

Use of 3D Stereo Vision in Industrial Applications

Utilisation of Machine Vision in Robotic Applications

Company Profile

ABOUT ROBOCEPTION GMBH



Roboception = **ROBOTICS** + **PERCEPTION**

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

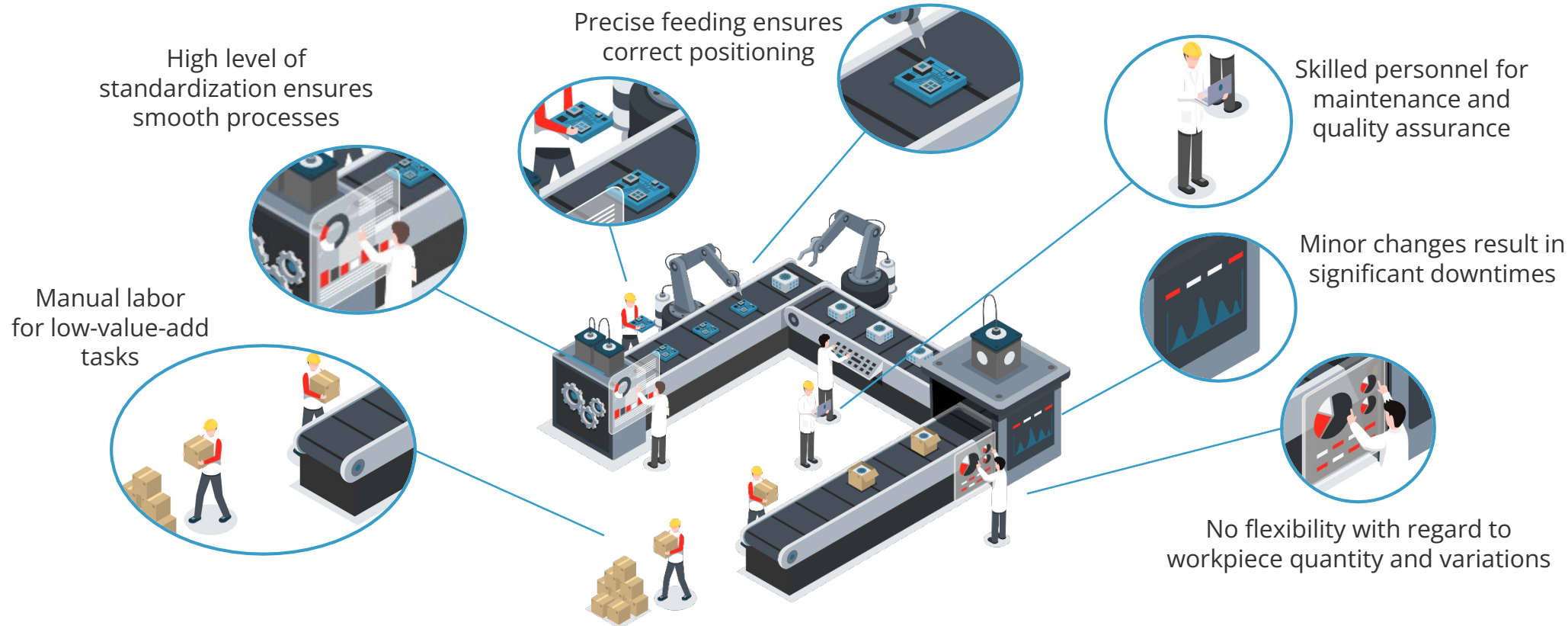
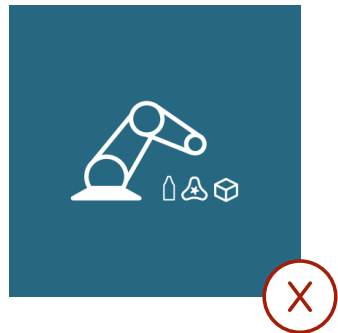
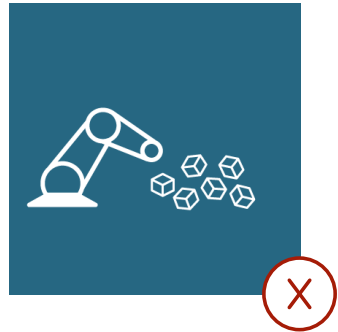
PIONEER in 3D sensor technology

Based in **MUNICH** (Pasing)

Going from pixel to action using perception.

