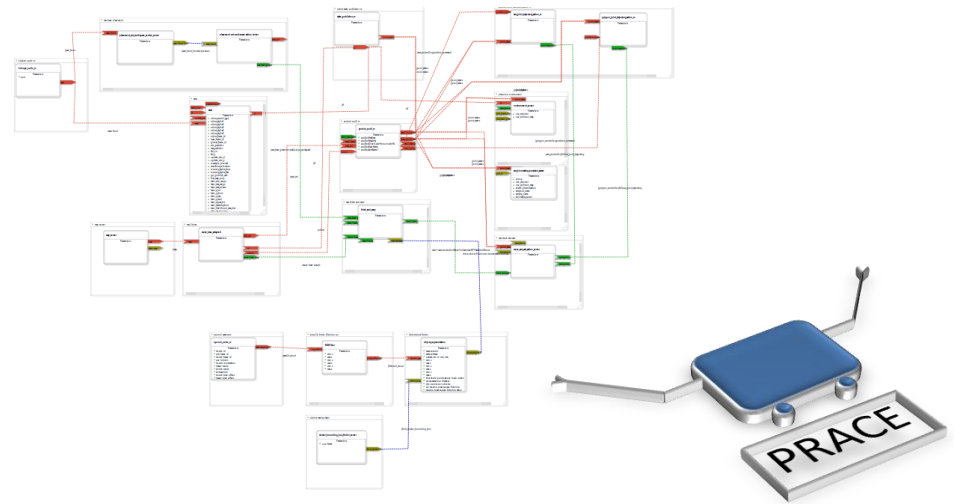
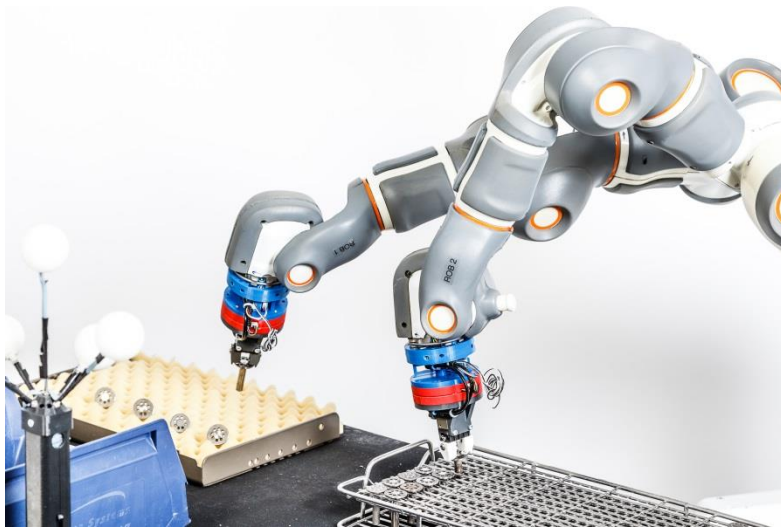


Development of dual arm mobile manipulation systems for small part assembly tasks

Alexander Bubeck, Benjamin Maidel, Felipe Garcia Lopez, Lorenz Halt, Alexander Koch
ROSCon 2014 Chicago



Outline

- Introduction to the PRACE Project
- Interfacing the ABB dual robot with the ROS industrial stack
- Planning dual arm motions with MoveIt!
- Rapid application development for a dual arm mobile manipulator
- Summary

PRACE

Overview

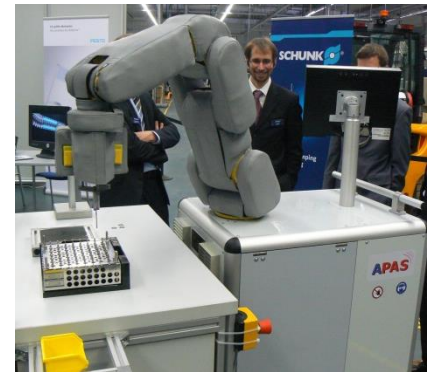


■ PRACE – The Productive Robot Apprentice

- Development of a mobile dual arm robot system for the automation of small batch assembly processes
- Automation during scale up processes (small lots, flexible processes)
- Application development on site by factory worker as an assistant

■ FoF EU Project with partners: Bosch, DTI, ABB, Lund University, Magellium and Fraunhofer IPA

