Motion Planning for Real Robots

Needs, Challenges and Solutions

>MoveIt! Advanced Tools for Mobile Manipulation

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Background

- PhD (GRASP, Penn - Vijay), Post-doc (Penn - Dan, Vijay, Mark)

- Willow Garage (2007-2013)

  - ❖ PR2, ROS

  - ❖ MoveIt!, ROS-Control, Arm Navigation

  - ❖ Key member of founding team for Redwood Robotics

    - ✓ JV between Willow Garage, MEKA Robotics, SRI

    - ✓ developing low-cost hardware for industrial robotics

  - ❖ Hosted Shaun Edwards (SwRI)

    - ✓ lead to ROS-Industrial Consortium

- Moved to SRI in beginning of October 2013

  - ❖ leading the software and systems group in the Robotics Program

  - ❖ definitely hiring!

Needs

- **Healthcare Robotics**

  - Changing demographics - more need for elder-care, assisted care
  - Supply of trained workers is not keeping up

    - ✓ lots of time spent doing tasks that don't add value

  - human environments where safety is paramount

- **Manufacturing**

  - Need common platforms for inter-operability
  - Lack of tools to allow users on the shop-floor to program robots
  - Cannot deal with flexible materials
  - Improve the ability to quickly reconfigure assembly lines
  - reliability is important (99.99999%)

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Needs

- Material Handling

  - 3 million workers spend all day picking up and putting down boxes[*]

  - $7.5 Billion in labor cost[*]

  - $7.5 Billion in workman's compensation[*]

  - dynamic constraints play a huge role

[*]Source: Kent Massey, HDT Robotics

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Approach

- **Flexibility**

  - Need to be able to easily re-program, re-task robots
  - Motion planning to quickly generate new paths and trajectories
  - Need to learn quickly from human interaction

    - ✓ Motion Planning + Learning

- **Safety**

  - Good environmental awareness
  - Fast reactive motions dealing with uncertainty

    - ✓ Motion Planning + Perception (and other sensing!)

      - tactile, proprioceptive, force

- **Reliability**

 - Bootstrap online planning using offline learning

Approach

- **Human-aware**

  - Consistent motions that people can learn to anticipate

  - Conform to human-interaction "rules"

    - ✓ e.g. move down the right of a corridor

- **Constraints**

  - deal with dynamics

  - deal with geometric constraints

    - ✓ plan in realtime (less than 100 ms)

- **Flexible materials**

  - model and plan for manipulation of such materials

  - account for uncertainty in models/execution

Related Research

- NRI-Small: "Rethinking Motion Generation for Robots Operating in Human Workspaces: An Integrated Approach to Planning and Manipulation"

  - Lydia Kavraki (Rice), Mark Moll (Rice), Sachin Chitta (SRI)

