DRC Team NimbRo Rescue: Mobile Manipulation Robot Momaro

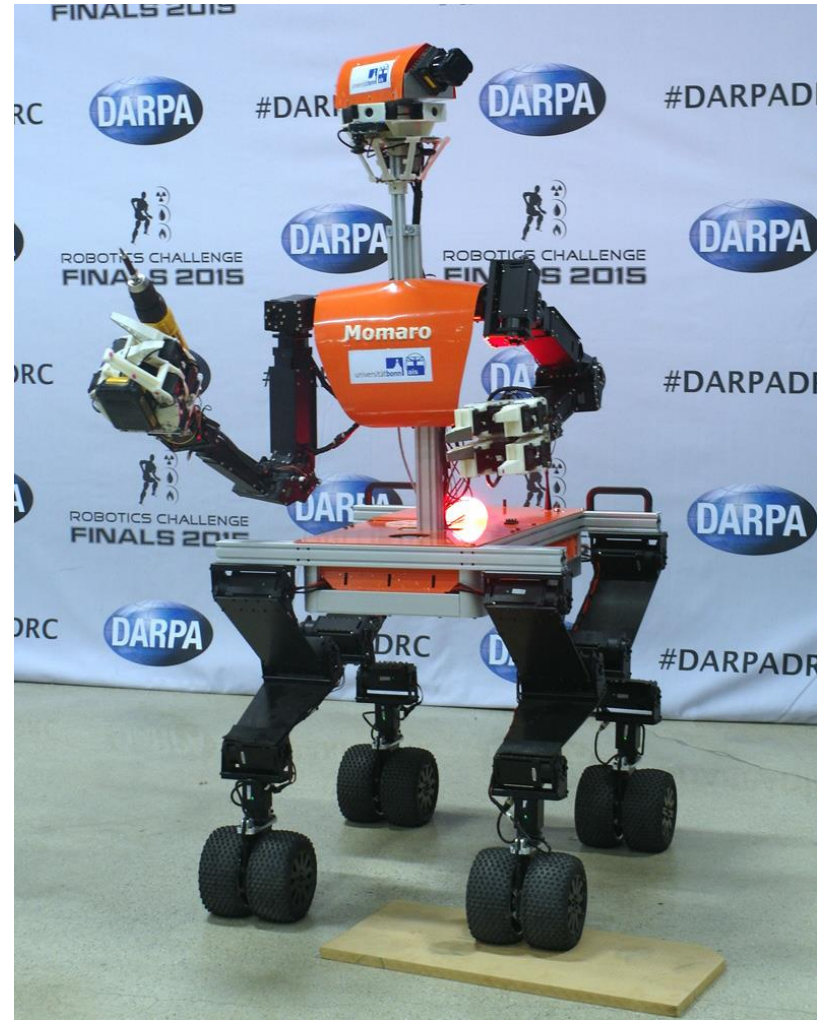**Sven Behnke**

Autonomous Intelligent Systems

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# Mobile Manipulation Robot Momaro

- Four legs ending in pairs of steerable wheels
- Anthropomorphic upper body
  - 7 DoF arms
  - Four-finger grippers with cameras
- Sensor head
  - 3D laser scanner
  - 3 panoramic cameras
  - Wide-angle camera
- Strong CPU (i7 Quad 4 GHz)

[Schwarz & Behnke, LBR, ICRA 2015; Rodehutskors et. al., Humanoids 2015]

