Spin-off
of University of Padua

IT+Robotics

MAKE IT AUTONOMOUS

Flexible Visual Inspection

IAS-13 – Industrial Forum Horizon 2020

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www.it-robotics.it

IT+Robotics

- Spin-off of University of Padua founded in 2005
  - Strong relationship with IAS-LAB (Intelligent and Autonomous Systems Laboratory)
- Mission:

Increase the flexibility of industrial processes by transforming the latest results of the academic research into industrial solutions.

IT+Robotics

What we do

- Technological transfer in the following fields:
  - Automation
    - Robotics simulation for off-line programming
    - Real-time systems for machine control
  - Machine vision
    - Visual inspection for quality control
    - Robot guide
- International research projects
  - 4 FP7 projects (robotics vision and simulation)
  - 2 national projects (video surveillance)

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Where we are

- Registered Office
  - Vicenza
- Operating Office
  - Padua
- Deep collaboration with:
  - IAS-LAB (University of Padua)

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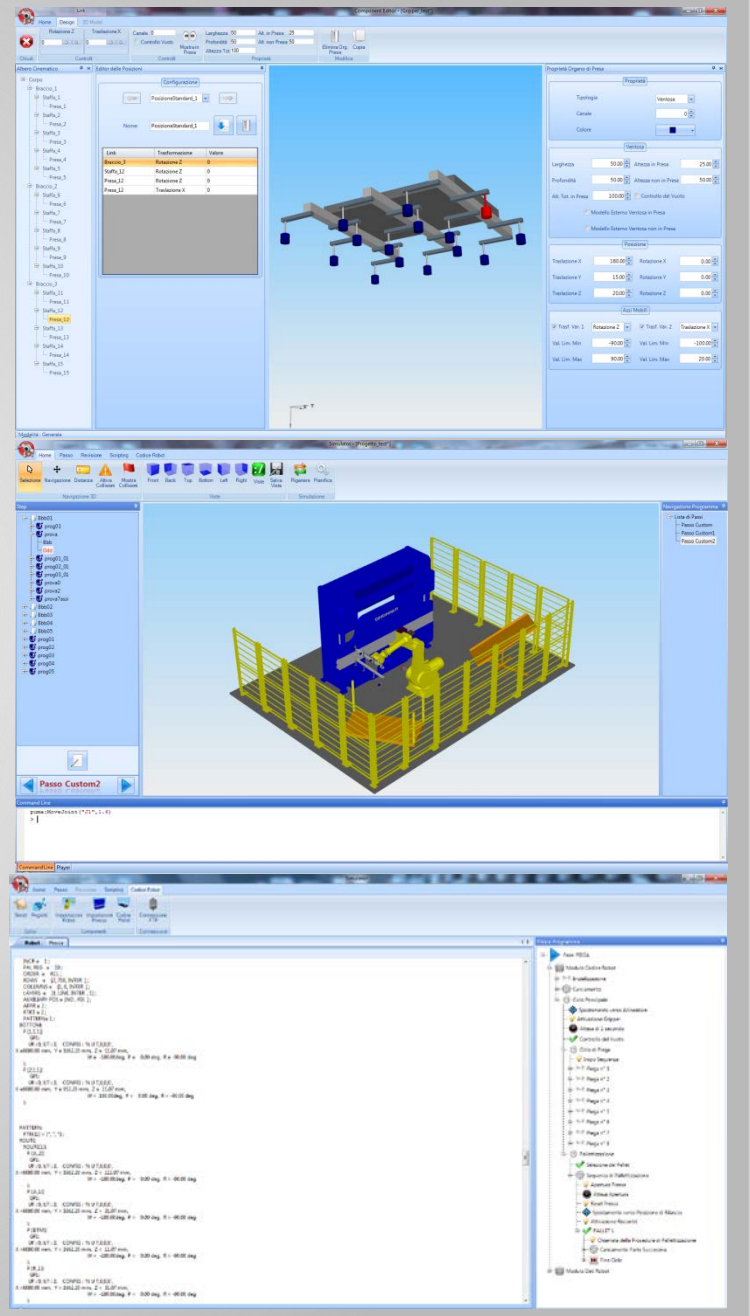
Workcell Simulator

- Software suite for off-line programming of work cells
  - Create the workcell
    - Modular plug-in architecture to adapt easily to any process
  - Simulation
    - Cutting-edge algorithm for automatic motion planning
    - Scripting engine to customize process
  - Controller code generation
    - Vendor independent code generation



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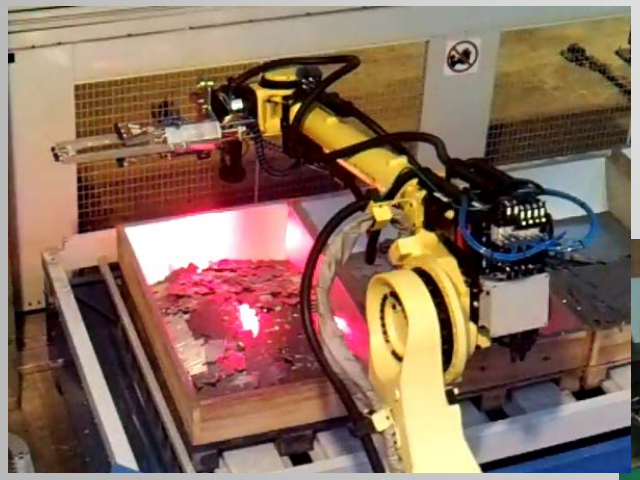
Smart Pick 3D

- Turn-key solution to random bin picking
- Key features
  - Model loaded using CAD or based on template
  - Robust to illumination changes
  - Single camera, multiple cameras, laser triangulation