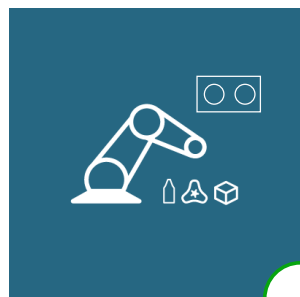
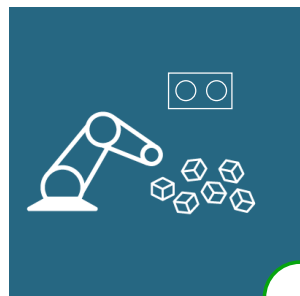
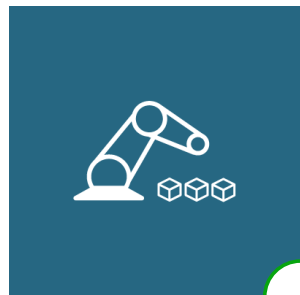
Robots not Smart Enough for Next-Level Industry 4.0

- Potential offered by automating simpler use cases has been exhausted
- Next evolutionary step for Industry 4.0 is urgently needed
- Robots must be enabled to automate more complex tasks



Eyes and Brains for Your Robot

This easy-to-use
3D vision solution is the
**ONE SINGLE ADDITIONAL
COMPONENT**
required to make
robotic systems smart.

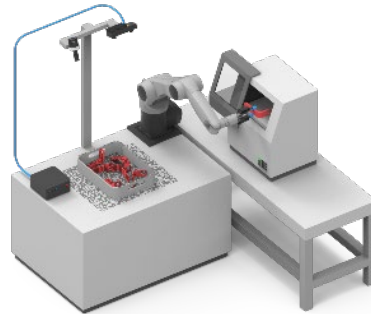


How to Scale Vision for Grasping in Robotics

FLEXIBILITY IS KEY

Industrial Automation and Automotive

- Classical approach to use mechanical fixtures
- Individual engineering for feeding and grasping
- Usually <100 different parts
- Model data available
- Pick-and-place



Logistics

- High cycle time with 1000 picks/h
- Usually >1000 parts
- Objects unknown
- Pick-and-drop



3D Vision System

- Removal of fixtures for flexible cell design
- Model-driven approaches require a model but allow for time-saving off-site training
- Combination with classical methods allows for accuracy and robustness

3D Vision System

- Enables application of robots in the domain
- Data-driven approaches require data, i.e. time-consuming on-site recording and training
- Combination with model-driven and classical approaches will reduce data greediness

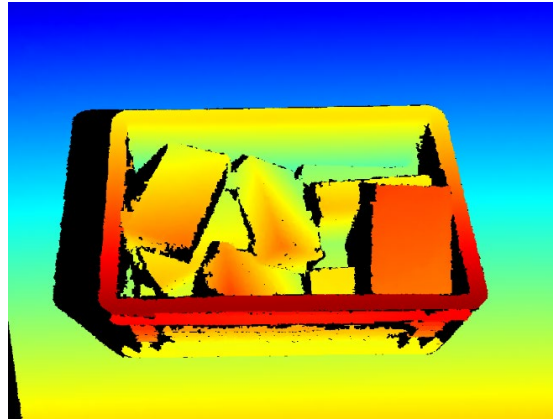
Why Stereo?

UNSTRUCTURED ENVIRONMENTS REQUIRE 3D DATA

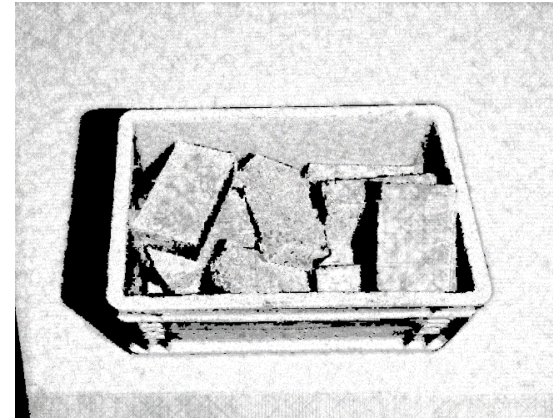
- Stereo delivers RGB-D data directly synchronized in time and calibrated
- Increase in computing resources allows for onboard computation in real-time
- Depth is needed for accuracy and flexibility, images are the key data base for machine learning
- Combination of algorithms and machine learning in one system