Car Driving Operator Interface

- Steering wheel and gas pedal directly mapped to car controls
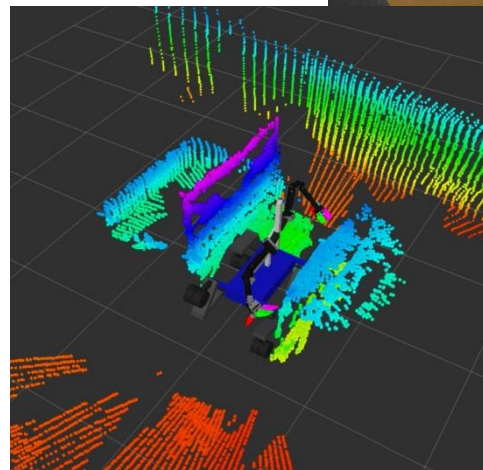
- Good situation awareness through cameras and 3D laser scanner
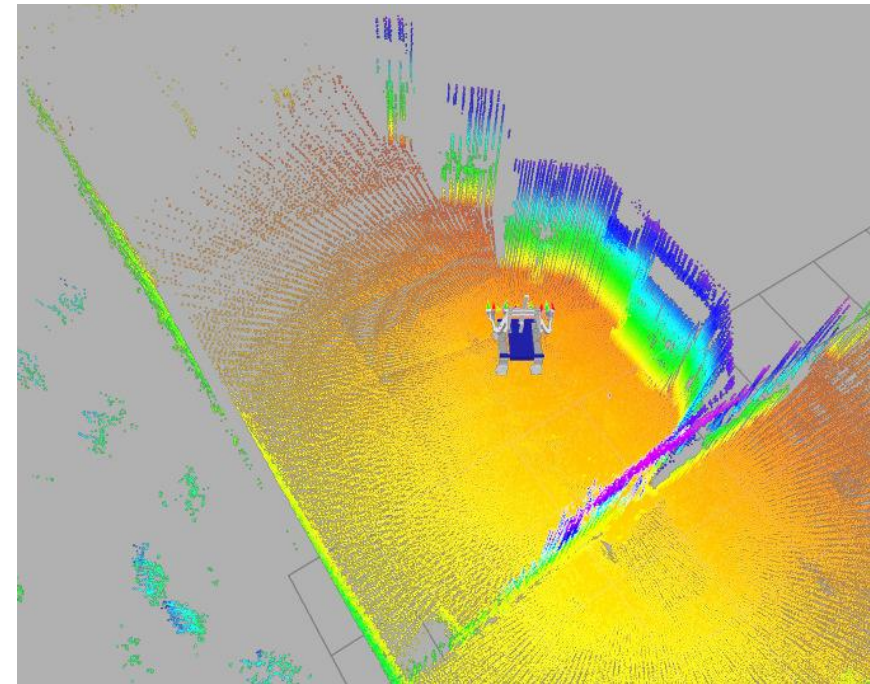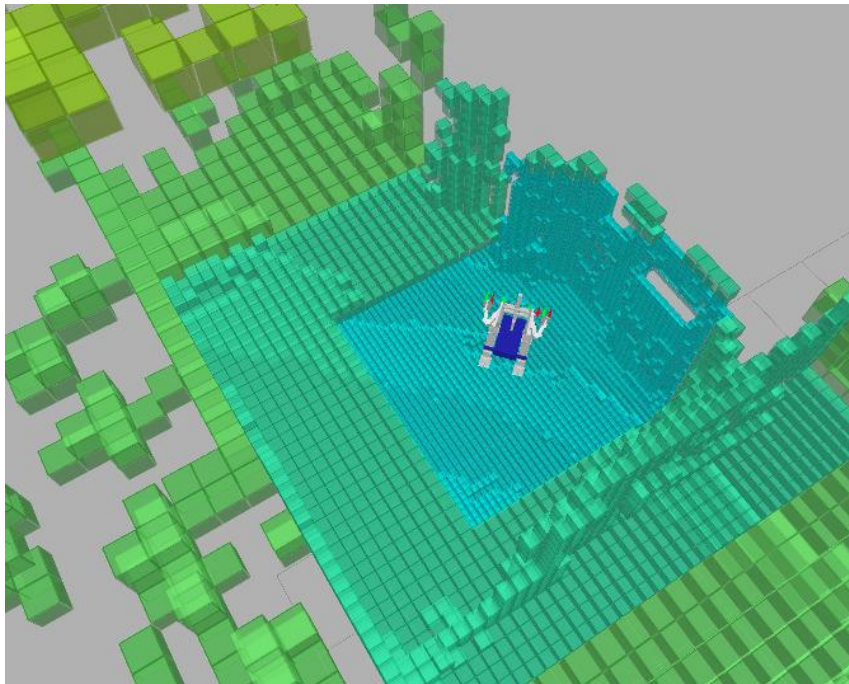
Car Driving at DRC

