MBZIRC Challenge 2 Winner NimbRo

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Autonomous Intelligent Systems

Autonomous Intelligent Systems Robots

- Cognitive robots for challenging domains
- Semantic perception, planning autonomous behaviors

Soccer   Domestic service   Aerial inspection   Space exploration   Bin picking

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Advanced Perception, Planning, and Learning Methods

- Perception
  - RGB-D and laser-based SLAM
  - Semantic mapping
  - Object detection/pose estimation/tracking
- Planning
  - Grasp and arm motion planning
  - Navigation planning
- Learning
  - Deep Learning
  - Transfer of manipulation skills

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Experience with Challenges and Competitions

- RoboCup
  - Humanoid Soccer
  - @Home domestic service
- DARPA Robotics Challenge
- European Robotics Challenges
- DLR SpaceBot Cup
- Amazon Picking Challenge

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Challenge 2 Second Trial

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Omnidirectional Drive

- Directly driven hub wheels

- Yaw actuators

- Three target velocities (x, y, θ)

- Direction and speed of each wheel computed accordingly
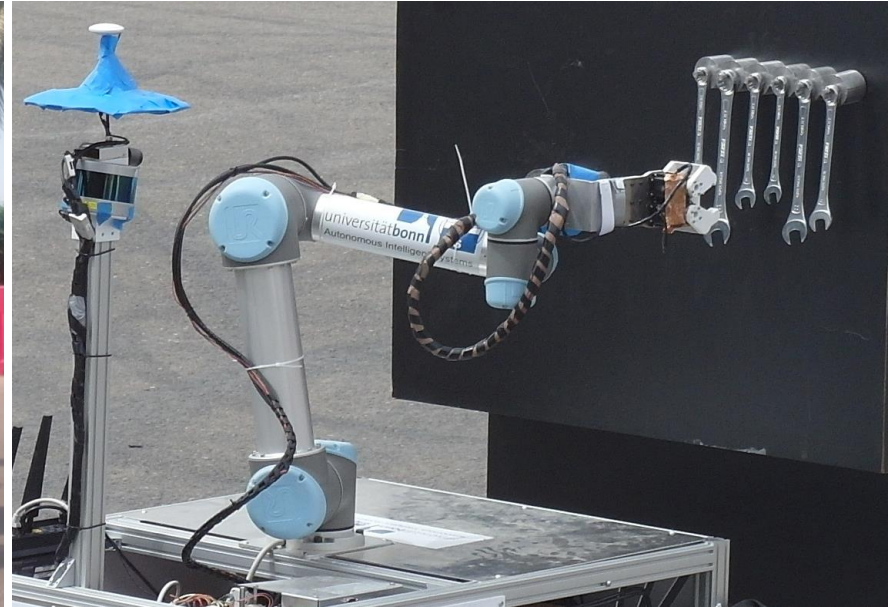

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Panel Detection

- Analyze individual scan lines in Velodyne Puck measurements

- Filter measurements

- Detect object of panel width

- Integrate intensity

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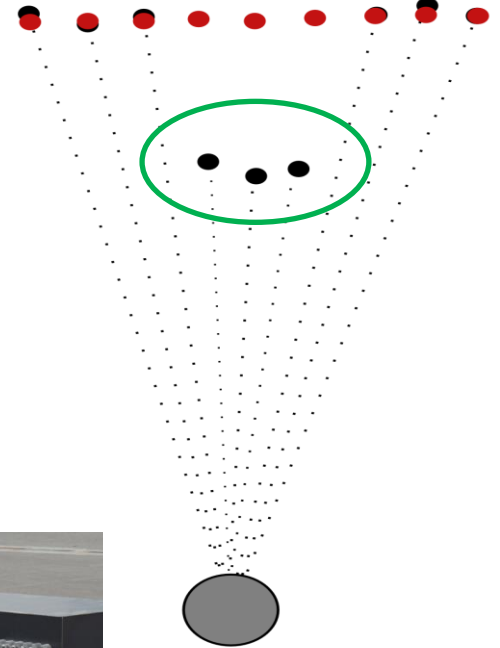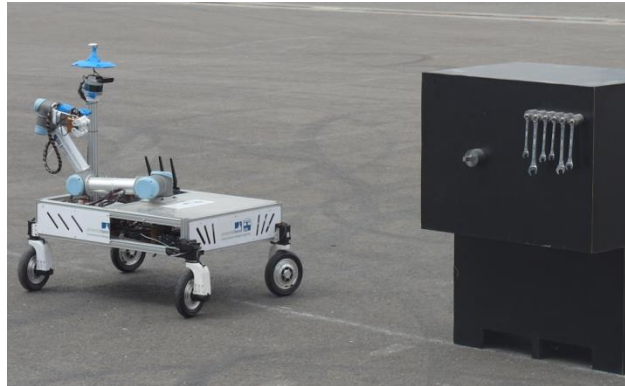
Robot Manipulator

