Chair for Cognitive Systems
Department of Electrical and Computer Engineering
Technische Universität München

RoboCup@Home Practical course

Tutorials

M.Sc. Roger Guadarrama
M.Sc. Constantin Uhde
Prof. Dr. Gordon Cheng

Technical University of Munich

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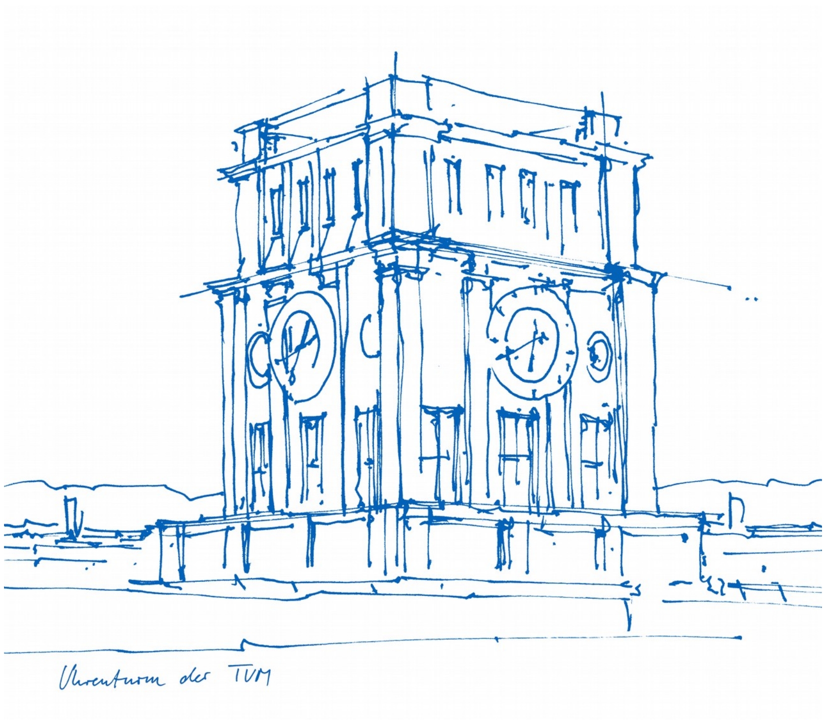

Definition of teams

1) **Hands-on tutorials:** introductory tutorials to get familiar with the equipment (robot & sensors) used for this course.

2) **Group definition tasks:** form groups according to the students' knowledge to address different challenges of the competition. The students designate a team leader.

3) **Development and test phase:** design and implementation of algorithms to solve the problems defined for your working team.

4) **Final phase:** test real scenarios on a mobile robot to evaluate the performance of the robots abilities.

Definition of teams

2) **Group definition tasks:** form groups according to the students' knowledge to address different challenges of the competition.

- Designate a **team leader**.

Responsibilities of the team leader:

- Coordinate the work of the group. Make sure that the work is correctly distributed.
- Be responsible for the key of the laboratory
- Direct communication with the supervisor(s)

Definition of topics

Check the competitions rule books: The challenges include:

- following a human,
- indoor navigation in crowded environments,
- recognizing & grasping alike objects,
- find a calling person (waving or shouting), etc.
- deal with incomplete information

IMPORTANT: Define the strongest capabilities of your team: Control, navigation, perception, and/or learning.

This semester

- 19 students.
- 5 Teams
- 3 Teams with TiaGo.
- 2 Teams with HSRB.

Tutorial 5: TIAGo – getting started

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Mobile base

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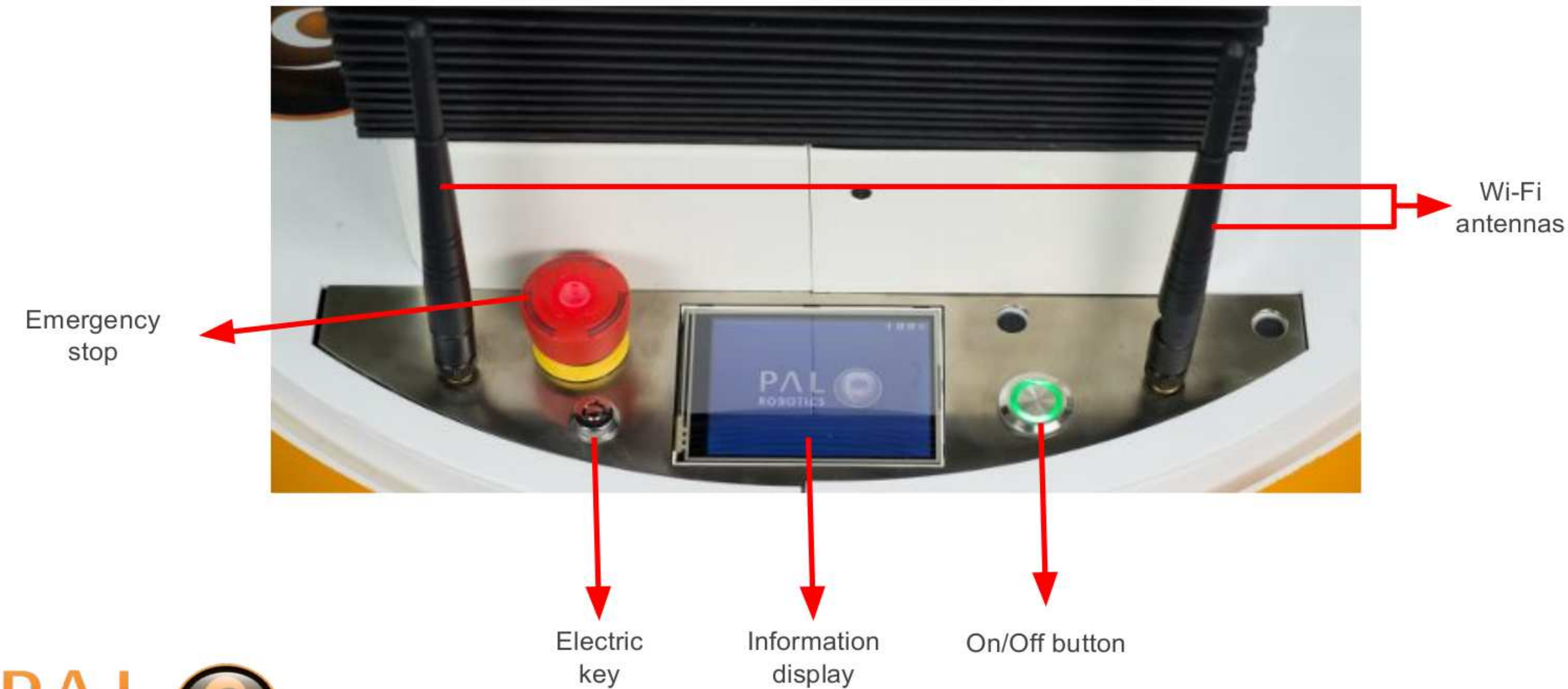
User panel