Egress the Car at DRC
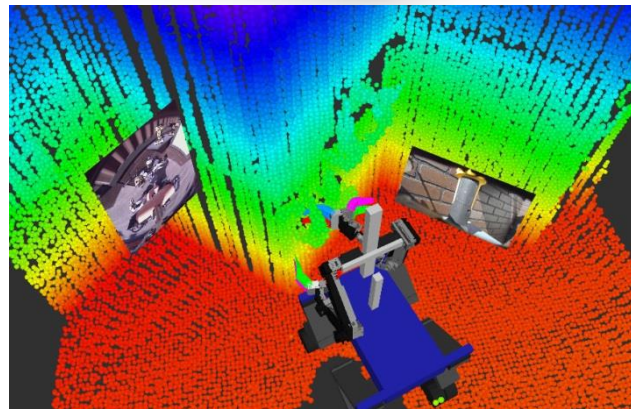
3D Environment SLAM

- Compensate for sensor motion to assemble 3D scans
- Register and aggregate scans to local multiresolution surfel maps, localize in these

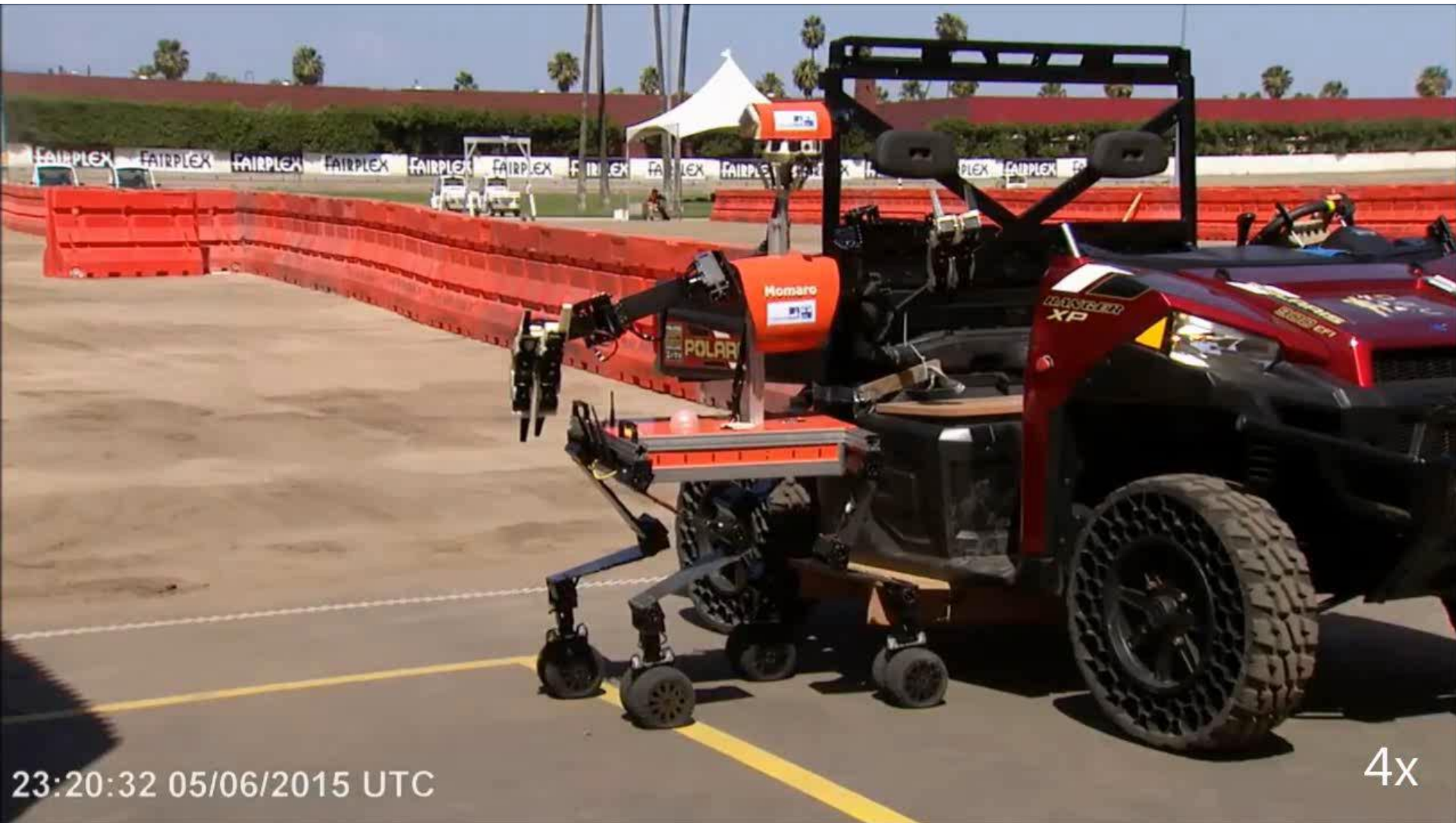[Droeschel et al., ICRA 2014, IAS 2014]

