Winning the Amazon Picking Challenge 2016

Team Delft – Motion Module and Lessons Learned

Warehouse Picking Automation Workshop (WPAW 2017)

Mukunda Bharatheesha

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Factory in a Day

TU Delft

DELFTROBOTICS

intelligence at work

Introduction

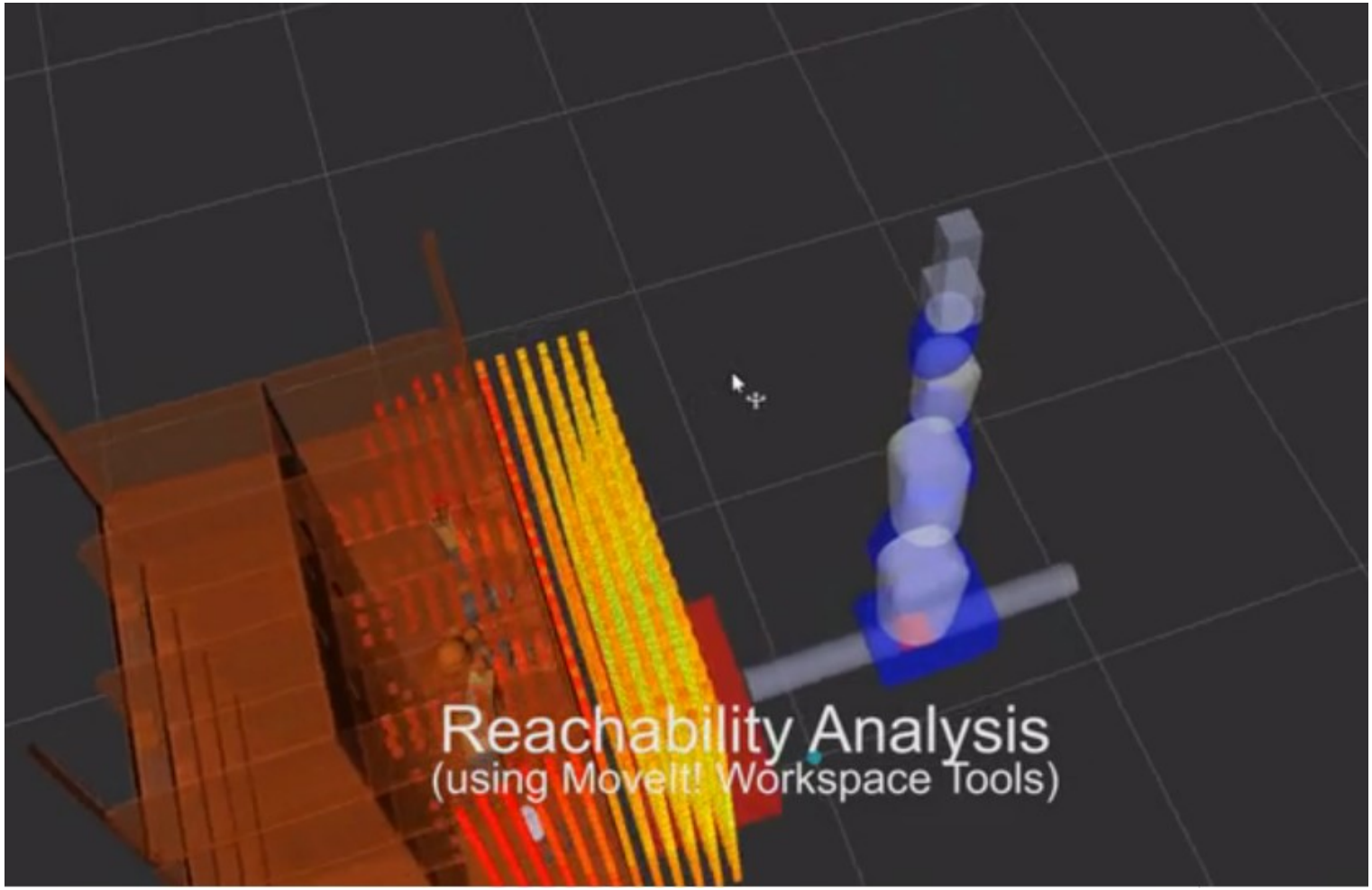
Stowing Challenge	Picking Challenge
Delft - 214	Delft – 105 (00:00:30)
NimbRo - 186	PFN – 105 (00:01:07)
MIT - 164	NimbRo - 97

