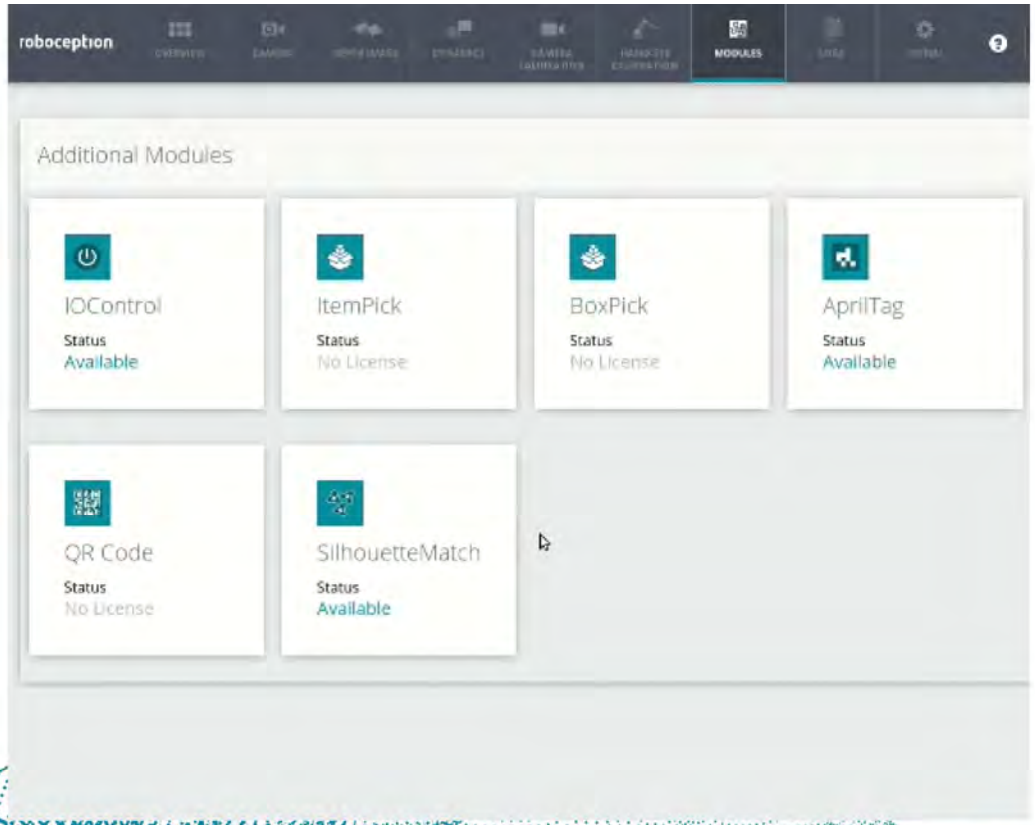
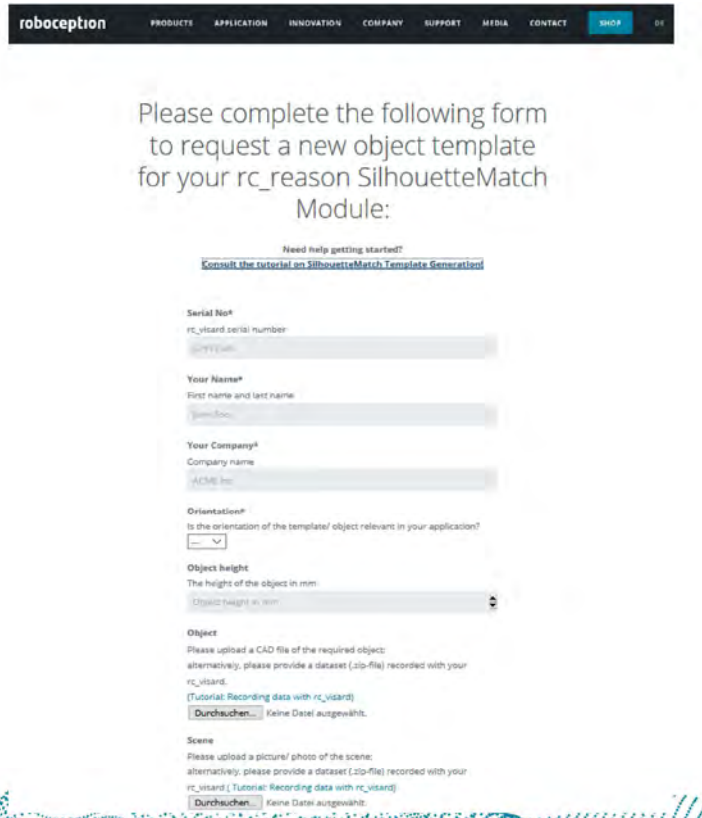
Silhouette Match