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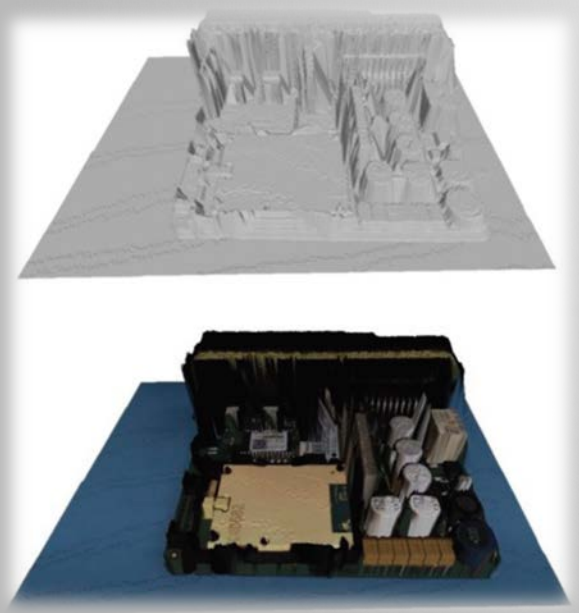
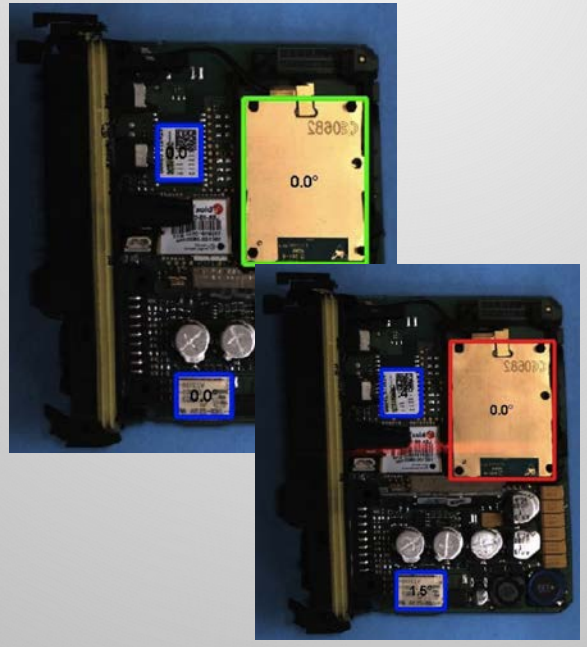
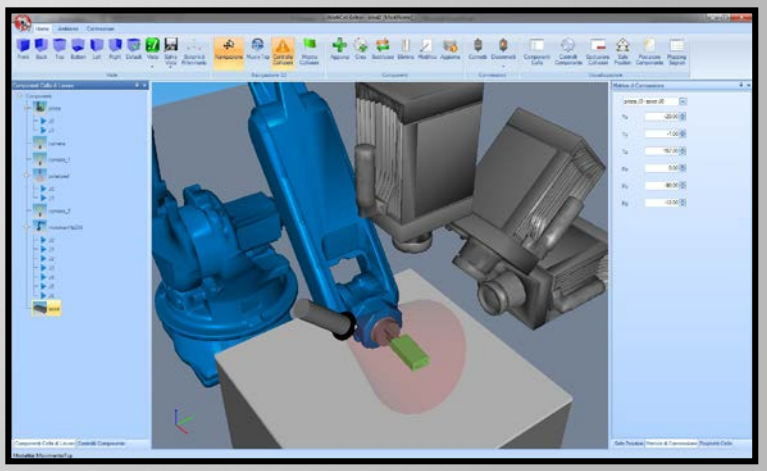
Smart Check 3D

- Vision system for visual inspection
- Key features
  - Robot manipulator to move the vision system OR the product
  - Off-line definition of inspection cycle







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Flexible visual inspection

SMART CHECK 3D

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Cost-effective visual inspection

- Introduction of visual inspection systems is not a matter of technical flexibility but of economic efficiency
- SMEs willing to archive lean production paradigm
  - Small batch size (down to the size of one)
  - Frequent introduction of new product models and change of product's quality assessment requirements

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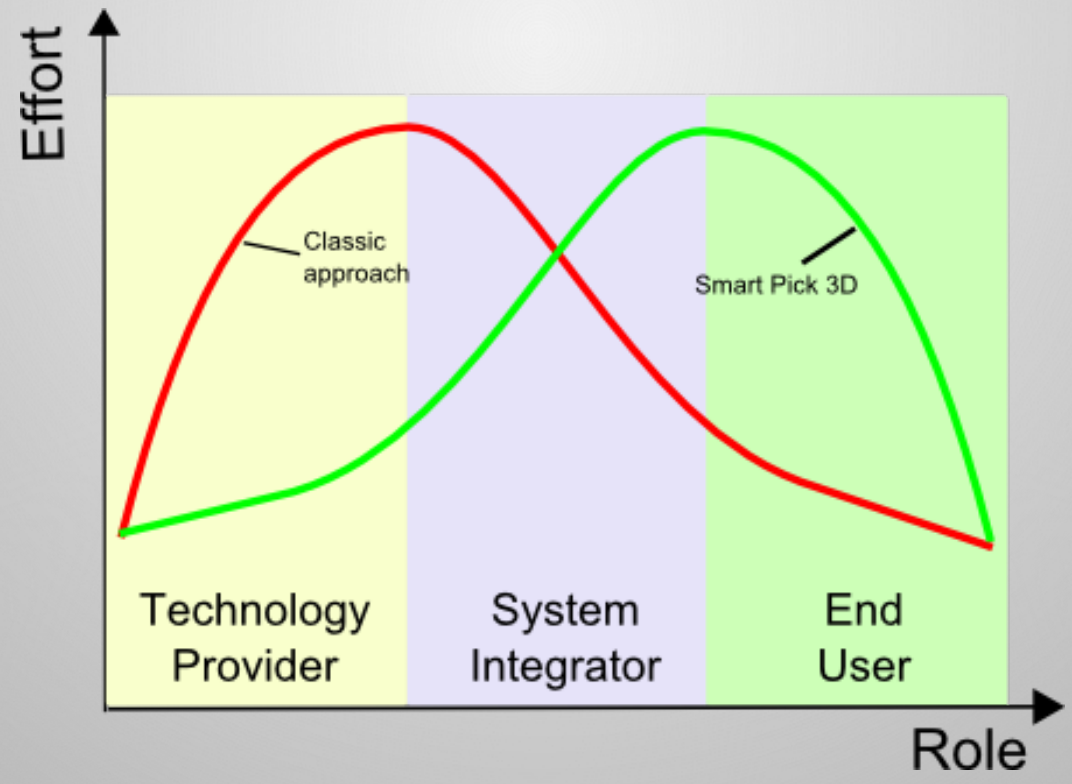
Cost-effective visual inspection

- Shift of programming effort to end-user
  - End-user must be able to introduce new products and rapidly change quality assessment requirements without requiring system integrator effort
  - Programming must be performed offline



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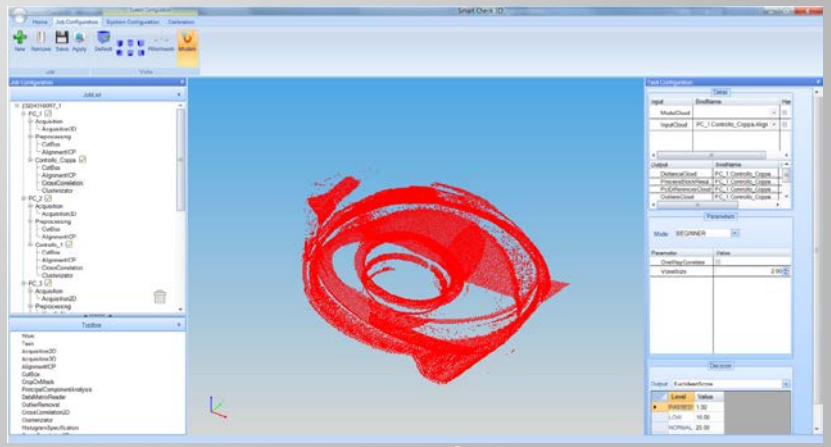
Objectives

Flexibility

- One work cell for many (different) products
- Archived using robot manipulator (to move the vision system OR the product)

Ease of programming

- Programming performed by end-users
- Archived using software developed to fully define inspection cycle offline