- 6DoF arm (UR5)

- Stereo cameras (Pointgray)
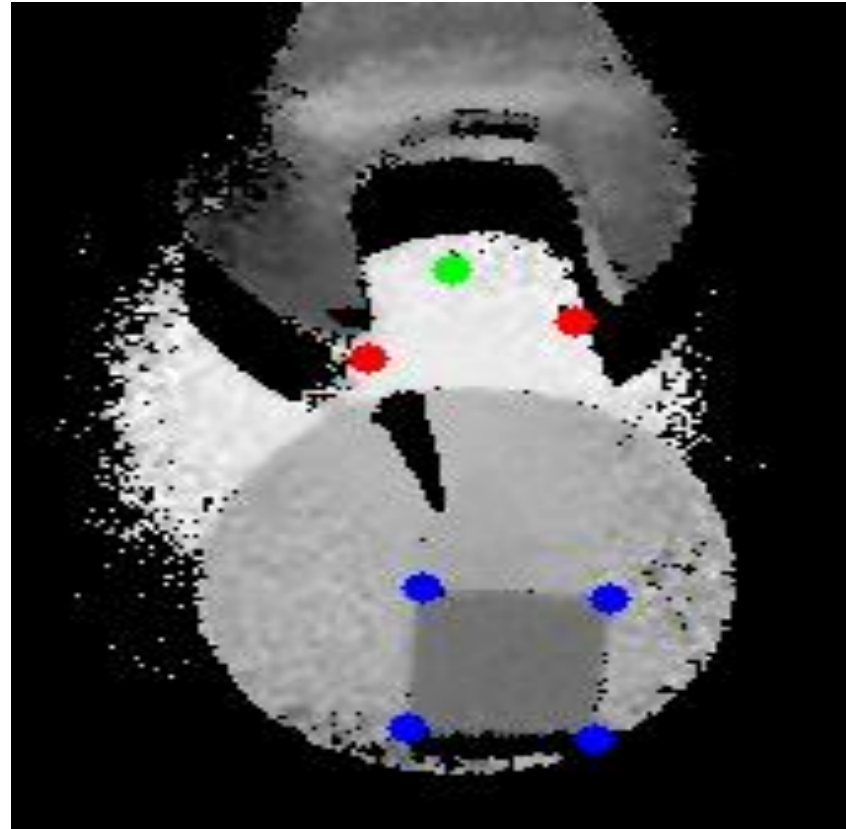
- ToF camera (PMD picoflexx)

- Two-finger gripper

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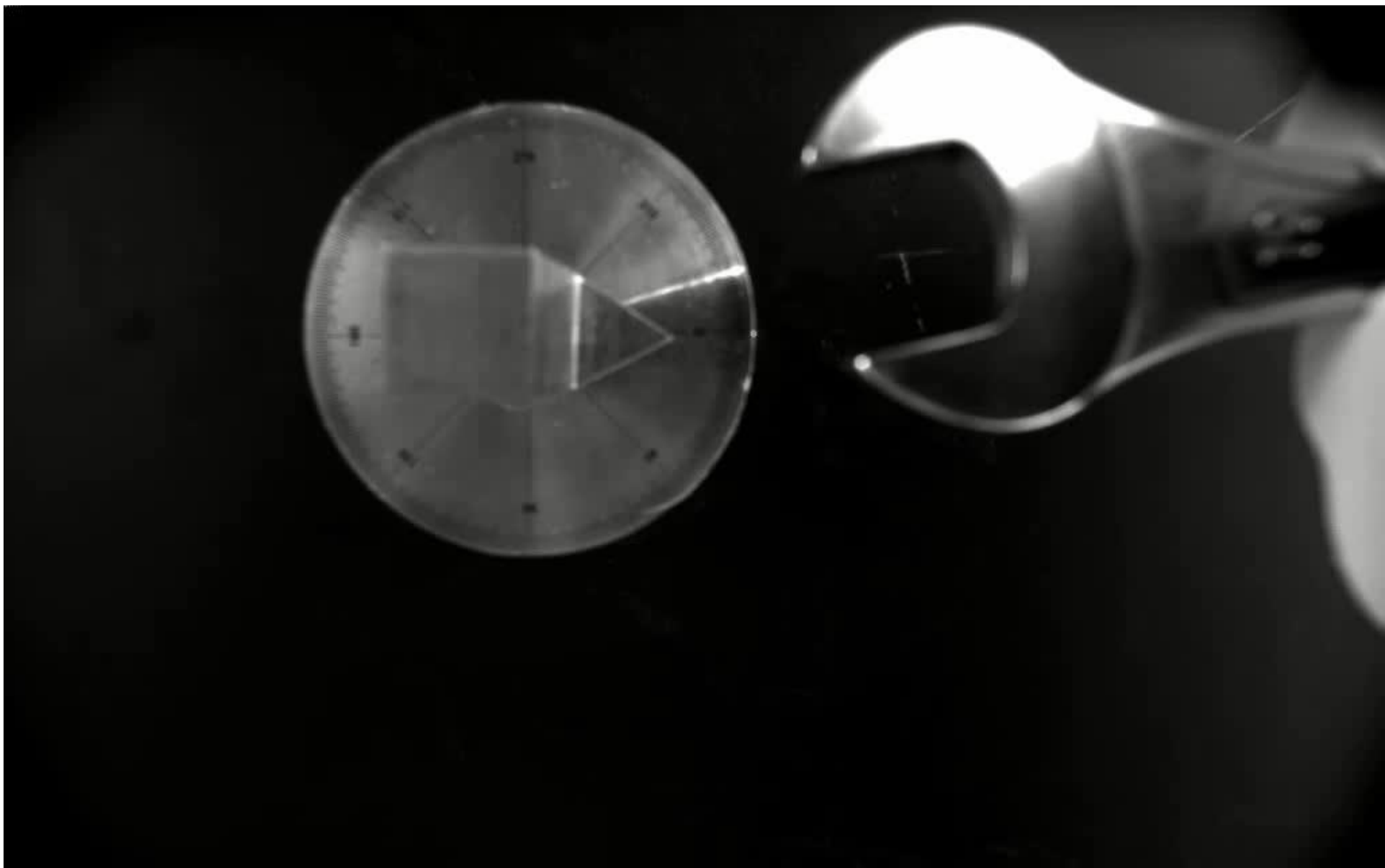
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Wrench Selection

