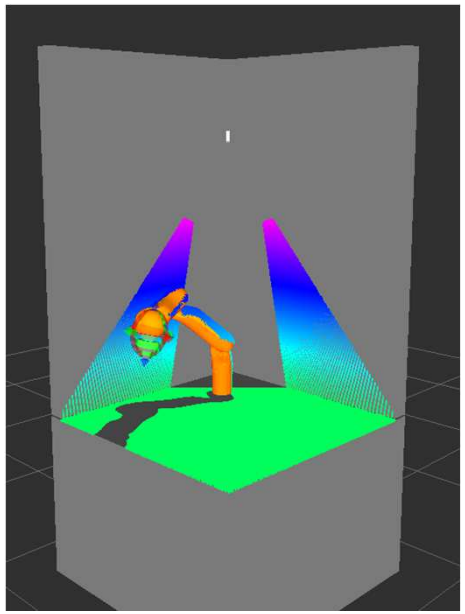
Motion Planning with ROS

Dipl.-Inform. Felix Meßmer

Technology Seminar – ROS in Industrial Applications



MoveIt!
moving robots into the future
moveit.ros.org

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Motion Planning with ROS
Goals

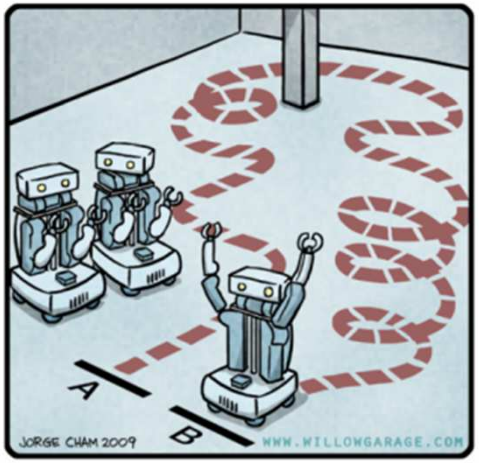
- Learn about Motion Planning Basics
  - Overview
  - Modules
- Learn about MoveIt!
  - Concepts
  - Capabilities
- Experience MoveIt!
  - Simulation
  - Robot Hardware

Motion Planning with ROS
Motion Planning Basics

- Problem formulation
  - Initial state q_{init} (position or configuration) is known
  - Goal state q_{goal} (position or configuration) is given
  - Environment (static and dynamic obstacles) is known
  - ➔ Find a path τ from q_{init} to q_{goal} that:
    - is (self-) collision-free
    - satisfies (joint, velocity, acceleration) limits
    - …

A basic motion planning problem is to produce a continuous motion that connects a start configuration S and a goal configuration G, while avoiding collision with known obstacles. The robot and obstacle geometry is described in a 2D or 3D *workspace*, while the motion is represented as a path in (possibly higher-dimensional) *configuration space*.

Source: Wikipedia



"HIS PATH-PLANNING MAY BE SUB-OPTIMAL, BUT IT'S GOT FLAIR."