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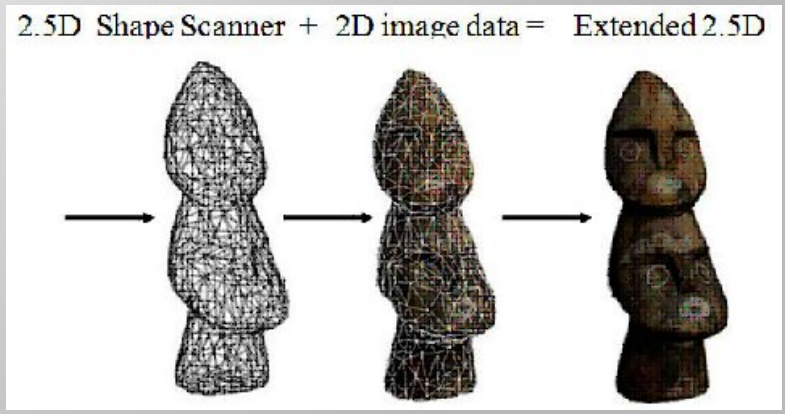
3D Complete

- Efficient 3D completeness inspection
- FP7 European Project
  - 2 years, start date September 2010
  - Research for SME (FP/-SME-2010-1)
- Objective:
  - Build a efficient system for 3D completeness inspection on assemblies combining both 3D shape and texture
    - Typical checks: presence of a part, part id, part position and orientation, …



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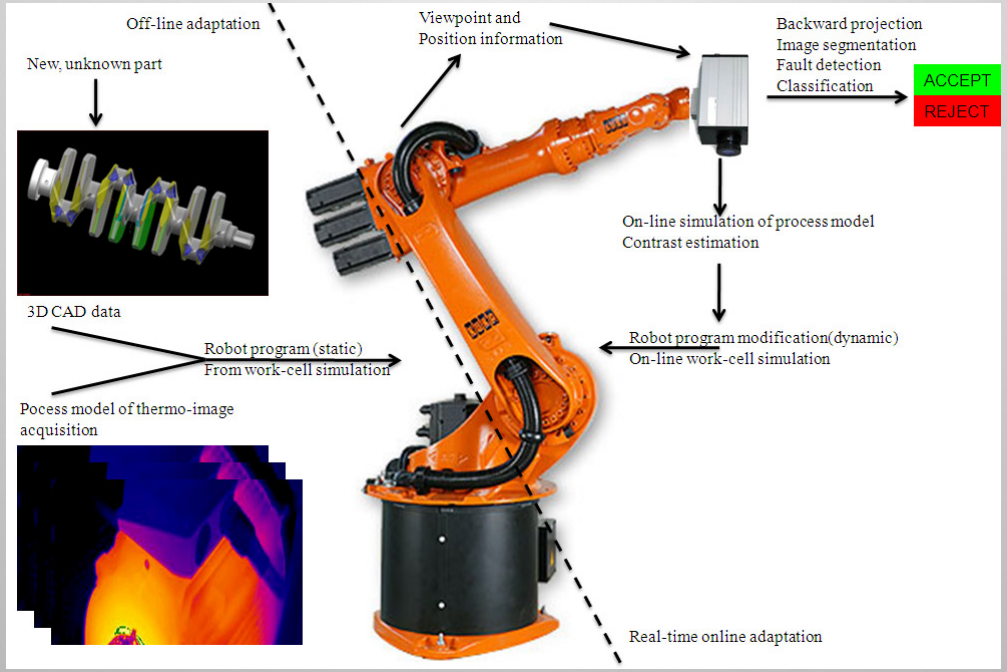
Thermobot

- Autonomous robotic system for thermo-graphic detection of cracks
  - FP7 European Project
  - 3 years, start date January 2012
  - Factory of the Future (FoF.NMP.2011-3)
- Objective:
  - Detection of cracks using thermography
  - Automatic definition of process using off-line programming starting from CAD data
  - Online adaptation of process using feedback from camera



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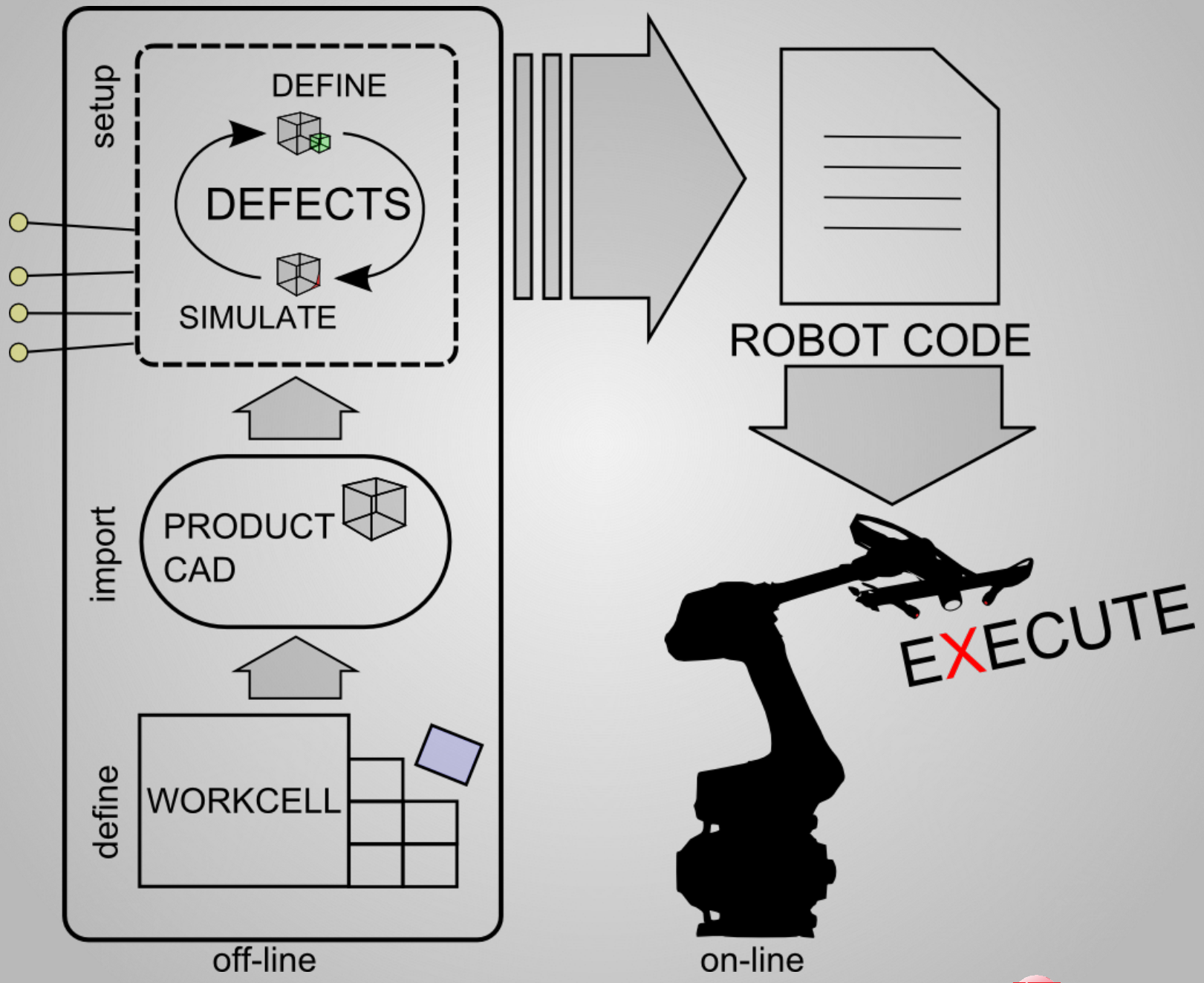
Smart Check 3D

