Winning with MoveIt!

Team Delft – Amazon Picking Challenge

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08.10.2016

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Self Introduction

Stowing Challenge	Picking Challenge
Delft - 214	Delft – 105 (00:00:30)
NimbRo - 186	PFN – 105 (00:01:07)
MIT - 164	NimbRo - 97

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Contents

- Getting started with the Amazon Picking Challenge (APC) [1]
- Team Delft APC motion module with MoveIt! [2]
- MoveIt! Specific lessons learnt
- General lessons learnt
- Concluding remarks

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Getting started with APC

[Fiad-tud-3me] Fwd: [robocup-worldwide] Amazon Picking Challenge @ RoboCup 2016

fiad-tud-3me-bounces@lists.tudelft.nl on behalf of G.A. vd. Hoorn - 3ME [g.a.vanderhoo...

To: fiad-tud-3me@lists.tudelft.nl

Attachments: (2) Download all attachments
Attached Message Part (246 B); ATT00001.txt (230 B)

Thursday, December 17, 2015 3:58 PM

so .....

;)

Gijs

-------- Original Message --------
Subject: [robocup-worldwide] Amazon Picking Challenge @ RoboCup 2016
Date: Thu, 17 Dec 2015 14:53:06 +0000
From: Durham, Joey <josepdur@amazon.com>
To: robocup-worldwide@cc.gatech.edu <robocup-worldwide@cc.gatech.edu>

Amazon Robotics is pleased to announce the second edition of our manipulation contest to be held at RoboCup at the end of June 2016 in Leipzig, Germany (http://www.robocup2016.org/).

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Why MoveIt!?

- Previous experience with pick and place applications.
- Knowledge of using pick and place pipeline for an industrial “boxpacking” task.
- Curiosity! [3]

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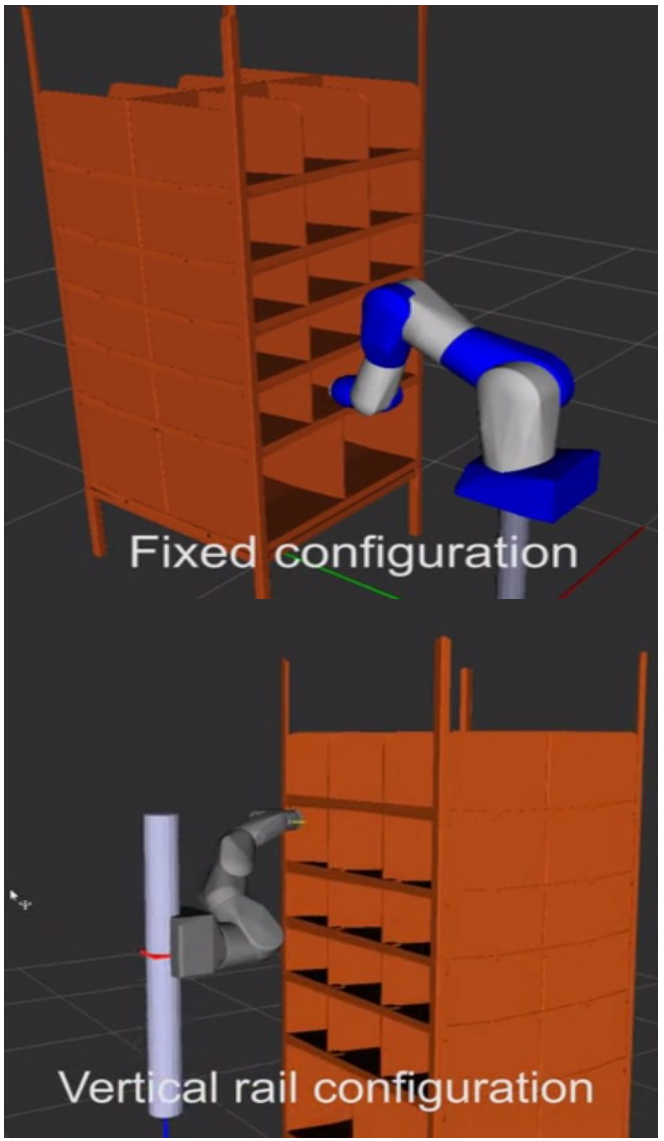
Robot setup

