

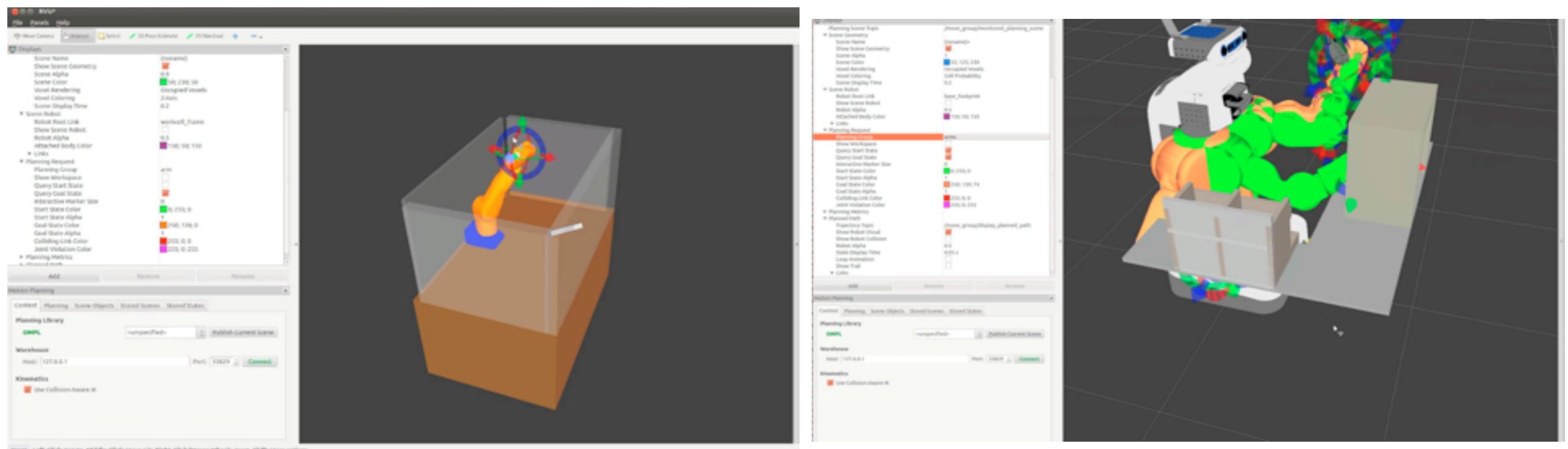


Sachin Chitta, Ioan Sucan, Acorn Pooley

with contributions from: Dave Coleman, Suat Gedikli, Mario Prats,
Matei Ciocarlie, Kaijen Hsiao, Jon Binney, Adam Leeper, Julius
Kammerl, David Gossow, Vincent Rabaud, Dave Hershberger and the
ROS and PR2 communities

What is MoveIt!

- MoveIt!- Software for building mobile manipulation applications
 - ❖ Motion Planning, Kinematics, Collision Checking integrated with Perception, Grasping, Control and Navigation for Mobile Manipulation



Motivation

- Build state of the art software platform for robotics applications and research
- “Simple things should be easy”
 - ❖ Provide out-of-the-box experience
 - easy to setup with new robots - Setup Assistant
 - ❖ Easy to use APIs - C++ and Python
- “Allow users to dive deeper to address harder problems”
 - ❖ Flexible platform - easy to add new components
- Performance
 - ❖ design for high performance

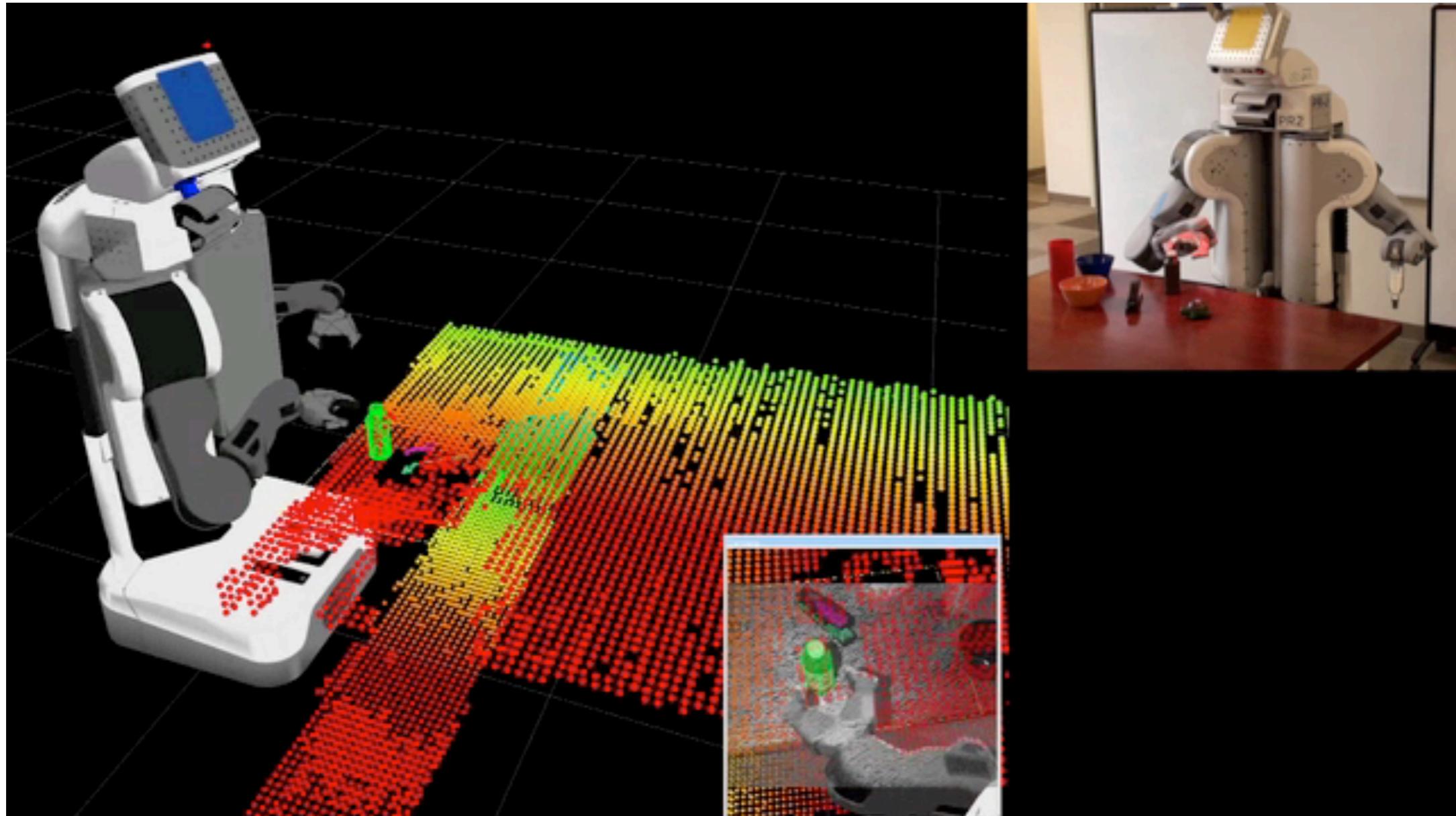
Motivation

- Developing new higher-level capabilities is time-consuming
 - ❖ building every capability from scratch is a waste of effort
- Environment awareness critical for new applications
 - ❖ Integrated 3D perception can provide situational awareness, improving safety, especially in human-robot collaborative tasks
- Motion Planning important for dynamic changing environments
 - ❖ essential for maintaining safety and performance in human-robot collaborative tasks
- Constrained manipulation tasks are hard to solve
 - ❖ increasingly complex types of constraints need to be handled

MoveIt!: Evolution

- MoveIt! has evolved from the arm_navigation and grasping pipeline set of stacks
 - ❖ essentially a rewrite from scratch
 - ❖ ROS API almost the same
 - ❖ incorporates lessons learnt