Camera Image



Depth Image



Confidence Image



3D Reconstruction

Product Portfolio

Product Portfolio

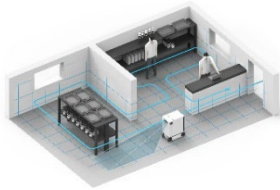
VERSATILE SENSORS AND INTUITIVE ROBOTICS SOFTWARE

Customer-Specific **Applied AI Solutions**

rc_reason Software Suite



TagDetect



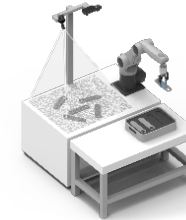
SLAM



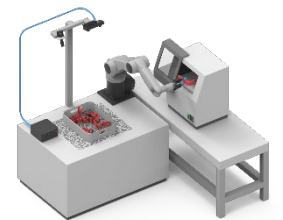
ItemPick



BoxPick



SilhouetteMatch



CAD Match

rc_visard Sensor Family

Comes with onboard Standard Software Package



rc_cube Industrial Edge Computer



rc_viscore Stereo Sensor



rc_randomdot Pattern Projector



Not a Vision Expert? Not a Problem!

INTUITIVE WEB INTERFACE ENABLES NON-EXPERT USE

Designed for quick and easy set-up and adaption, no vision expertise needed

- Highly intuitive user interface, accessible via a web browser
- Basic software and add-on modules managed via same interface
- ‚Try out‘ functionality for quick assessment of selected settings

The screenshot displays the roboception web interface for an 'rc_cube' system. The interface is clean and modern, with a dark sidebar on the left containing navigation options: Dashboard, Pipeline 0: rc_visard, Camera, Depth Image, Modules, Configuration, Database, and System. The main content area is divided into two primary sections:

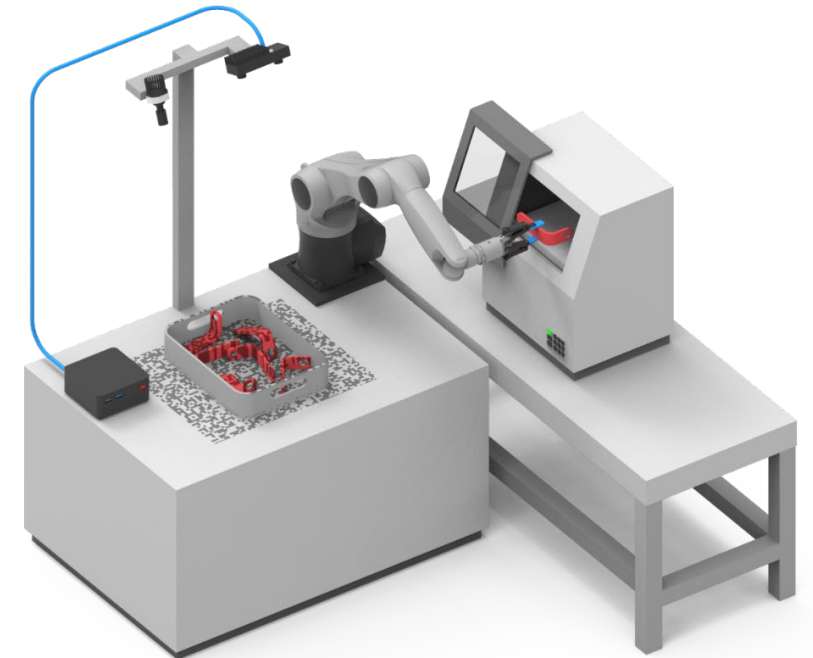
- rc_cube System Info:** This section provides a quick overview of system status. It includes a 'Go to System Page' button and three key metrics:
 - Link Speed:** 1000 Mbit/s
 - Time Synchronization:** NTP, Status: synchronized
 - IP Configuration:** DHCP
- rc_cube Camera Pipelines:** This section allows for the configuration of camera pipelines. A 'Configure Pipelines' button is present. The selected pipeline is '0: rc_visard (160m)'. Its settings are:
 - Frame Rate:** 25.0 Hz (current) vs 25.0 Hz (desired)
 - Link Speed:** 1000 Mbit/s

The interface also features a 'Collapse Sidebar' button at the bottom left and a language selector (EN) at the top right.

rc_reason CADMatch ROBOTIC MACHINE TENDING

Detects position and orientation of objects using CAD models.