Workspace analysis of different configurations



- Fixed Configuraton
  - Upper and lower bins at the centre.
  - Deep corner bins.
- Vertical configuration
  - Side and corner bins.
  - Practicalities with the rail.

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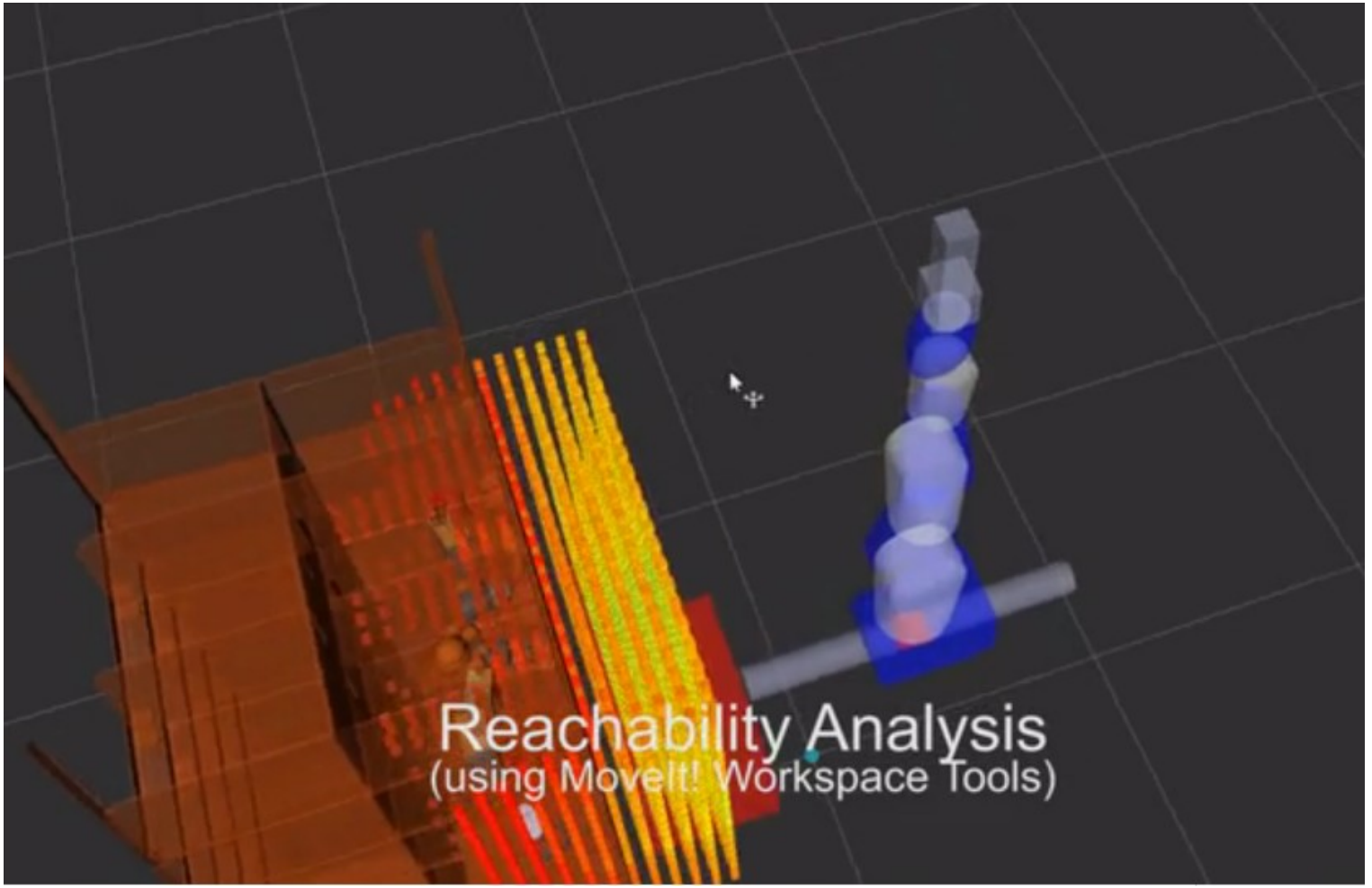
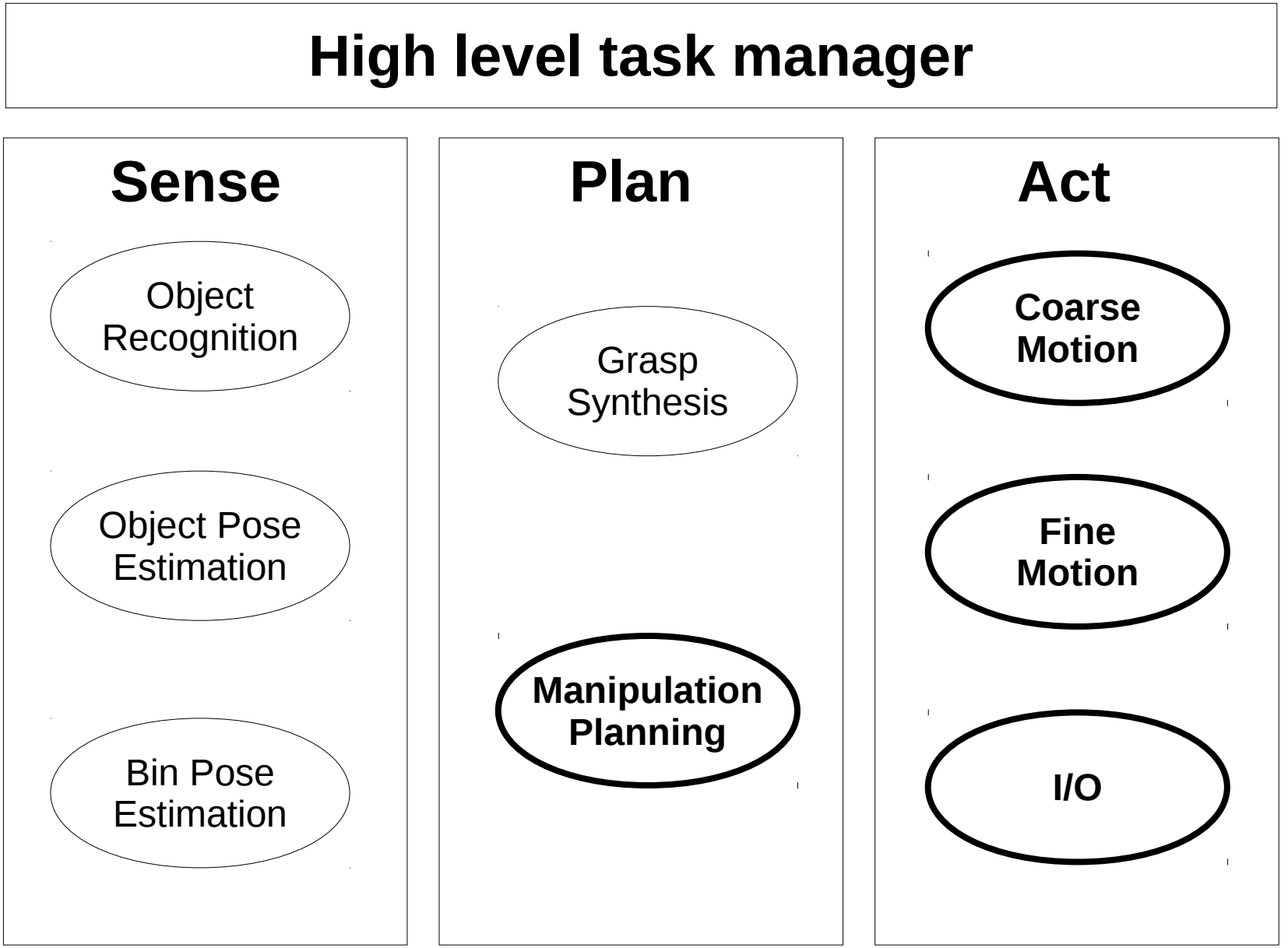
Robot Setup