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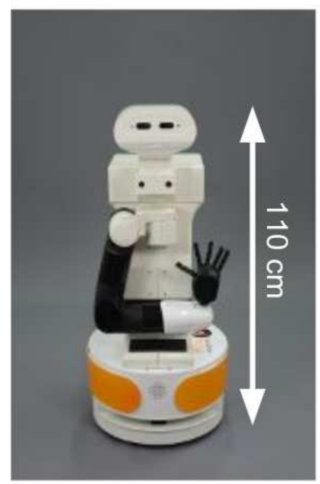
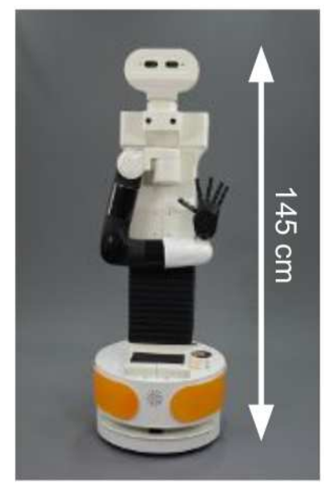
Torso lifter

Stroke: 350 mm
Max speed: 50 mm/s





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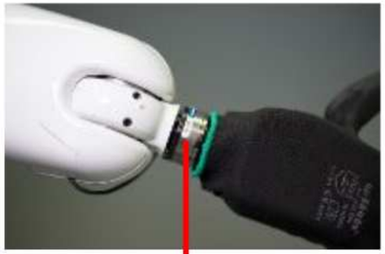
Arm and end-effector



Force/torque sensor

Hey5 hand

PAL gripper

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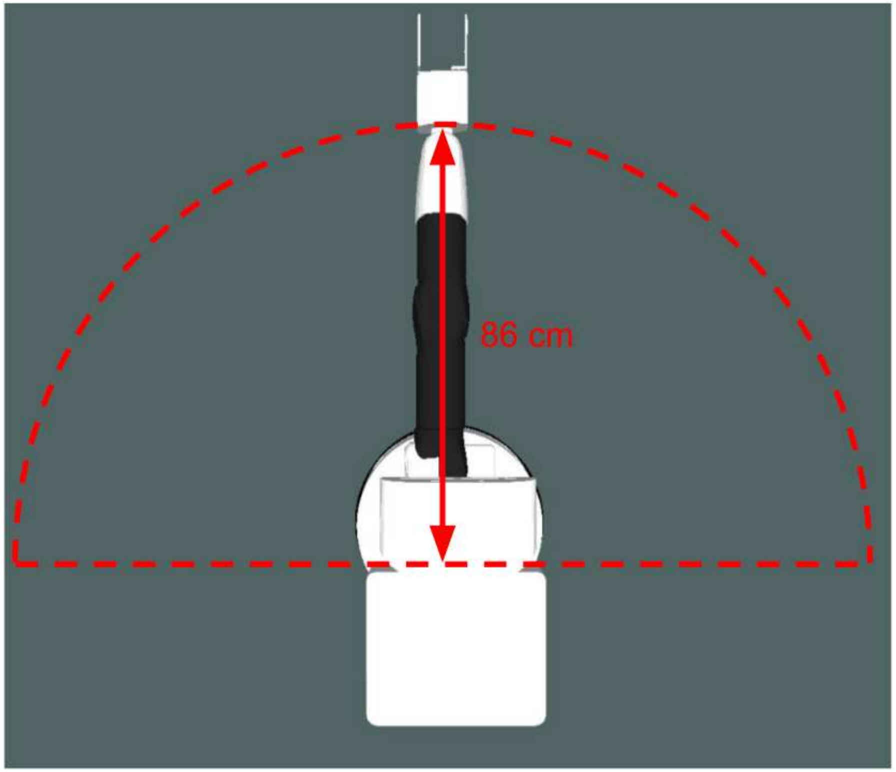
Arm reach



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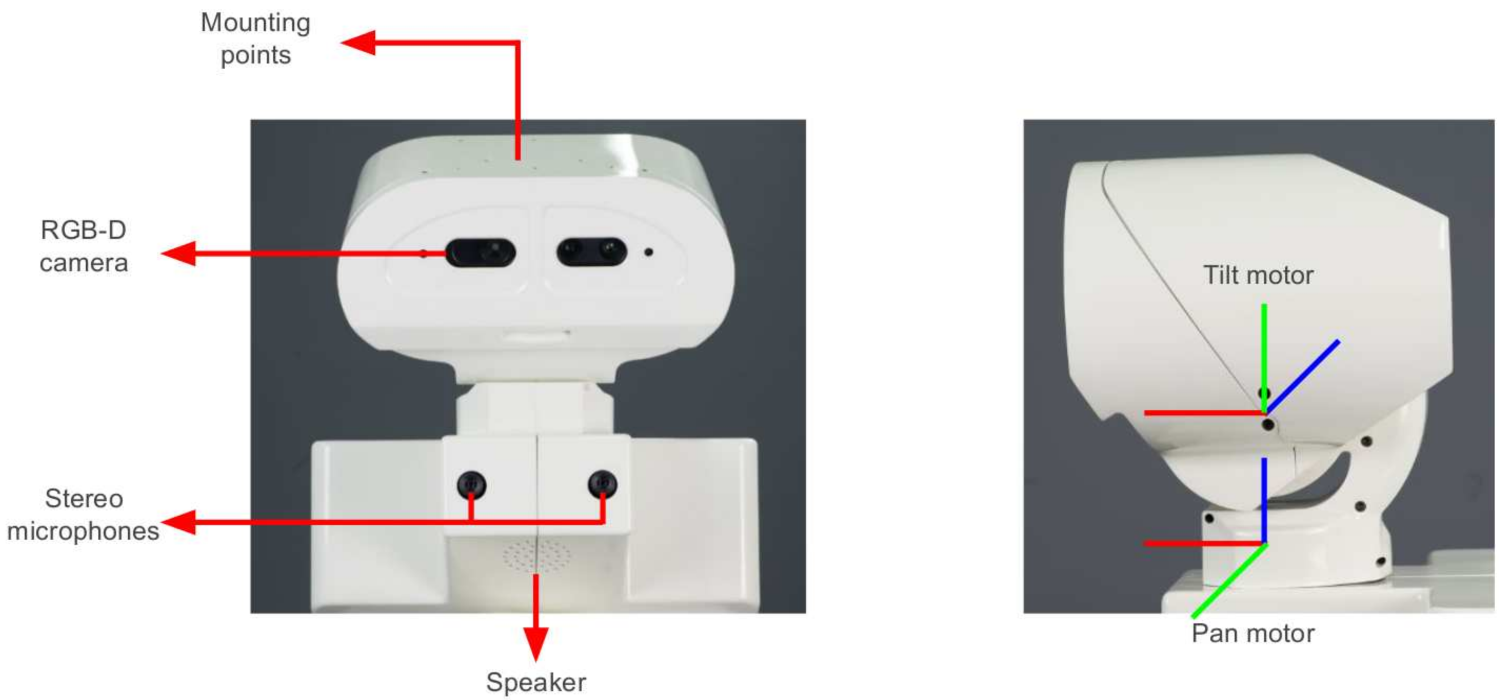
Head