Mobile Manipulation: State of the art



Chitta, Jones, Ciocarlie, Hsiao, Sucan, 2011

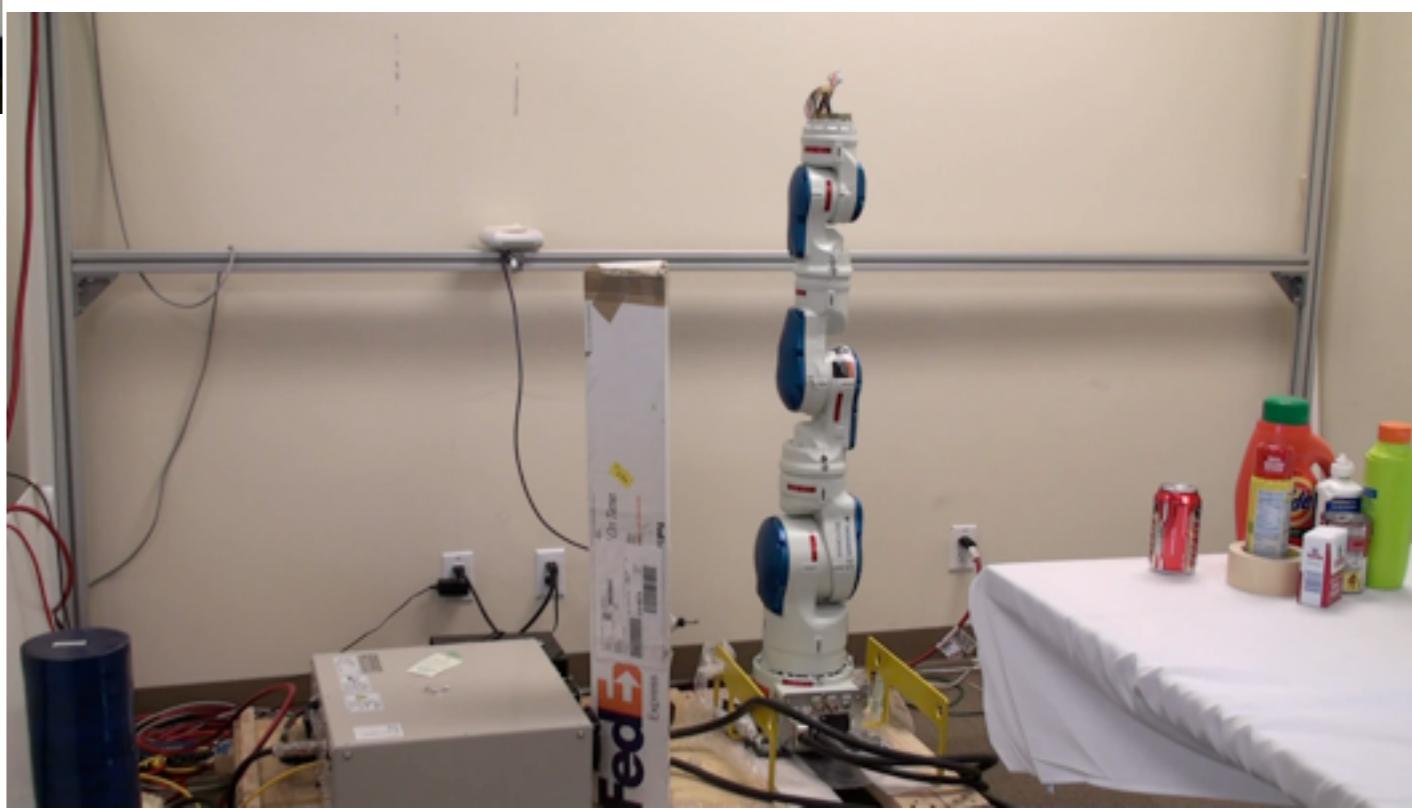
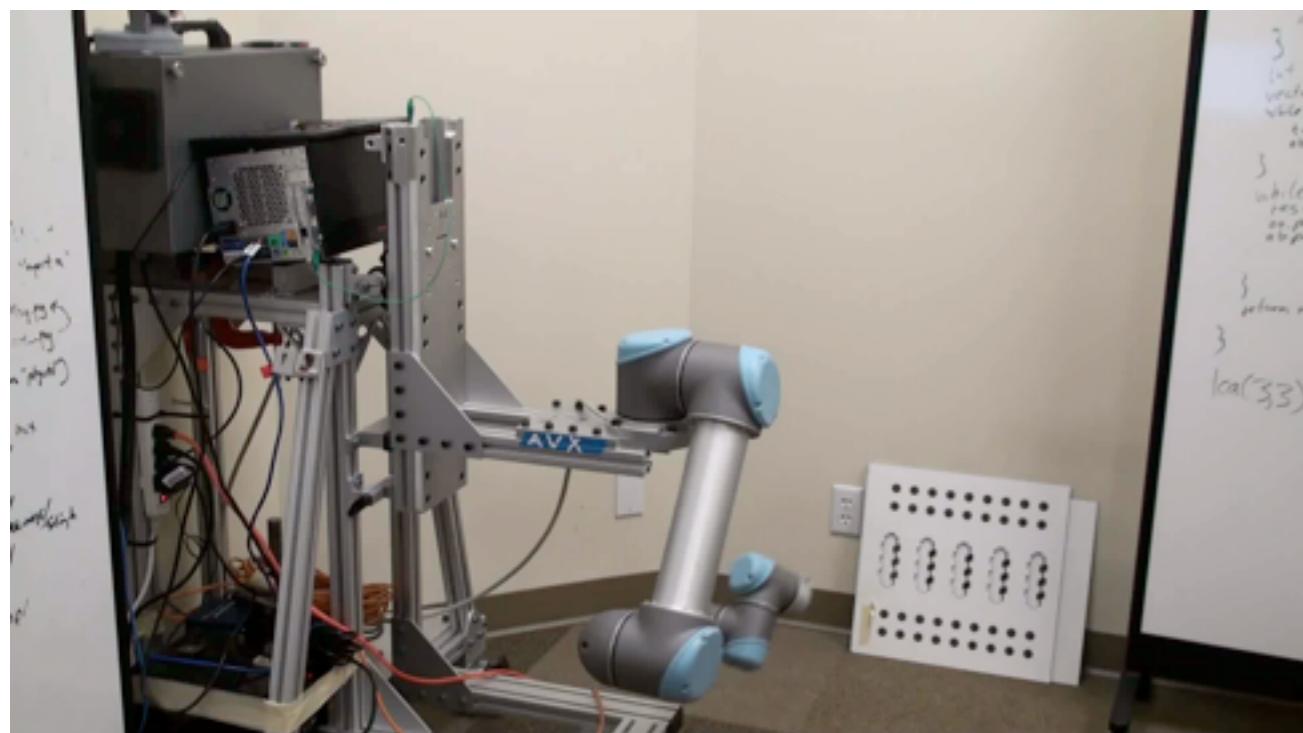
Robots Using Our Software



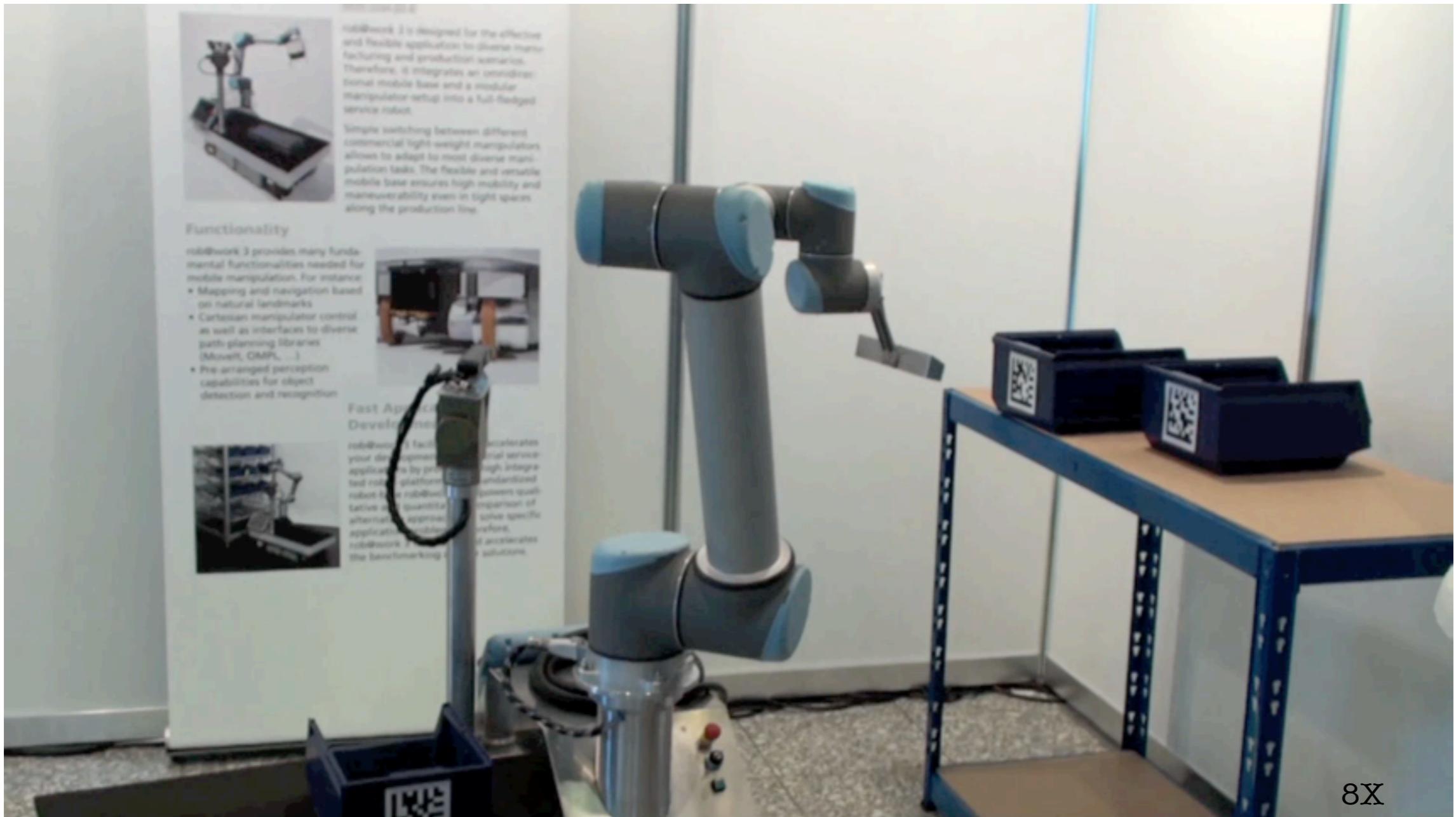
Application - ROS-Industrial

Same Software Running on Industrial Hardware

MoveIt!



Application - ROS-Industrial



MoveIt!

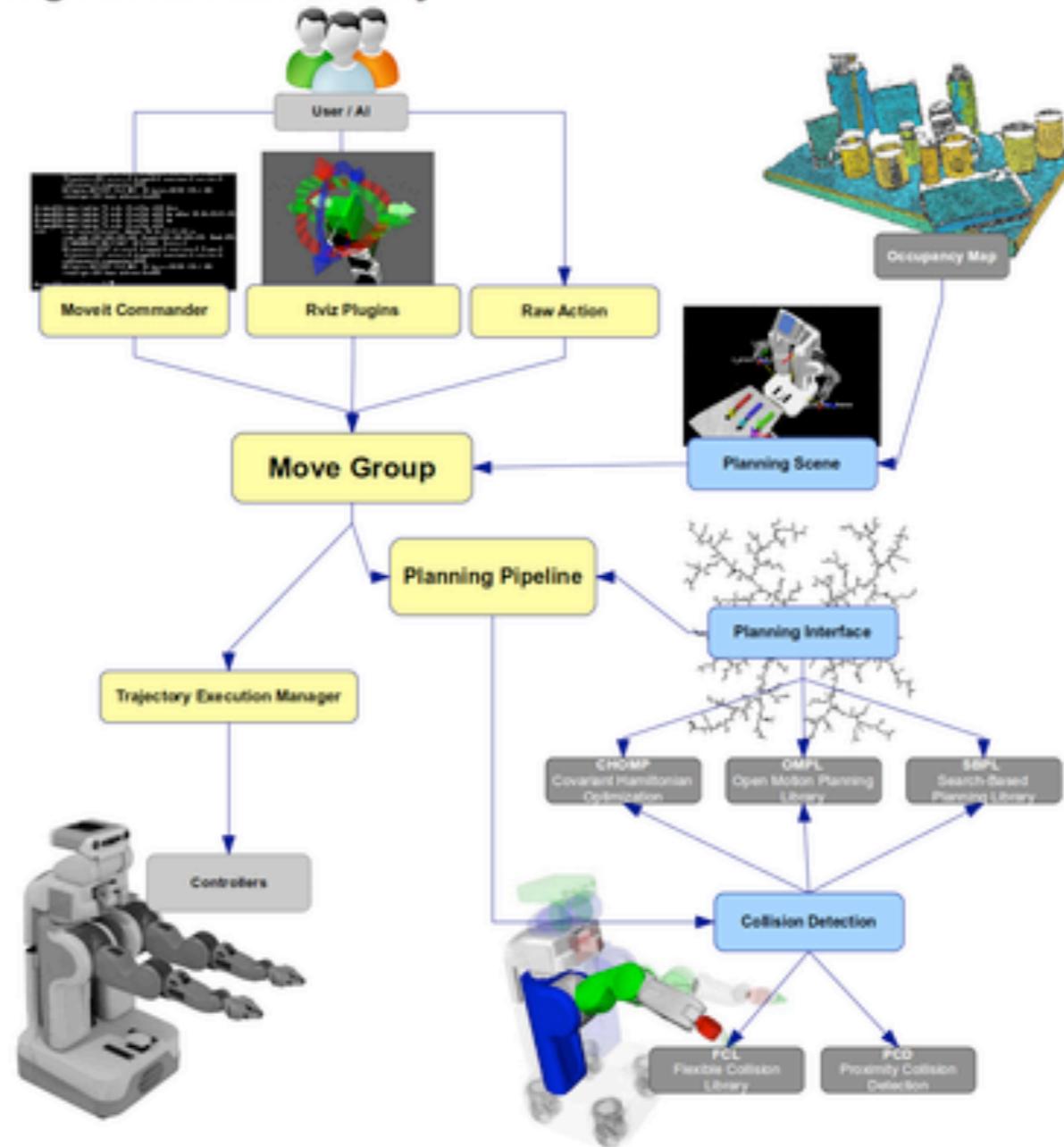
- Technical Capabilities

- ❖ Collision Checking: fast and flexible
- ❖ Integrated Kinematics
- ❖ Motion Planning
 - fast, good quality paths
 - kinematic constraints
- ❖ Integrated Perception for Environment Representation
- ❖ Standardized Interfaces to Controllers
- ❖ Execution and Monitoring
- ❖ Kinematic Analysis

MoveIt!