Source: Willow Garage

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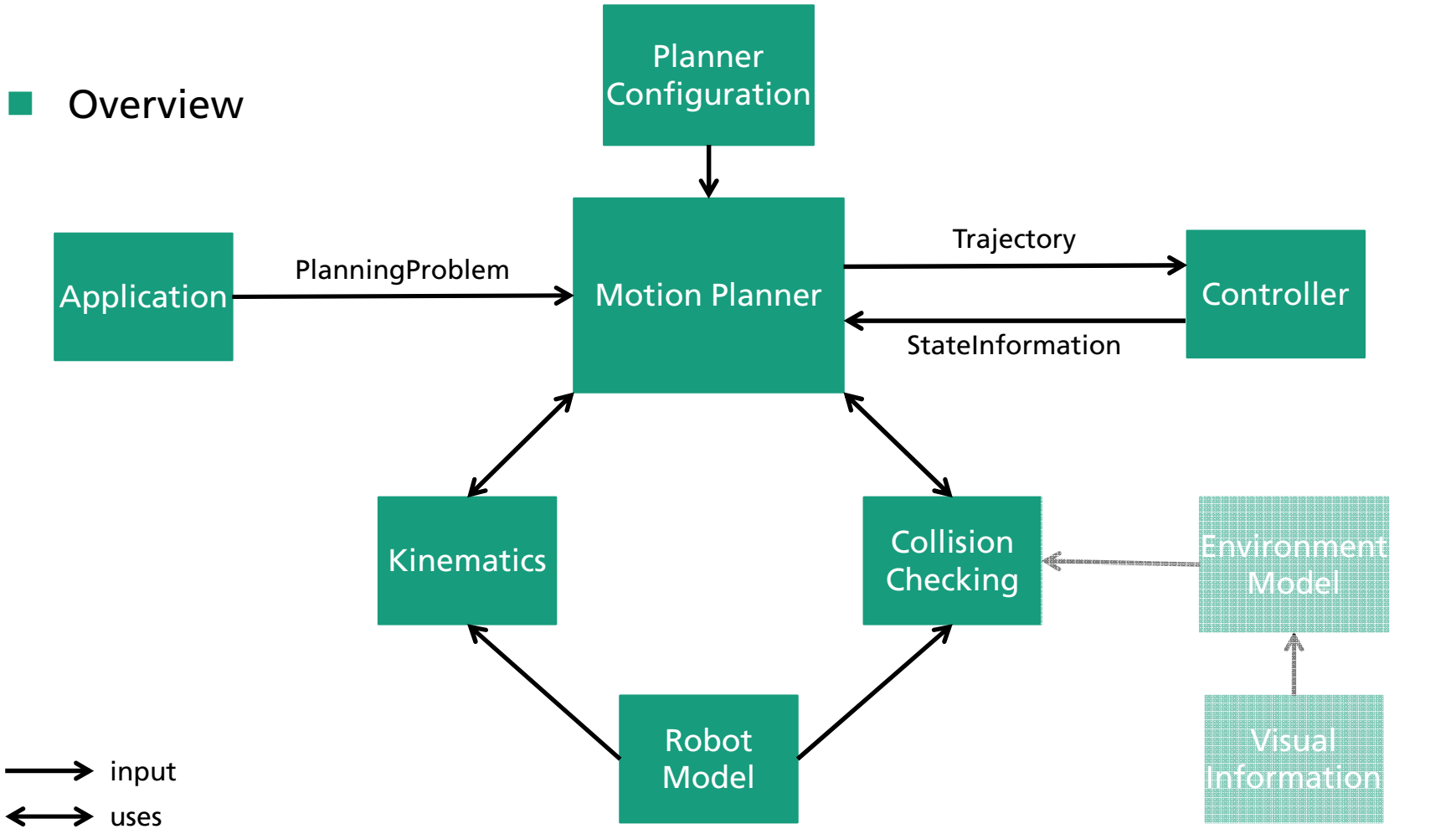
Motion Planning with ROS
Motion Planning Basics

- Overview



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Motion Planning with ROS
Motion Planning Basics

- Prerequisites
  - Robot Model (URDF)
    - Description of kinematic chain (→ Kinematics)
    - Description of robot geometry (→ Collision Checking)
  - For execution
    - Controller (HW driver or simulation)
  - Environment Model
    - None → Self-Collision Checking
    - Obstacles Description → static Collision Checking
    - Visual Information → dynamic Collision Checking + reactive Planning

Motion Planning with ROS
Introduction to MoveIt!

- State-of-the-art software framework for motion planning in ROS
- MoveIt! integrates core and low-level capabilities out-of-the-box:
  - Kinematics (e.g. KDL, IKFast)
  - Collision Checking (FCL)
  - Motion Planning libraries (OMPL, SBPL, CHOMP)
  - Environment representation & Perception (octomap)
  - Execution & Monitoring

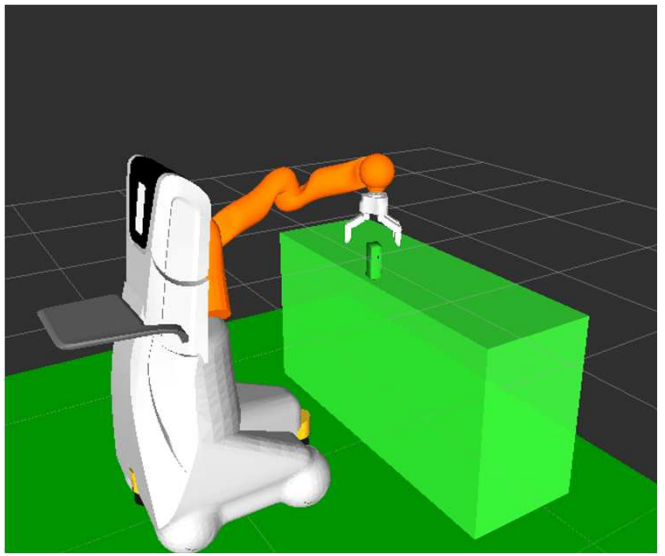
Motion Planning with ROS
Introduction to MoveIt!

- High(er)-level capabilities:
  - Pick-and-Place (grasp planning)
  - Constraint-aware Motion Planning
    - joint constraints
    - position constraints
    - orientation constraints
  - Benchmarking
    - evaluate and optimize planner performance
  - Workspace Analysis
    - robot design
    - robot placement

Motion Planning with ROS
Introduction to MoveIt!

- MoveIt! in robotics research:
  - Optimized for performance (single-process, parallelization)
  - Flexible, plugin-based
  - Easily exchange capabilities (e.g. planners)
  - Easily add your own capabilites/algorithms

Care-O-bot
Research



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Motion Planning with ROS
Introduction to MoveIt!

- MoveIt! in robotics applications:
  - No need to implement everything from scratch every single time!
  - Suitable for both Navigation and Maniputlation
  - Simple and easy-to-use API (C++ and Python)
  - ➔ Focus on development of mobile manipulation applications!