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Start the robot

Turn the electric key

Release the emergency button

Press On button during 1 second

Tutorial 5: TIAGo – getting started

Charging TIAGo

- Use the charger supplied with TIAGo in order to charge the robot

Open the lid located in the rear part

Insert charging connector with metal lock facing up, push until you hear a 'click'

The duration of the charging is about 4 h for 1 battery completely discharged, and about 8 h for 2 batteries

Insert charging connector with metal lock facing up, push until you hear a 'click'

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Tutorial 5: TIAGo – Safety measures

Safety measures

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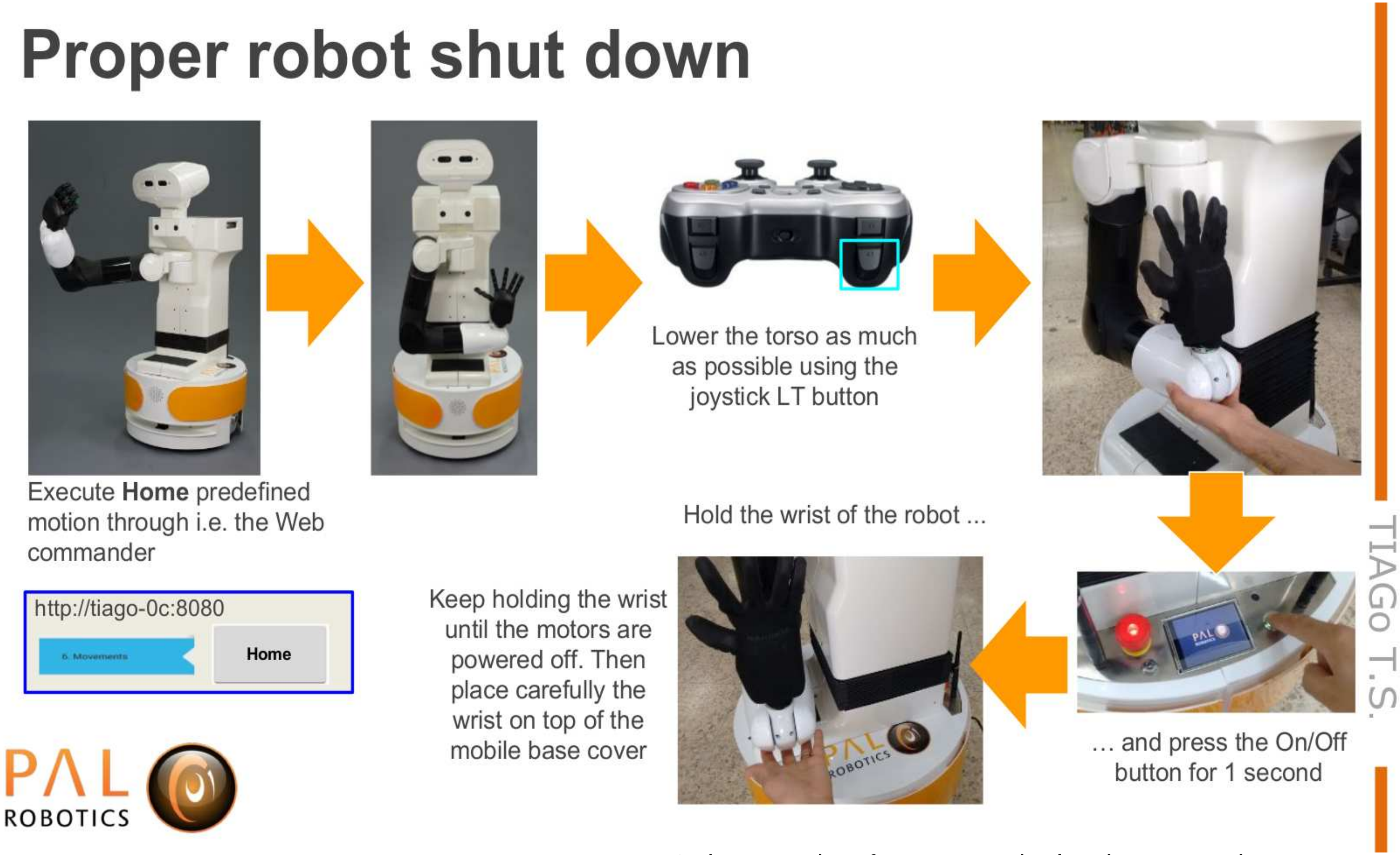
Tutorial 5: TIAGo – Safety measures



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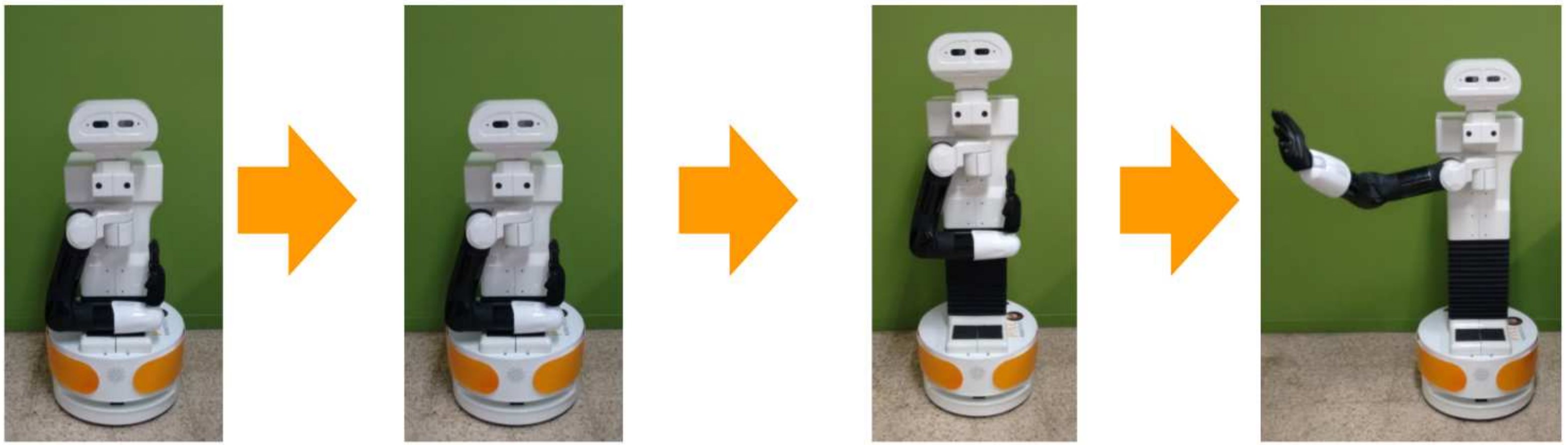
Tutorial 5: TIAGo – Safety measures