MoveIt – A Planning Framework
High Level Functionality

24 Mar 2013



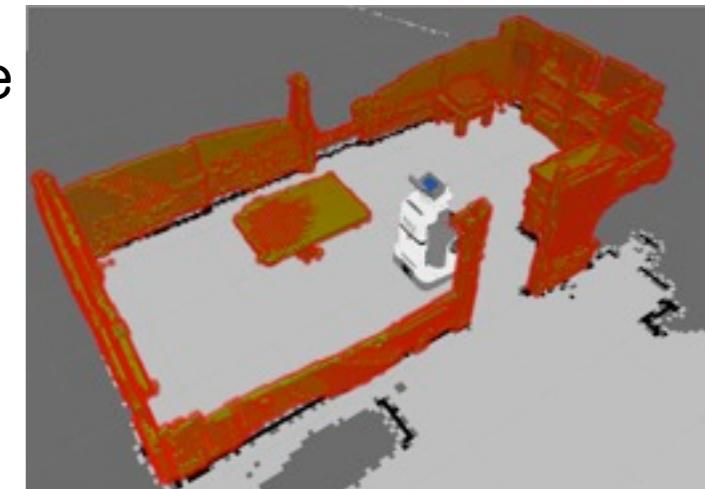
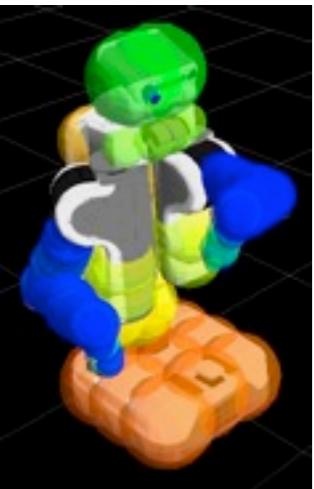
Collision Checking

- FCL - Flexible Collision Library*

- ❖ parallelizable collision checking
- ❖ Maximum about 2-3,000 full body collision checks for the PR2 per second
 - ✓ with realtime sensor data
- ❖ + high fidelity mesh model

- Proximity Collision Detection

- ❖ Uses 3D distance transform to determine distance to nearest obstacle and gradient
- ❖ + very fast - 40 to 80,000 collision checks per second for the full body of the PR2
- ❖ - not as accurate



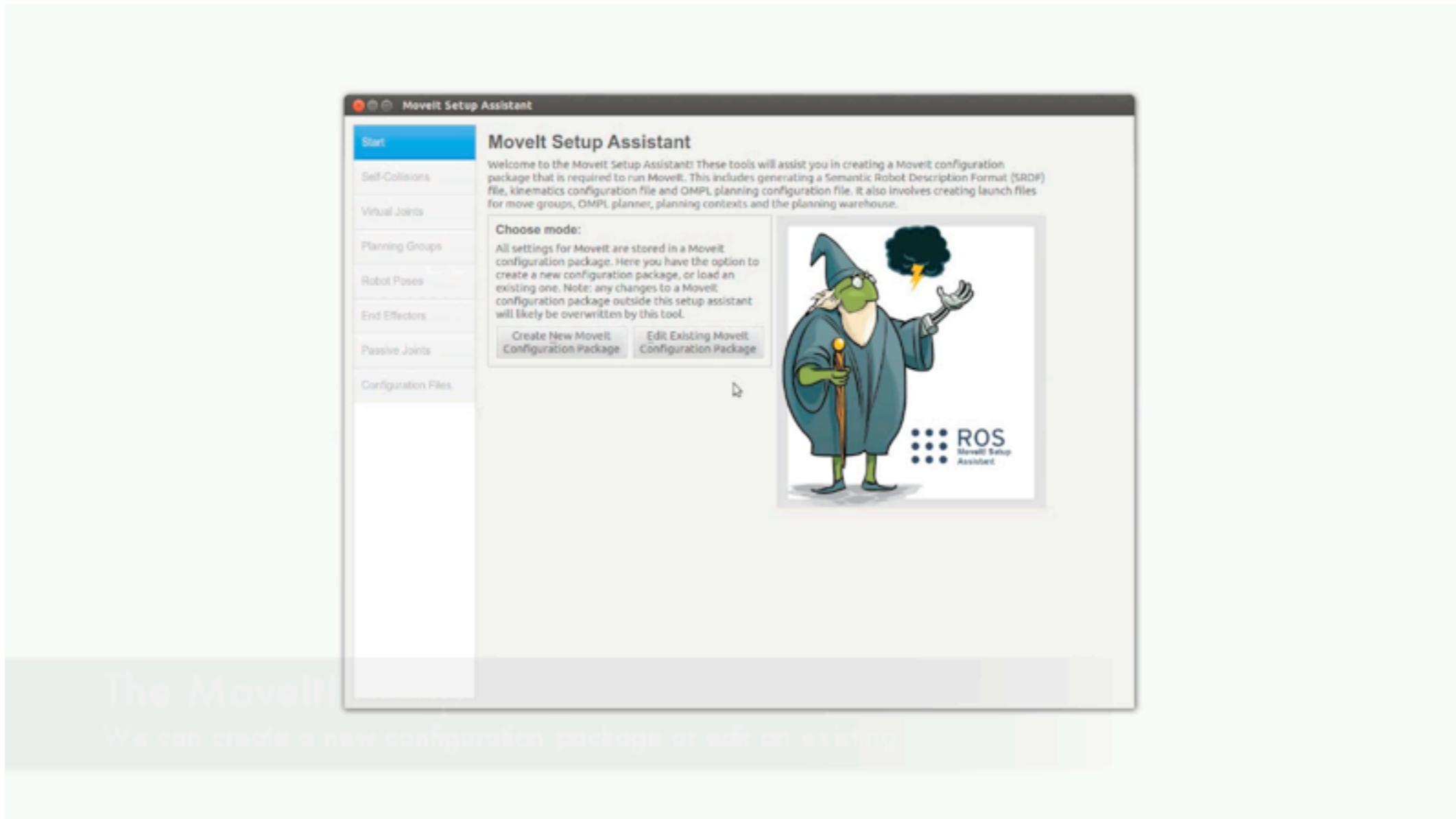
*Pan, Sucan, Chitta, Manocha - 2012

Motion Planning

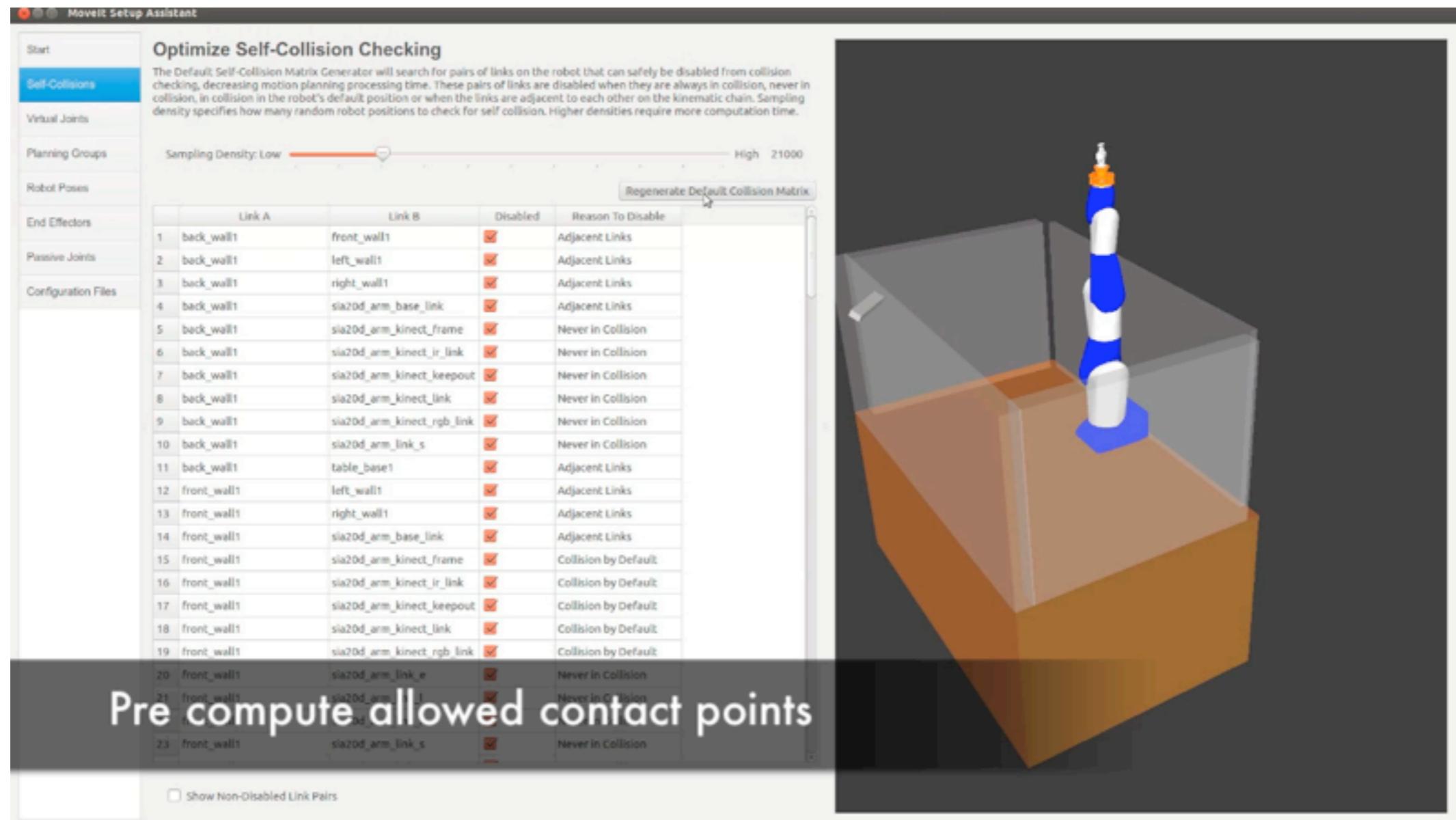


- Plugin interface for planners
- Integration with robots through MoveIt!
- Automatically configured using the MoveIt! Setup Assistant
 - ❖ Sampling based planners (OMPL) [*http://ompl.kavrakilab.org](http://ompl.kavrakilab.org)
 - ❖ Search Based Planning Library (SBPL) [*http://www.ros.org/wiki/sbpl](http://www.ros.org/wiki/sbpl)