Manipulation Operator Interface

- 3D head-mounted display

- 3D environ-ment model + images

- 6D magnetic tracker
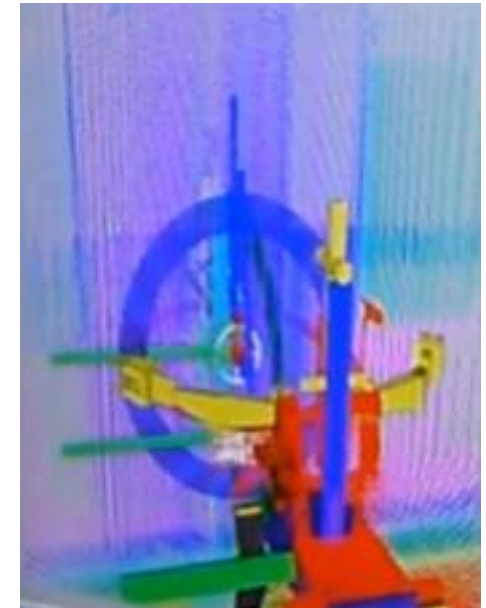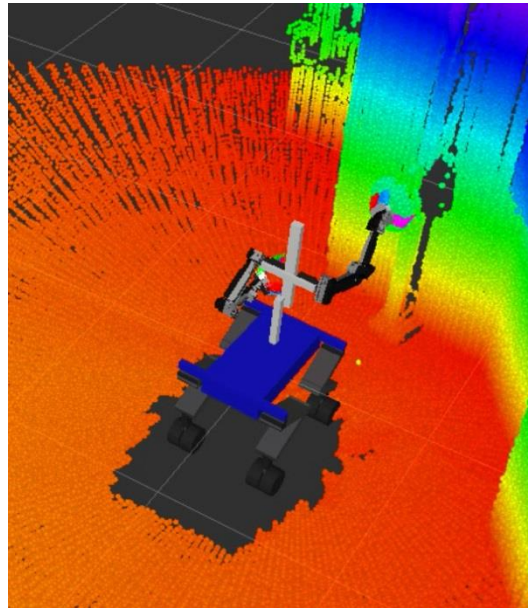
[Rodehutskors et. al., Humanoids 2015]

