MoveIt Land, Sea, & Space
ROS Industrial Asia Pacific 2021

Dave Coleman, PhD
CEO, PickNik Robotics
davetcoleman
Outline

- Background
- About MoveIt
- Land, Sea, Space
- MoveIt 2 Roadmap Update
- ROS 2 Hardware Support
- Future Outlook
We are your partners in strategically developing custom robotics software, while de-risking open source usage.
The Dream: A Multi Purpose Robot

Powered by MoveIt and ROS

Willow Garage
MoveIt: A Hardened Motion Planning Platform

- **arm_navigation**
  - Version 1.0: 2010
- **MoveIt!**
  - Beta: 2013
- **MoveIt!**
  - Version 1.0: 2019
- **MoveIt2**
  - Version 2.0: 2020
- **MoveIt3?**
  - Version 3.0: 2022?
## A Feature-Rich Ecosystem

<table>
<thead>
<tr>
<th>Global Planners</th>
<th>Cartesian Planners</th>
<th>Inverse Kinematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMPL</td>
<td>RobotState</td>
<td>KDL</td>
</tr>
<tr>
<td>SBPL</td>
<td>Descartes</td>
<td>IKFast</td>
</tr>
<tr>
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</tr>
<tr>
<td>STOMP</td>
<td>PilzMotion</td>
<td>LMA</td>
</tr>
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<td>CHOMP</td>
<td></td>
<td>BioIK</td>
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<tr>
<th>Grasping Libraries</th>
<th>Collision Checking</th>
<th>Perception / Octomap</th>
</tr>
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<tbody>
<tr>
<td>MoveIt Grasps</td>
<td>Fast Collision Library (FCL)</td>
<td>Depth Images</td>
</tr>
<tr>
<td>Grasp Pose Detection (GPD)</td>
<td></td>
<td>Point Clouds</td>
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<tr>
<td>Intel OpenVino GPD</td>
<td>Bullet</td>
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**Global Planners**
- OMPL
- SBPL
- TrajOpt
- STOMP
- CHOMP

**Cartesian Planners**
- RobotState
- Descartes
- JogArm
- PilzMotion

**Inverse Kinematics**
- KDL
- IKFast
- TracIK
- LMA
- BioIK

**Grasping Libraries**
- MoveIt Grasps
- Grasp Pose Detection (GPD)
- Intel OpenVino GPD

**Collision Checking**
- Fast Collision Library (FCL)
- Bullet

**Perception / Octomap**
- Depth Images
- Point Clouds
<table>
<thead>
<tr>
<th>Metric</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot types integrated to work with MoveIt</td>
<td>152</td>
</tr>
<tr>
<td>Downloads per month of moveit_core</td>
<td>29,843</td>
</tr>
<tr>
<td>Academic citations of MoveIt</td>
<td>733</td>
</tr>
<tr>
<td>Unique users to moveit.ros.org in 2021</td>
<td>162,630</td>
</tr>
<tr>
<td>Members of Discourse, MoveIt's Discussion Forum</td>
<td>5,600</td>
</tr>
<tr>
<td>Github users have starred the MoveIt project</td>
<td>1,136</td>
</tr>
<tr>
<td>Github code contributors to MoveIt</td>
<td>262</td>
</tr>
<tr>
<td>International attendees of 2020 MoveItWorld online event</td>
<td>167</td>
</tr>
</tbody>
</table>
An Active Community

- MoveIt Workshop @ ROSCon 2021
- World MoveIt Day (annually)
- Monthly MoveIt Manipulation Working Group meetings
Land, Sea, Air
Land

Agriculture
Plant Harvesting

Food
Kitchen Assistant

Logistics
Bin Picking
Sea

Subsea

Remotely Operated Underwater Vehicles (ROVs)
Our Common Approach

Supervised Autonomy

- Smarter than teleop, but not full automation
- Human in the loop
MoveIt Migration to ROS 2

Updates
Migration Progress: ~98.5%
All but MSA, Pilz, Python bindings!

MoveIt 2 Git Stats:
- 340 PRs, ~500 commits in MoveIt 2 out of 7.9k total
- MoveIt 1->2 diff: 828 files touched, 18688+, 31696-
- 2x GitHub stars since July 2020 (120 -> 243)
## Comparison of MoveIt 1 and MoveIt 2

<table>
<thead>
<tr>
<th>Feature</th>
<th>MoveIt 1</th>
<th>MoveIt 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROS 1 Support</td>
<td>✓</td>
<td>✓ via roslaunch bridge</td>
</tr>
<tr>
<td>ROS 2 Support</td>
<td>×</td>
<td>✓</td>
</tr>
<tr>
<td>Motion Planning</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Inverse Kinematics</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Perception</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Grasping</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Setup Assistant</td>
<td>✓</td>
<td>in development</td>
</tr>
<tr>
<td>MoveIt Task Constructor</td>
<td>✓</td>
<td>pending</td>
</tr>
<tr>
<td>Game Controller Integration for Servo</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

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<tr>
<th>Feature</th>
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<th>MoveIt 2</th>
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<tr>
<td>Industrial Trajectory Generator</td>
<td>✓</td>
<td>planned</td>
</tr>
<tr>
<td>Probabilistically complete Cartesian Planning</td>
<td>✓</td>
<td>stale patch</td>
</tr>
<tr>
<td>Composable Nodes</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Planning for Differential Drive Bases</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hybrid Planning (global + local planners)</td>
<td>✓</td>
<td>pending</td>
</tr>
<tr>
<td>Based on Realtime Capable DDS Messaging</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Native Windows Build</td>
<td>✓</td>
<td>via RoboStack</td>
</tr>
<tr>
<td>New Feature Development by PickNik</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Development Coordinated with ROS 2 Technical Steering Committee</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Built for Industrial Security</td>
<td>✓</td>
<td>✓</td>
</tr>
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</table>
Major Achievements