How to get the arm out of Home safely



Get the arm out of collision:

Raise the torso to its maximum height with the joystick

Execute the movement **unfold_arm** through i.e. the Web commander

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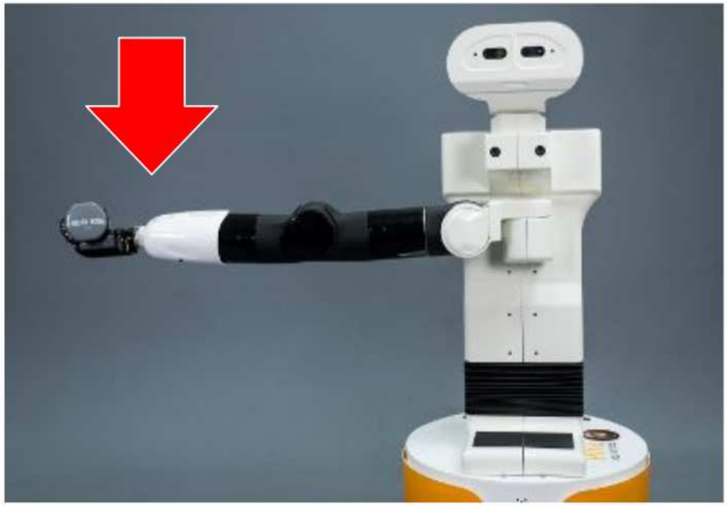
Tutorial 5: TIAGo – Safety measures

Measures to prevent the robot falling (I)

- The robot has been designed to be stable even when the arm is holding its maximum payload in its most extreme kinematic configuration
- Nevertheless, some measures need to be respected in order to avoid the robot falling



Do not apply external forces to the arm when it is extended and holding a weight

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Tutorial 5: TIAGo – Safety measures

Measures to prevent the robot falling (II)

Do not navigate at **high speeds** with the arm extended and holding a weight specially when the torso is extended

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Measures to prevent the robot falling (III)

- Do not navigate on floors with slope higher than 6º
- And in that case navigate with the torso at its lowest level and with the arm folded, i.e. in **Home** configuration

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Tutorial 5: TIAGo – Safety measures

Measures to achieve a safe navigation

- When carrying a weight:

It is highly recommended to navigate with the arm folded and the torso at low extension, like in the **Home** configuration

- Reduces the footprint of the robot and lowers the probability to collide with the environment with the arm
- Ensures the stability of the robot

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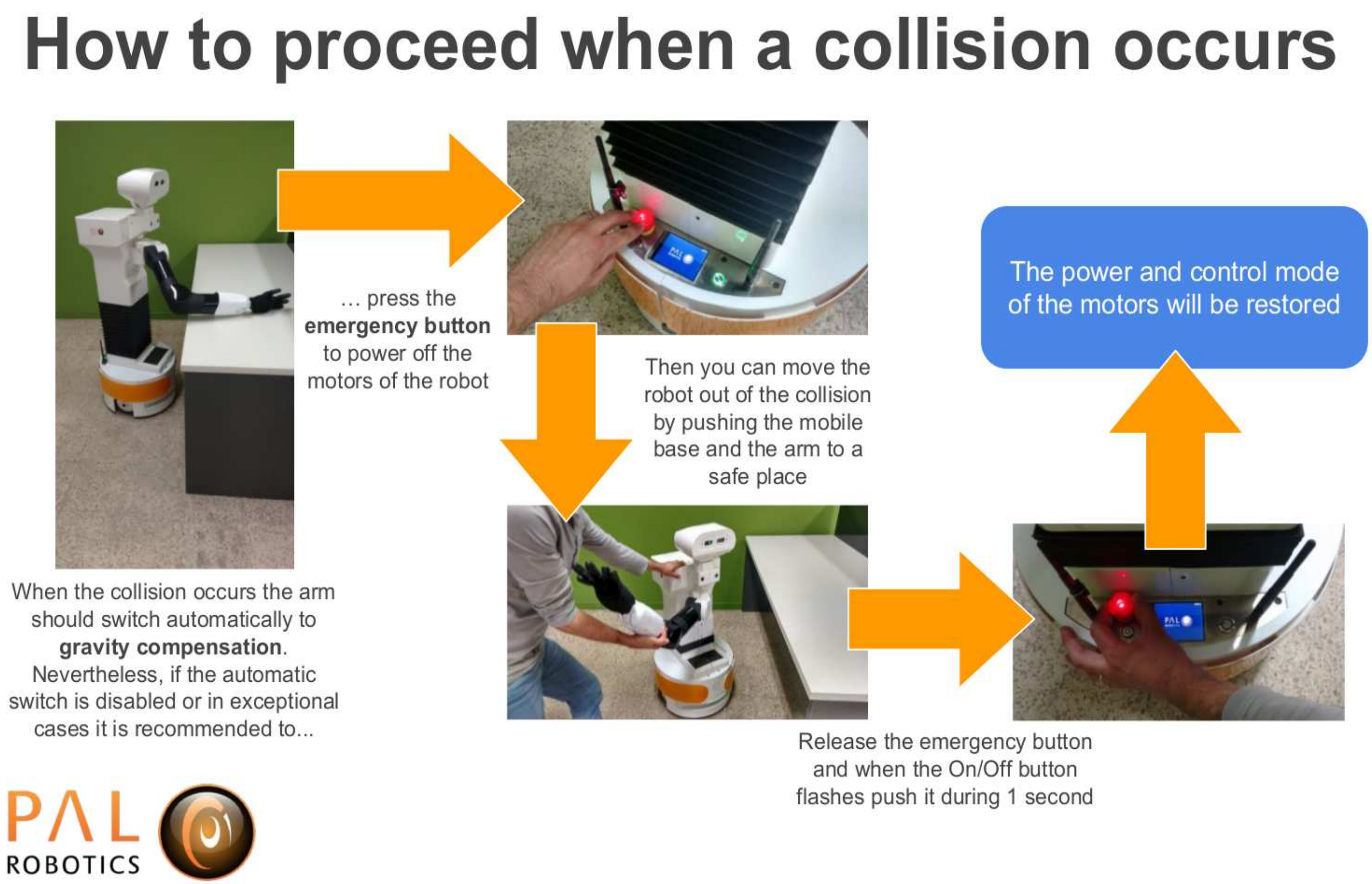