Selected configuration




```
roslaunch moveit_workspace_analysis
workspace_analysis.launch
roslaunch moveit_workspace_analysis
reader.launch
```

Basic Software Architecture



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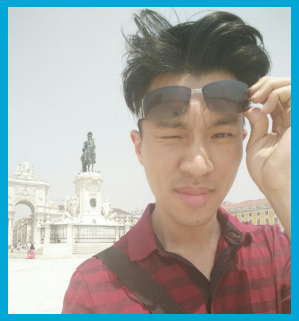

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Motion Module - Manipulation

- Grasp pose scoring
  - Perpendicular distance to CoM.
  - Approach direction of the robot.
  - Preferred grasping direction.

- Grasp strategy based MoveGroups
  - Top Suction.
  - Front Suction.
  - Pinch.

- Final grasp pose selection
  - Highest scoring grasp pose `(the_chosen_one)`.
  - Collision check based pruning (`moveit_msgs::GetPositionIK`).

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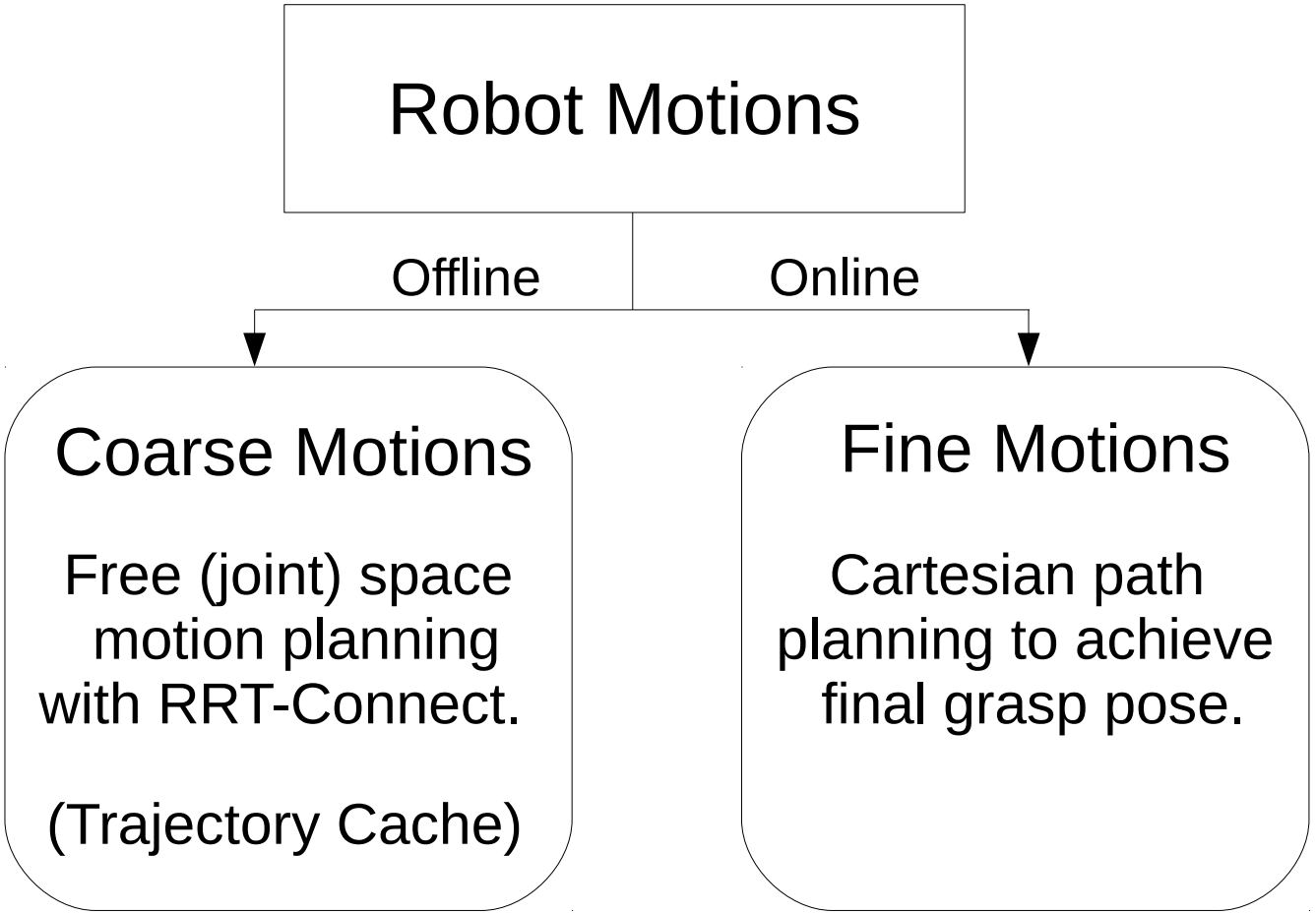
Motion Module – Robot motion