- Detection and localization of objects based on CAD data
- Delivers grasp point(s) for reliable pick-and-place
- Grasp teaching interface
- Applied AI-based part training process
- Works with static and robot-mounted sensors coupled with rc_randomdot pattern projector
- Runs offboard on rc_cube

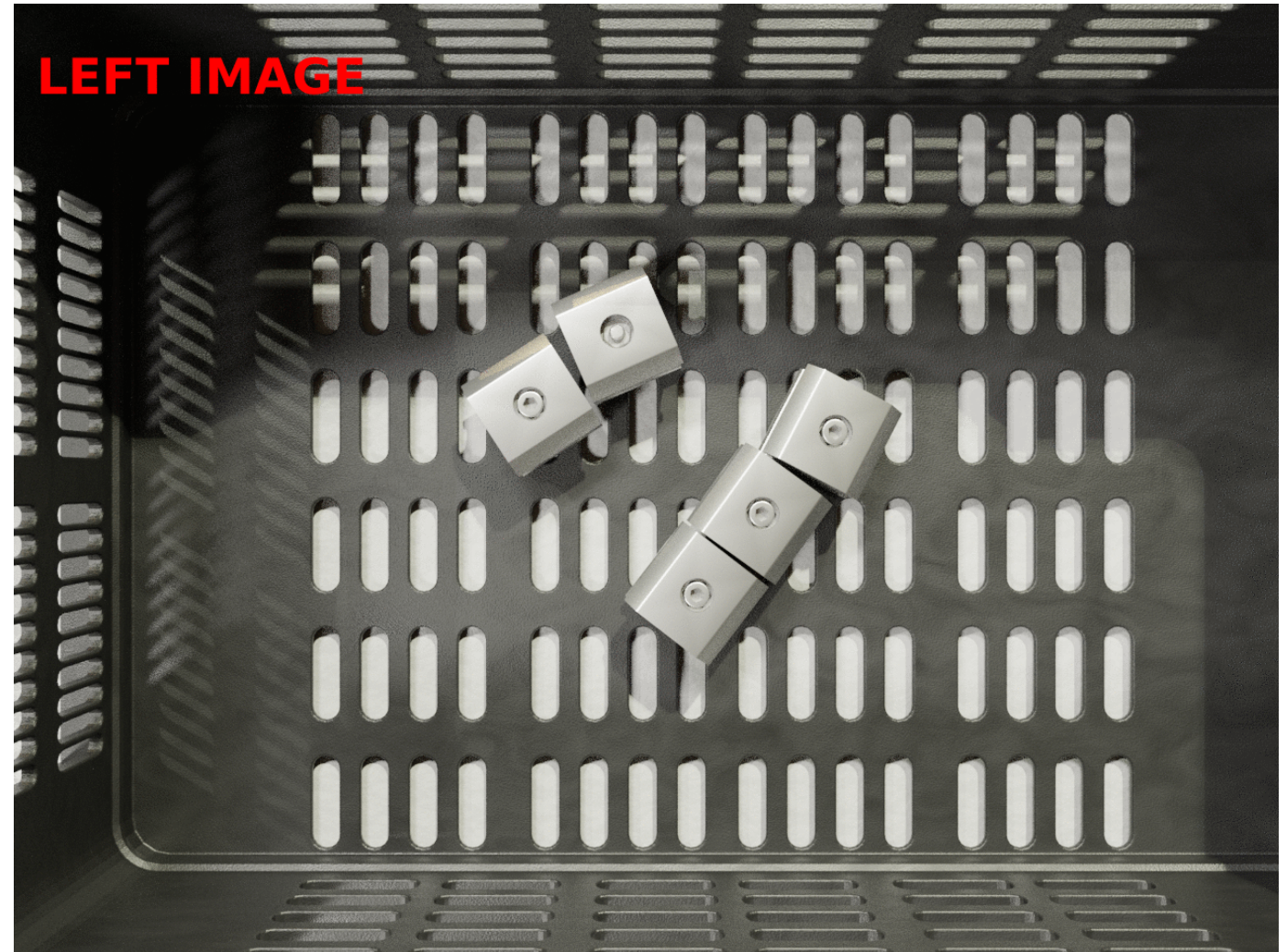


rc_reason CADMatch

TWO-STAGE DETECTION USING CAD MODELS

Stage 1: Object detection and pose estimation using machine learning (CNNs). Automated training procedure on simulation images, no manual labeling required