■ Project period: Nov. 2011 – Oct. 2014

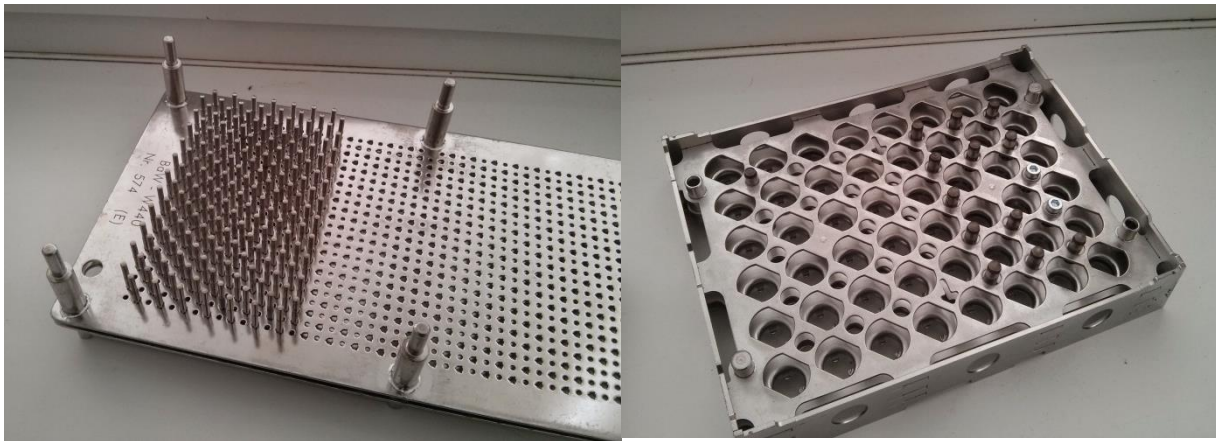


APAS System by Bosch

PRACE

Use cases

- Small part coating processes
- Palletizing of needles
- Different shapes and trays



