

>Movelt!

Motion Planning for Industrial Robots using MoveIt!

Sachin Chitta

Associate Director Robotics Systems and Software

SRI International

- Manager and Research Scientist, Willow Garage, (2007-2013)
 - MoveIt!, Arm Navigation, ROS Control, 3D Navigation, FCL, SBPL, OMPL, ROS, PR2
- Founding Team, Redwood Robotics, (2010-2013)
 - ✤ acquired by Google last year
- Post-doc, University of Pennsylvania (2005-2007)
- PhD, GRASP Lab, University of Pennsylvania, 2005

Robots In Industry







Hard to program

Robots in automation are currently inflexible - hard to setup and hard to program.

Expensive

 Typical cost of deploying/programming a robot is 70-80% of the cost of a robotics application

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

MoveIt!

- A user-friendly platform for building FLEXIBLE industrial, research and commercial applications
 - Easy Configuration, Easy Programming, Quick switch-over
 - ✤ High Performance
 - Cross Platform

Evolution - Arm Navigation

http://youtu.be/tzUrdvhWgx8

Arm Navigation - Chitta, Jones, Ciocarlie, Hsiao, Sucan, 2011

Initial Industrial Application

http://youtu.be/_WG-45cZSUQ

Willow Garage, SwRI, Yaskawa Motoman

MoveIt!

- Thread-based architecture
 - Parallelize motion planners and collision checking
- GPU acceleration for 3D perception
- Script based user interface
 - designing complex programs/tasks
- GUI based interface
 - make things easier for users
- Setup Tools
 - easy to import new robots

MoveIt! - Initial Robots





Willow Garage

ROS-Industrial



Fraunhofer, Willow Garage

What does MoveIt! offer?

• 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









ROS Control



ROS-Control is based on the set of controllers originally developed for the PR2 robot

ROS Control





Taurus (SRI)



Gazebo

REEM-C (PAL Robotics)



The Redwood Arm

MoveIt!

- MoveIt! works online
 - ✤ directly deals with perception data
 - \diamond directly talks to controllers
- MoveIt! also works offline
 - ✤ import CAD model data
 - offline programming and planning of complex multi-step paths
- MoveIt! enables full applications

Collision Checking

- FCL Flexible Collision Library*
 - ✤ parallelizable collision checking
 - Maximum about 2-3,000 full body collision checks for the PR2 per second
 - \checkmark 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

Motion Planning



- Plugin interface for planners
- Integration with robots through MoveIt!
- Automatically configured using the MoveIt! Setup Assistant
 - * Sampling based planners $(OMPL)^*$
 - ✤ Search Based Planning Library (SBPL)[^]

* Lydia Kavraki, Ioan Sucan, Mark Moll, Ryan Luna, Sachin Chitta [^]Maxim Likhachev, Mike Phillips, Ben Cohen, Andrew Dornbush, Sachin Chitta

Easy Setup and Configuration

Start	Movelt Setup Assistant	1
Self-Collisions	Welcome to the Movelt Setup Assistant! These tools will assist you in creating a Movelt configuration package that is required to run Movelt. This includes generating a Semantic Robot Description Format (SRDF) file, kinematics configuration file and OMPL planning	6
Virtual Joints	configuration file. It also involves creating launch files for move groups, OMPL planner, planning contexts and the planning warehouse.	
Planning Groups	Choose mode:	
Robot Poses	All settings for MoveIt are stored in a Moveit configuration package. Here you have the option to create a new configuration package, or load an existing one. Note: any	
End Effectors	changes to a Movelt configuration package outside this setup assistant will likely be overwritten by this tool.	
Passive Joints	Create New Movelt Edit Existing Movelt Configuration Package Configuration Package	
Configuration Files		
	Load a URDF or COLLADA Robot Model	
	Specify the location of an existing Universal Robot Description Format or COLLADA file for your robot. The robot model will be loaded to the parameter server for you. Note: an XACRO URDF must first be converted to a regular XML URDF before opening here. To convert a file run the following command: <i>rosrun xacro xacro.py model.xacro > model.urdf</i>	
	an/projects/swri-ros-pkg/mantis/mantis_config/urdf/mantis_sia20d.xml Browse	
	Success! Use the left navigation pane to continue.	

Robots Using MoveIt!

















Motoman (SIA5)/SIA10d Universal Robots /(SIA20) UR5/(UR10)

ABB IRB 2400

Kawada Hiro Summit XL-Terabot

HRP 4 Pioneer P3AT

PhantomX Pincher ClamArm HDT Arm

Lynxmotion Servo Erector Arm



Comau NM45

KUKA OmniROB





Schunk 7-DOF



PAL Robotics REEM Schunk Powerball

Barrett WAM

PR2 Baxter Research Robot



Cyton Veta

Kinova Jaco

BDI Atlas



KUKA LWR/LBR

Robonaut/Robonaut2



Schunk Dextrous Hand Aldebaran Romeo CKBot

Aldebaran NAO



Clopema Robot



X-WAM

iCub











DI R-Hit Hand





MEKA M3

REEM-C

Hoap3

80

Fanuc m10ia BioRob Arm





Hubo



Katana

Shadow Robot and Hand

KUKA Youbot







HRP-2







Industrial





New Generation of Robots













Kawada Hiro

200

Schunk 7-DOF

.

.



Sã

Aldebaran NAO

C chris (

...

Summit XL-Terabot



HRP 4

Care-O-Bot



Pioneer P3AT





HDT Arm



PhantomX Pincher ClamArm

Lynxmotion Servo Erector Arm



X-WAM

PAL Robotics REEM Schunk Powerball

Barrett WAM



Fanuc m10ia BioRob Arm

Hoap3

Cyton Veta

.



KUKA LWR/LBR

TUM Rosie



Schunk Dextrous Hand Aldebaran Romeo CKBot Denso Robot (vs060)

-

HRP-2



DI R-Hit Hand iCub REEM-C

1001 bd



Comau NM45

KUKA OmniROB





Rob@Work



Hubo



Korus Homemate Robot



Katana







MEKA M3

Shadow Robot and Hand

KUKA Youbot











Humanoid



http://moveit.ros.org

Kinematic Workspace Analysis







27

MoveIt! in Industry

Unstructured Pick and Place



MoveIt! in Industry

Workcell Programming



A Montage of Applications

3 Movell

MONTAGE 2013

More Info ...