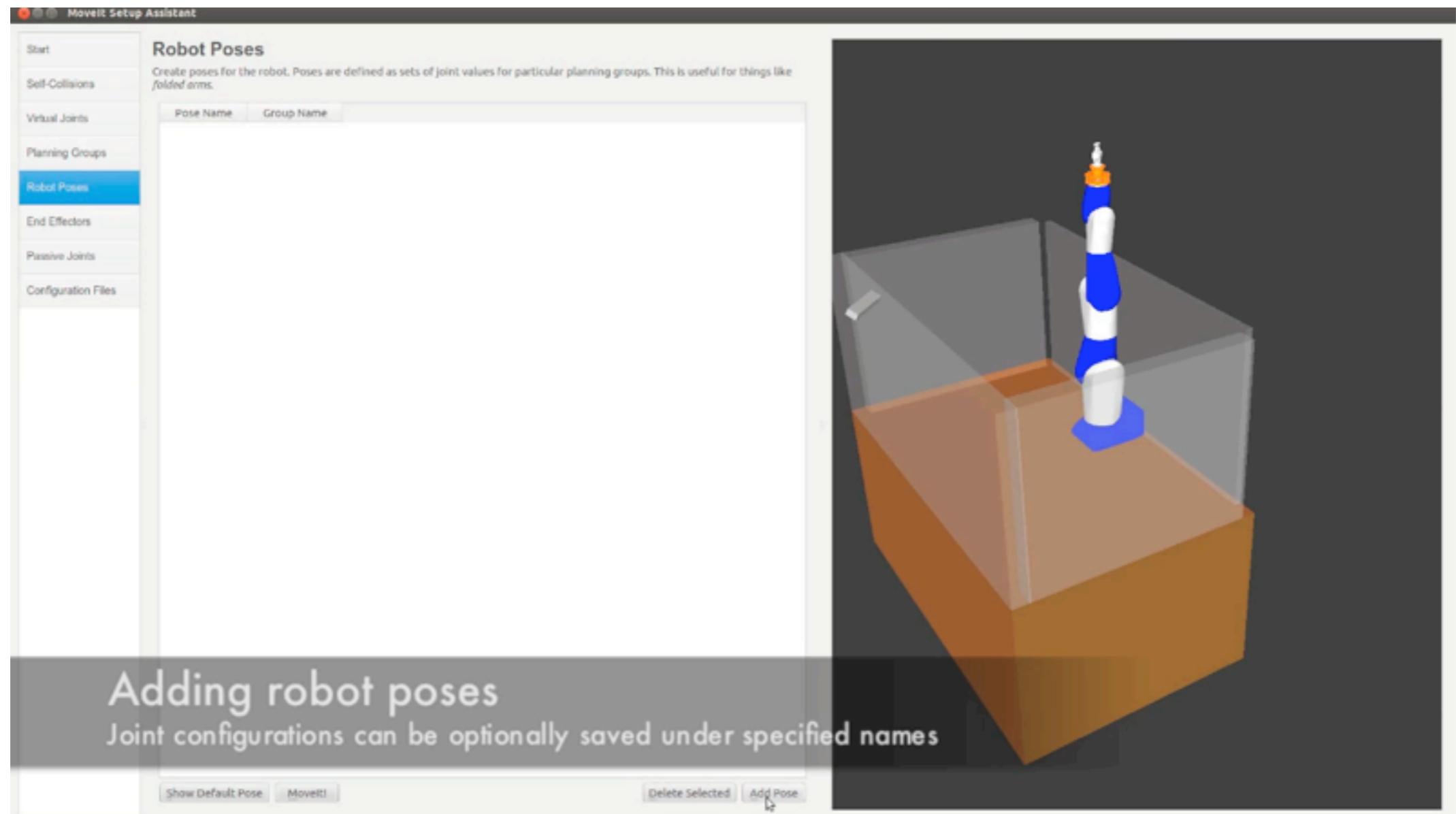
Easy Setup and Configuration



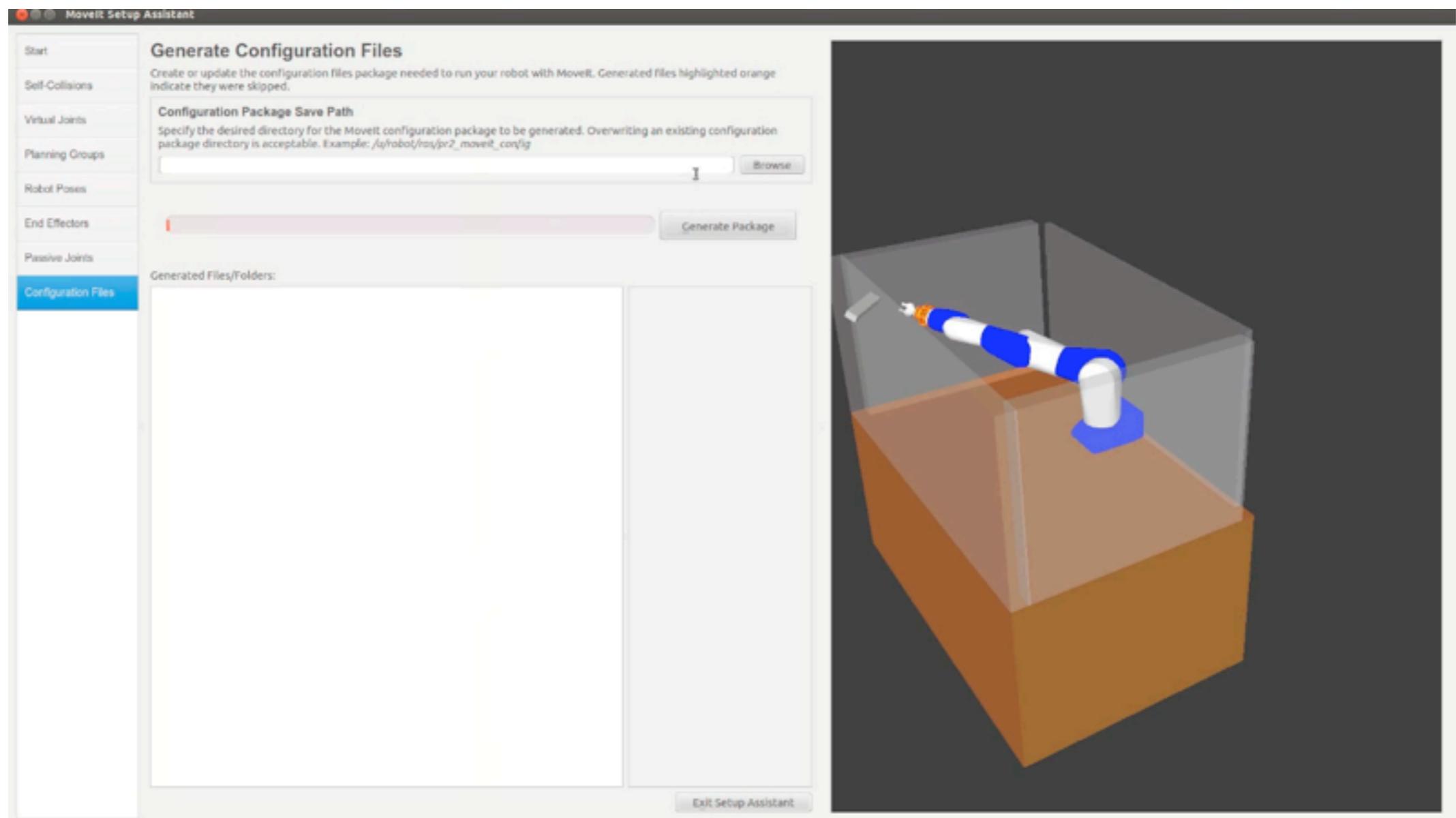
Easy Setup and Configuration



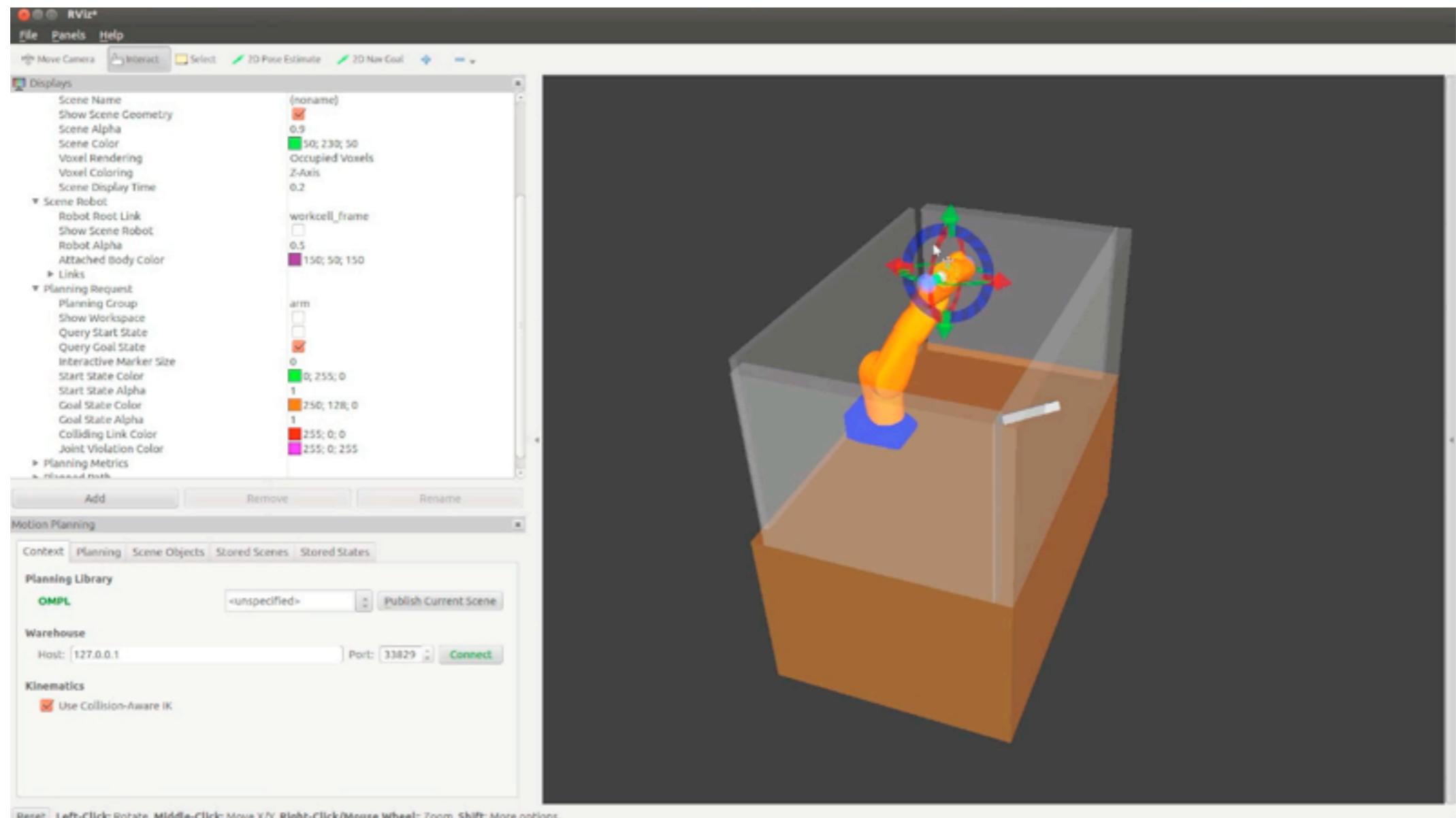
Easy Setup and Configuration



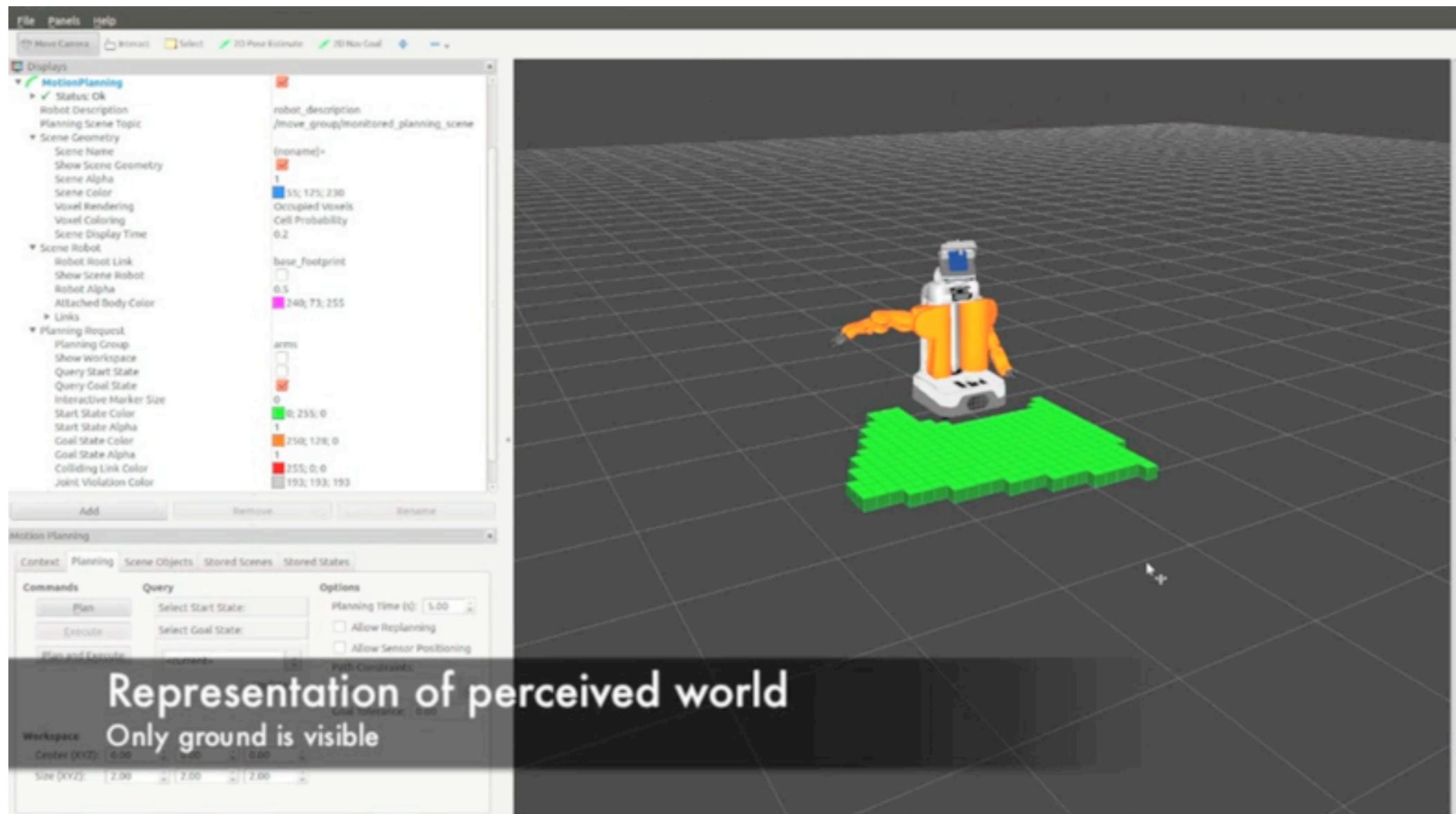