- IT+Robotics solution for visual inspection:
  - Combines 3D vision and 2D vision using a single sensor
  - Focused on completeness inspection, but can be extended to any visual inspection check
  - Two configurations:
    - Product on conveyor belt: maximizes cycle time
    - Vision system mounted on robot: maximizes flexibility
- Advantages of our solution:
  - Combination of 2D and 3D
  - Offline programming software to define inspection cycle
    - Easy to configure & re-configure
    - Automatic computation of viewpoints
  - Auto-calibration procedure
  - Fast production change

Workflow



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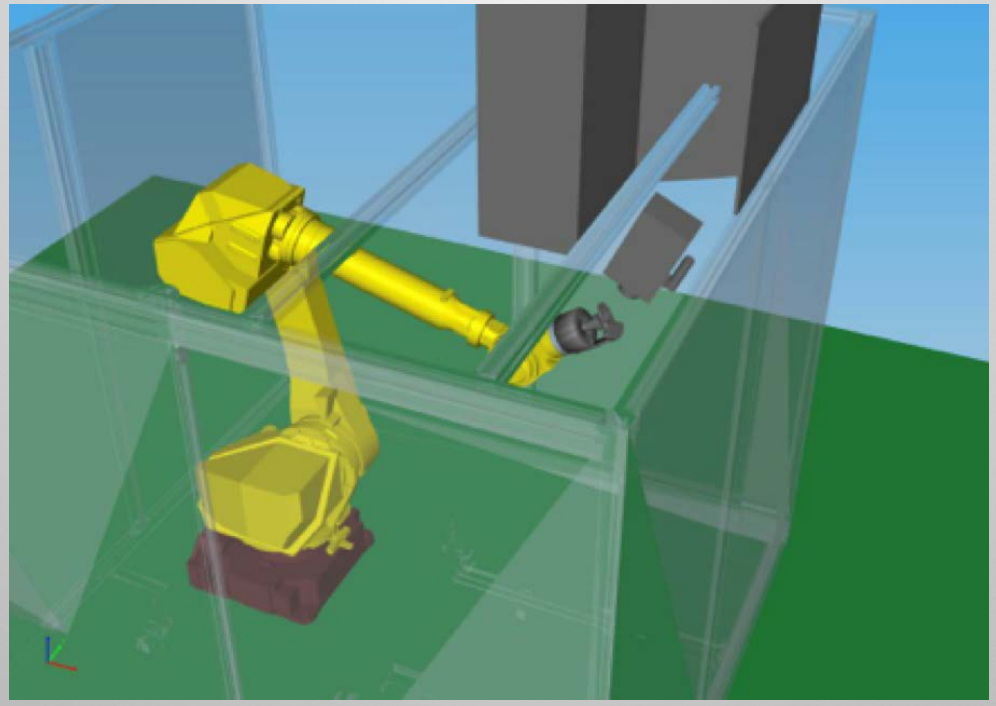
Work cell Definition

- Import components to simulated environment
  - Define robot and other objects in the workcell
  - Define sensor(s)
    - currently standard camera or laser triangulation system
- Perform calibration
  - Sensor calibration
  - Robot-sensor calibration
  - Product position calibration



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Configuration of inspection task

Configure acquisition

- Choose sensor
- Define ROI on the product
- Define required resolution

Configure inspection

- Define inspection task
- Configure parameters

Test inspection

- Virtual defect generation
- Assess quality inspection performance

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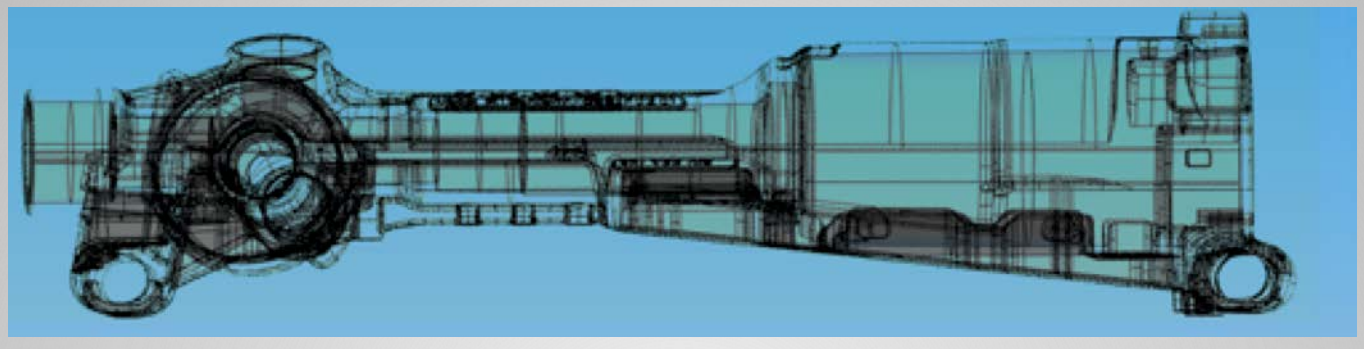
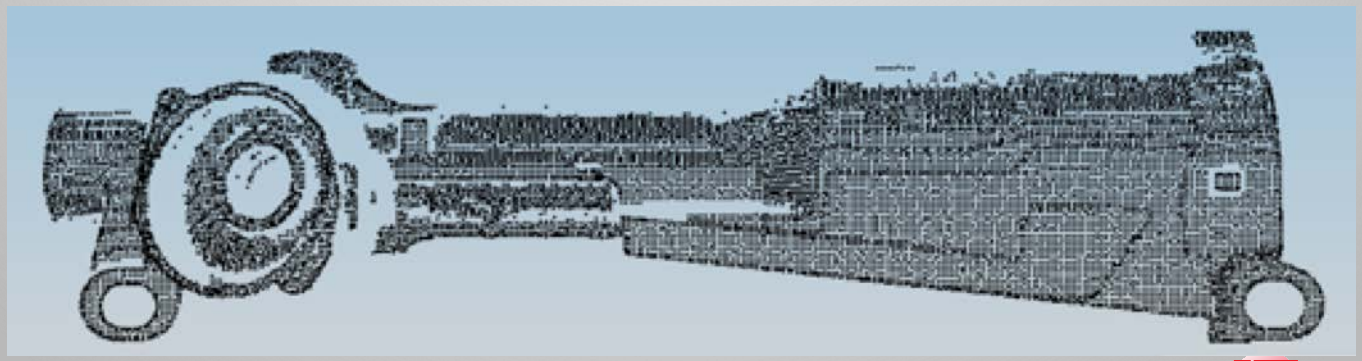
Virtual acquisition