PRODUCT





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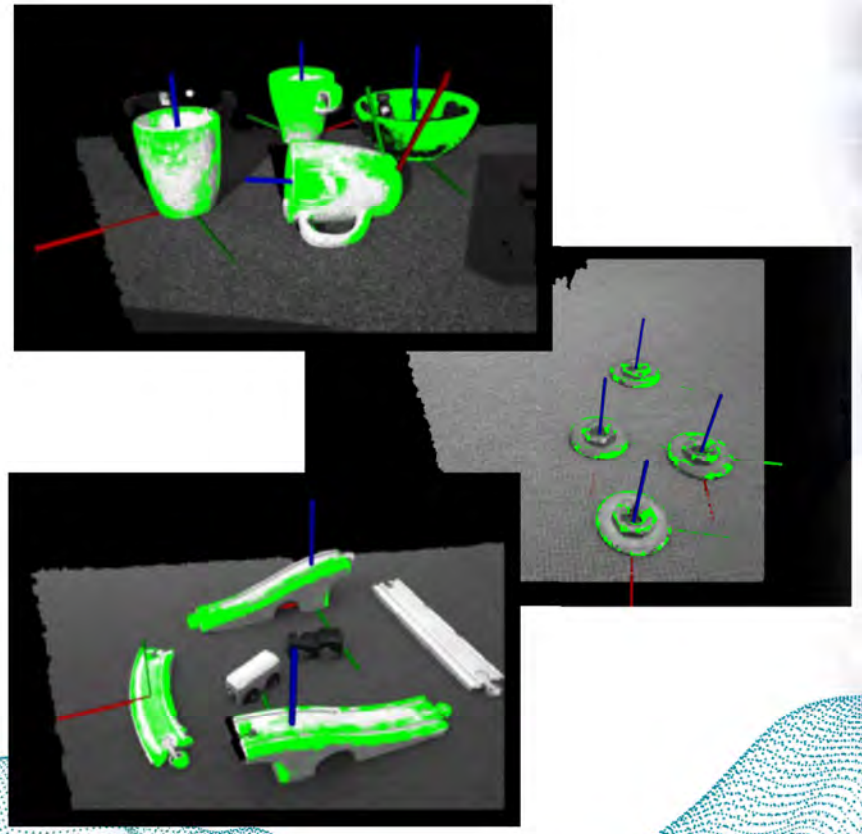
CAD-Based Detection

PROTOTYPE

Detects position and orientation of arbitrary objects on a planar surface in unmixed scenes.

- Clustering of point cloud
- Matching is based on geometrical features calculated on each cluster



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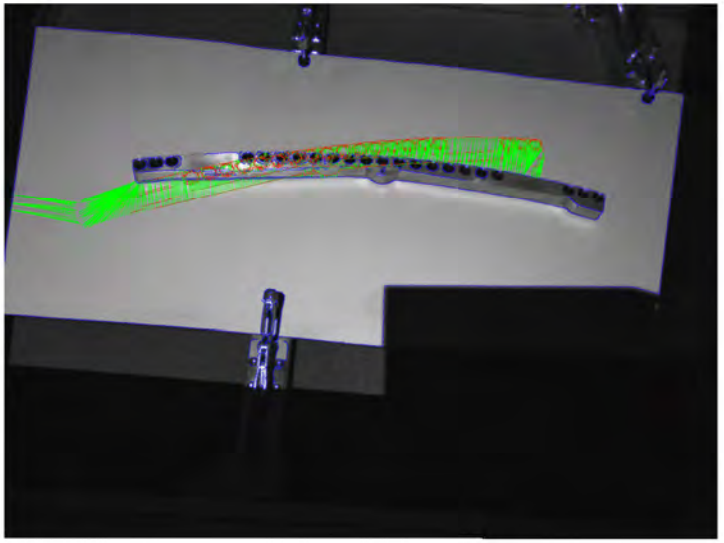
CAD-Based Pose Refinement