Stage 2: Object pose refinement to reach target accuracy

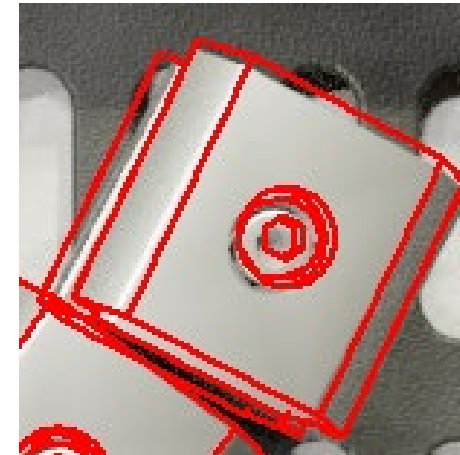


rc_reason CADMatch

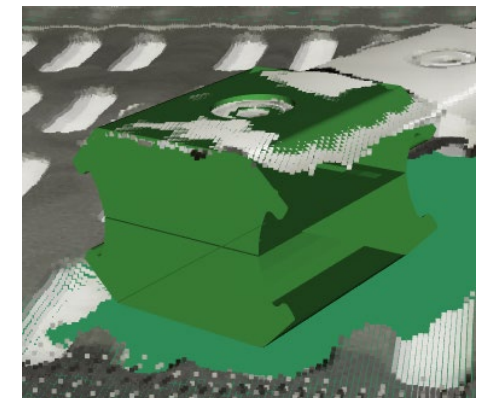
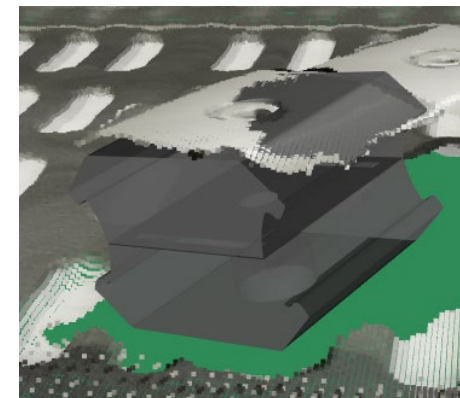
EDGES AND POINT CLOUD ALIGNMENT FOR ACCURATE DETECTION

- Object poses estimated by the AI component are refined to reach the target accuracy
- The pose refinement component:
 - Aligns edges in the CAD model to edges in the 2D image
 - Aligns the CAD model surface to the 3D point cloud
- Advantages of this solution
 - Robustness to environment conditions from AI component
 - Robustness to missing data in 3D reconstruction
 - Leverage multi-object view from stereo system

Stage 1



Stage 2



rc_reason CADMatch FROM 3D CAD MODEL

Input data to template generation pipeline:

- CAD model (with sub-millimeter accuracy)
- Picture of the part
- Application description, e.g. use-case (bin picking, structured picking) and expected working range



CAD model
and use-
case data



Generated
CADMatch
template file
(.rccmt)



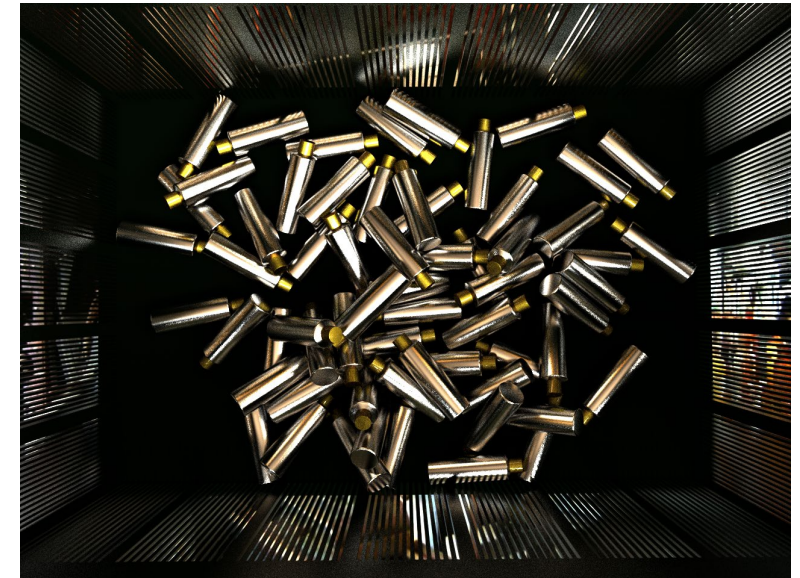
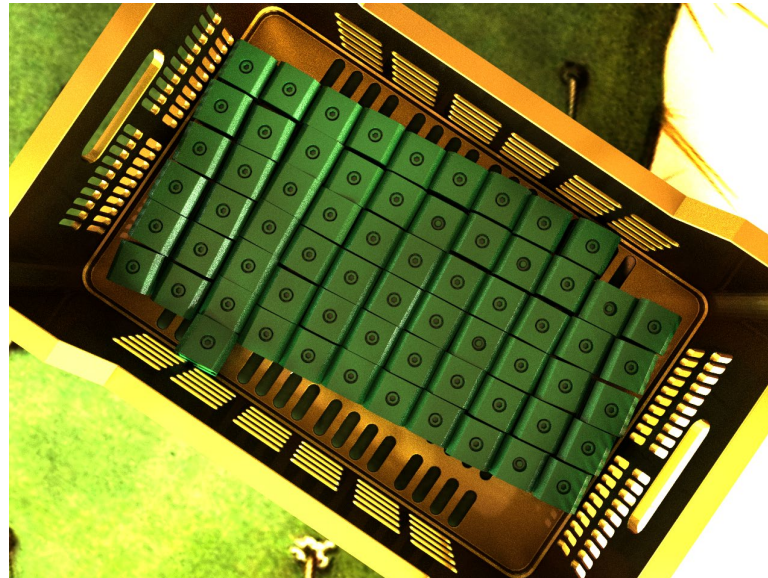
CADMatch
Simulation
Report