Easy Setup and Configuration



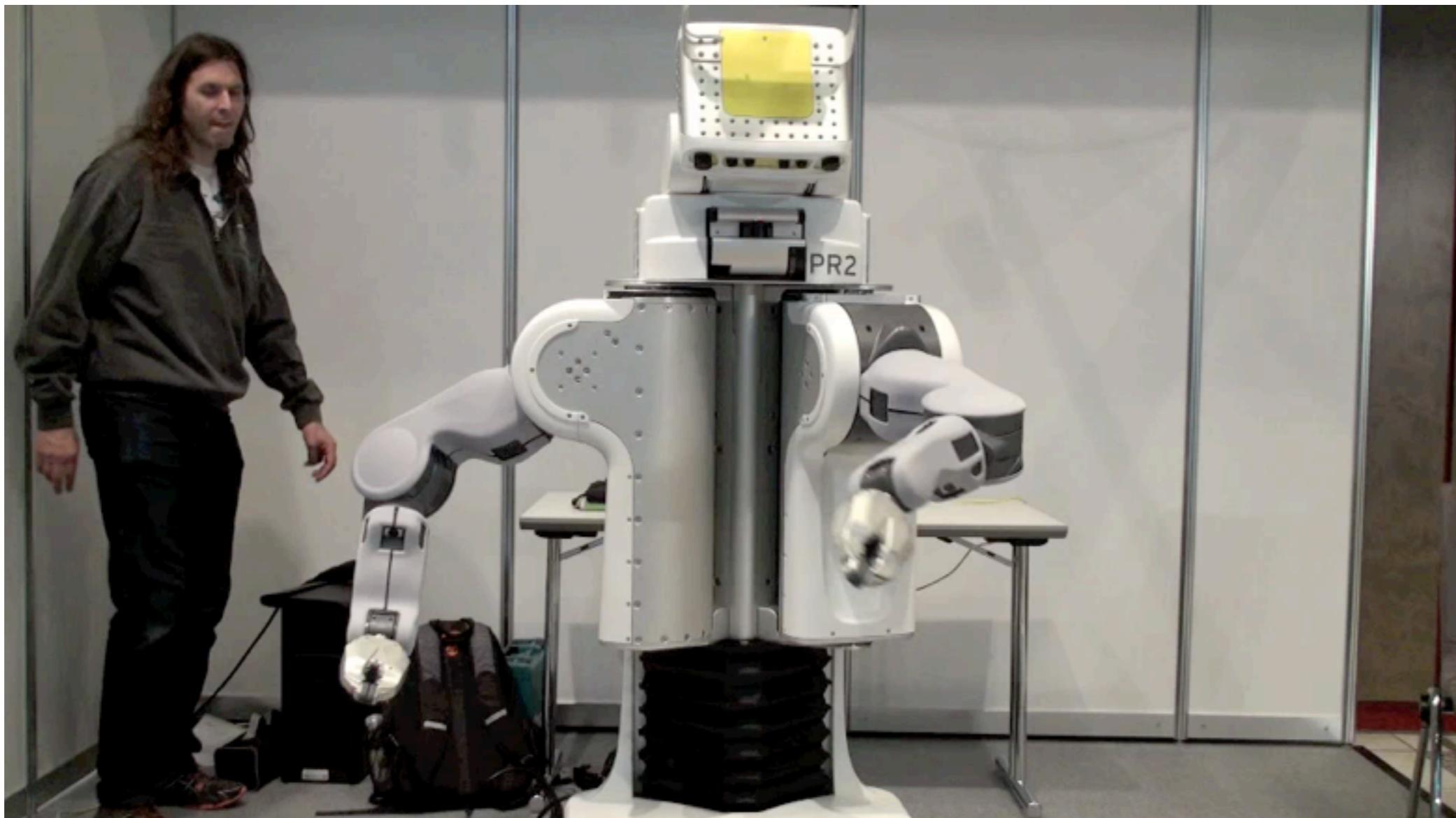
Easy Setup and Configuration



Integrating Perception

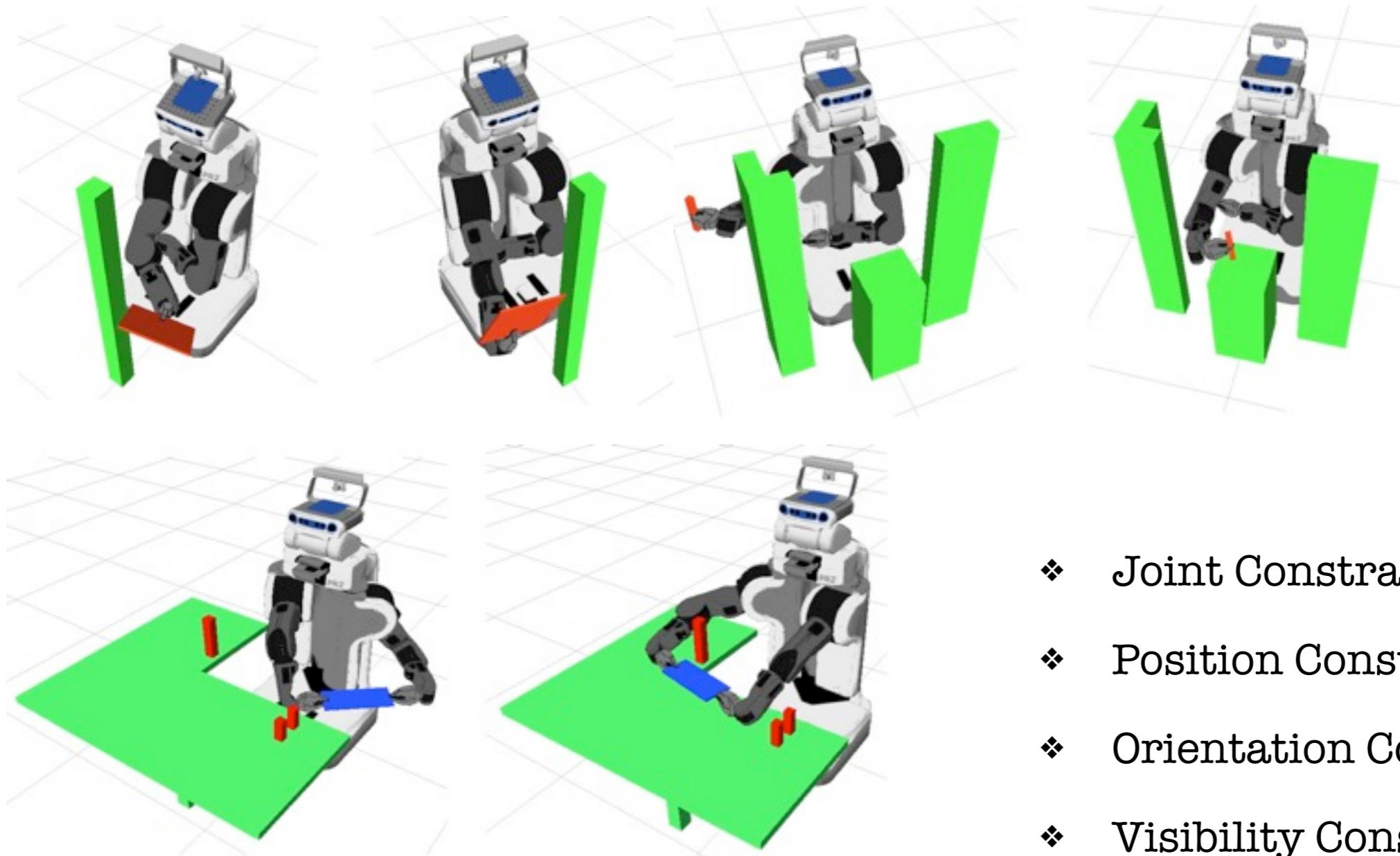


Reactive Motion

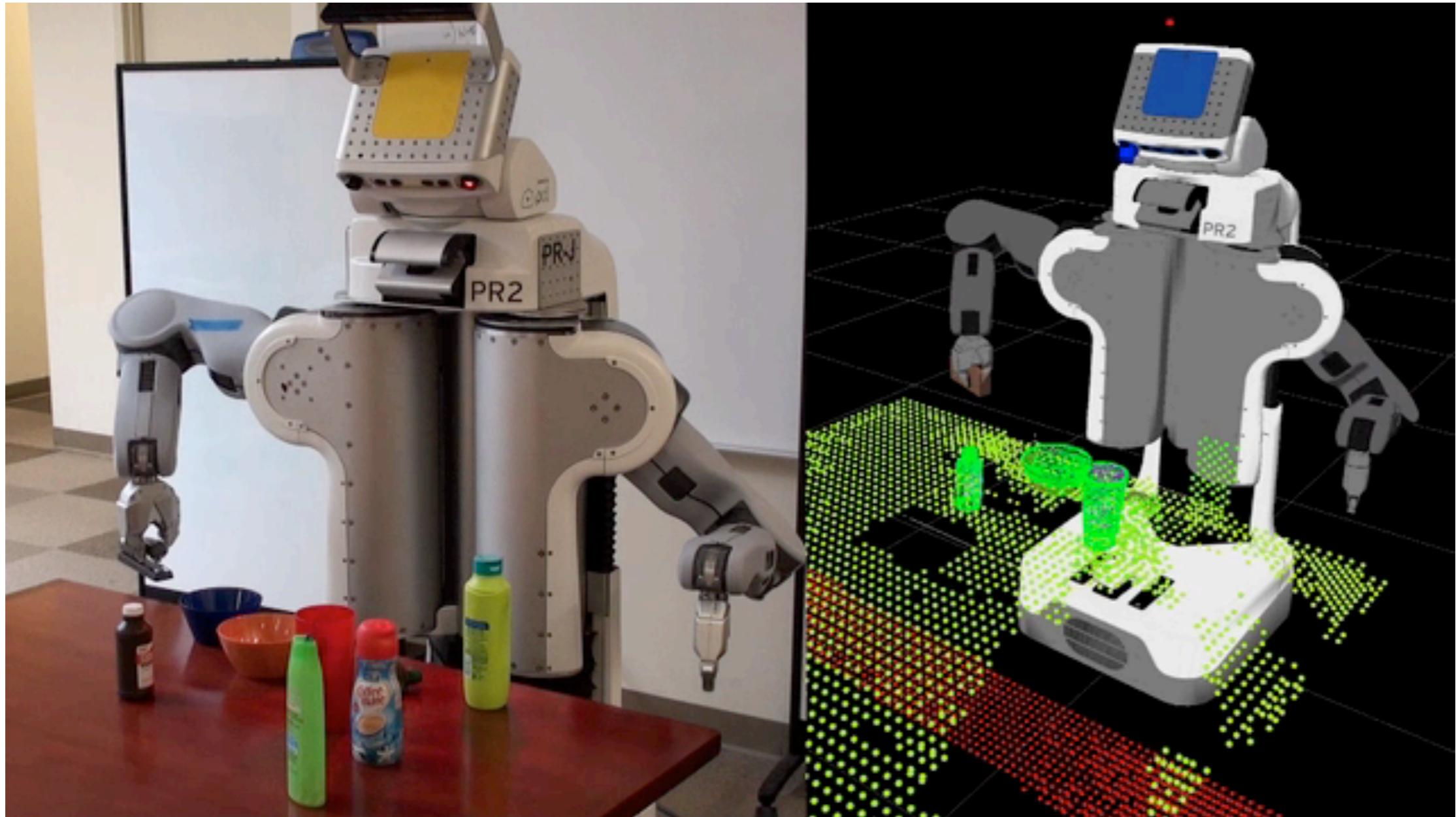


* Live Demo later!!