    - ❖ deal with constraints arising through human-robot interaction

    - ❖ easy human-interaction to specify high-quality paths

    - ❖ develop cost-aware primitives for sampling-based motion planners
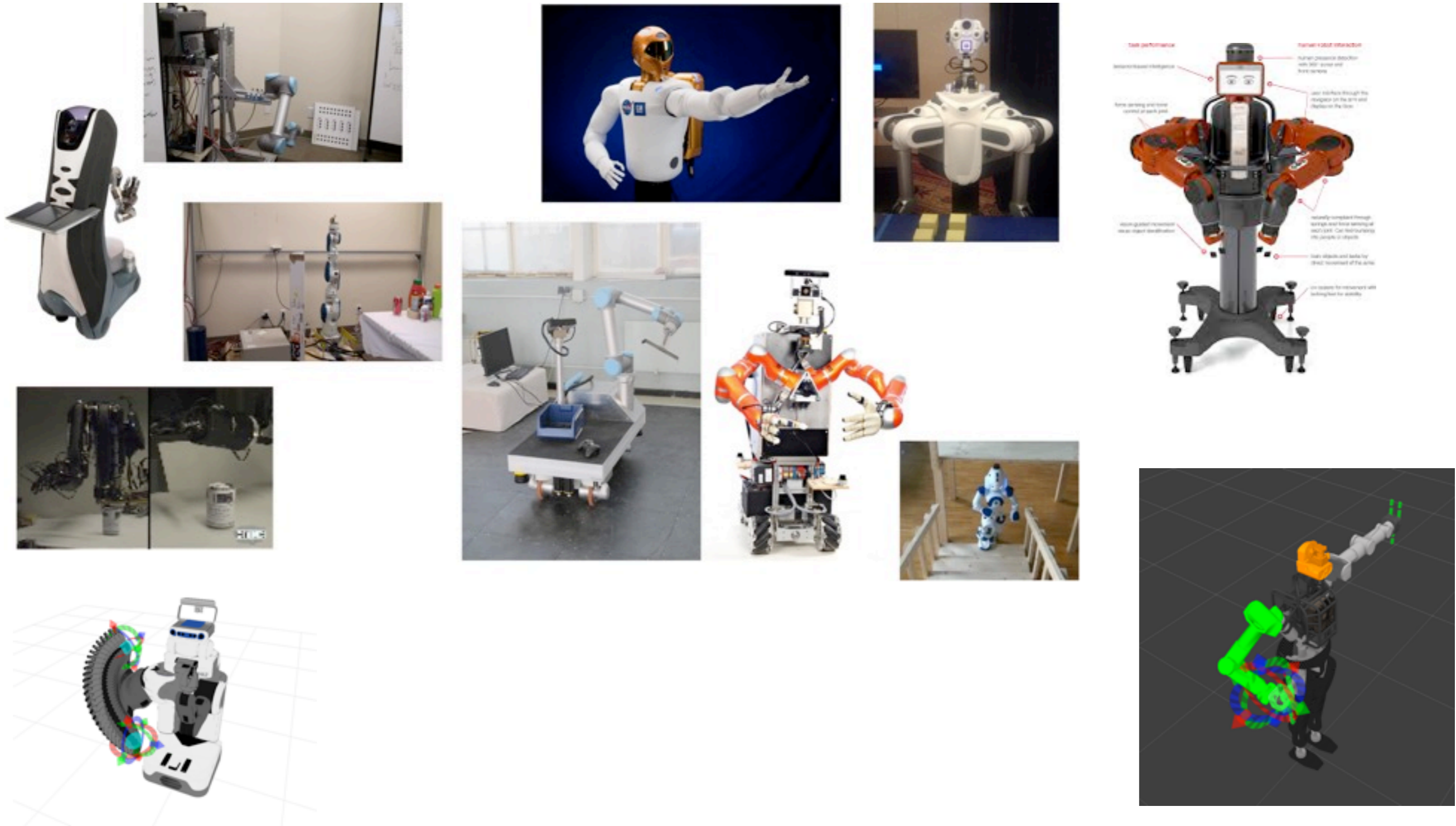
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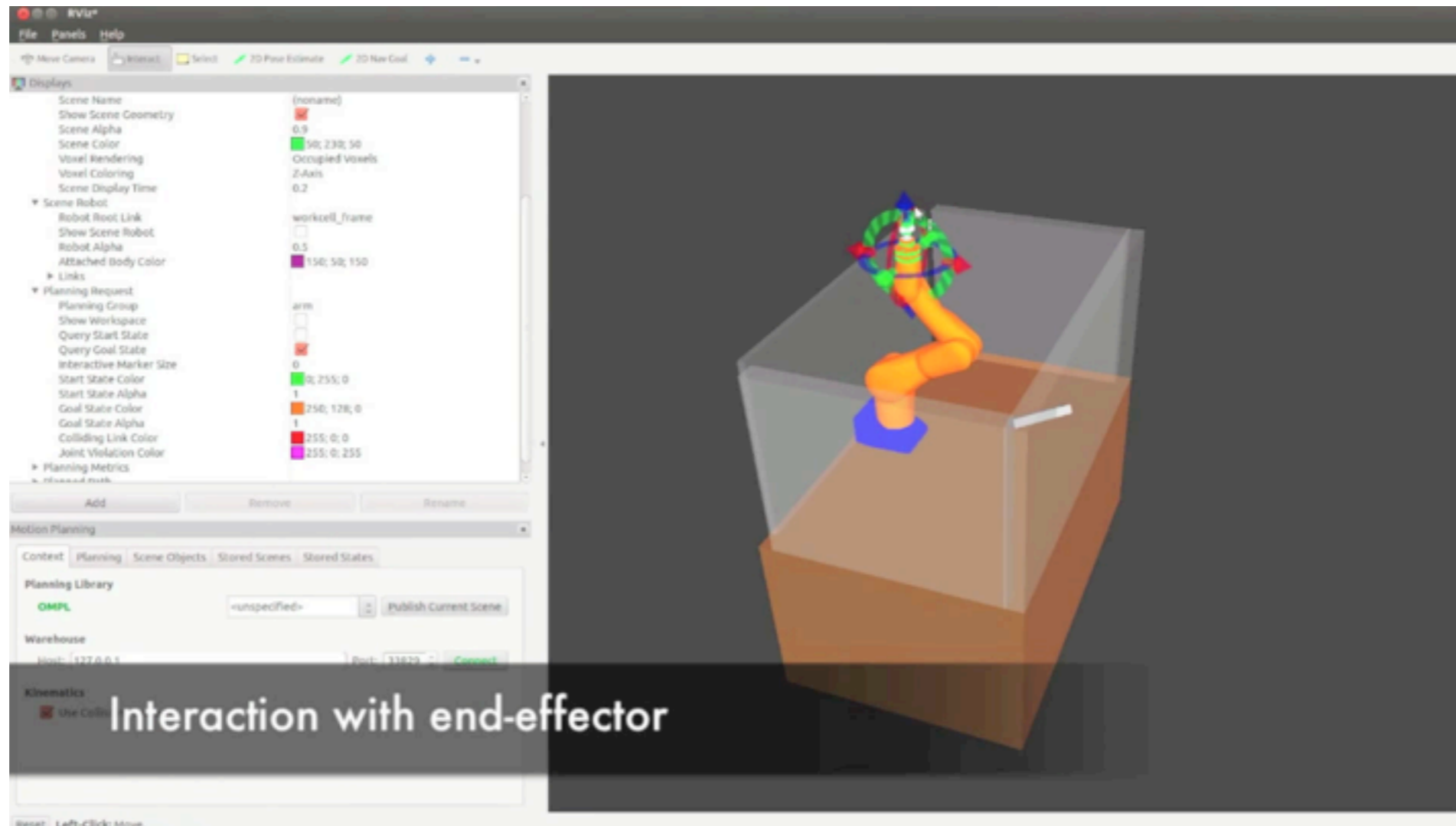
MoveIt!