- `robot_state::RobotState` APIs for setting various "MasterPoses".
- `planning_interface::MoveGroup` APIs for planning.

Motion Module – I/O (1)

- “Event” based I/O
  - Key waypoints - “approach”, “contact”, “lift”, “retreat”
  - I/O actions - “vacuum on”, “suction on”, “front suction activate”, …
- Reliable trajectory tracking
  - Track trajectory waypoints (distance to waypoints).
  - Stable tracking regardless of other tasks.
  - Dedicated callback queue and background spinner.

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Motion Module – I/O (2)

- Requires additional “AsyncSpinner”
  - `MoveGroup::execute()` already running an AsyncSpinner.
- New `SimpleAsyncSpinner`
  - No dependencies besides ROS and standard library.
  - Lock-free using atomic variables.
- Multiple AsyncSpinners now supported in ROS-Kinetic [4]

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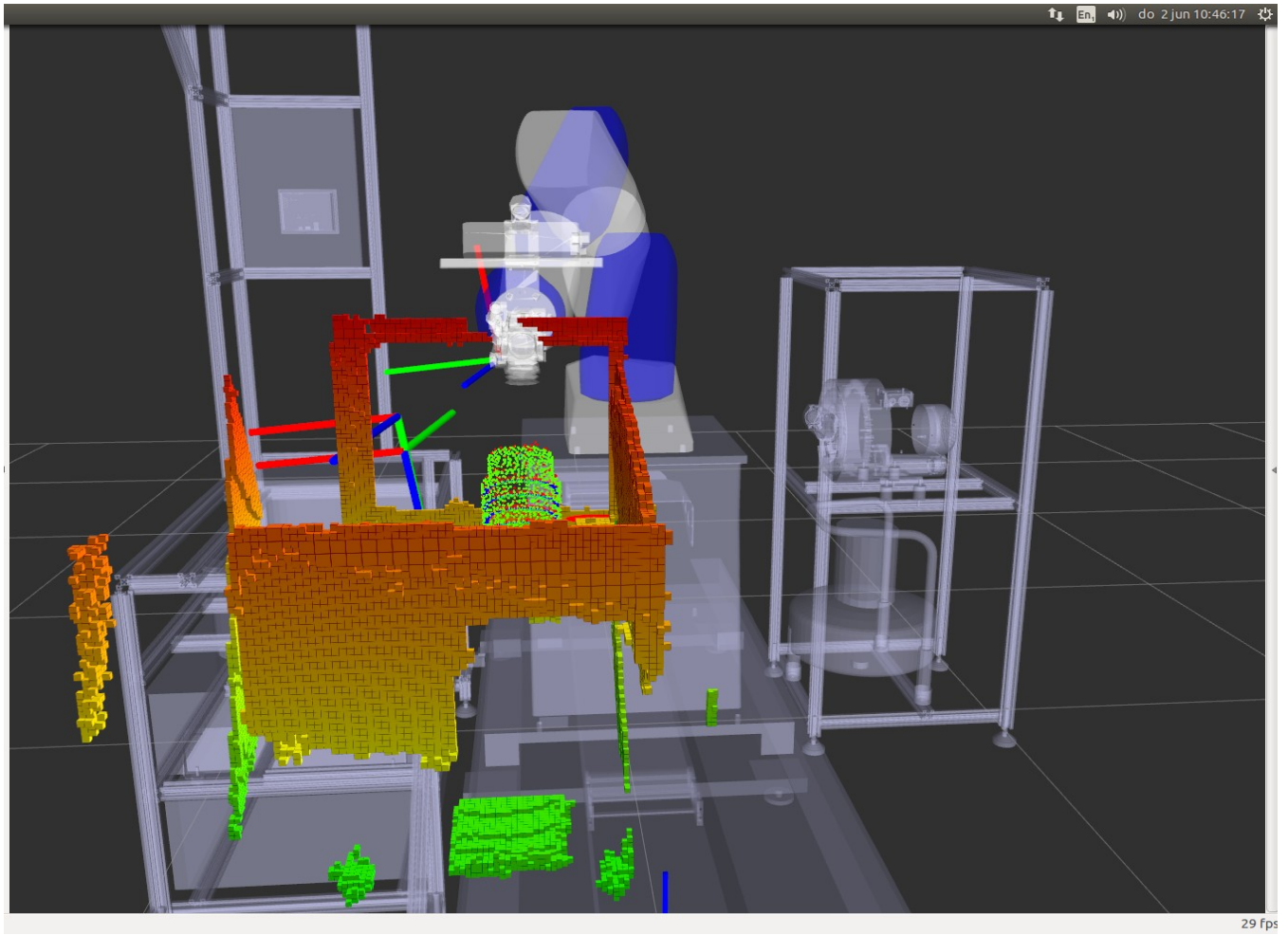
Lessons Learnt

1. Collision checking redundancy



"Gap" in octomap due to reflections

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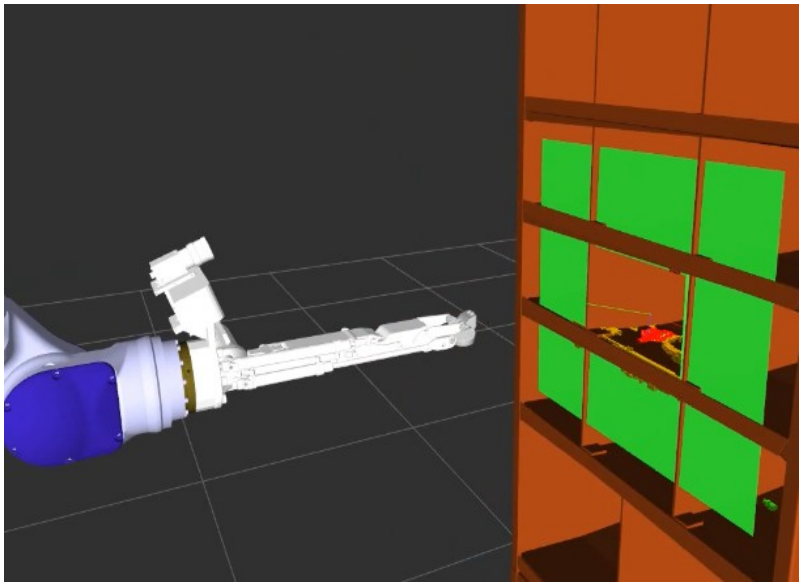
Lessons Learnt