PRACE

The dual arm mobile manipulator

Pneumatic gripper with passive compliance

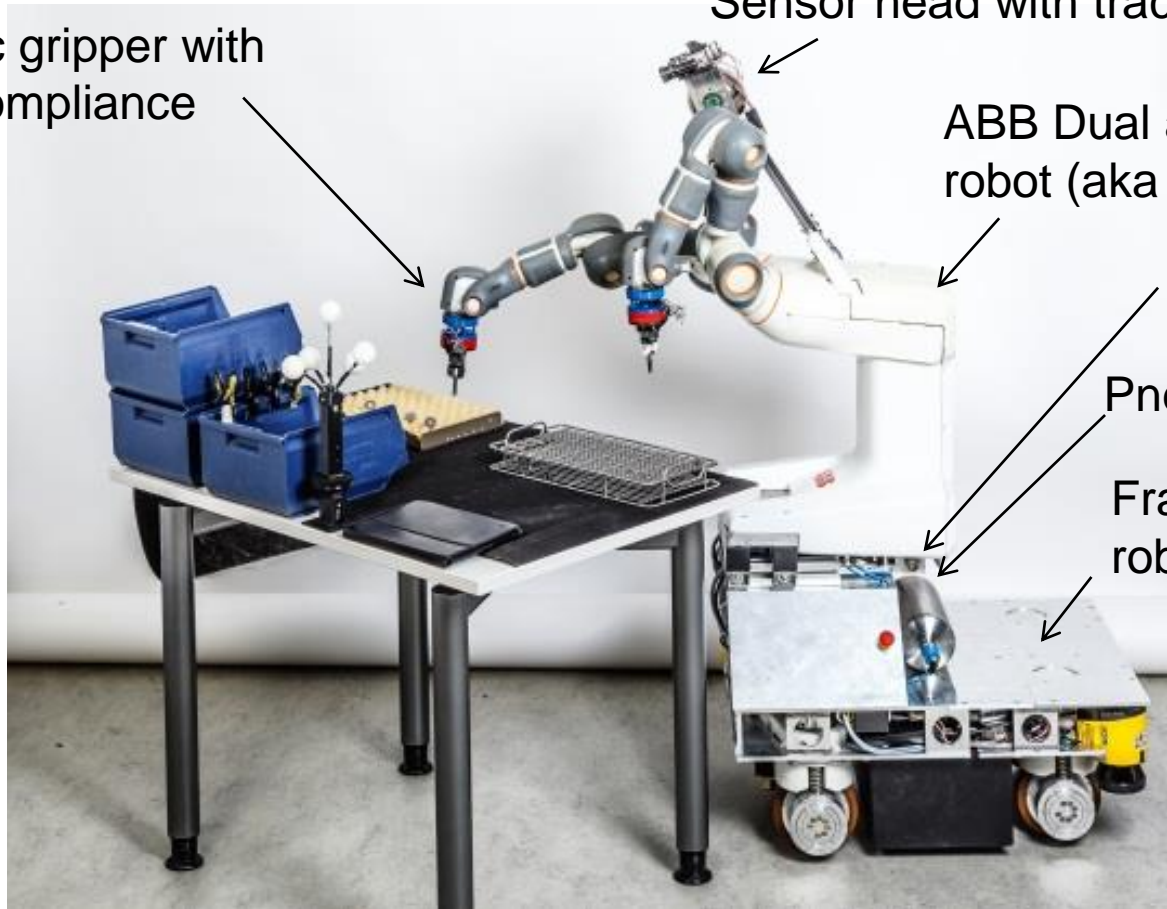
Sensor head with tracking system

ABB Dual arm concept robot (aka Frida)

Lifting unit

Pneumatic tank

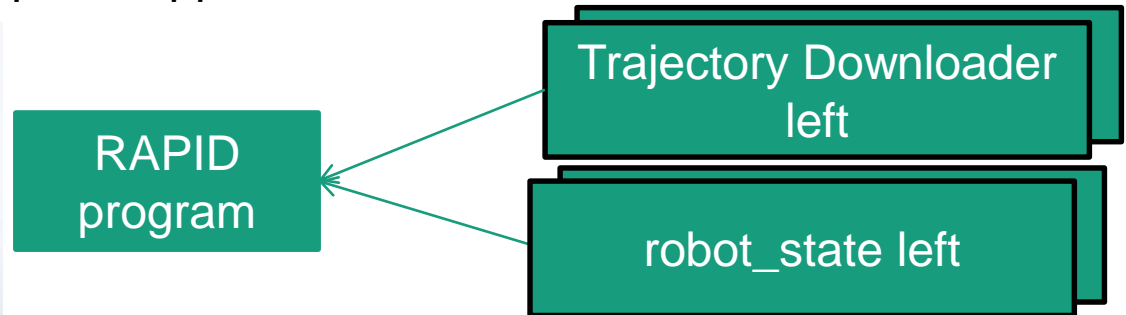
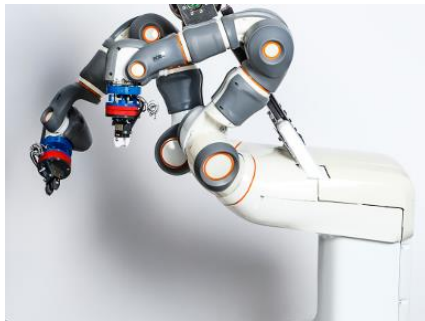
Fraunhofer IPA rob@work 3



Interfacing the dual arm manipulator

Basic ros-industrial interface

- ABB dual arm manipulator has standard ABB controller in it's body
- Two industrial-client instances running, one for each arm
- Industrial-client can be run without change
- Extension of RAPID script to support 7 DOF and two arms



- Performance slow due to large TCP/IP overhead, trajectory points are submitted separately

Interfacing the dual arm manipulator

Performance extensions

- Extending the RAPID/industrial_client setup with an additional message type
- Extending default size of simple_message from 1024 Byte to 16000 Byte
- Submission of all Trajectory points at once
 - Large improvement of submission of motion commands (1/10)

- Additional msg type to support Cartesian trajectory points

Planning dual arm motions with MoveIt!

Configuration and setup

- Configuration of 3 separate move_groups:
 - one for each arm
 - one for both arms (with all 14 DoF)
- More move_groups because of multiple „tools“ (gripper, camera, tool exchanger)
- Simplification of trajectories problematic

Development of applications with two arms is difficult !

<https://vimeo.com/106815072>

<https://vimeo.com/106815073>

<https://vimeo.com/106815076>

Planning dual arm motions with Movelt!