PROTOTYPE

Allows for refining of position and orientation for high accuracy

- Requires a good initial guess
- Post-processing step



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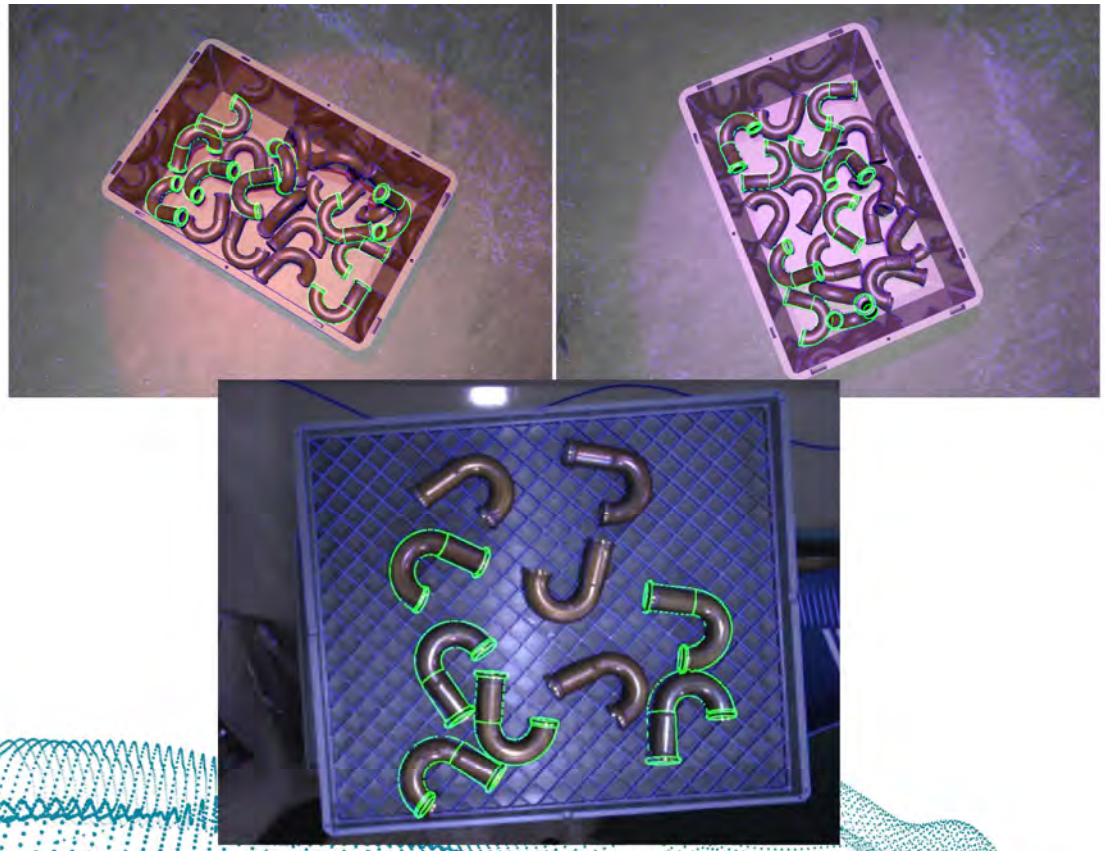
Machine Learning-Based Object Detection



Detects position and orientation of arbitrary objects in cluttered, unmixed scenes.

- Combination of ML approaches to detect position and orientation
- Stereo-system improves performance
- Refinement as post-processing step

Requires training data and offline training phase!