1. Collision checking redundancy

- Bin collision models



- Collision checking with “new” meshes in the planning scene
  - Non-reproducible but random failures in collision checking.
- Add sanity checks for “impossible” motions.

Lessons Learnt

2. Octomap – Planning Scene

- "Static" point cloud
  - One point cloud snapshot instead of a point cloud "live feed".
  - Simulated point cloud stream using a topic.

- `MoveGroup::getCurrentState()` takes long time to return while using octomaps
  - Use `robot_state::JointModelGroup` to avoid delays when real robot state is different from "test" robot state during online planning.
  - Cause: Planning scene monitor prioritises servicing octomap updates(*)

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Lessons Learnt

3. Octomap clearance

- “Static” point cloud
  - One point cloud snapshot instead of a point cloud “live feed”.
  - Simulated point cloud stream using a topic.

- `/clearOctomap()` - Inconsistency with clearing the current octomap.
  - Publish “out of range” valued point cloud.
  - Octomap always cleared on service call.

Lessons Learnt

4. Trajectory stitching

- Combine fine motions with coarse motions
  - IK solution need not necessarily match with coarse motion start.
  - RRT-Connect from last IK point to “MasterPose”
- Trac-IK with “distance” setting
  - ROS parameter namespace issues.
- Possibly stitch entire trajectory to destination.
  - Combine multiple motion segments in joint space.
  - Re-(time) parameterize the “stitched” motions in time (`iptp.computeTimeStamps()`).

Lessons Learnt

5. I/O as joints?

- Common practice
  - Define various I/O as joints with a very small range.
  - “Plan” solutions to command I/O and use `actionlib` interface.

- Our approach via external trajectory monitoring
  - Dependency on `/joint_states` topic.
  - Dedicated I/O support possibly the way to go forward?

Lessons Learnt

Behavior design

- Interspersed Plan-Act
  - Robot stuck in the bin.
  - Design adequate and appropriate recovery behaviour.
- Fake components
  - Provide lots of room for testing.
  - Clarity in interface definitions.
  - Easy integration when real components are available.
- Writing “json” files correctly

Lessons Learnt

Assumptions

- Optimal planners
  - Euclidean distance NOT default.
  - Effort-based, time-based, etc.
- Trac-IK cost functions
  - Distance
  - Speed
  - Manipulability
- Robot Driver*
  - Sanity checks
  - Joint naming

“Assumptions bear the roots of all disasters!”

“Gravity is a heartless entity!”