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Tutorial 5: TIAGo – Software

-Ubuntu 16.04 Real-Time patched

-Ros Kinetic Kame

-Pal robotics ros-erbium

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Tutorial 5: TIAGo – Software

ROS packages

- **ROS** Indigo packages:

  Installation path: **/opt/ros/indigo**

- **PAL** dubnium packages:

  Installation path: **/opt/pal/dubnium**

- **User** packages:

  Installation path: **/home/pal/deployed_ws**

Sub-folder	Description
bin	nodes (executables)
include	package header files
lib	package dynamic libraries and python files
share	packages cmake, launch and config files
etc	other files

All the ROS software in the robot is executed with the user **pal**

PAL ROBOTICS

Tutorial 5: TIAGo – Deploy new software in the robot

Connect to the robot ROS topics from the remote PC

On you local PC execute following commands:

1) export ROS_MASTER_URI=http://tiago-24c:11311

2) export ROS_IP=*ip_of_your_PC*

Tutorial 5: HSRB – getting started

Tutorial 5: HSRB – getting started

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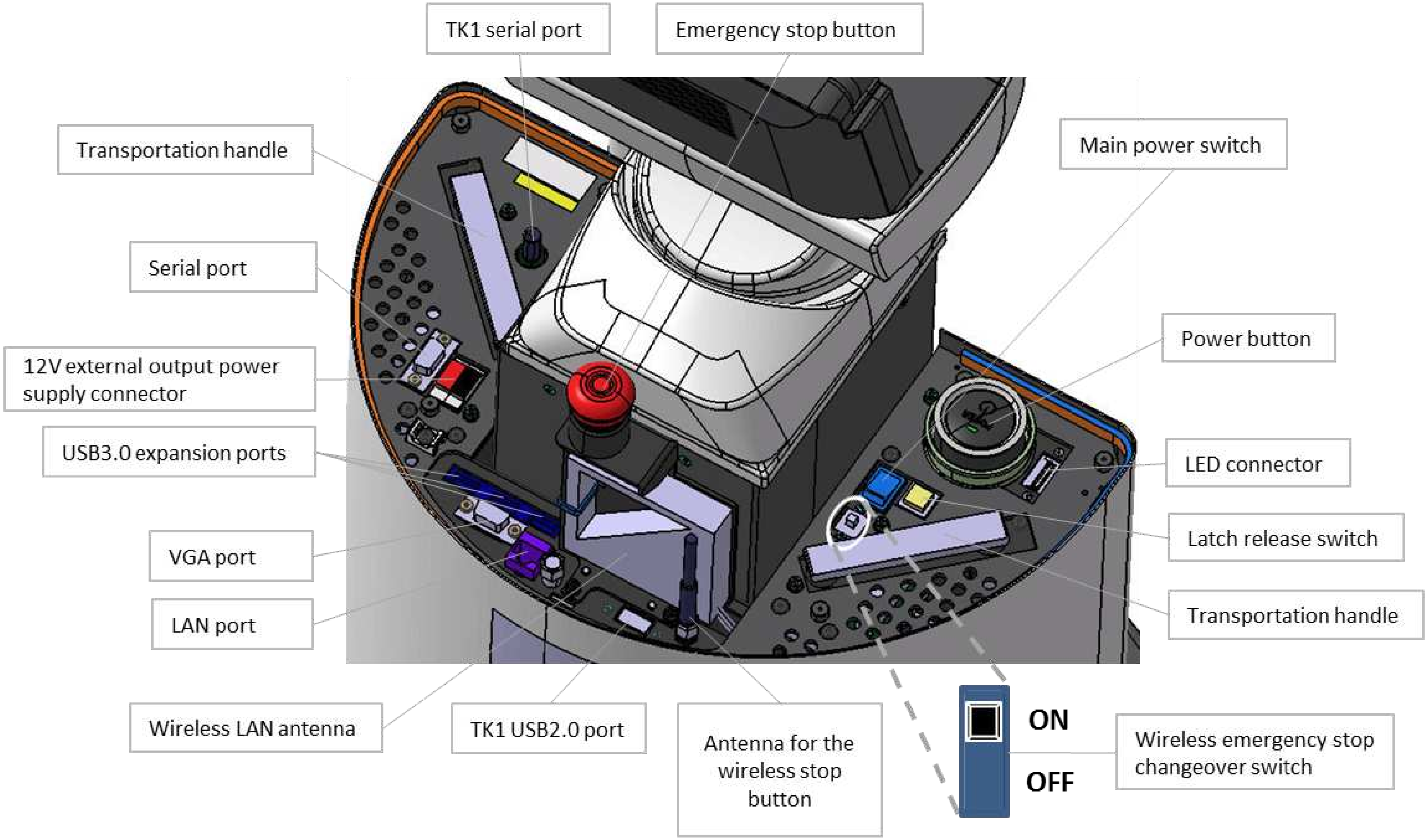
Tutorial 5: HSRB – getting started



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Tutorial 5: HSRB – DO NOT

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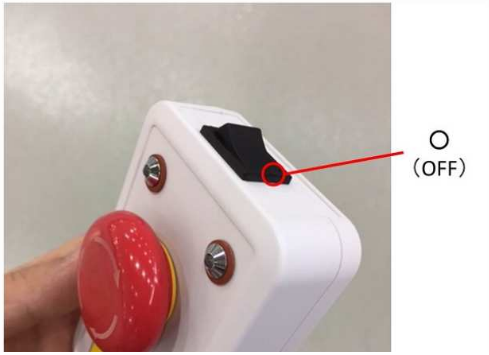
Turn on procedure.

1. Press the robot's emergency stop button.

2. Press the wireless stop button and turn off wireless stop button power switch.



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Turn on procedure.

3. Open the back cover and turn ON ("|") the switch which enables the wireless stop button.

4. Open the back cover and turn ON ("|") the main power switch.

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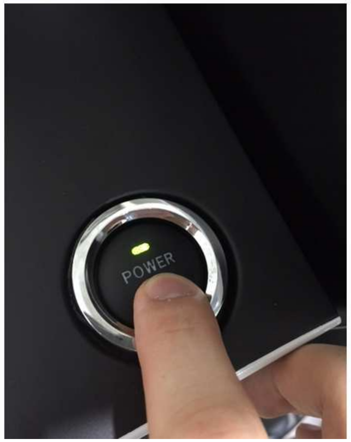
Turn on procedure.