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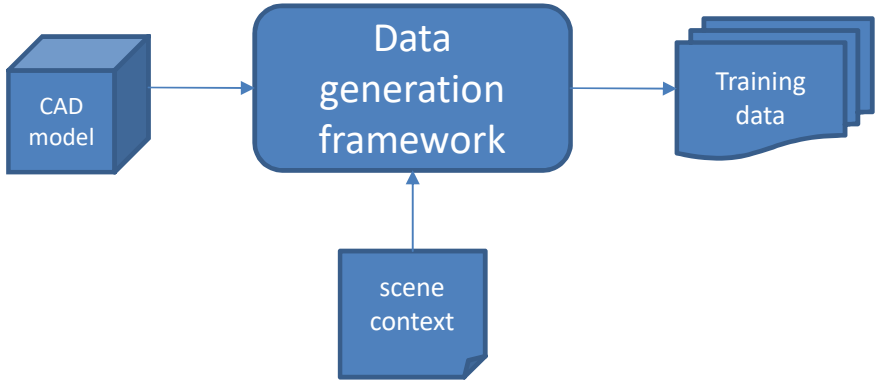
Synthetic Data Generation for Machine Learning



Allows generation of artificial training data for training machine-learning algorithms (e.g. CNN)

- Reduces effort for manual labeling of training data
- Input:
  - CAD model
  - Application context
- Output:
  - Hundreds/thousands of training data
  - Variation in light, color, background, textures, etc.
  - Labels for bounding boxes, segmentation mask

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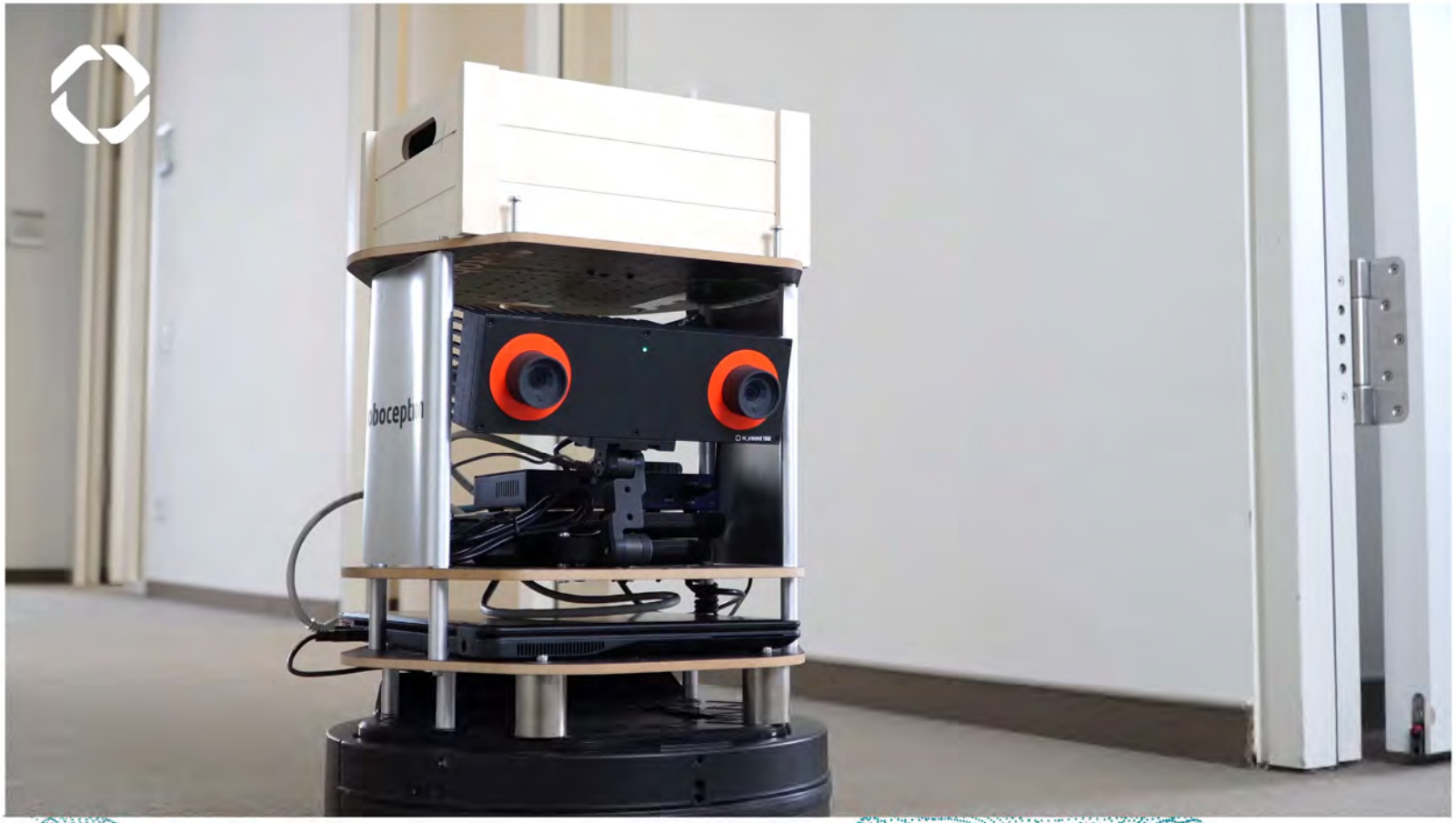
Applications
TagDetect, SLAM, ItemPick