Source: SwRI@Automate2013

Motion Planning with ROS
Introduction to MoveIt!

- Robots using MoveIt!









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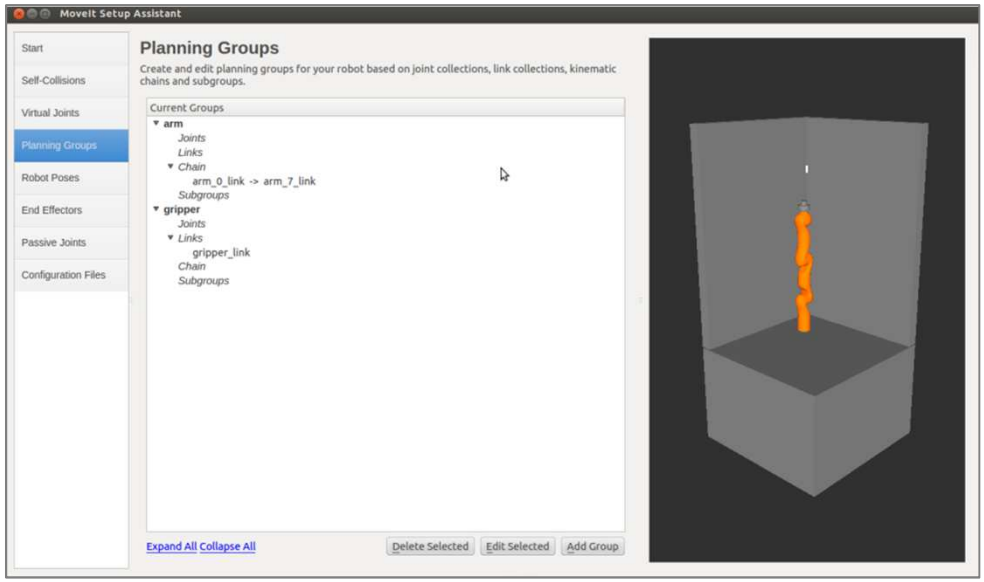
Motion Planning with ROS
Introduction to MoveIt!

- MoveIt! Documentation
  - Official website: http://moveit.ros.org/wiki/MoveIt!
  - ROS-Wiki: http://wiki.ros.org/moveit
  - Tutorials: http://moveit.ros.org/wiki/Tutorials
  - API documentation: http://docs.ros.org/hydro/api/moveit_core/html/
  - Code repository: https://github.com/ros-planning/
  - Mailinglist: mailto: moveit-users@googlegroups.com

Motion Planning with ROS
Usage of MoveIt!

- MoveIt! - Setup Assistant
  - Graphical User Interface
  - Uses kinematic description (URDF)

1. Pre-compute self-collision
2. Define Planning Groups
3. Define Robot Poses
4. Generate files automatically
   - Configuration files
   - Startup files



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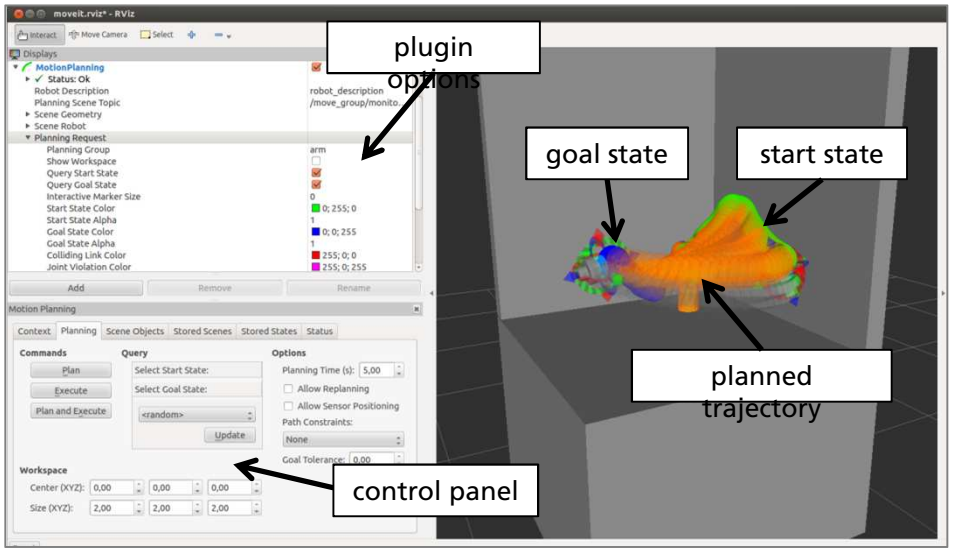
Motion Planning with ROS
Usage of MoveIt!

- MoveIt! – Interfaces
  - RVIZ-Plugin
    - graphical tool
    - visualization
  - Command-Line Tool
    - terminal-based tool
  - Scripting API
    - application development
    - C++ and Python API



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Motion Planning with ROS
Your manipulation expert

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