- Deep learning object detection

- Training set: 100 stereo pairs

- Two classes: Ring and mouth

- Expected wrench distance projected into image

- Data association

- Select third largest wrench

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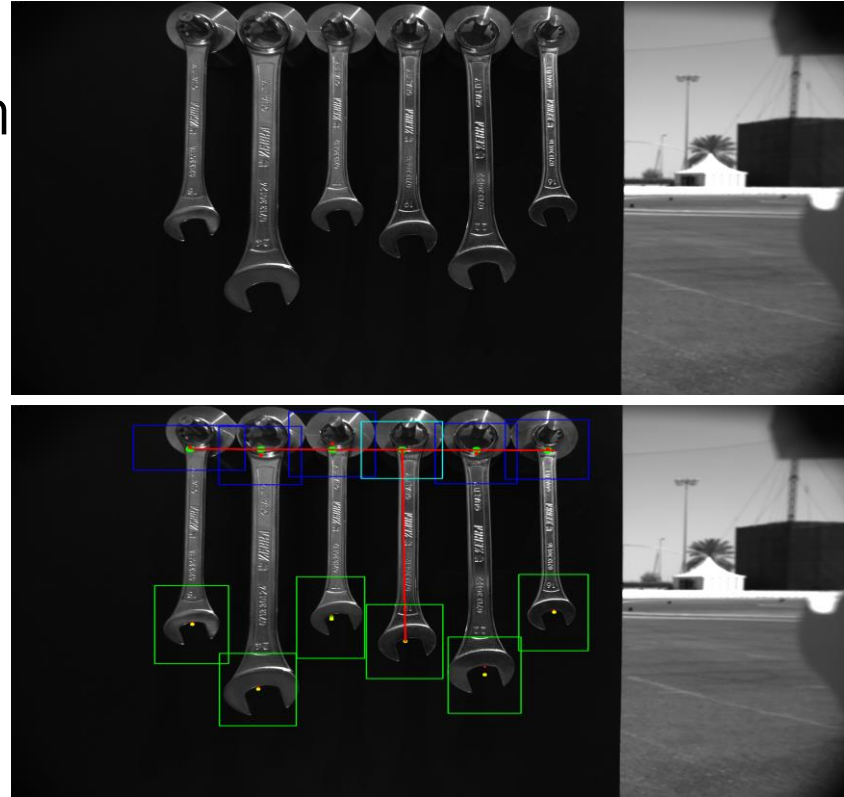
Valve Registration

- Laser based panel ICP gives ~1 cm precision
- Picoflexx Camboard sees wrench and valve stem
- Euclidean clustering
- Rotating calipers for estimating valve stem angle and size

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Wrench Insertion

Operator Situation Awareness

High-level Mission Control (I)

Sequential finite state machine:

1) Navigate along a set of GPS waypoints
2) As soon as there is a panel detection, navigate to the panel position
3) When close enough, circle the panel to the front side
4) Approach precisely using ICP registration

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High-level Mission Control (II)

1) Extend arm, select the correct wrench, grasp it
2) Move to ICP-corrected valve position
3) Detect precise valve position and orientation
4) Insert wrench
5) Turn!
6) Repeat until stopped by operator.

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Challenge 2 Second Trial Robot Perspective

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