12. Confirm that the power supply status LED is flashing green or is continously lit as green.

13. Press and hold the power button for 3 or more seconds then the robot will start.



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Turn on procedure.

Finally, when the robot finishes booting, release the emergency stops.

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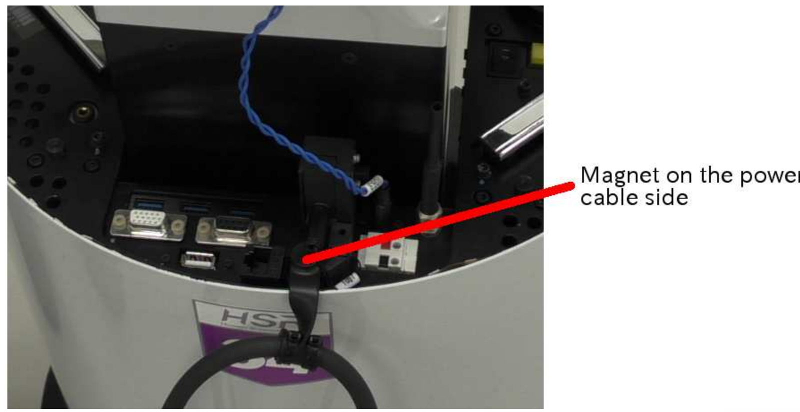
Tutorial 5: HSRB – Charging the robot.

1.- Make sure the charger is switched off.

2.- Connect the cable.

3.- Fix the cable in the magnetic holder.



4.- Switch on the charger.

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Tutorial 5: HSRB – Charging the robot.

Attention

When you are connecting the power cable, please put the red mark on the power cable connector together with the red mark on the power connector on the HSR. Also, please insert it all the way as in the following illustration.

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Tutorial 5: HSRB – Charging the robot.

Attention

Please be careful not to pinch the wiring in the cover.

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Tutorial 5: HSRB – Charging the robot.

4.- When the robot is charged, remove the charger.

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Tutorial 5: HSRB – Charging the robot.

4.- When the robot is charged, remove the charger.

Attention

Please hold the connector part shown in the illustration below.
If the cable part is held and pulled, then it is possible that it can be disconnected.

Tutorial 5: System integration on TIAGo

- **Finish all the tutorials.**
- **Get really familiar with the Navigation and manipulation packages.**

Tutorial 5: System integration

Exercise 1

- **Mapping and Navigation**

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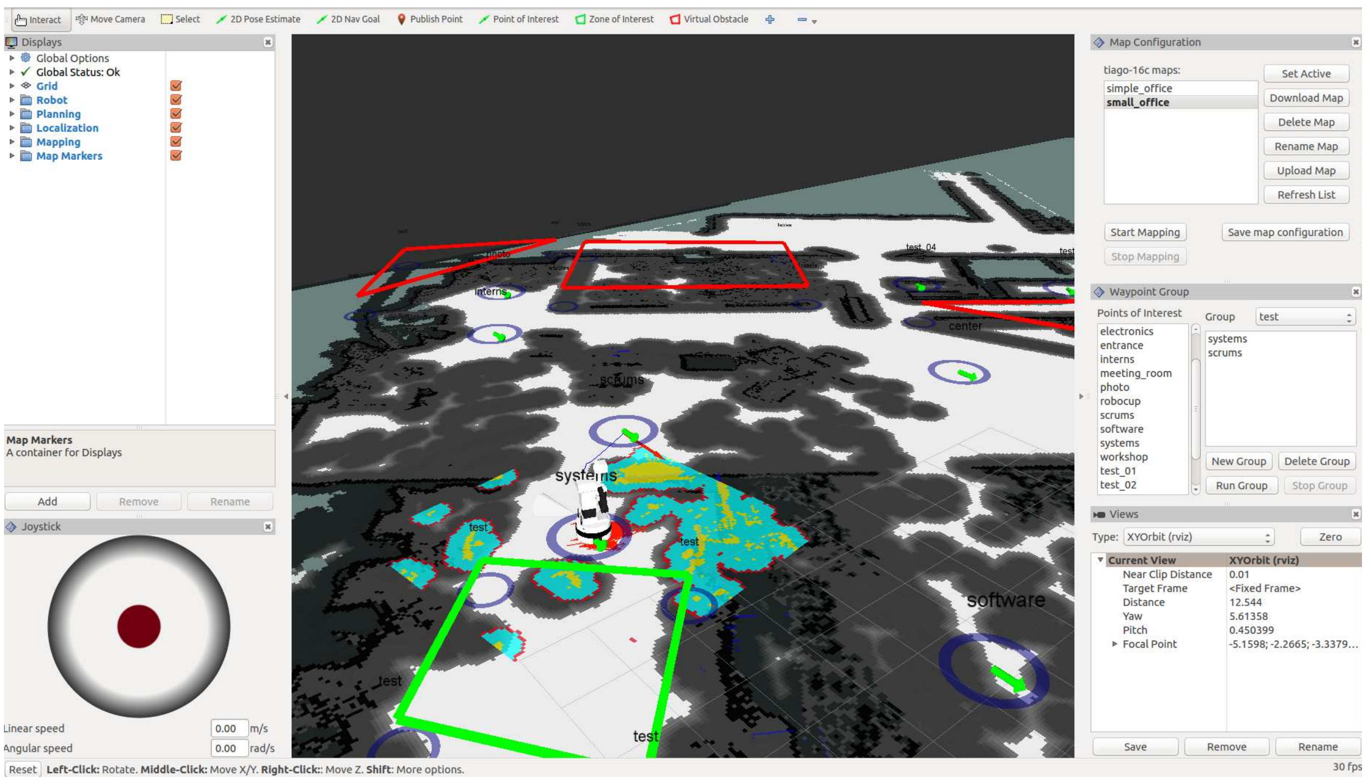
Exercise 1: Build a map of one of the lab. The robot should be able to navigate in the lab.



Tutorial 5: System integration

Exercise 2

- **Object Recognition**
- **Robot Manipulation**
- **Mapping and Navigation**

Tutorial 5: System integration

Exercise 2: The robot needs to move to one table grab one item and move it to the other table.