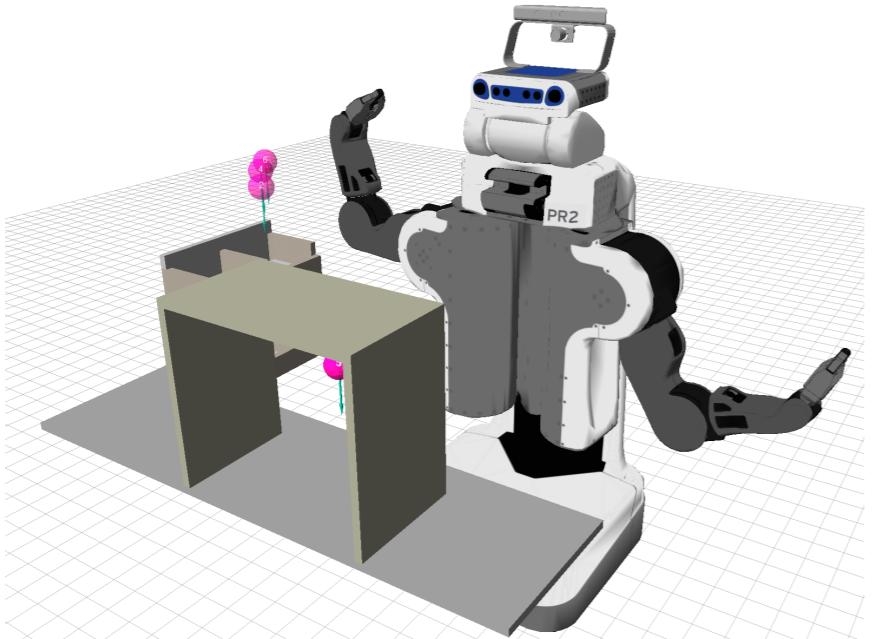
Constraint Representation



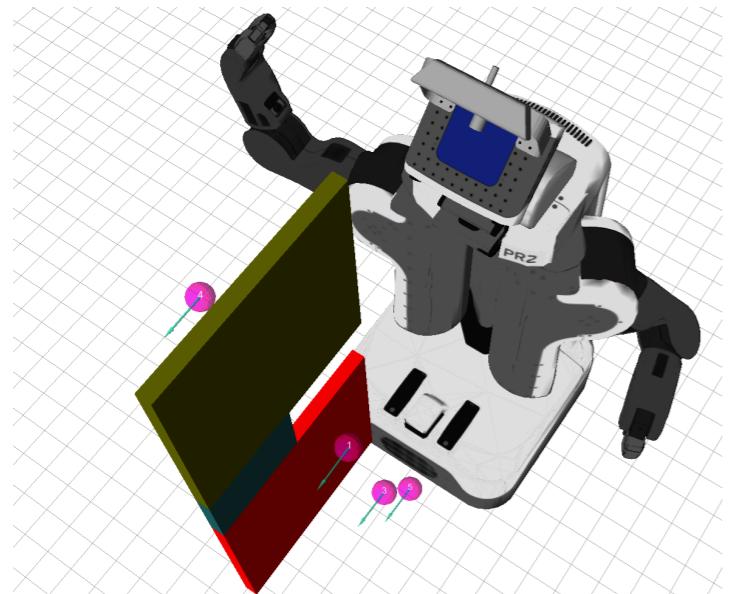
Orientation Constraints



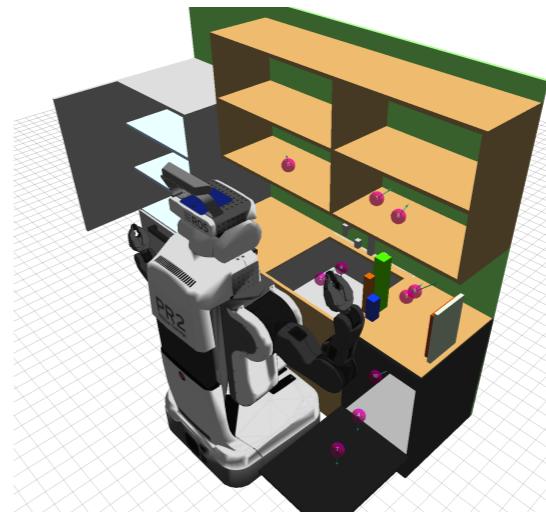
Applications: Benchmarking



- Industrial Environment



- Narrow Passage Environment



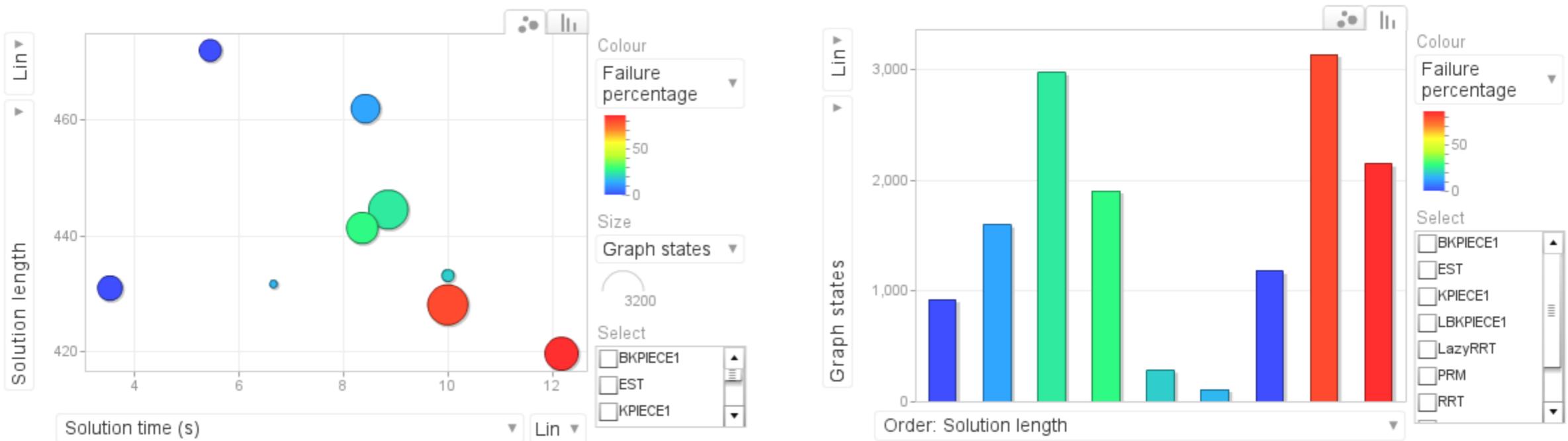
- Kitchen Environment



- Tabletop Environment