Comparison of IK Solvers

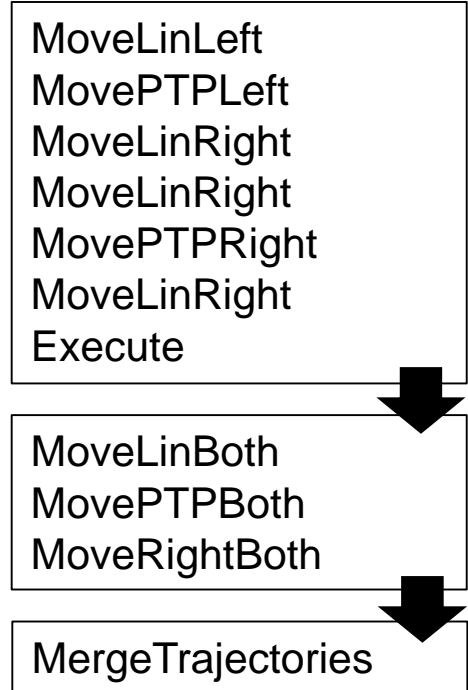
- Applications included multiple linear Cartesian motions
- ABB robot has small joint constraints
- Movelt!:
 - KDL → often reconfigurations
 - IKFast → often no solution
 - LMA (Levenberg-Marquardt) → better performance than KDL
 - You gain collision checking
- ABB controller → Extension of industrial_client
 - Reliability
 - Performance
 - Repeatability

Planning dual arm motions with MoveIt!

Dual Arm Motion Scheduler

- Queuing of multiple motion commands (ActionServer)
- Synchronization command
- Scheduling of both manipulators to generate dual arm motion requests
- Merging of planning results to generate one motion trajectory after each sync (performance)
- Lookup of move_groups

http://github.com/ipa320/prace_control



<https://vimeo.com/106815079>

Dual arm manipulation with MoveIt! + ros-industrial

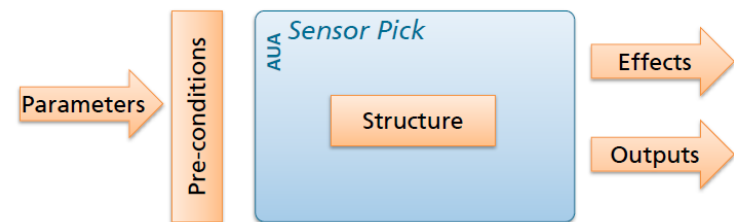
Challenges

- Exchangeability of implementation of Cartesian motion with industrial manipulators
- Standardization of Cartesian interfaces
- MoveIt! documentation regarding trouble shooting could be better
- Calibration of kinematic properties to URDF model is hard
 - Visual calibration
 - Downloading of kinematic data from controller

Rapid application development

Concept: Task development with AUA's

- Development of High-level „Assembly Unit Actions“:
 - AUA: platform-independent parts of an application that represent a functionality of the robot system
 - Every robot system implements a specific implementation of a number of AUA's
 - AUA's consist of a formal description of parameters, pre/post-conditions and effects
- End users develop applications by assembling AUA's