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Questions?

Roboception GmbH

Kaflerstraße 2
81241 Munich

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APPLIED AI FROM THE LOGISTICS PERSPECTIVE

Dr. Maximilian Beinhofer, TGW Logistics Group

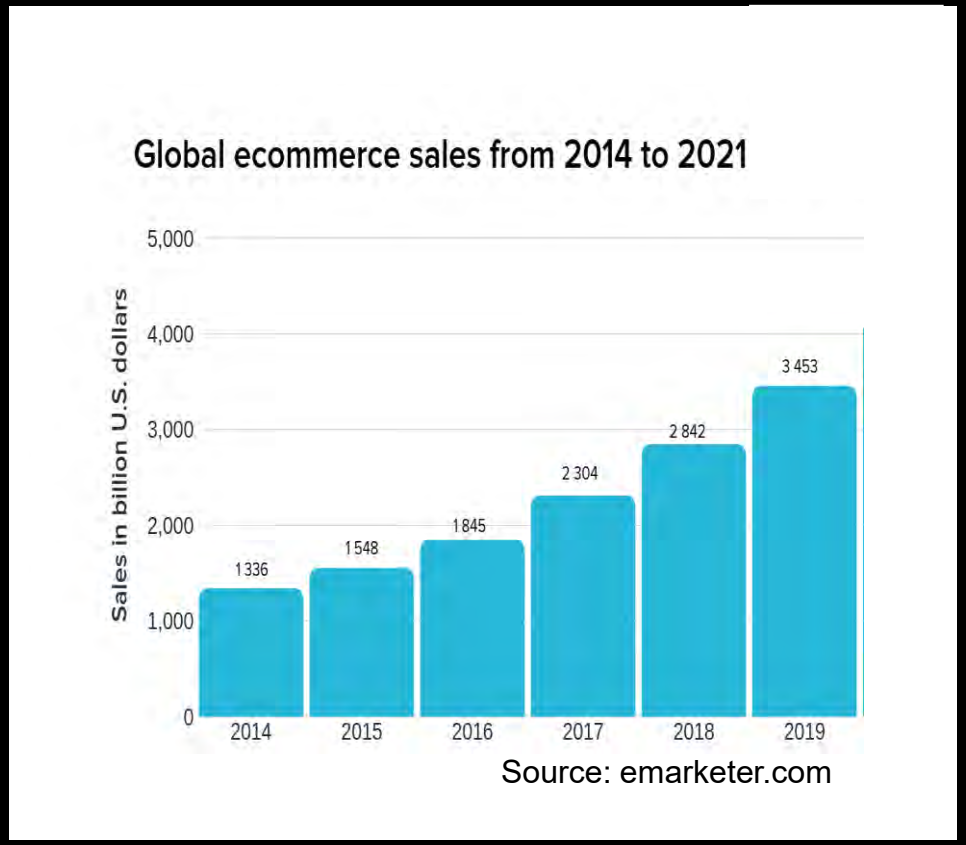
LIVING LOGISTICS

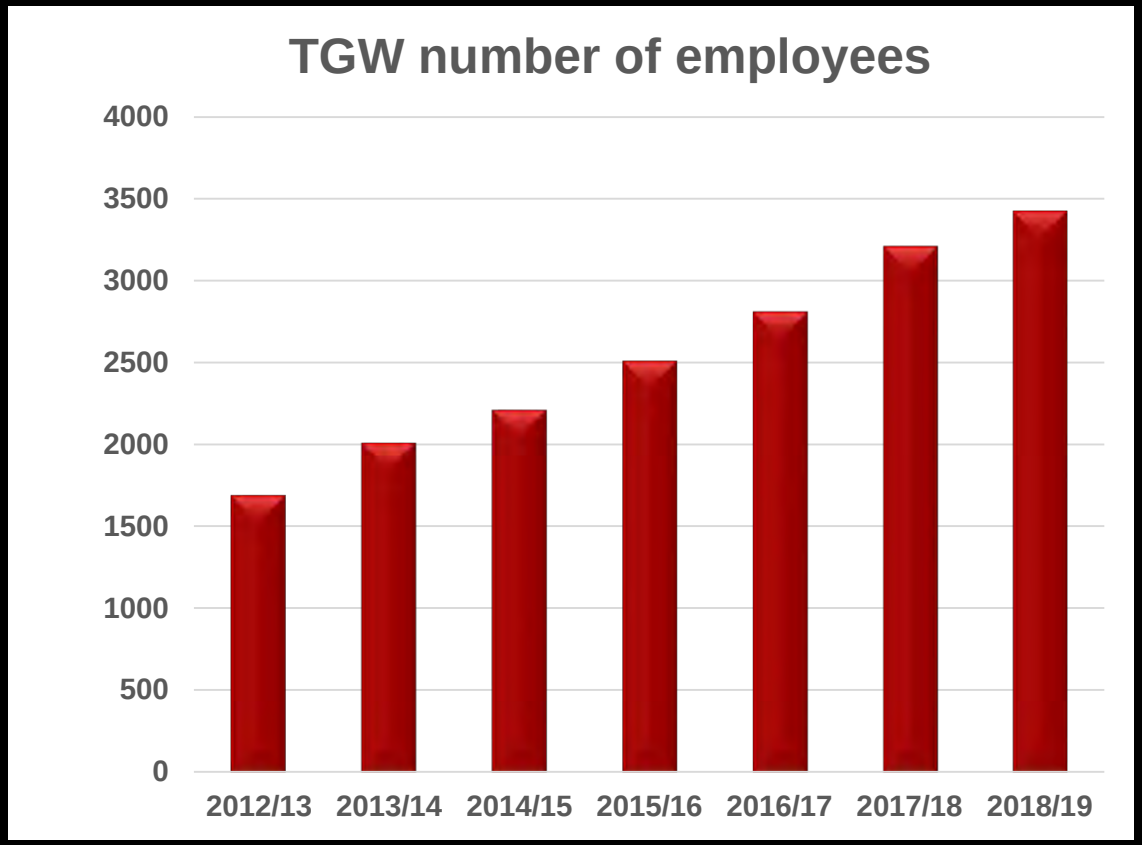
Transport logistics

Warehouse logistics

TGW

- Founded 1969