* Cohen, Sucan, Chitta, “A Generic Infrastructure for Benchmarking Motion Planners”, IROS 2012, Portugal

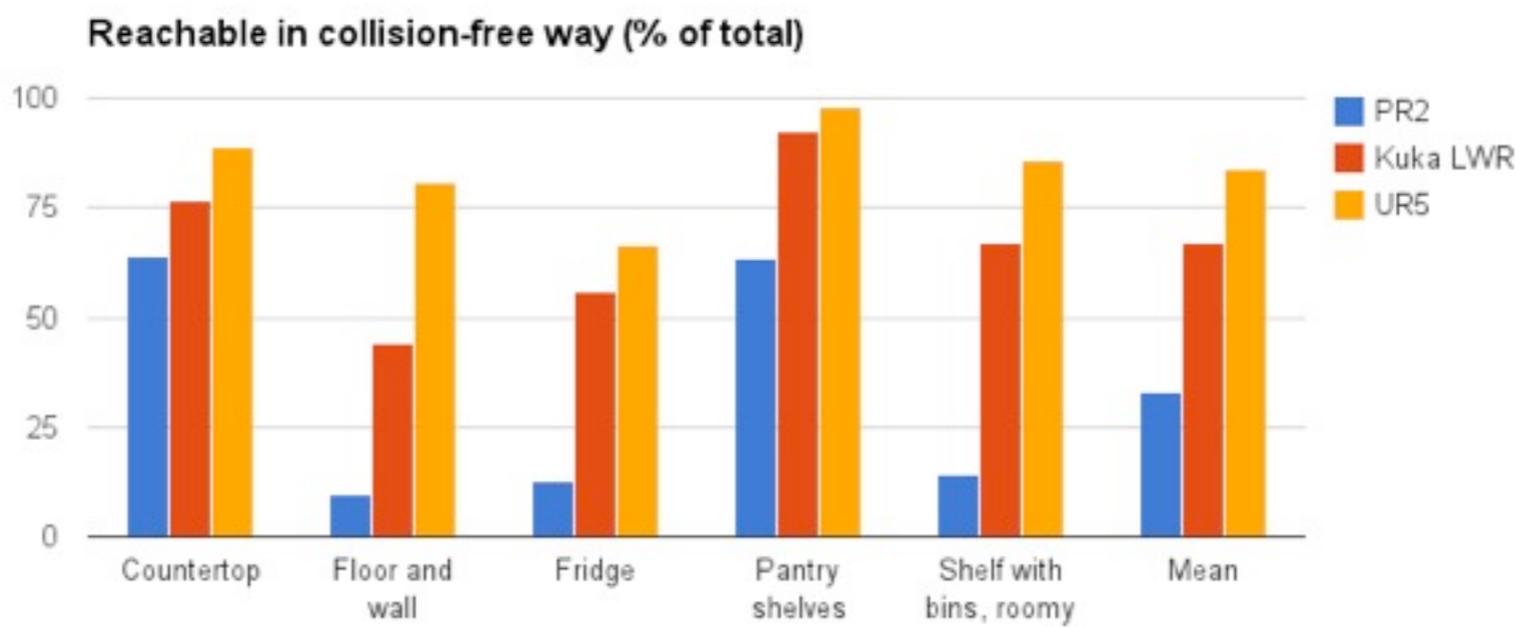
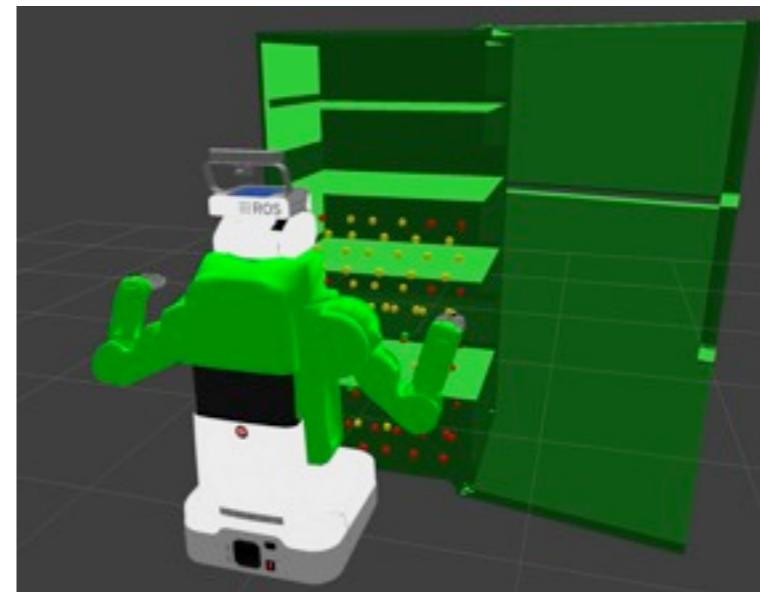
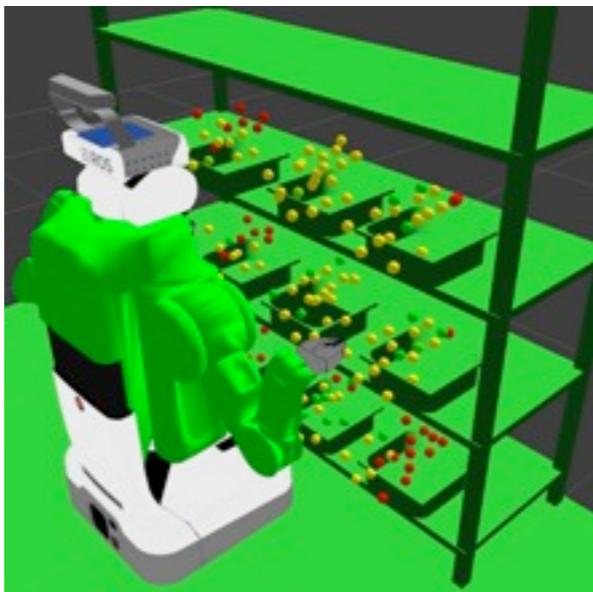
Benchmarking



Applications: Kinematic Workspace Analysis

- Robot Design Evaluation
- Robot Workspace Placement

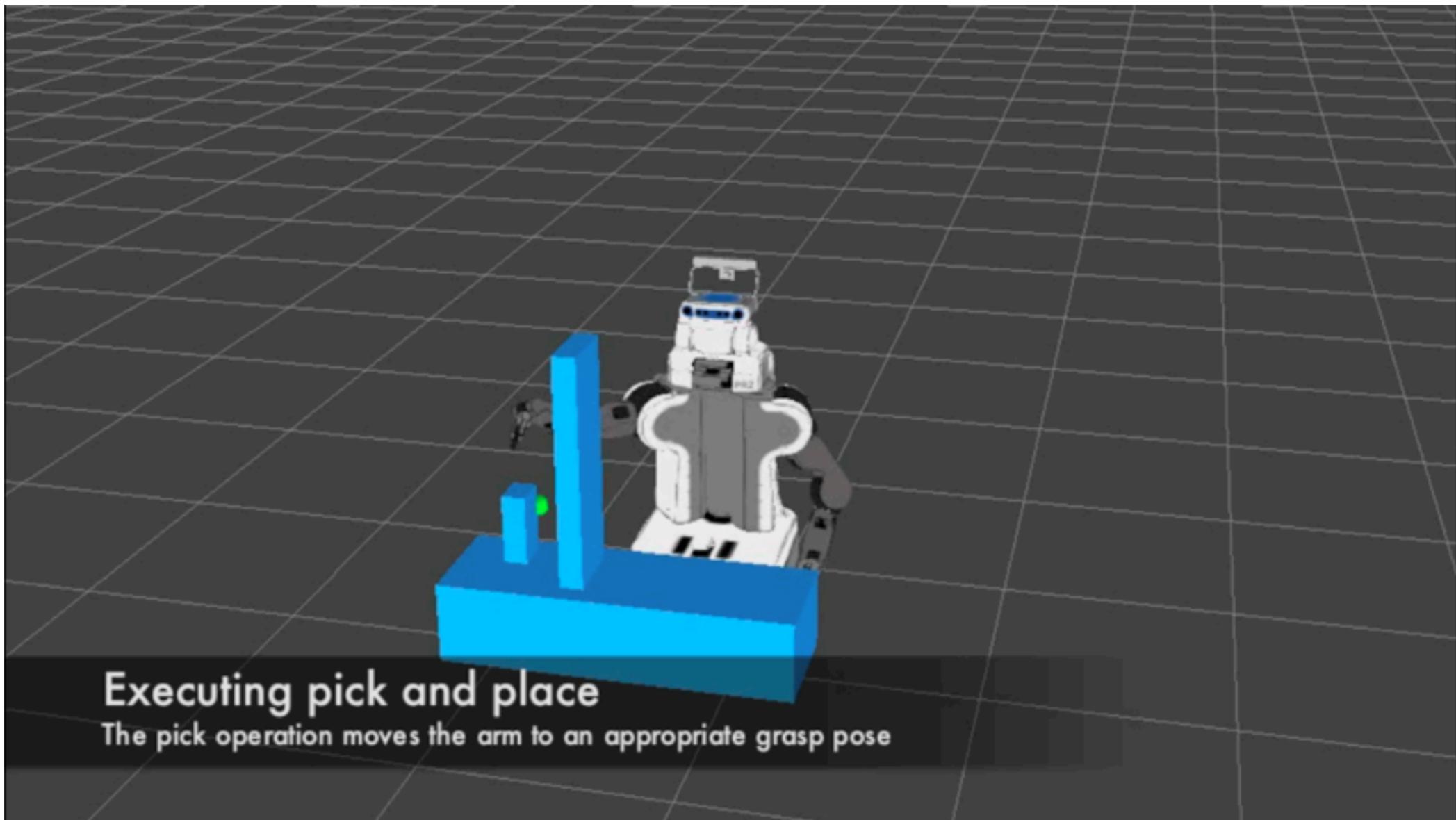
Kinematic Workspace Analysis



MoveIt!