Rapid application development

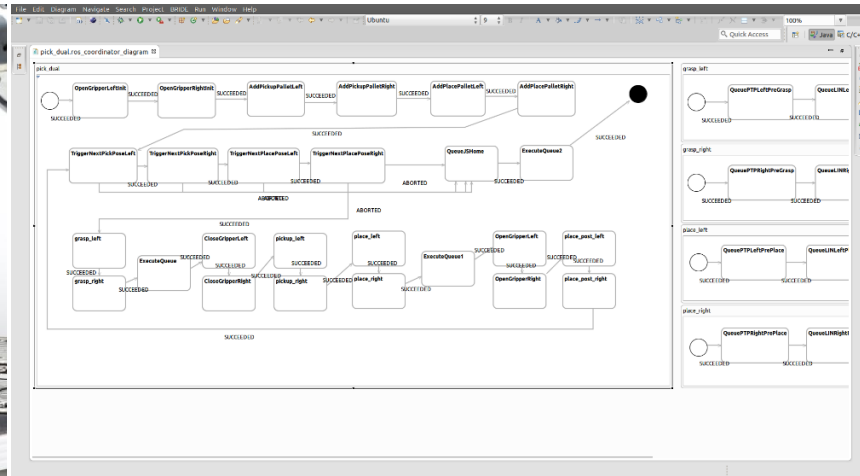
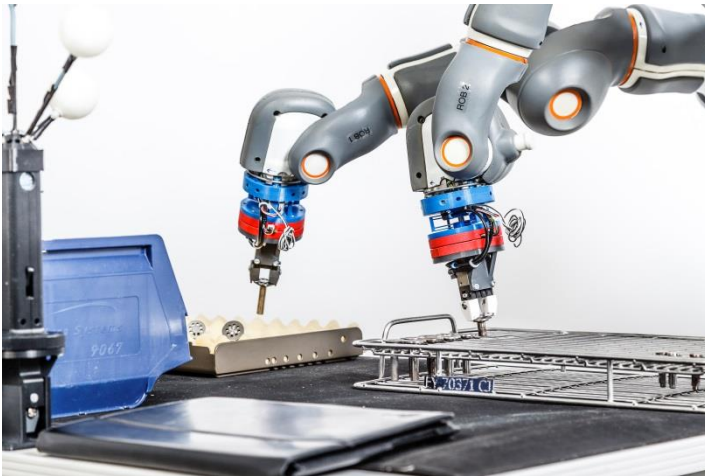
Model driven task development system

- Formal description of AUA's based on model driven engineering
- Development of a model driven engineering tool chain for Rapid Robot Application Development
 - Clear separation of capabilities, coordination and configuration of the robot system
 - BRIDE as an engineering tool chain for the implementation of AUA's
 - Integration in the coordinator development editor
 - Separation of AUA's and Primitives

Rapid application development

PRACE development workflow

- Robot developer creates AUA's state machines with BRIDE
- Exports these state machines as „AUA's“
- Selects state configuration that can be configured by end user
- AUA' appears on end-user GUI
 - Solution for fast and easy configuration required



Rapid application development

Configuration of AUA's and primitives

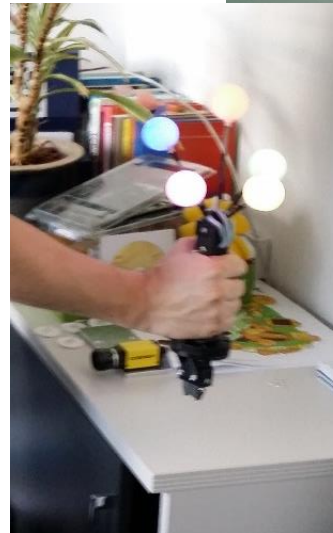
- cob_teacher
 - Parses yaml files holding rosmmsg entries
 - Visualizes fields of rosmmsg's for input
 - Allows the usage of “teacher_plugins” for common rosmmsg types
- Configuration of applications with multiple modalities
 - Teach-In handle
 - Touchup
 - Perception system

<https://vimeo.com/106815080>

Rapid application development

Tracking devices as teacher plugins

- Optitrack
 - specific HW
- TIY <https://code.google.com/p/tiy/>
 - arbitrary IR stereo camera system
- Commercial system by Magellium
 - regular monocular color camera



Rapid application development

Configuration of AUA's by the end user

■ Configuration of sequences of AUA's with Web-GUI

Fraunhofer IPA PRACE

▶ || ■ ↺ ↻ 🔒 Options ▾

/move_ptp +

/move_lin +

Skill Provider: /rosWebGateway
Skill Topic: /move_lin/goal
Skill Type: /move_lin

/move_base +

/move_lin ^ v -

/move_base ^ v -

/move to table ^ v -

Skill Provider: /rostopic_11116_1406036201842
Skill Topic: /move_ptp
Skill Type: /move_ptp 🗑

/move_base ^ v -

Deployment

Examples from factory tests

<https://vimeo.com/106816110>

Teaching dual arm motion with tactile feedback

Summary and Outlook

Dual arm mobile manipulation systems for small part assembly tasks

- Usage of ros_industrial driver with the ABB dual arm concept robot
- Usage of MoveIt! for precise dual arm motion planning
- Implementation of a rapid application development system

- Currently process of revising and open sourcing the work
- Demonstrator will be used after the project by Bosch and Fraunhofer IPA
- Continue to use rapid application development system in other projects

More information: <http://prace-fp7.eu>