Template Optimization:

- Parameter optimization using recorded data
- Training data set (approx. 300 simulated images) enrichment with real data (1-5 images)

CADMatch Template Generation SIMULATION ENVIRONMENT

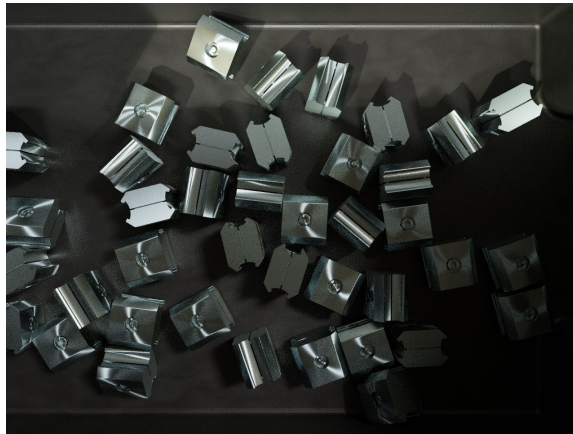
- Training images generated in a photorealistic simulation environment
- Large material library for robustness against color response and lighting conditions
- Requires **no on-site** data recording
- Support for different use-cases and multi-material parts



CADMatch Template Generation

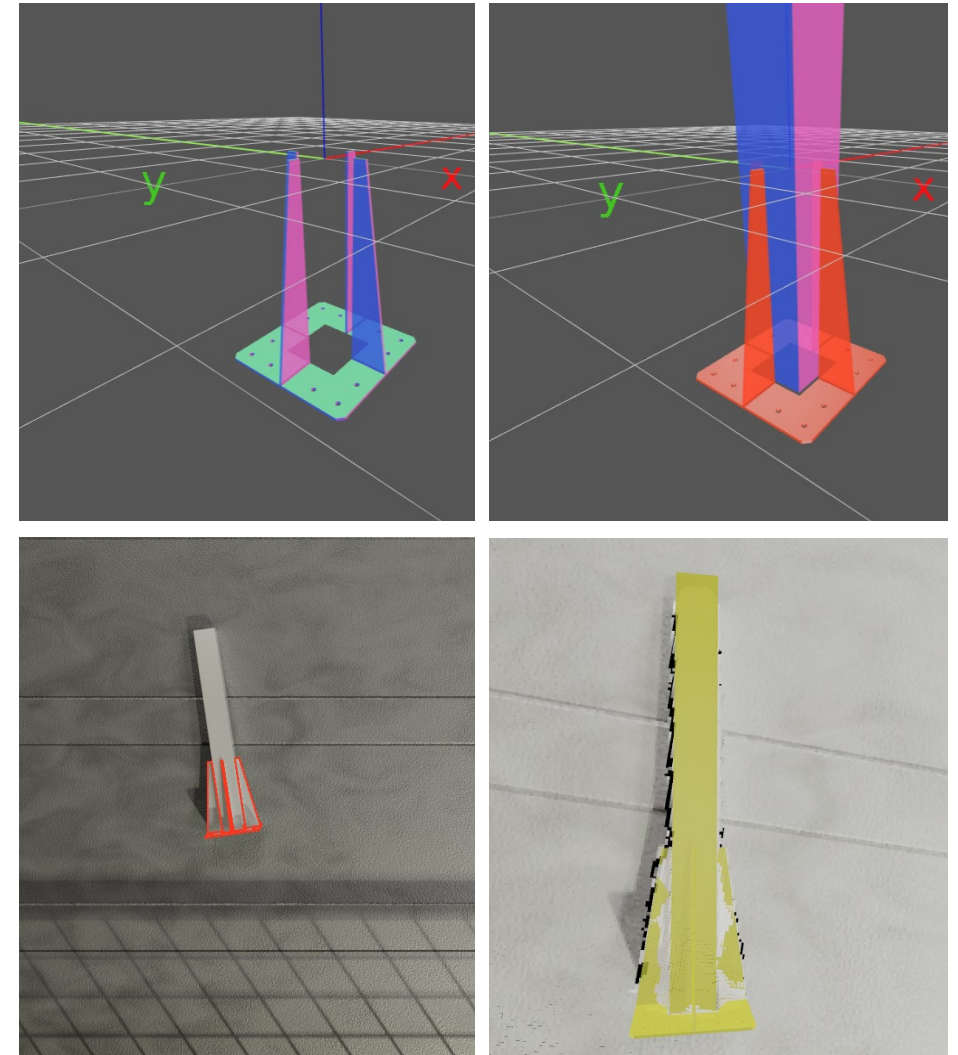
PERFORMANCE EVALUATION IN SIMULATION ENVIRONMENT

- The simulation environment is also used to estimate the achievable detection accuracy for each part
- The 3D point cloud is computed using Roboception stereo algorithm from a simulated stereo image pair (high realism of 3D data, including sensor noise)
- Training can be enriched with real data
- Simulation results included in a report provided with each template



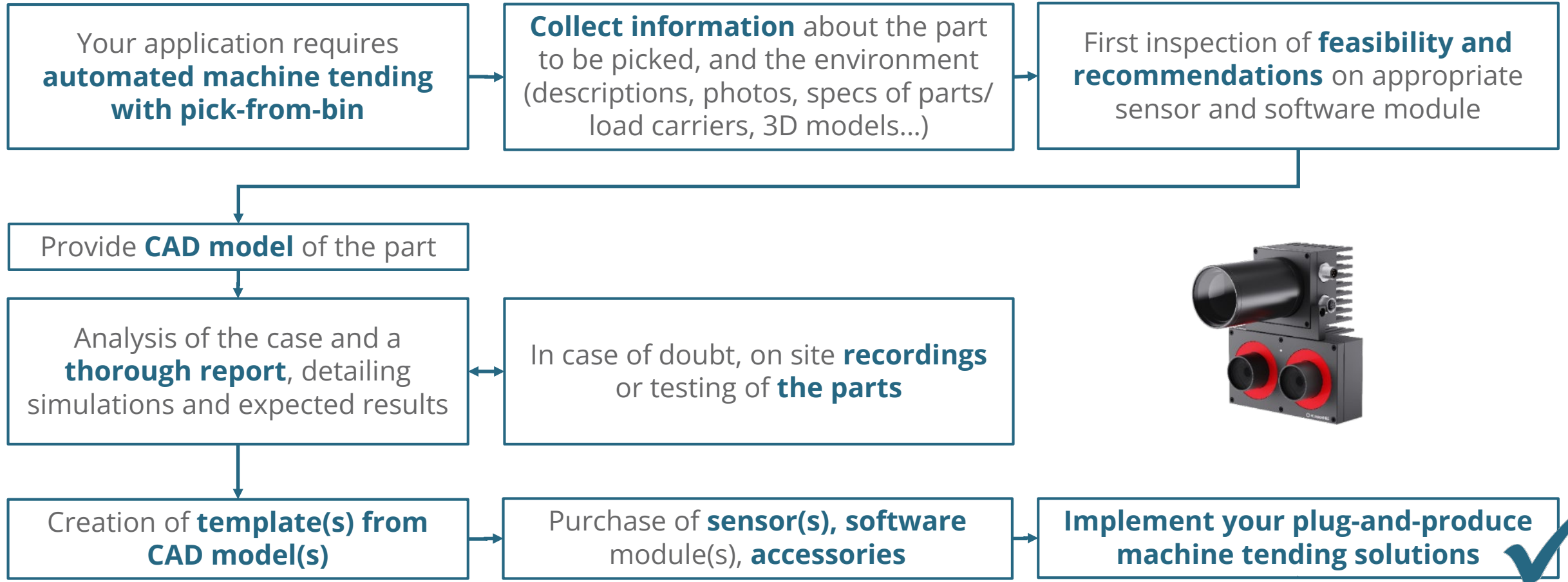
CADMatch Template Generation PARTIAL TEMPLATES