Perception:

- 3D object localization
- Object detection
- Identify the shelf/table

Robot manipulation:

- Command the robot arm to a desired pose
- Grasp the object

Navigation:

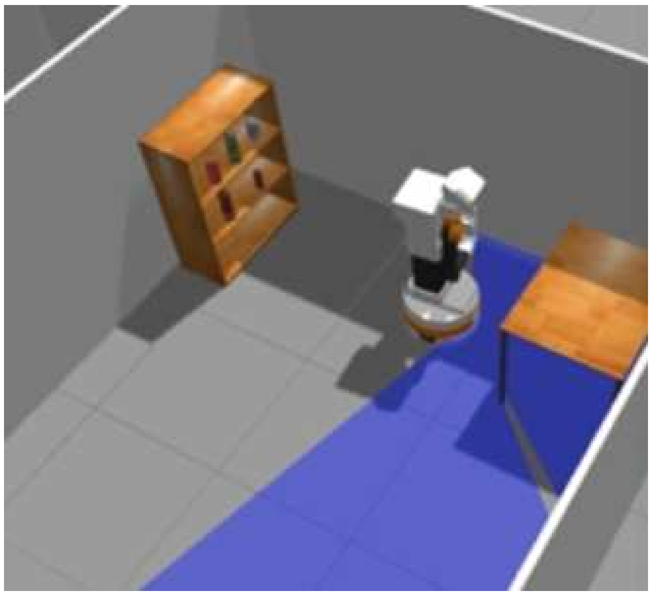
- Move to the shelf and avoid collisions
- Move to the table

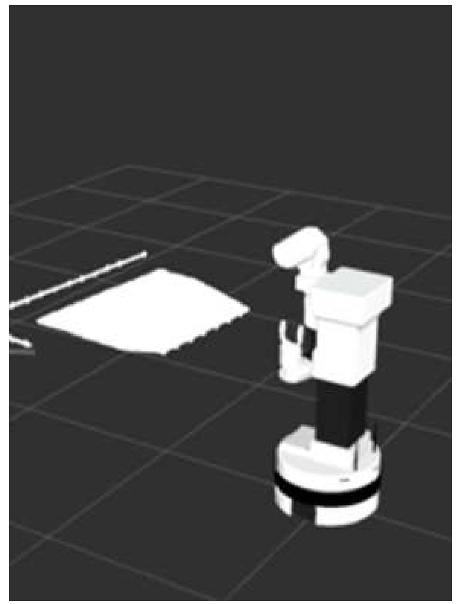
Tutorial 5: System integration

- **Object Recognition**

Perception

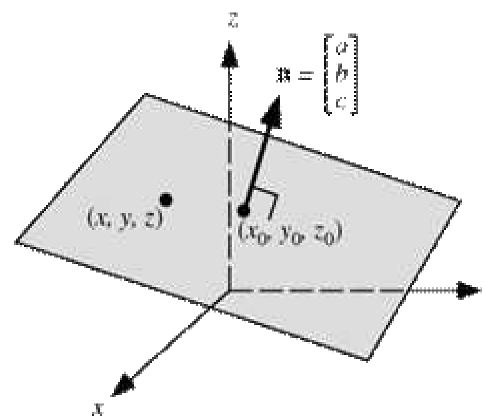
From plane segmentation to table computation





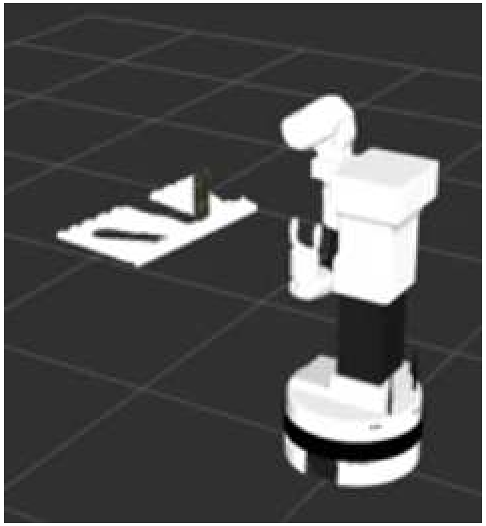
```
pcl::ModelCoefficients::Ptr
```

$$ax + by + cy + d = 0$$



Perception

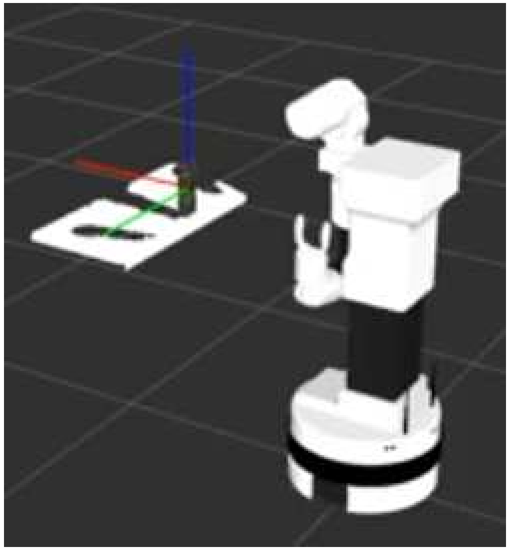
Segmenting the objects on the bookshelf



- Transform to frame if needed (pcl_ros::transformPointCloud)
- Filter limits (Passthrough)
- Downsample (VoxelGrid)
- Remove the planes (pcl::SACSegmentation)
- Find the cylinders (pcl::SACSegmentationFromNormals)
- Remove outliers (pcl::StatisticalOutlierRemoval)
- Publish the list of poinclouds or the one needed

Perception

What else we can get from the Point Cloud data?



- Shape coefficients: cylinder [point_on_axis (x,y,z), axis_direction, (x,y,z) radius]
- 3D centroid
- Orientation
- Bounding box: min (x,y,z) and max (x,y,z) | centre (x0,y0,z0)
- Colored Texture: VoxelGrid.setDownsampleAllData(true);
- Descriptors
- Distance to the object

In order to grasp we need the **pose** of the object.