CAD Model

- Region of interest
- Required resolution
- Sensor model and calibration



Virtual acquisition

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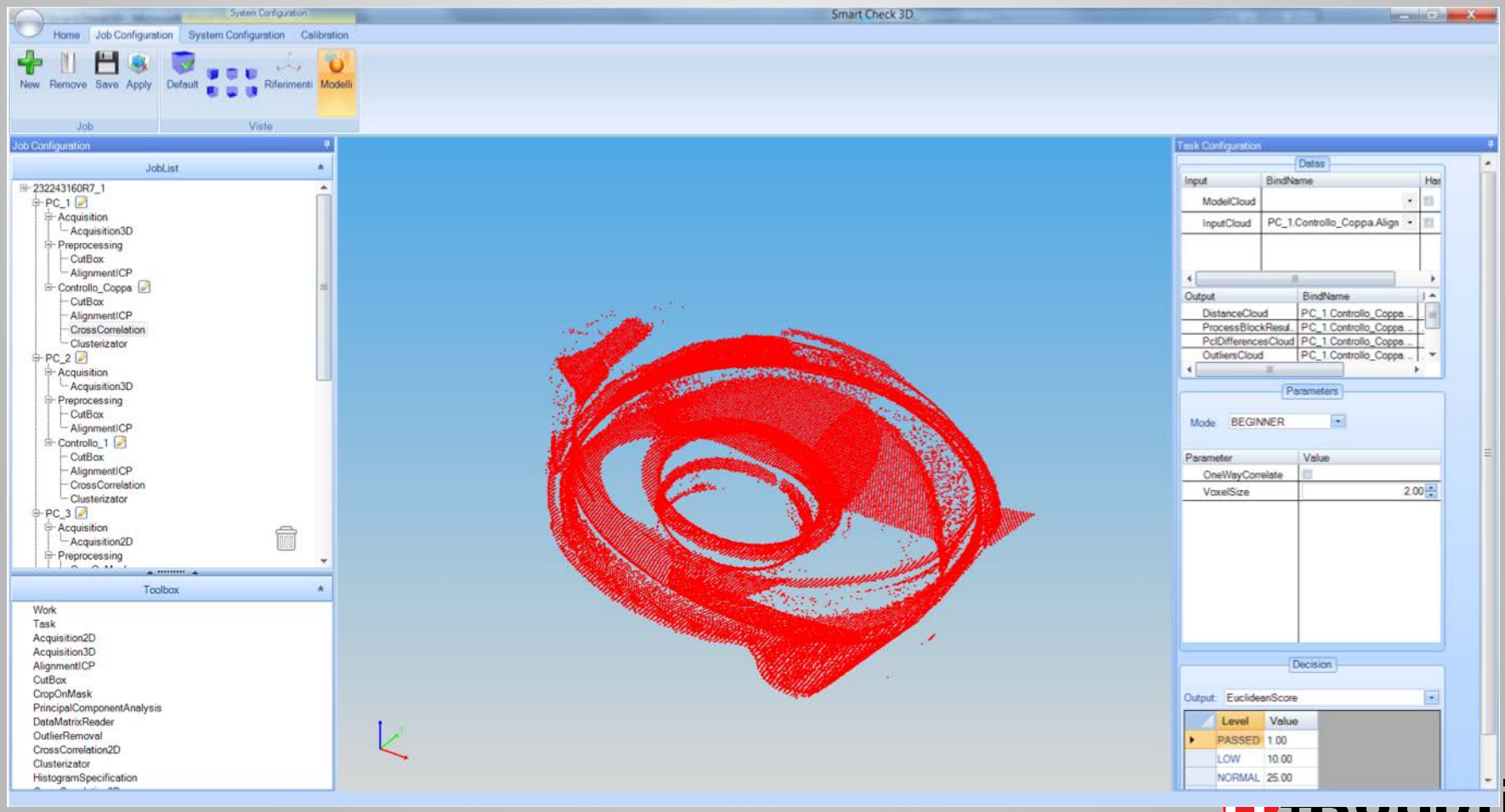
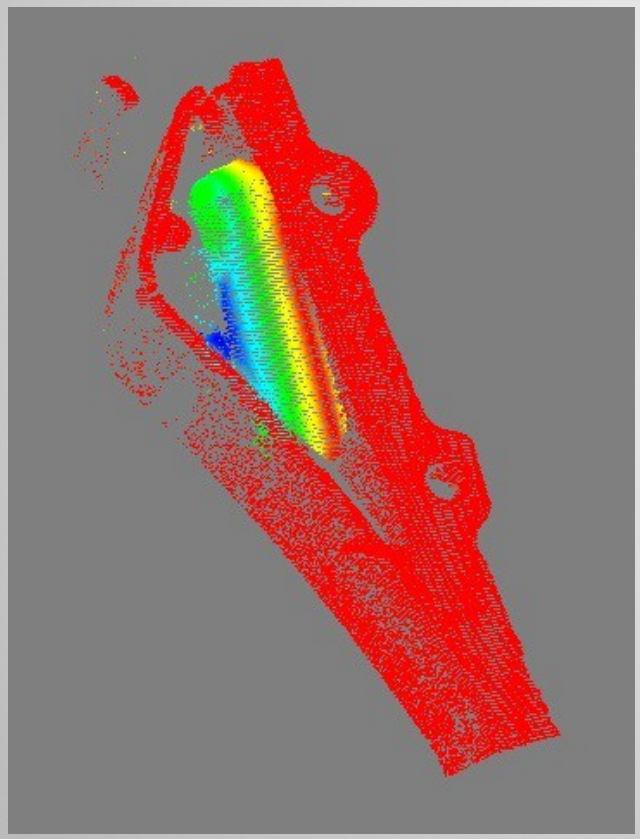
Definition of inspection algorithm

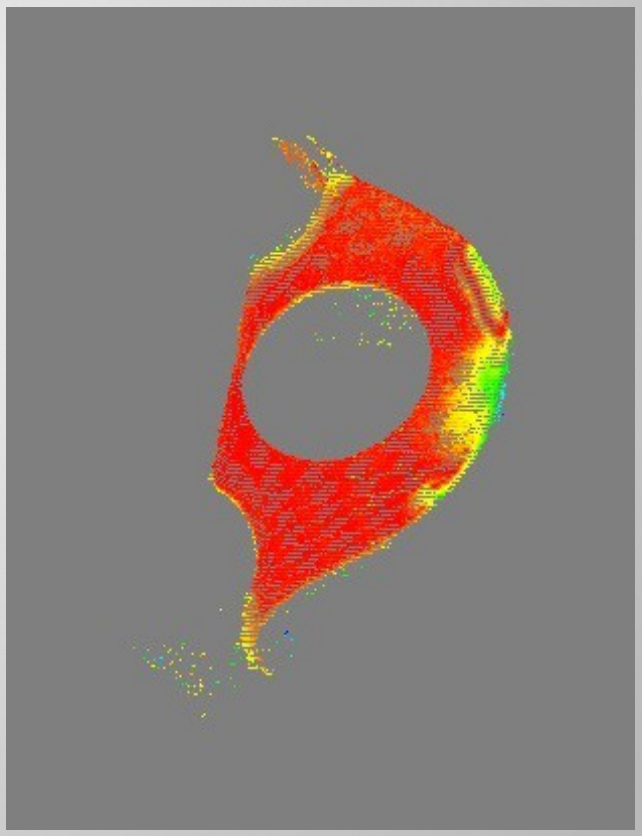
- Add inspection task
  - 3D: alignment, cut-box, cross-correlation, …
  - 2D: alignment, image mask, edge-detection, …