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Door Opening at DRC

23:20:32 05/06/2015 UTC
4x

Valve Turning Interface

- Align wheel model with 3D points using interactive marker
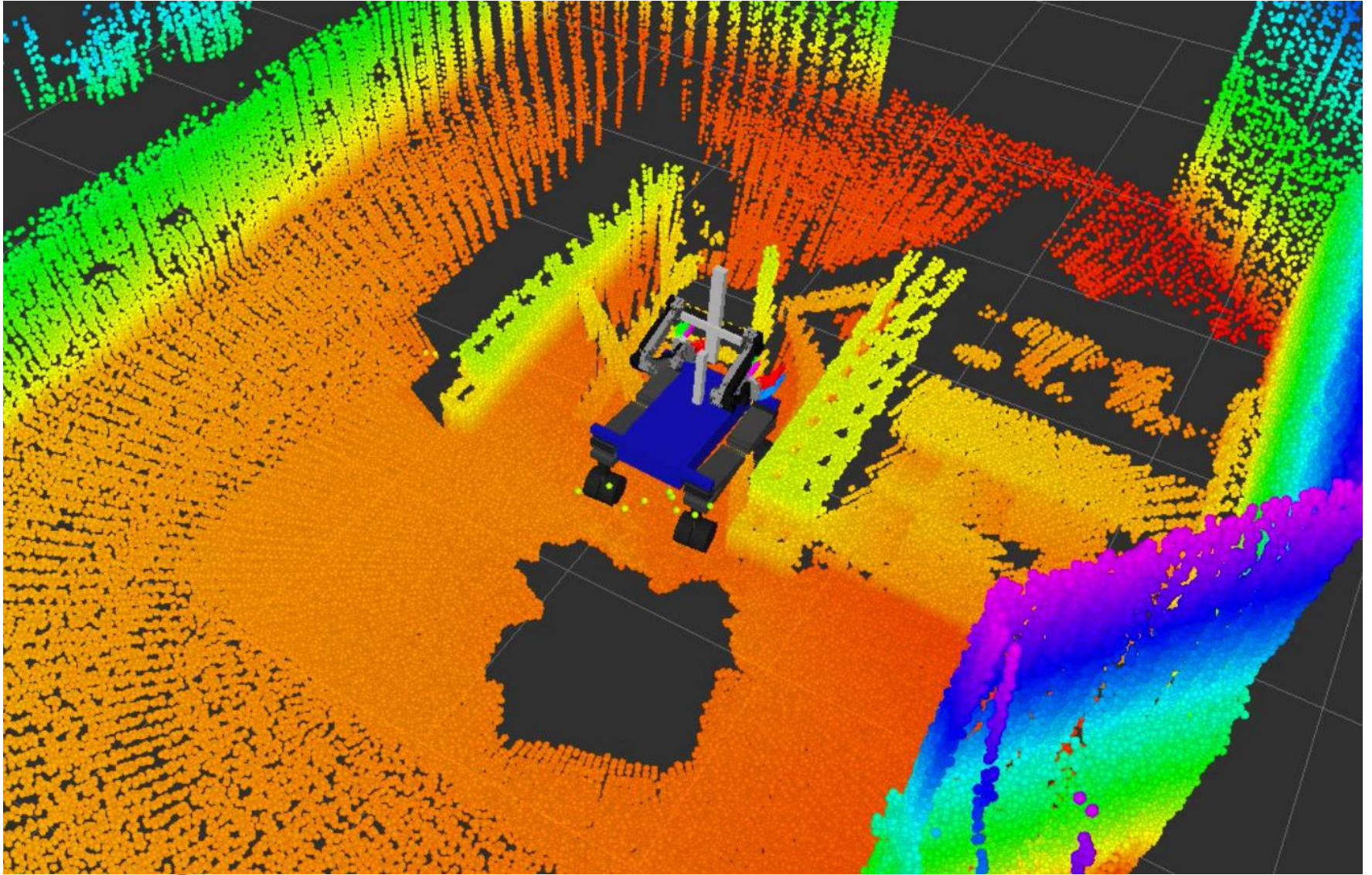- Turning motion primitive