Contents

- Team Delft APC motion module with MoveIt! [2]
- MoveIt! Specific lessons learnt
- General lessons learnt
- Concluding remarks

Robot Setup

Selected configuration




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

Basic Software Architecture

High level task manager

Sense

- Object Recognition
- Object Pose Estimation
- Bin Pose Estimation

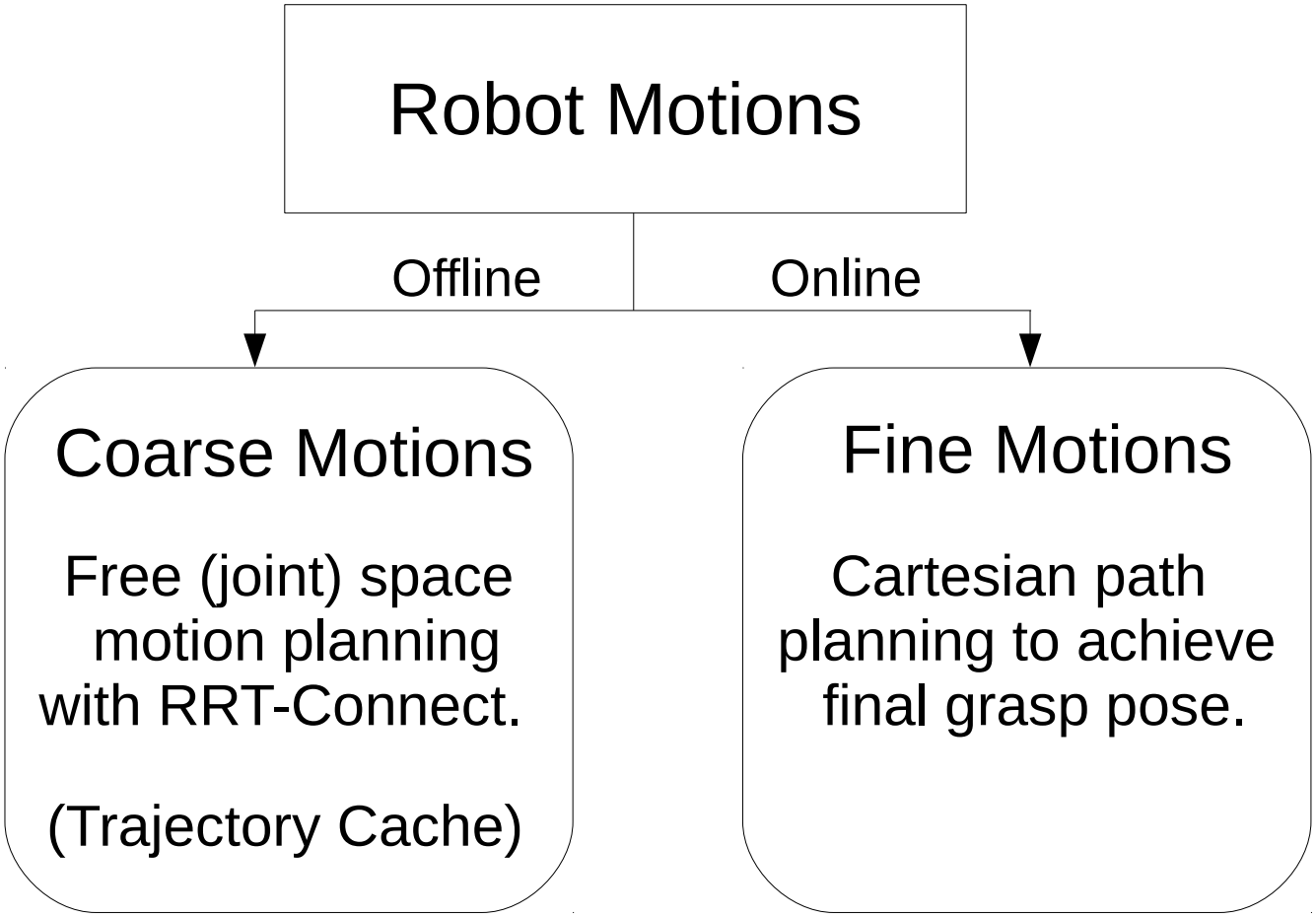
Plan

- Grasp Synthesis
- **Manipulation Planning**

Act

- **Coarse Motion**
- **Fine Motion**
- **I/O**

Motion Module – Robot motion



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

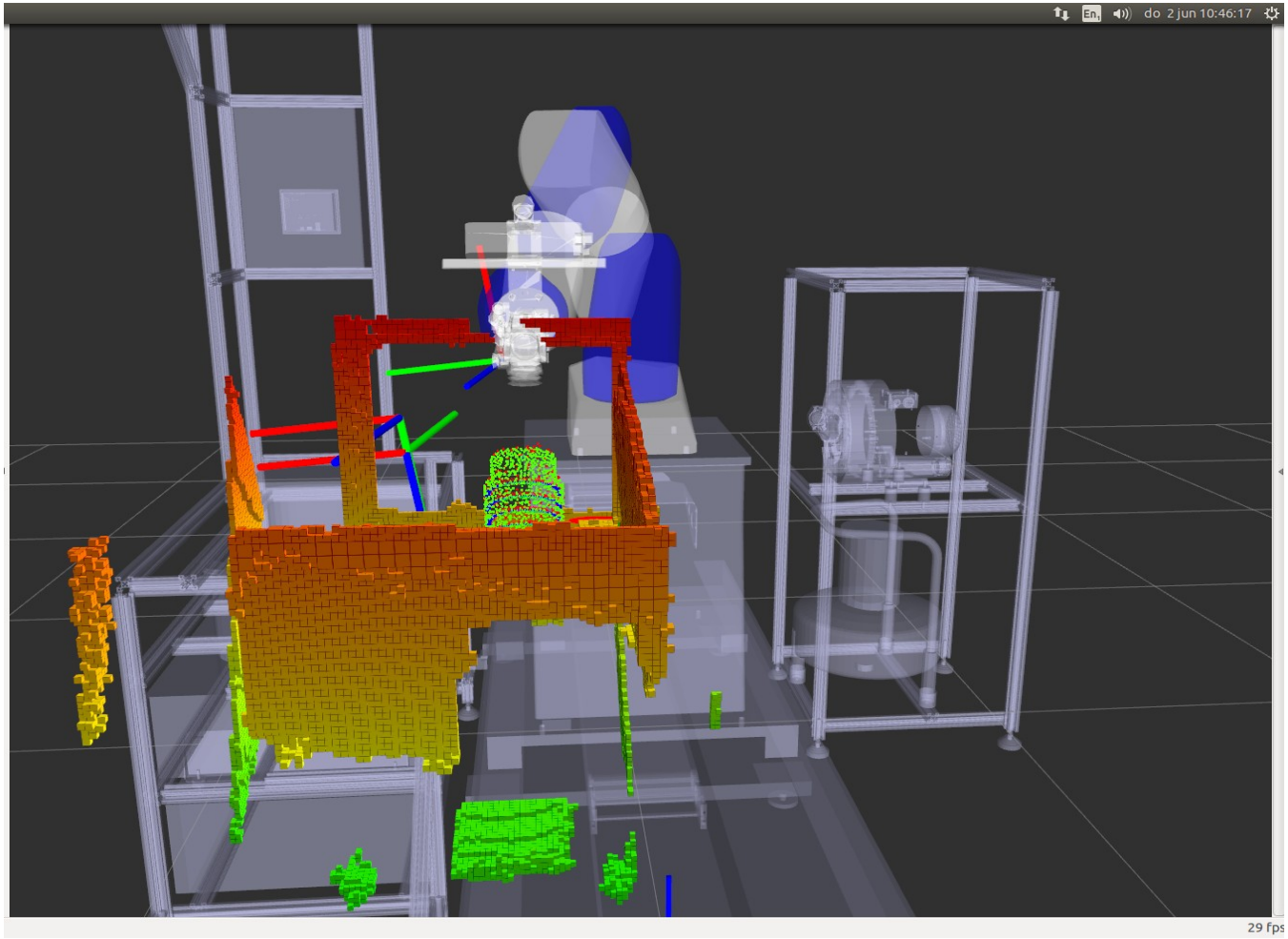
Motion Module – I/O

- “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.