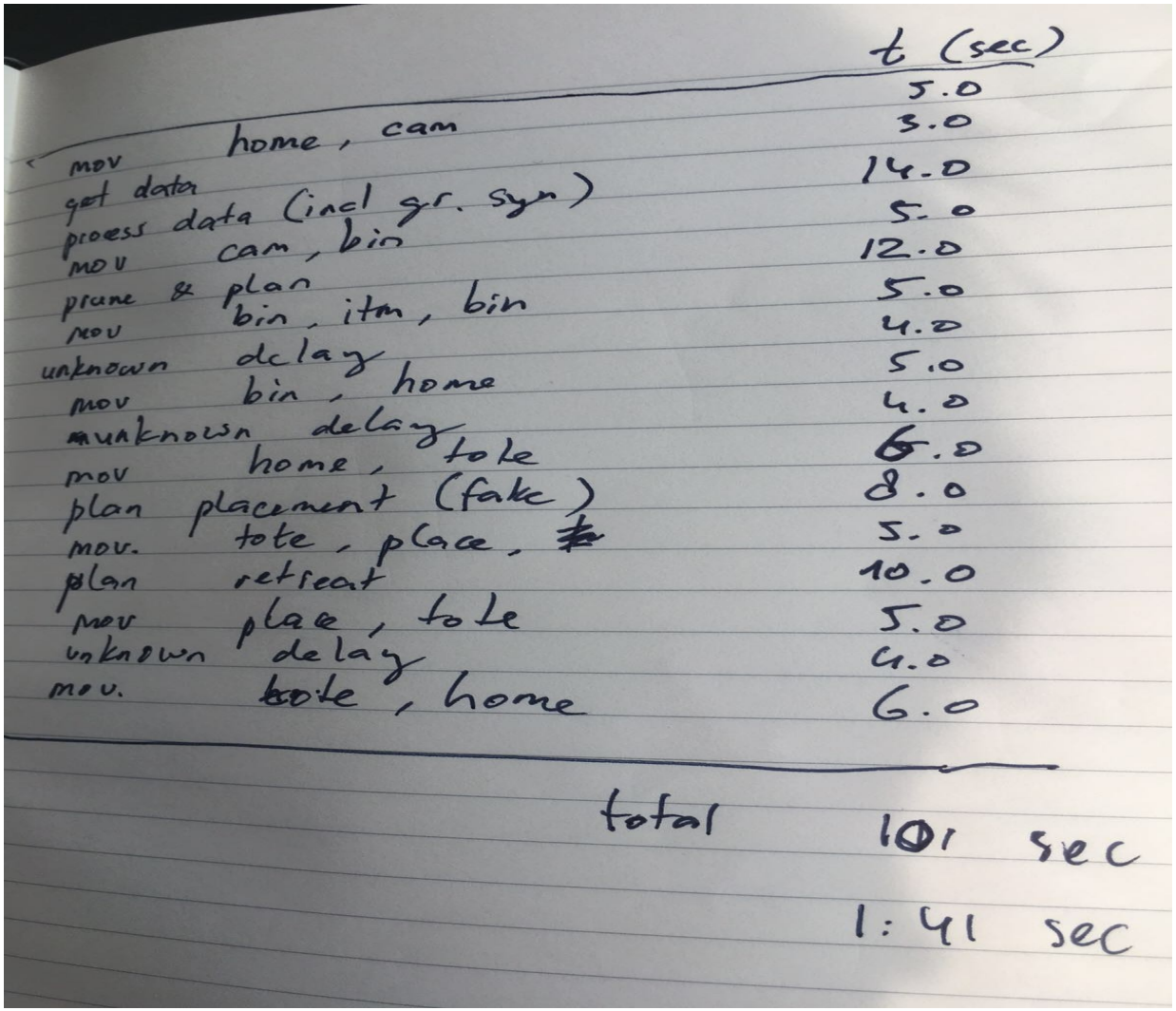
Concluding Remarks

How MoveIt! is designed to be used.

How we used it!

Image Sources:
www.dx.com
www.northerntools.com

Concluding Remarks



20 days before the challenge!

(No stowing yet!)

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Concluding Remarks

- Stowing completed in almost half of allotted time.
- More than 16 picks performed in the given time (including “move jobs”)
- Not moving like Icebergs anymore!

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Acknowledgements

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Made possible by:

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YASKAWA MOTOMAN

PHAER COMPUTER VISION EXPERTS

IDS It's so easy!

ROBO VALLEY

ikbenstil

INDUVAC

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Thank you for your attention!

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References

[1] www.amazonpickingchallenge.org

[2] moveit.ros.org

[3]
MoveIt! - Strengths, Weaknesses and Developer Insigh
ts
, Dave T. Coleman, RosCon 2015, Hamburg.

[4] AsyncSpinners

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