Valve Turning at DRC

23:25:56 05/06/2015 UTC
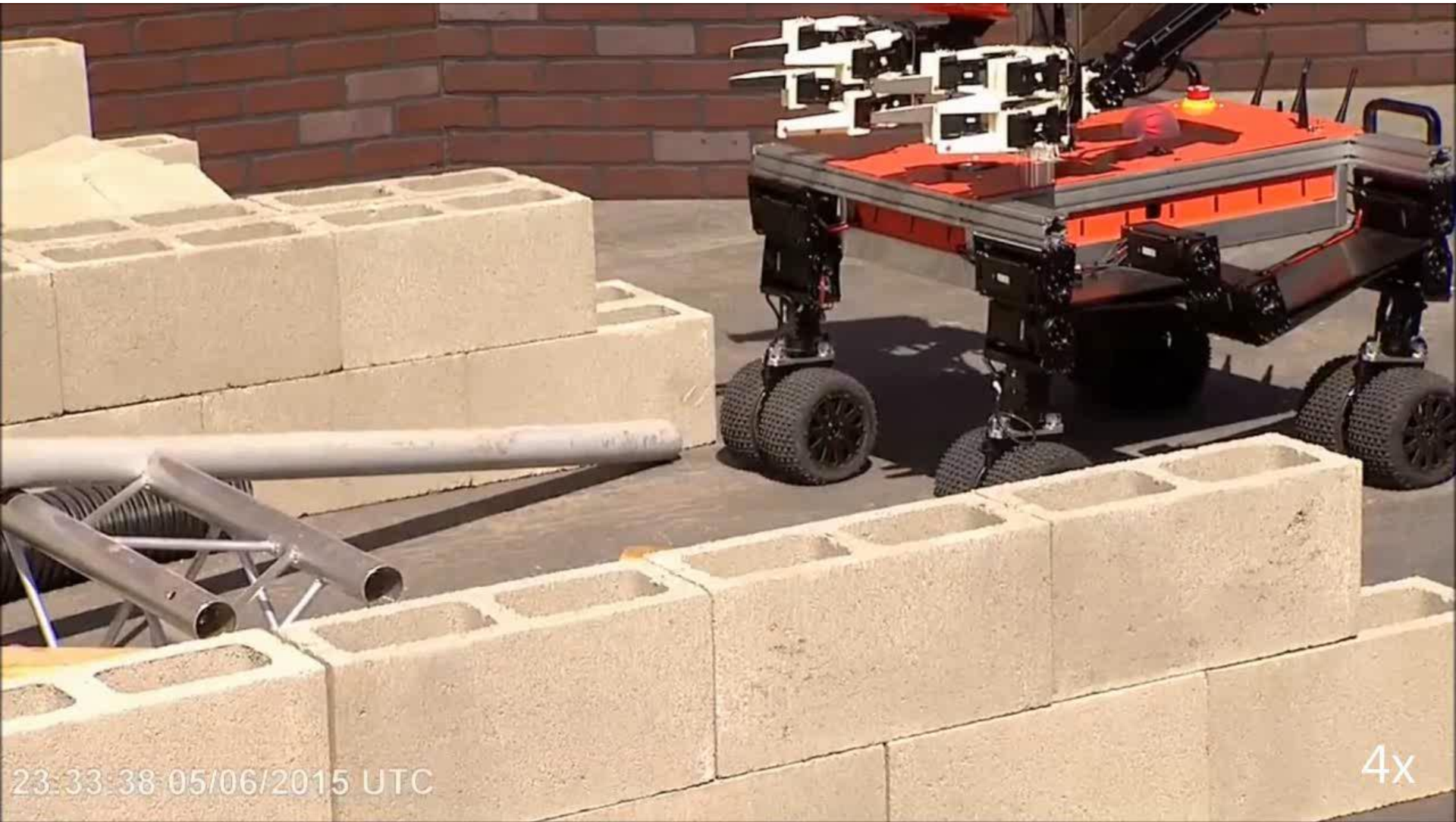
4x

DRC Team NimbRo Rescue: Mobile Manipulation Robot Momaro

Operating a Switch at DRC

23:28:21 05/06/2015 UTC   4x

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Plug Task at DRC

02:23:20 07/06/2015 UTC

4X
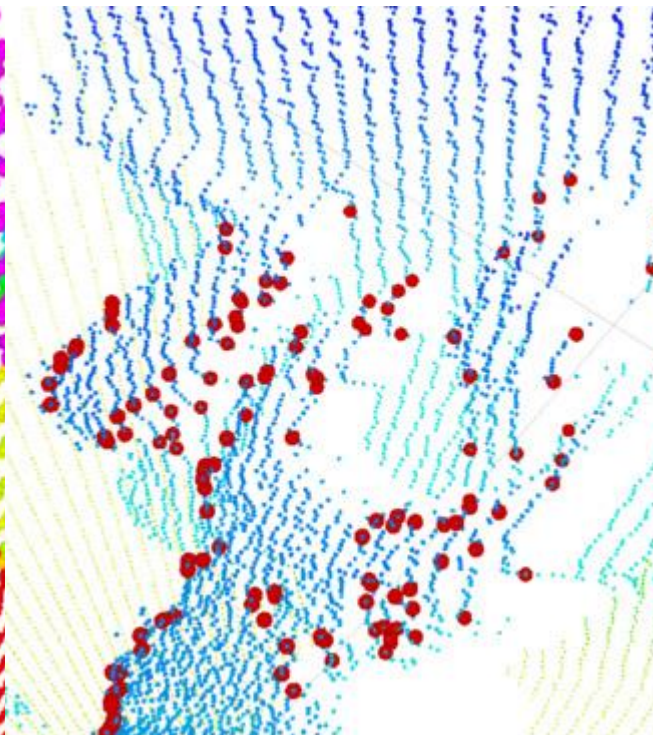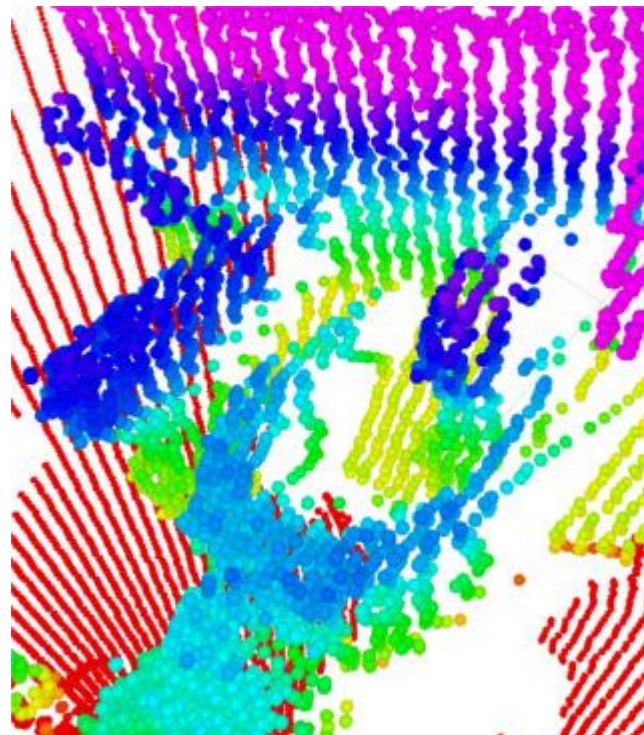