General software including capabilities for motion planning, manipulation and mobile manipulation applicable to a wide variety of robots.
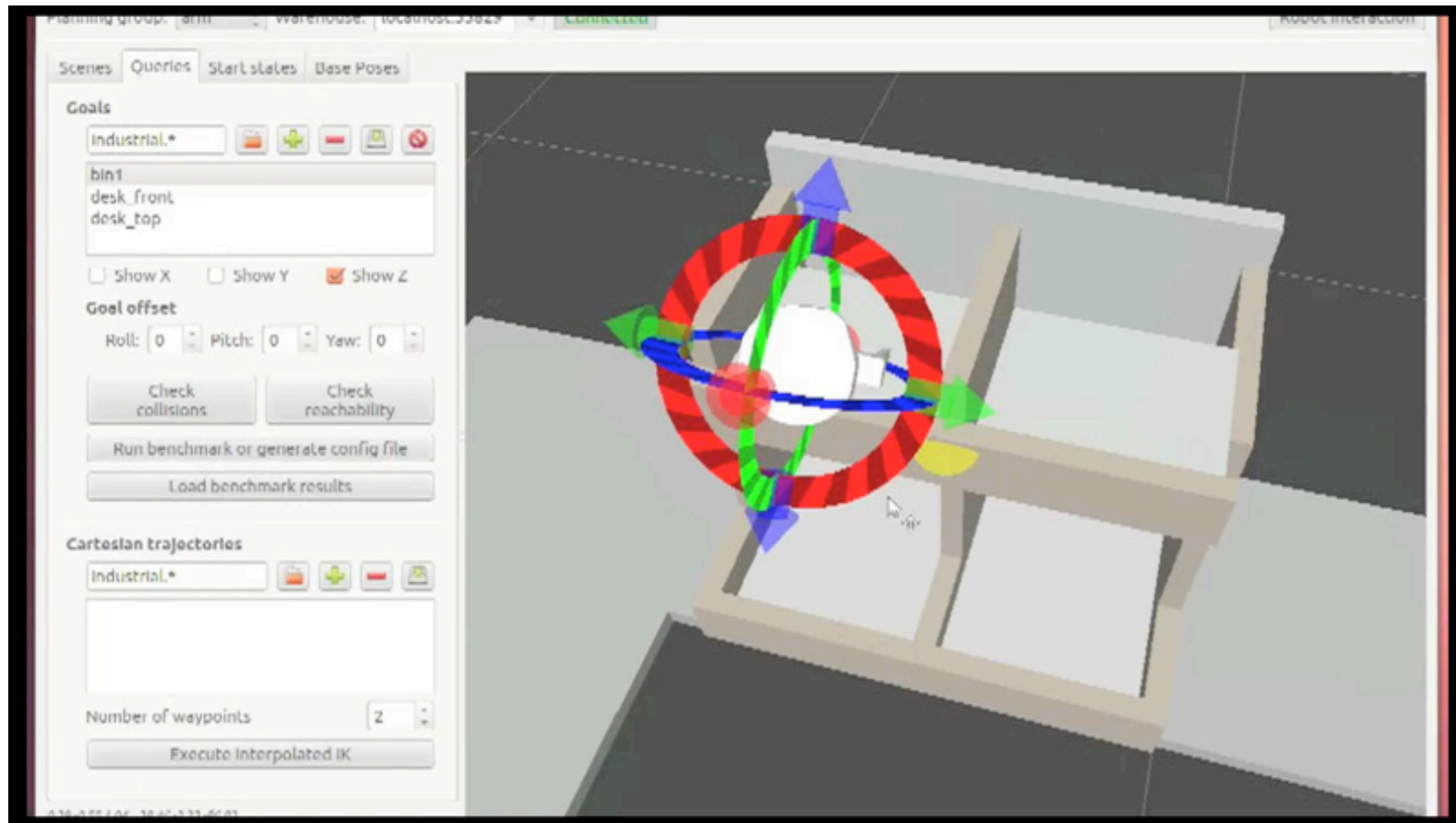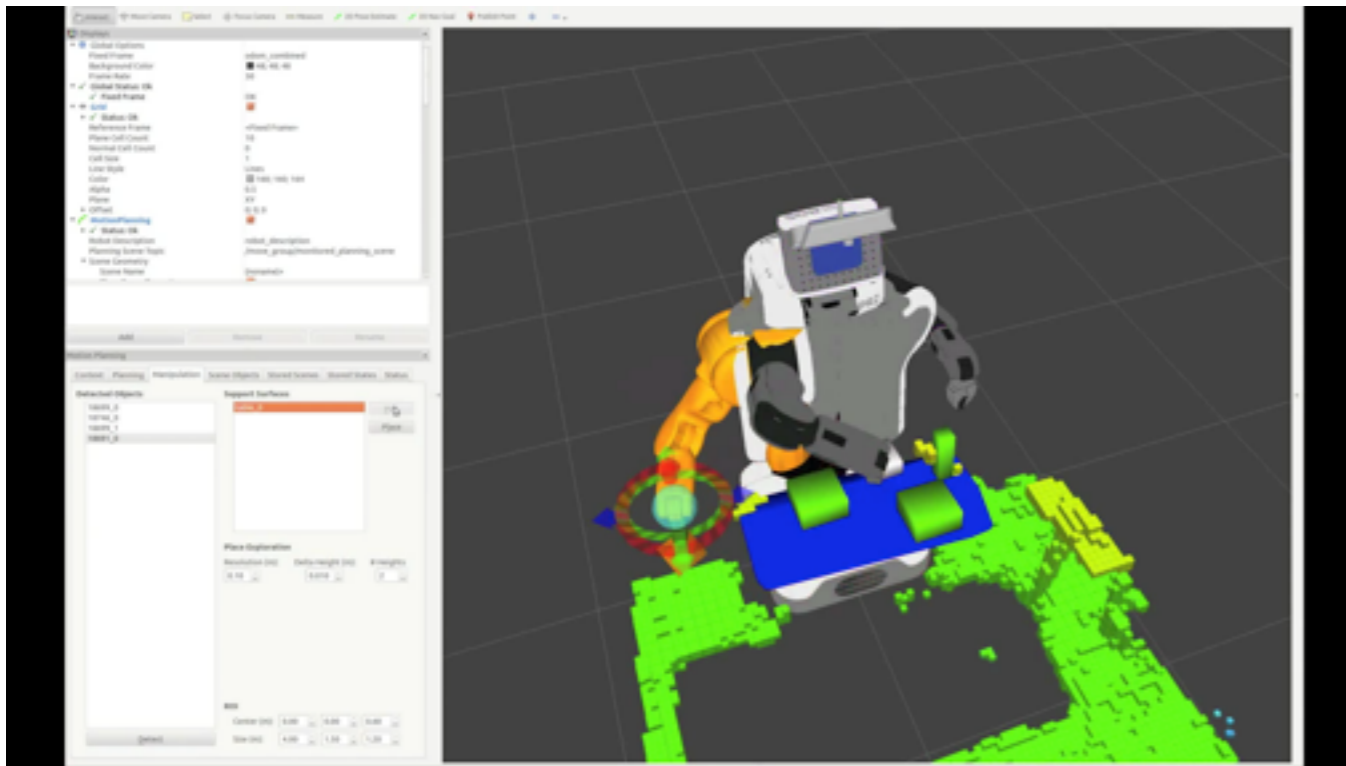
For more information: http://moveit.ros.org

Robots Using Our Software

MoveIt! Workcell Analysis

MoveIt! Applications aimed at Industrial Tasks and Customers

For more information: http://moveit.ros.org

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Pick and Place (MoveIt!)

Generalized Capabilities for Pick and Place

For more information: http://moveit.ros.org

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MoveIt!

Can be your platform for Motion
Planning and Mobile Manipulation

MoveIt! Survey

http://moveit.ros.org

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