Lessons Learnt

1. Collision checking redundancy

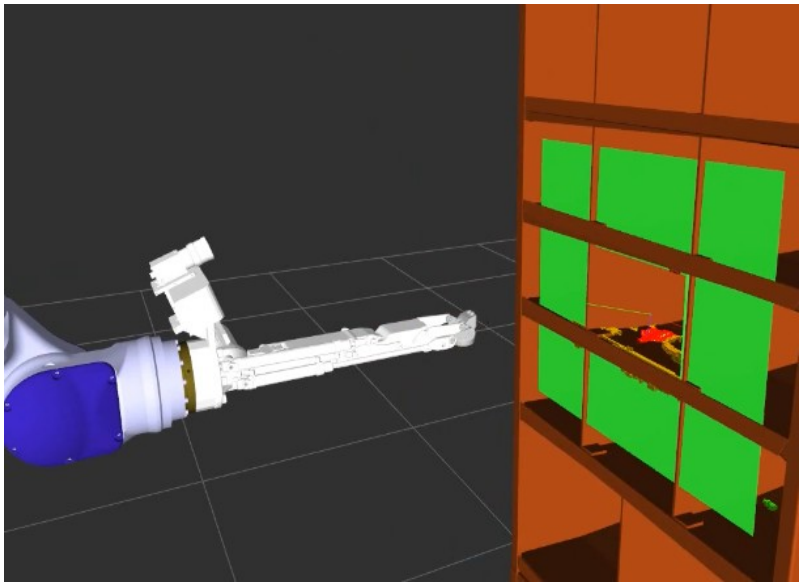


“Gap” in octomap due to reflections

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
  - “You Only Look Once”
  - 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(*)

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.