- Located in Wels, Austria
- >3.400 employees
- Delivers automated warehouse solutions


Global ecommerce sales from 2014 to 2021
Sales in billion U.S. dollars
5,000
4,000
3,000
2,000
1,000
0
1336
1548
1845
2 304
2 842
3 453
2014
2015
2016
2017
2018
2019
Source: emarketer.com

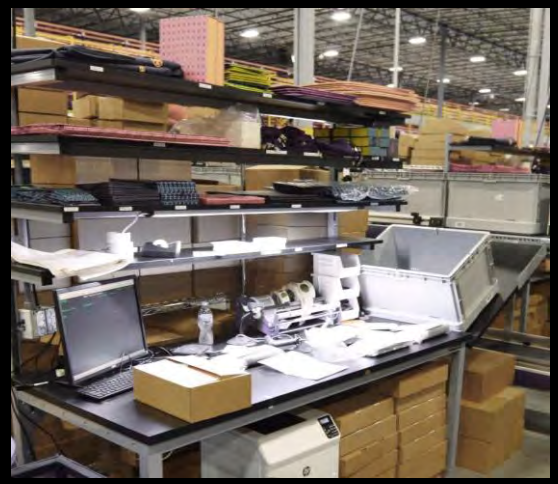

TGW number of employees
4000
3500
3000
2500
2000
1500
1000
500
0
2012/13
2013/14
2014/15
2015/16
2016/17
2017/18
2018/19