- Ported MoveIt Task Constructor, MoveIt Visual Tools
- Fully switched to GitHub Actions CI
- Servo/PoseTracking redesign, Component Nodes
- OMPL Constrained Planning (partial support)
- ROS2-Control integration, “fake driver” mode
- Mobile base joint support, Ignition Gazebo
- Hybrid Planner
- Multi-planner support
Demos of MoveIt 2

**MoveGroup**


**MoveItCpp**

1. **Reactive Closed-loop control**

- New pose tracking feature based on MoveIt Servo
- 6-DOF PID controller for stable Cartesian motions
- Runs distance-based collision checking
- Supports dynamic scene updates

### Realtime Support

- Reactive, closed-loop control to sensor input
  - Visual servoing, faster octomap updates
  - Preempt motion if new collision detected

- Separate global and local planner (hybrid planning)
  - Global planner (full collision checking): ~10hz
  - Local planner (IK-based, field-based): ~300hz

- Zero-memory copy integration to controllers (ros_control)
  - Tighter integration to ros_control

- Integrate pilz_industrial_motion
2. Separate Global/Local Planner (Hybrid Planning)

Project Status
- Initial research completed
- Working on architecture design
- Selecting & Testing Planner Candidates

Realtime Support
- Reactive, closed-loop control to sensor input
- Visual servoing, faster octomap updates
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- Zero-memory copy integration to controllers (ros_control)
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- Integrate pilz_industrial_motion
3. ROS 2 Controllers - Zero-memory Copy Integration

- Demos running on simulated ROS 2 controllers
- Integration was paused due to breaking API changes
- Part of “Hardware Integration” efforts
- Possibly supporting ROS 2 Controllers as “Local Planner”

Realtime Support

- Reactive, closed-loop control to sensor input
  - Visual servoing, faster octomap updates
  - Preempt motion if new collision detected
- Separate global and local planner (hybrid planning)
  - Global planner (full collision checking): ~10Hz
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- Zero-memory copy integration to controllers (ros_control)
  - Tighter integration to ros_control
- Integrate pilz_industrial_motion
4. Integrate Pilz Industrial Motion Planner

- Computes standard robot motions: PTP, LIN, CIRC
- Supports motion sequences via trajectory blending
- Integration and tutorials are **feature complete**

**TODO:** Port to ROS 2
Hardware Support
Hardware Integration Challenges

“Chicken and Egg” Problem:

- ROS 2 user adoption is driven by hardware support
- Broad hardware support requires user adoption

PickNik is working on multiple hardware integration efforts...
ROS 2 Supported Hardware

Major contributions to ros2_control

- Admittance controller (PR in review)
  - Currently used for streamed waypoints
  - Trajectory controller in progress
- Dynamic loading, starting, stopping and unloading of HW interfaces
- Port of gripper action controller
- Extensive testing on industrial and cobot hardware
ROS 2 Supported Hardware

Hello Robot - “Stretch”
Universal Robots UR5
ROS 2 Supported Hardware

Kinova Gen3
Future Outlook
Future Versions

**MoveIt3?**

Version 3.0
2022?

- End effector switching at runtime
- Lifecycle Management of MoveIt Nodes
- Leverage ROS2 component nodes

*Seeking funding sources!*
<table>
<thead>
<tr>
<th>FEATURE</th>
<th>ESTIMATED DATE</th>
<th>FEATURE LEAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid Planning</td>
<td>June 2021</td>
<td>Sebastian Jahr, Henning Kayser</td>
</tr>
<tr>
<td>Migrate Pilz Industrial Motion Planner to ROS 2</td>
<td>July 2021</td>
<td>Henning Kayser</td>
</tr>
<tr>
<td>Movelt Config Redesign - Migrate MSA to ROS 2</td>
<td>October 2021</td>
<td>Henning Kayser, Tyler Weaver</td>
</tr>
<tr>
<td>Scene Graph Support</td>
<td>December 2021</td>
<td>Felix von Drigalski, OMRON SINIC X</td>
</tr>
<tr>
<td>OMPM Orientation Constraints</td>
<td>December 2021</td>
<td>TBD</td>
</tr>
<tr>
<td>Add ability to attach and detach end-effector links</td>
<td>December 2021</td>
<td>TBD</td>
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- **WIP: Will be completed with Fraunhofer collaboration**
- **WIP: Almost completed**
- **WIP: Just recently got support from third-party company, might require to be broken up into multiple goals**
- **Inactive**
- **WIP: lots of work on this**
- **WIP: initial investigations**
Versions & Release Cycle

Supported on all three primary ROS 2 Distros:

- ROS 2 Foxy, Galactic, Rolling
- Focusing only on Galactic and Rolling
- Active development on Windows
Contribute to Open Source

Get Involved

https://moveit.ros.org/about/get_involved/

Enhance Documentation
Expand and improve upon our tutorials and example code.

Answer User Questions
You probably know more than you realize, share that knowledge!

Fix Bugs
Any active and growing project inevitably has regressions that need cleanup.

Add New Features
MoveIt is actively developed: help improve the #1 ROS manipulation platform.
Thanks!

PickNik Robotics
picknik.ai
Colorado, USA
@picknikrobotics

Dave Coleman
dave@picknik.ai
@waffle