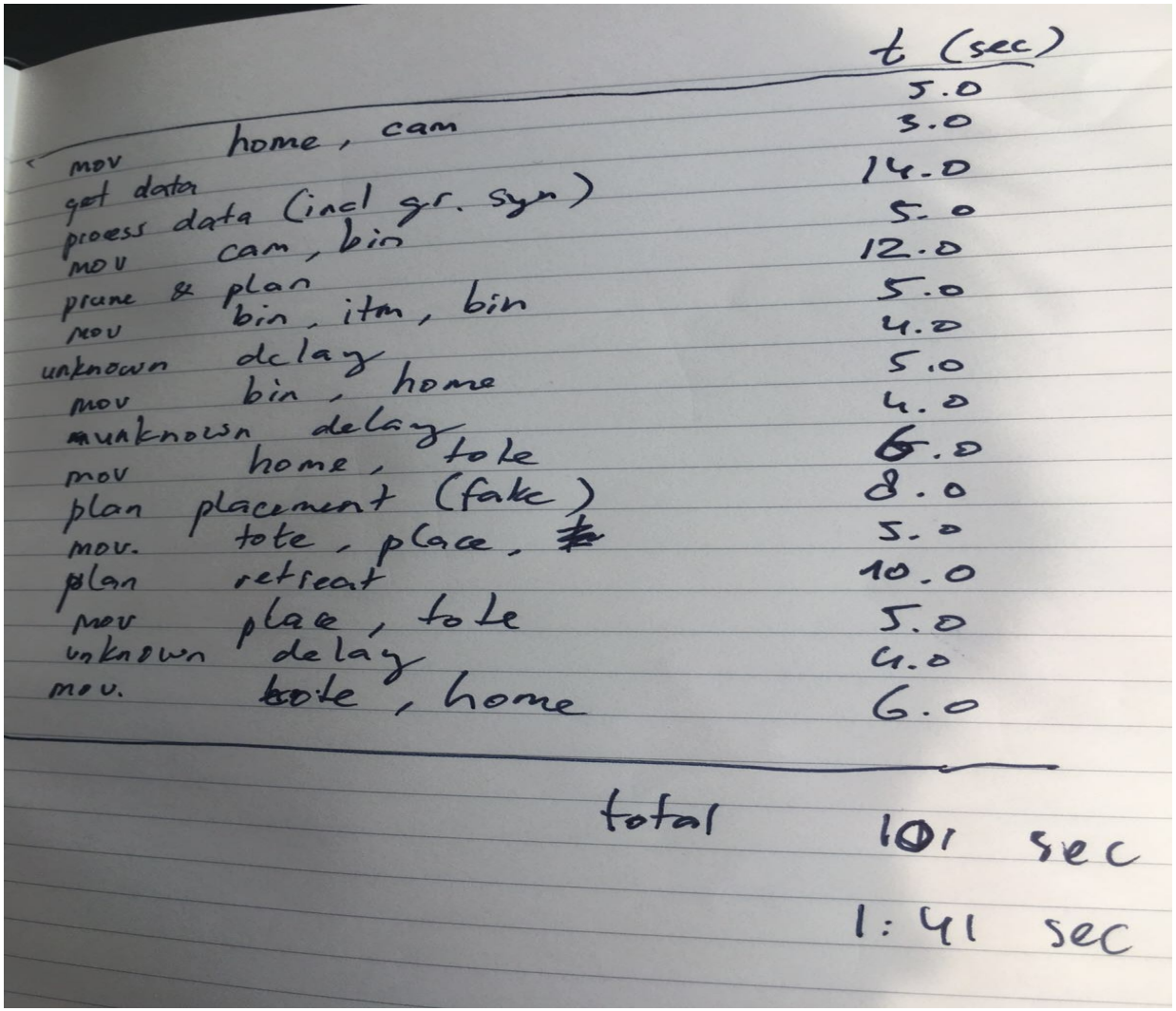
Lessons Learnt

Assumptions

- Optimal planners
  - Euclidean distance NOT default.
- Fake components
  - Clarity in interface definitions.
  - “Easy” integration.
- Writing “json” files correctly
  - Especially when pick/stow attempt fails.
- Robot Driver*
  - Sanity checks.

“Assumptions bear the roots of all disasters!”

Concluding Remarks



		t (sec)
mov	home, cam	5.0
get data		3.0
process data (incl gr. syn)		14.0
mov	cam, bin	5.0
prune & plan		12.0
mov	bin, item, bin	5.0
unknown	delay	4.0
mov	bin, home	5.0
unknown	delay	4.0
mov	home, tote	6.0
plan	placement (fake)	8.0
mov.	tote, place,	5.0
plan	retreat	10.0
mov	place, tote	5.0
unknown	delay	4.0
mov.	tote, home	6.0
	total	101 sec
		1:41 sec

20 days before the challenge!

(No stowing yet!)

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!

Acknowledgements

Made possible by:

The work leading to these results has also received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement No. 609206.

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Thank you for your attention!

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Robotics Institute

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

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
  - Default is “speed” setting.

- Combine multiple motion segments in joint space.
  - Re-(time) parameterize the “stitched” motions in time (`iptp.computeTimeStamps()`).