Perception

Tips for visualization in rviz:

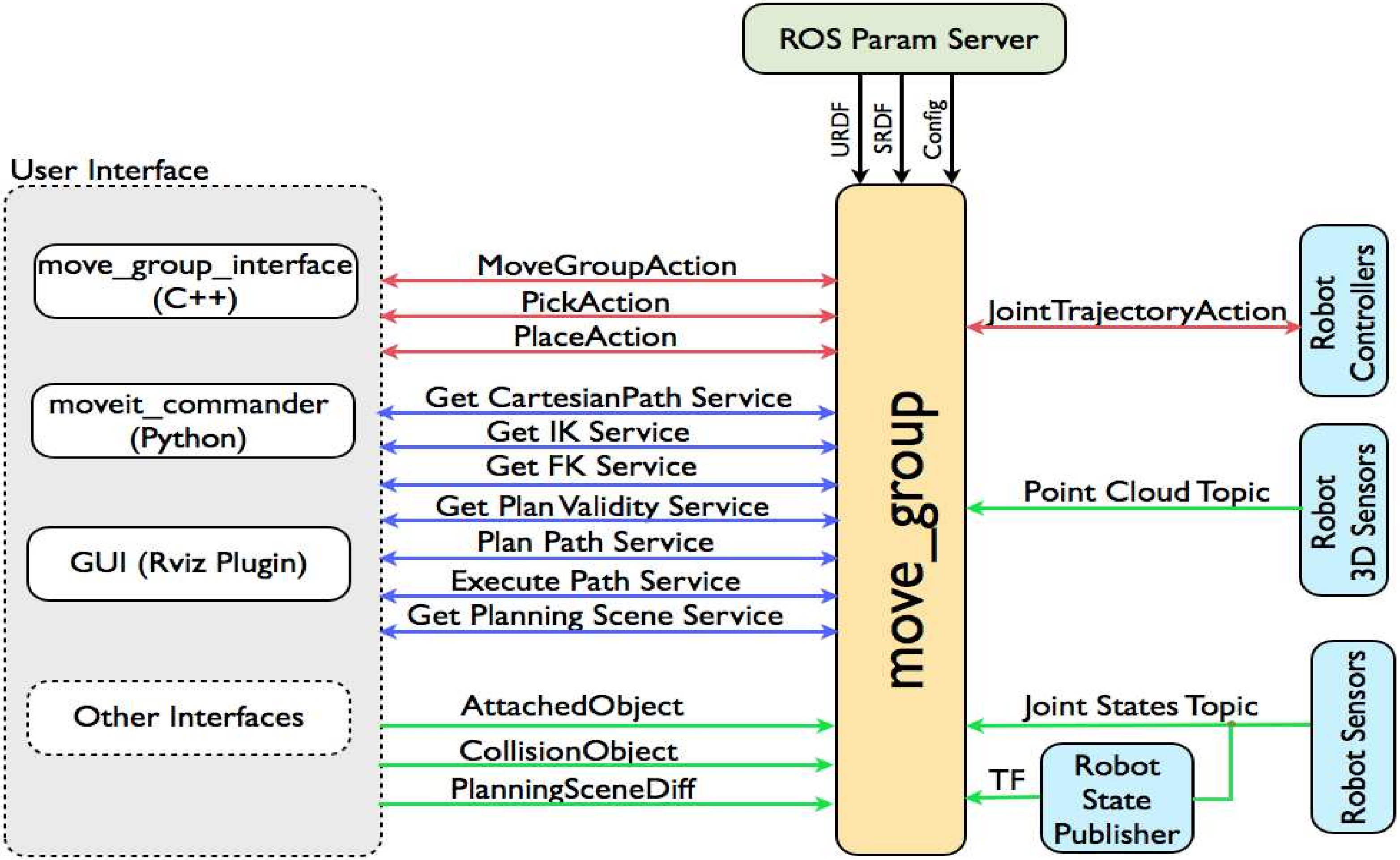
- One object: send the PointCloud2
- Several objects: use markers (visualization_msgs/MarkerArray.msg)

```
#ifdef PUBLISH_MARKERS
visualization_msgs::Marker ObjectClustering::getCloudMarker(const pcl::PointCloud<PointType>::Ptr  cloud, int id)
{
  //create the marker
  visualization_msgs::Marker marker;
  marker.header.frame_id = processing_frame_;
  marker.header.stamp = ros::Time();
  marker.action = visualization_msgs::Marker::ADD;
  marker.lifetime = ros::Duration(5);
  marker.ns = "segmentation";
  marker.id = id;
  marker.pose.orientation.w = 1;

  marker.type = visualization_msgs::Marker::POINTS;
  marker.scale.x = 0.002;
  marker.scale.y = 0.002;
  marker.scale.z = 1.0;

  marker.color.r = ((double)rand())/RAND_MAX;
  marker.color.g = ((double)rand())/RAND_MAX;
  marker.color.b = ((double)rand())/RAND_MAX;
  marker.color.a = 1.0;

  for(size_t i=0; i<cloud->size(); i++) {
    geometry_msgs::Point p;
    p.x = (*cloud)[i].x;
    p.y = (*cloud)[i].y;
    p.z = (*cloud)[i].z;
    marker.points.push_back(p);
  }

  return marker;
}
#endif
```

Tutorial 5: System integration

- **Object Recognition**
- **Robot Manipulation**

MoveIt! Motion planner



Grasping with MoveIt! planner

1) Define object position (From perception node)
2) Feed the object position and geometry restrictions to the move_group node.
3) Request a planning service.
4) Wait for response.
5) Execute the motion.

6) Check MoveIt! Tutorial from http://wiki.ros.org/Robots/TIAGo/Tutorials

7) Check the HSRB samples

Tutorial 5: System integration

- **Object Recognition**
- **Robot Manipulation**
- **Mapping and Navigation**

Navigation and Mapping

Hints:

- Generate a map for the testing environment.
- Use the obtained map to do navigation.
- Use MoveBaseGoal to move the robot with respect to the base_link.

If you want to navigate in the unknown environment (without previously building a map) you can check other SLAM packages :

http://wiki.ros.org/hector_slam or http://wiki.ros.org/slam_karto

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Tutorial 5: System integration

Tutorial 5: System integration

Tutorial 5: System integration

- **To deliver: (by teams)**

1. Map file.
2. Packages of your system integration. (Remember to add a readMe file)
3. Live demo (or Video).

Tutorial 5: System integration

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Wednesday
04th of December
15:00 hrs.

Important Remarks

- **DO NOT** copy all the Workspace into the zip file.
- **DO NOT** copy the darknet packages or the tiago packages in your solutions.
- Copy only the packages needed for the solution.
- Be clear when writing your read me file.
- Specify which robot you used in the first line the read me file.
- Include the list of the packages needed your solution.
- Include all the commands to compile, execute and operate your solutions.
- Use good coding standards.
- Make sure that your solution compiles and runs in a single try.
- Deliver your solution before the deadline.
- Record a video to proof that your solution works. (Sometimes live-demos fail.)

Final Project Definition

- **Check the World Robot Summit Rule Book**
  https://worldrobotsummit.org/download/rulebook-en/rulebook-Partner_Robot_Challenge.pdf
- **Check the Robocup at Home Rule Book.**
  http://www.robocupathome.org/rules
- **Definition meeting:** Friday 29th November 15:00
  We will propose topics from the challenges.
- **Confirmation meeting:** Friday 06th December

Thank you

robocup.atHome.ics@tum.de

www.ics.ei.tum.de