- Applications - Pick and Place

- ❖ Integrated Grasping, Planning, Perception and Execution



User API

- Really simple API (e.g. moving an arm):

```
move_group_interface::MoveGroup group("arm");  
group.setRandomTarget();  
group.move();
```

MoveIt!

- New Architecture (different from arm navigation)
 - ✓ Minimize transport and messaging overhead - Single process for planning and perception, shares environment representation (planning scene) vs. multiple ROS nodes each performing individual functions
 - ❖ Computation - Core capabilities (e.g. motion planning, kinematics, etc.) are setup in C++ libraries
 - ❖ Communication and Configuration through ROS
 - ❖ Emphasis on speed and efficiency – parallelize collision checking, kinematics, etc.

MoveIt!

- Capabilities (differences to arm navigation)
 - ❖ Collision Checking
 - ✓ Parallelizable
 - ✓ can switch between different types of collision checkers
 - ✓ cleaner C++ interface
- Motion Planning
 - ✓ plugin based C++ interface (in addition to ROS interface)
 - ✓ Parallelizable
 - ✓ planning pipeline includes trajectory smoothing

Highlights

- Technical
 - Performance
 - ❖ Single process sharing environment representation
 - ❖ Parallelizable collision checking and kinematics
 - ❖ Parallelizable pick and place (upcoming capability)
 - Integrated Perception for Environment Representation
 - ❖ Can incorporate any source of point clouds
 - ❖ Fast self-filtering and environment representation
 - Reactive Motion Planning
 - ❖ Safer operation in collaborative environments

Highlights

- User Friendly

- ❖ Easy configuration for new robots
- ❖ Graphical User Interfaces
- ❖ Better Visualization and Introspection
- ❖ Easy to use C++ API
- ❖ Python bindings

Highlights

- Integrated Applications
 - ❖ Collision-free Motion Planning and Execution
 - ❖ Kinematic Analysis/ Reachability Analysis
 - ❖ Benchmarking
- More applications in development ...
 - ❖ Pick and Place - more about this in afternoon session

Documentation - Wiki

MoveIt – (Private Browsing)

moveit.ros.org/wikib/index.php/MoveIt!

Willow Garage

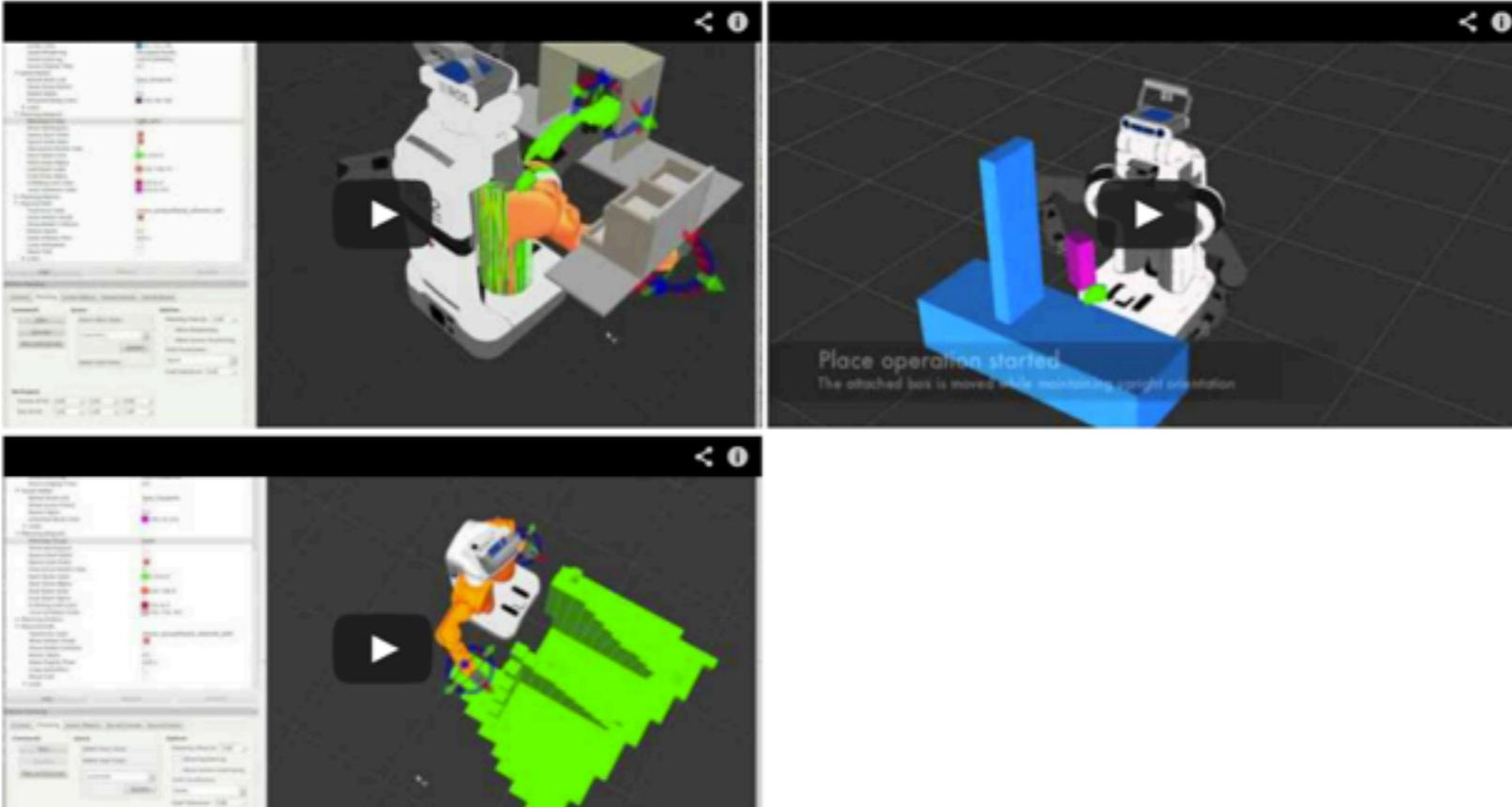
Page

Template:Ambox

MoveIt!

MoveIt! is a new software framework for motion planning in ROS. MoveIt! is a core part of ROS and will replace the Arm Navigation packages.

MoveIt! is still not fully ready yet. We will send out an email on ros-users once it is ready for use. In the meantime have a look at these videos to see how MoveIt! works.



Navigation

- Main page
- Installation
- Quick Start
- Capabilities
- Applications
- Code API
- Robots
- News
- Help

Toolbox

- What links here
- Related changes
- Special pages
- Printable version
- Permanent link

Github Repository

The screenshot shows a GitHub repository page for 'ros-planning/moveit_ros'. The repository is public and has 34 issues and 13 forks. The 'Code' tab is selected, showing a list of 1000+ commits. The commits are listed in reverse chronological order, with the most recent commit by 'loan Sucan' 22 minutes ago. Other commits are from various contributors like 'marioprats', 'loansucan', and 'davetcoleman'.

Author	Date	Message
loan Sucan	22 minutes ago	fix error reporting for trajectory execution when ensureActiveControl...
marioprats	a day ago	added goal existance checks [marioprats]
loansucan	20 hours ago	publish scene when cleared, initialize start, goal states [loan Sucan]
loansucan	17 hours ago	fix how we transform frames in pick&place [loan Sucan]
loansucan	a day ago	code to fill in a grasp [loan Sucan]
loansucan	5 days ago	0.3.22 [loan Sucan]
loansucan	a day ago	bugfixes and optimizations for processing depth images [loan Sucan]
loansucan	22 minutes ago	fix error reporting for trajectory execution when ensureActiveControl... [loan Sucan]
loansucan	24 minutes ago	disable keeping of attached objects for query states when scene state... [loan Sucan]
loansucan	5 days ago	0.3.22 [loan Sucan]
.gitignore	8 days ago	Ignore emacs temp files [davetcoleman]
README.md	3 months ago	added readme [loan Sucan]

Issue Tracking

The screenshot shows a GitHub Issues page for the repository `ros-planning/moveit_ros`. The page displays 34 open issues. The sidebar on the left provides filters for issues assigned to you, created by you, or mentioning you, along with a list of labels: bug (1), enhancement (8), nice to have (2), CRITICAL (0), MAJOR (0), MINOR (0), duplicate (0), invalid (0), question (0), and wontfix (0). A 'Manage Labels' button and a 'New label name' input field are also present. The main area lists the 34 open issues, each with a title, a 'bug' label, and a timestamp indicating when it was last updated.

Issue ID	Title	Last Updated
#210	modify speed of trajectory execution (a scale) at runtime	by lsucan 2 days ago
#207	Package naming inconsistency	enhancement by davecoleman 19 days ago
#196	rviz dies when disabling plugin / re-enabling	bug by davecoleman a month ago
#193	move eef offset computation from benchmark core to benchmark gui	by lsucan a month ago
#192	split run_benchmark into lightweight node + library	by lsucan a month ago
#191	Make benchmark service more general	by mariopatr a month ago
#181	split planning/ into planning/ and common/	by lsucan a month ago
#180	default location for loading ros params	by lsucan a month ago
#171	Add double-buffering to occupancy map updates	enhancement by aleeper 2 months ago
#168	Add ability to initialize using static octomap to occupancy_map_monitor	enhancement by sachinchitta 2 months ago
#166	Add ability to specify variable offsets to the control frame for end-effector markers	by aleeper 2 months ago
#162	names for background jobs in rviz plugin	by sachinchitta 2 months ago

Community

- moveit-users@googlegroups.com - questions related to how you can use MoveIt!

Where are we going?

- MoveIt!
 - ✓ what does it take to use MoveIt! in products
 - ✓ interest in enterprise level, supported versions of MoveIt! and associated capabilities in ROS?

More information



Email: moveit@willowgarage.com