3D inspection

- Sample: completeness inspection
  - Check part presence/absence
  - Measure deviation from reference object





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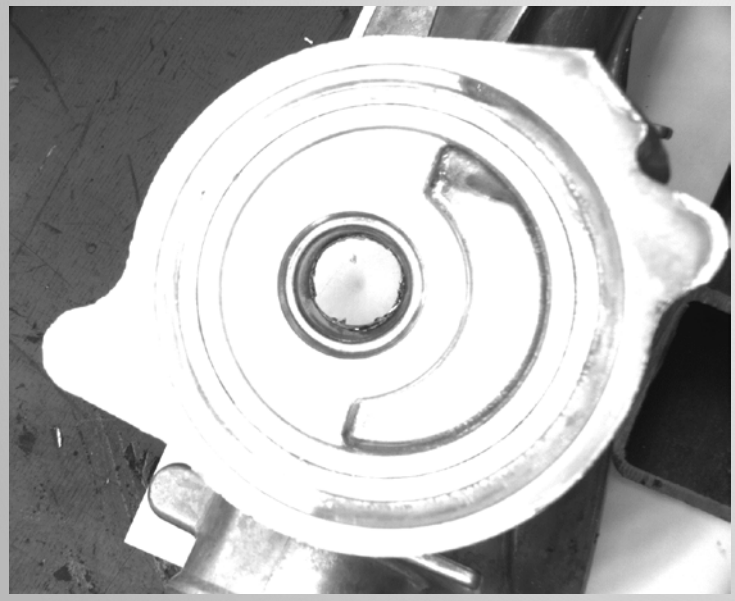
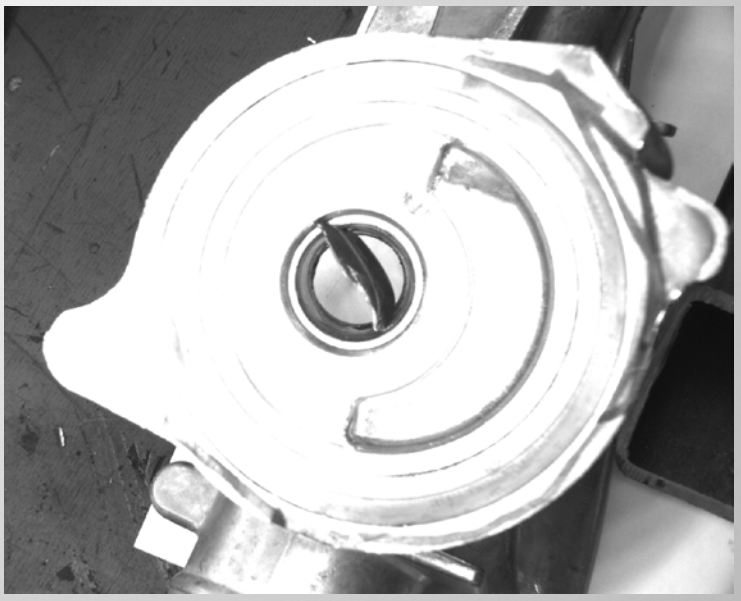
2D inspection

- Sample: check for inclusions
  - Acquisition of reference 2D image
  - Acquisition of 2D image during cycle to compare it with reference

Correct



Defect



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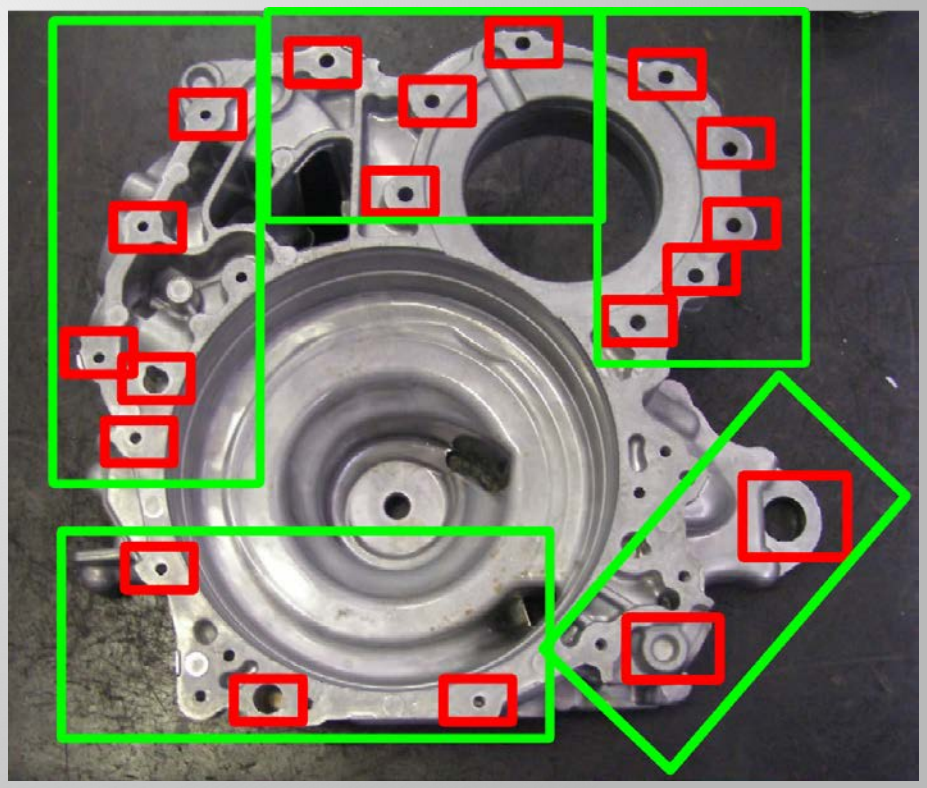
Merging of acquisitions

- Configuration may include several tasks
  - Objective: reduce cycle time
- Definition of groups of neighbor defects may cause performance degradation due to start-stop motion
- Acquisition merging allows to overcome this issue
  - Merge near acquisitions with compatible parameters