INBOUND

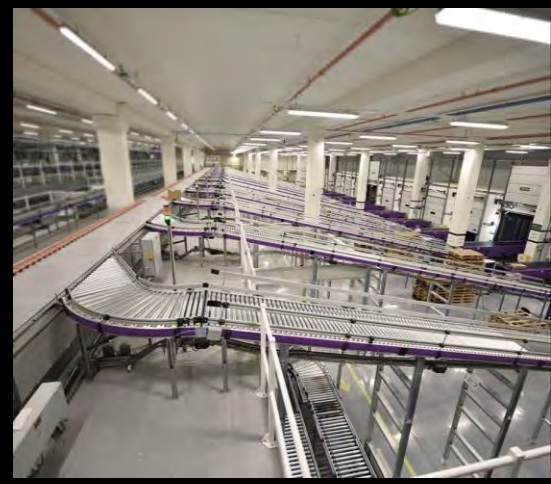
STORAGE

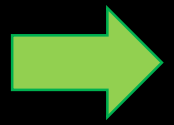
ORDER FULFILLMENT

PACKING



OUTBOUND






XXL
65 WÄSCHE
Weißer
45 + 5
Clarky's
Nussvariation
Tea Latte
CAPPUCCINO
CASHEWS

Production:
1 item

Logistics:
50.000 items

- Standard Approach: **industrial robotics**
  - Precise positioning and exact measuring necessary
  - High efficiency in the sunshine case
  - Human intervention necessary at each small unforeseen change
  - Standard example in logistics: pharmaceutical products

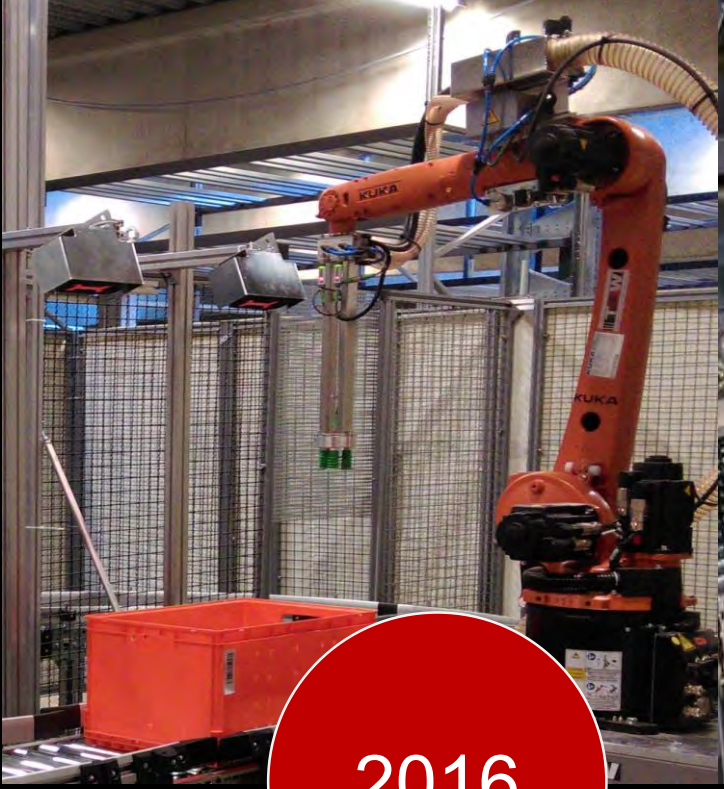
- TGW Approach: **cognitive robotics**
  - Unforeseen situations are explicitly allowed and can be handled autonomously by the robot
  - Imprecise and complex situations possible (deformable objects, chaotic arrangement in tote)
  - Drastic reduction of need for human intervention
  - Broad article-spectrum in logistics possible

Handling low precision

- Don‘t even try to be 100% error-free
- Try to detect unplanned situations with 100% detection rate
- Solve unplanned situations autonomously (data correctness!)
- Optimize autonomy and cycle time, NOT precision


00:00:00:00
TSW
LIVING LOGISTICS
PickCenter


TRIKA



2016

2017

2018

2019

AUSTRIAN ROBOTICS AWARD

GERMAN INNOVATION AWARD '19 GOLD

THANK YOU