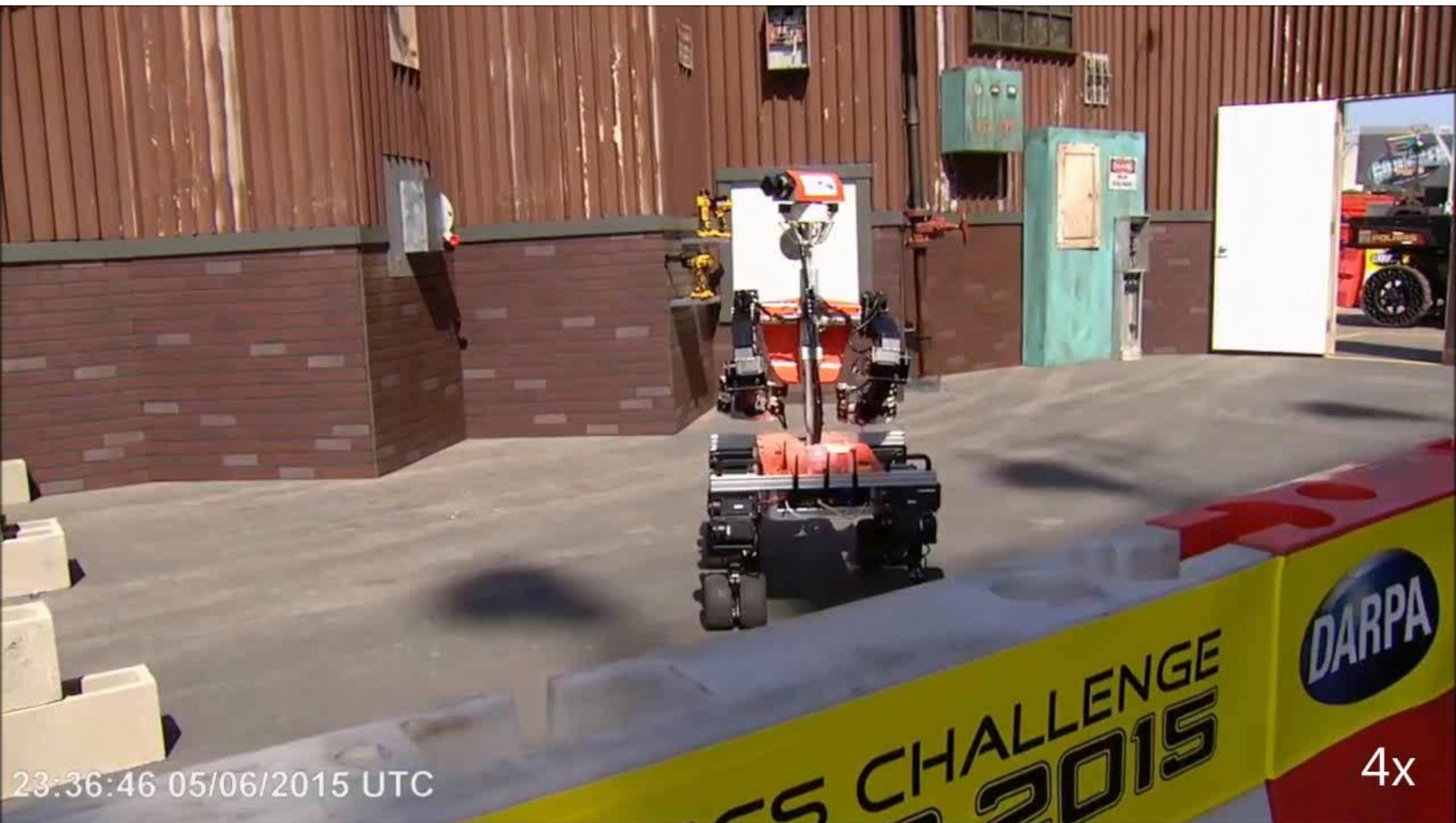universität**bonn** ais

Debris Task

Traversing Debris at DRC

Low-bandwidth Feedback

- Compressed image stream
- Edge points in 3D laser scans
- Joint angles, IMU, temperature, audio level, …

Cutting Drywall at DRC

23:36:46 05/06/2015 UTC

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Team NimbRo Rescue

Best European Team (4th place overall), solved seven of eight tasks in 34 minutes

Conclusions

- Compliant wheeled-legged base allows for flexible locomotion using omnidirectional driving, terrain adaptation, and making steps when necessary

- Anthropomorphic upper body with large workspace and flexible grippers

- Rich sensors for environment perception

- Intuitive teleoperation interfaces

- Solved seven of eight tasks in 34 minutes

- Future work: More autonomous functions