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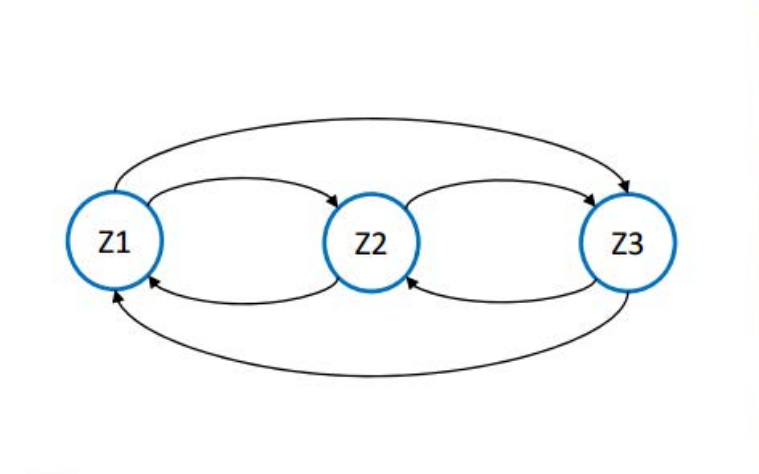
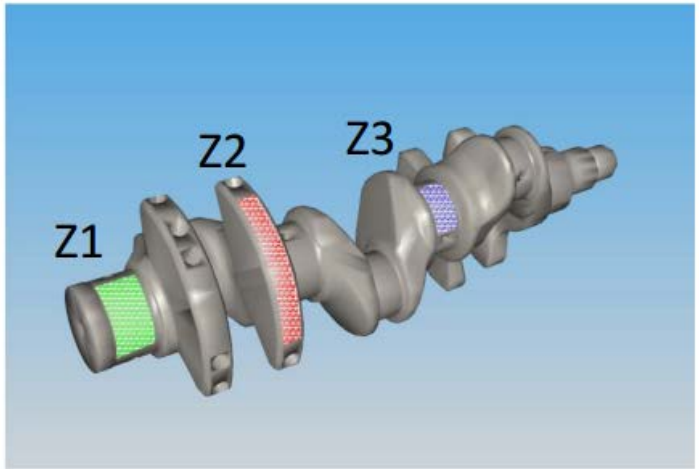
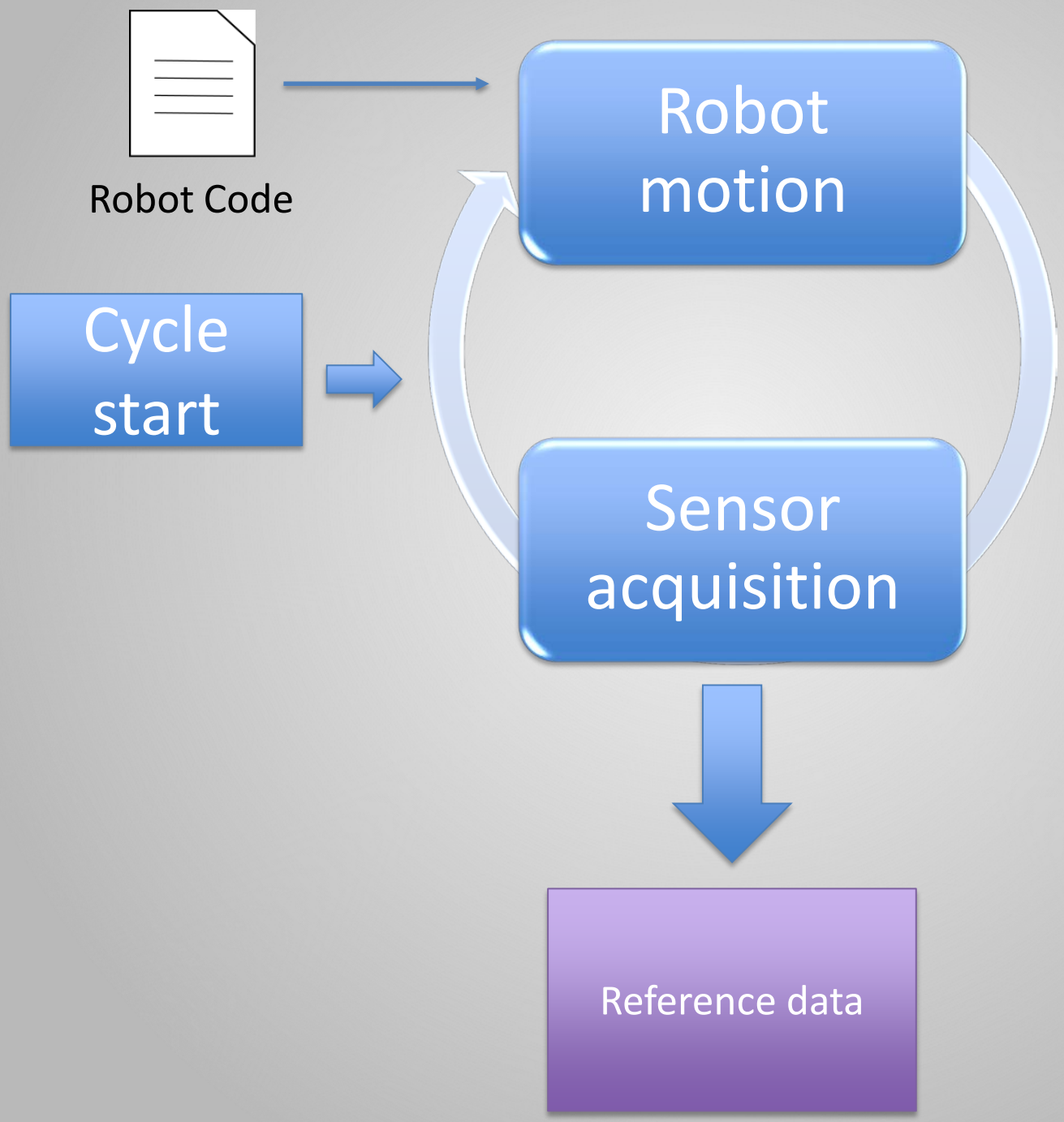
Path planning

- Objective: generate collision-free path
  - Uses motion planning algorithms of WorkcellSimulator to compute a collision-free path between inspection points
- Objective: reduce cycle time
  - Reorder acquisitions to reduce overall inspection time (TSP problem)