- Enables detection of portions of a complete CAD model (partial objects)
- Target use-cases:
 - Large objects that cannot be entirely in one camera view
 - Objects that are highly occluded when placed in a bin (e.g. large stacks of flat parts)
 - Configurable objects (e.g. a switch that can change between two configurations)
 - Partially solid objects: object that have a partially soft or changing structure (e.g. brushes)



Getting Started with Robot Vision

Getting Started on a Machine Tending Project SIMPLE STEPS TO A SUCCESSFUL IMPLEMENTATION



rc_reason SilhouetteMatch

HANDLING AN ENORMOUS AMOUNT OF PARTS THANKS TO 3D VISION

“We have been quite impressed with the camera’s ability to detect parts etc. from a far distance [...], and the support from the Roboception team, they have been easy to get in touch with and very service minded.”

QRS

- QUALITY ROBOT SYSTEMS



<https://qrs.dk/2020/11/09/automatiseret-produktionsanlaeg-der-kan-haandtere-81-forskellige-emner/>

Clever Eyes: Pick & Place of Boxes

rc_visard 160 | rc_randomdot | rc_reason BoxPick

Challenge: The workers in the incoming goods department of the sales center at Würth struggled with monotonous manual labour for commissioning the single orders.

Roboception enables the identification of grasp points for suction grippers on each box independent of its size to allow for precise picking operations, while delivering the orientation of the box for exact placement.



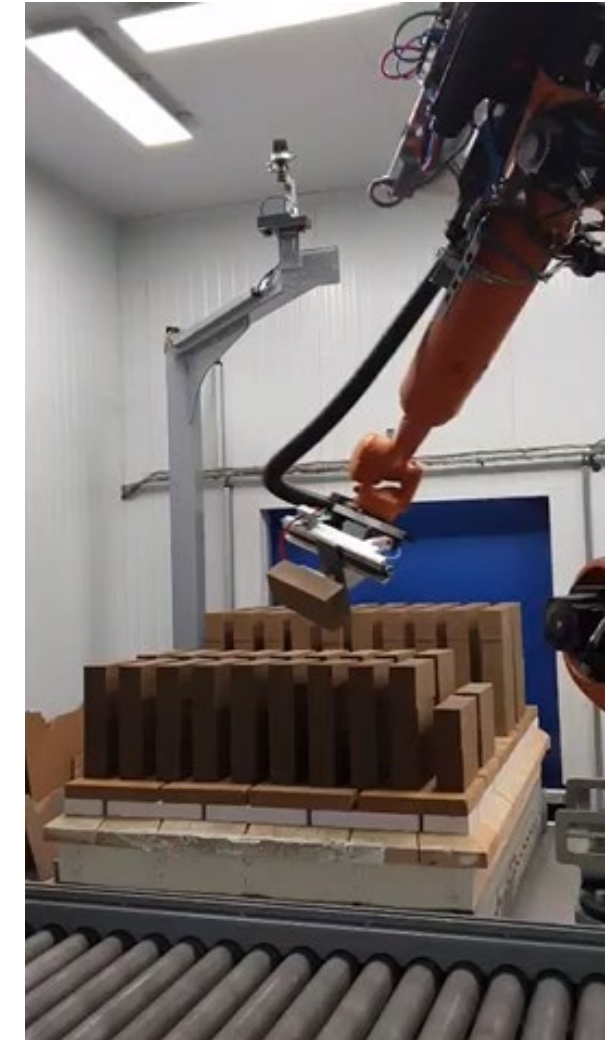
<https://www.schmalz.com/en/about/news/press-releases/application-report-wurth/> | Footage: © J. Schmalz GmbH

Depalletizing of Oven Bricks

rc_visard 160 | rc_randomdot | rc_reason BoxPick

Challenge: Depalletizing of oven bricks that are not 100% uniform, stacked in varying positions; sizes can change with the baking process.

Roboception's BoxPick module enables a reliable recognition of rectangular surfaces of all kinds and therefore a robust identification of the bricks and the definition of the required grasp points.



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