Online execution: learning



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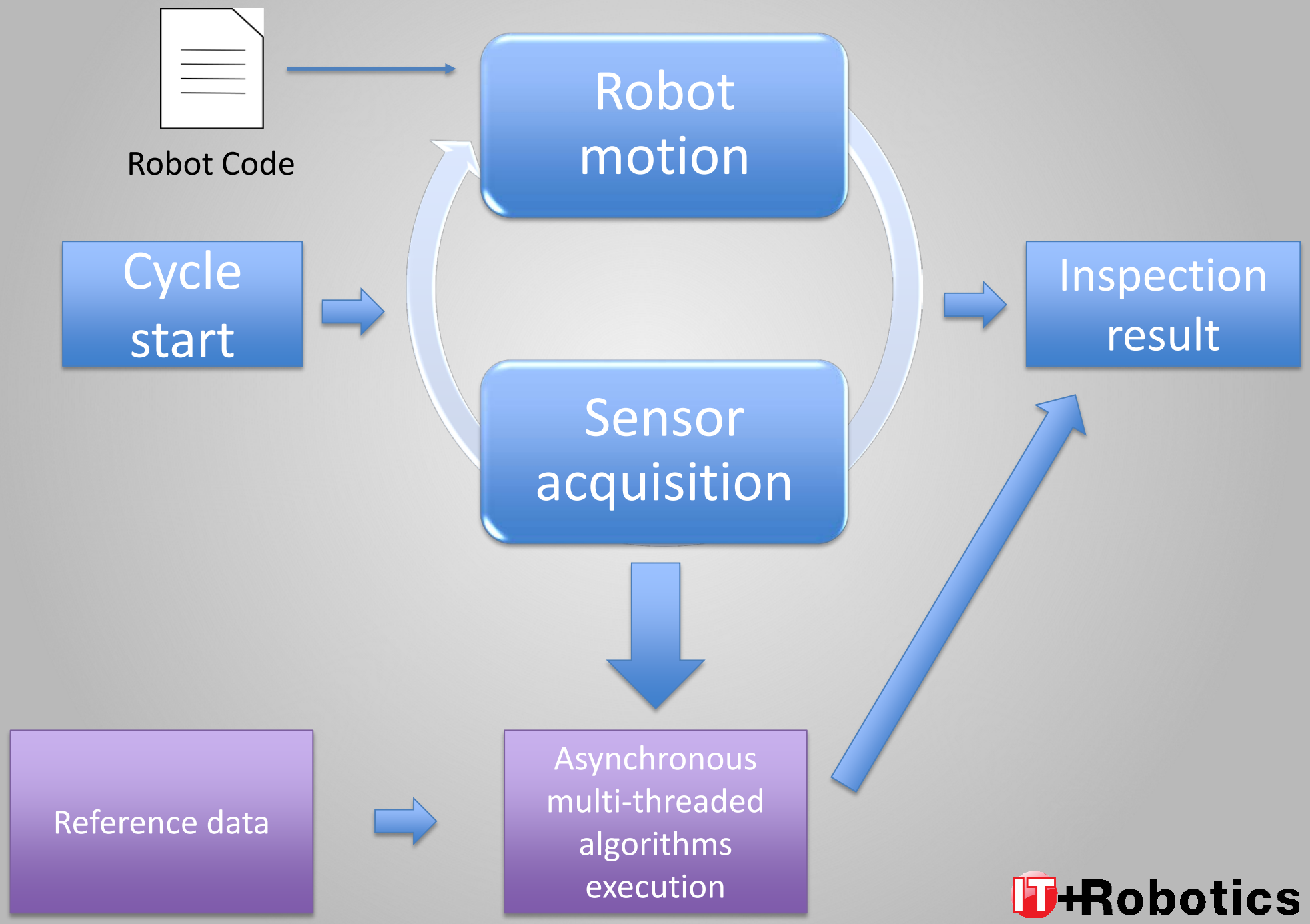
Online execution: inspecting



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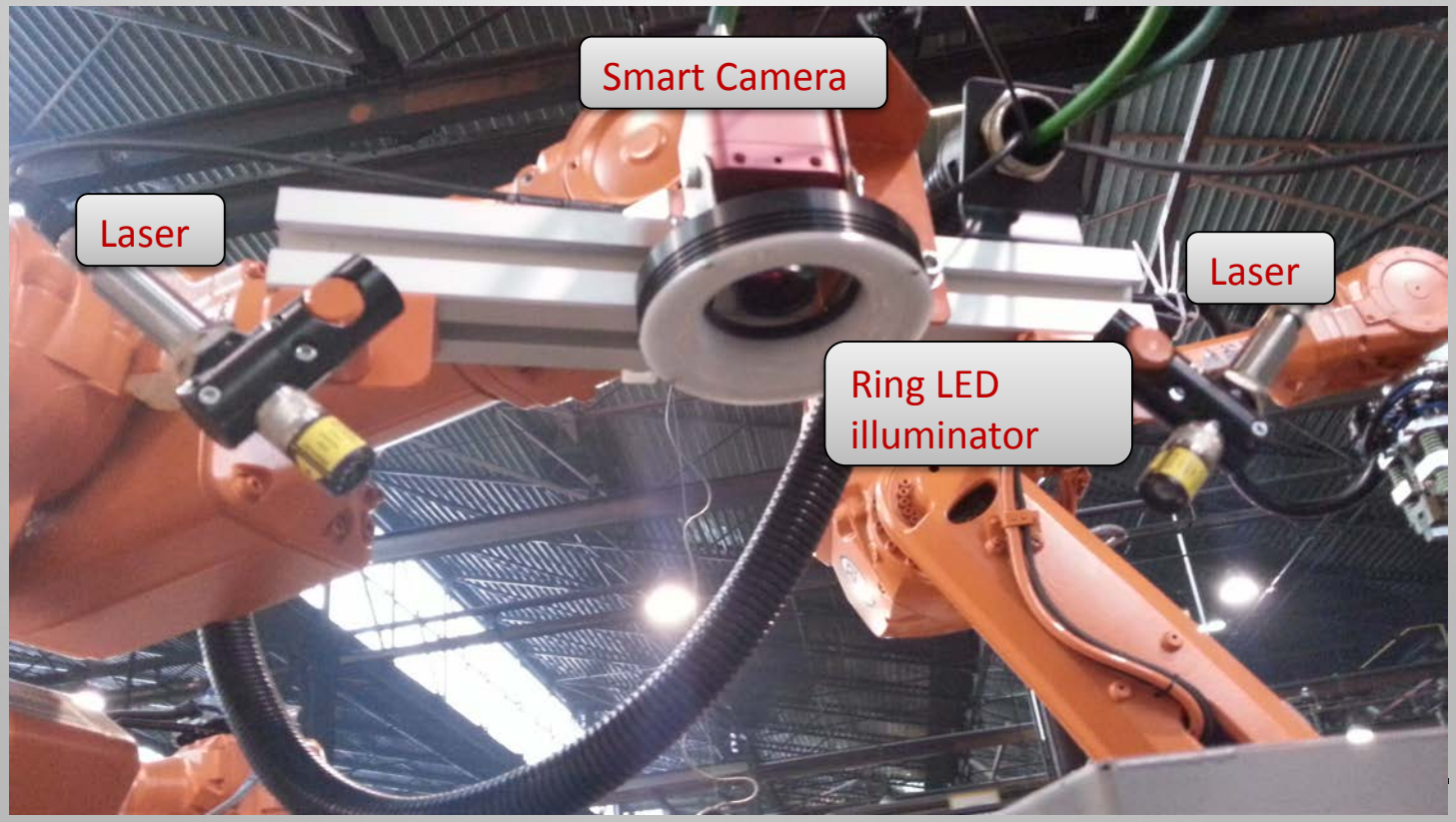
Case study

- Inspection of cast aluminium products for leading supplier in the automotive sector
- Robot manipulator equipped with smart camera featuring peak detection in hardware
  - Dual-laser pattern projector for 3D acquisition
  - Ring LED illuminator for 2D acquisition



botics

Future works

- Metrology
  - Improve precision in the acquisition of point cloud using laser triangulation system
  - Continuous feedback from robot controller to associate precise robot position to each frame
- Online trajectory planning
  - Determine acquisition sequence based on current cycle results
    - E.g.: if doing a rough scan result is uncertain, perform a more detailed scan on the required spot
  - Requires fast online planning algorithms

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THANK YOU

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