Mobile Robot Navigation with ROS

Dipl.-Ing. Alexander Bubeck

Mobile robot navigation with ROS

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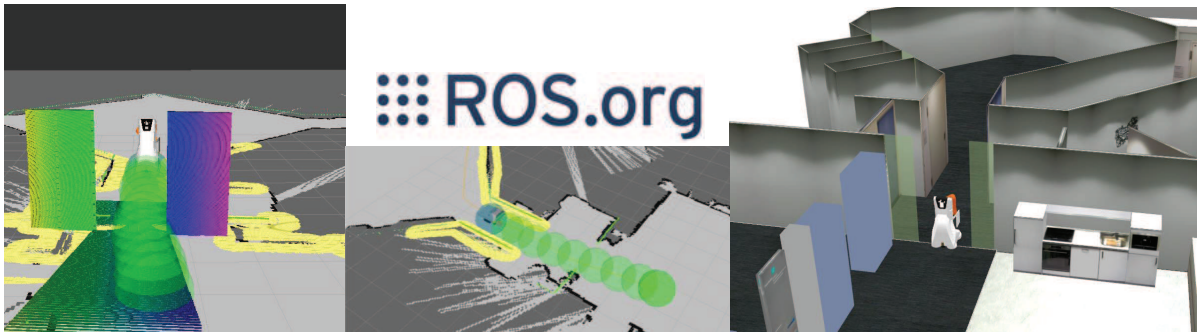
Technology Seminar – ROS in Industrial Applications



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Mobile robot navigation with ROS
Goals

- Learn about localization and navigation systems
  - Overview of modules of a mobile robot navigation
- Learn about the ROS navigation
  - Mapping components
  - Localization components
  - Planning compontents
- Experience the ROS navigation
  - Deploying the navigation
  - Application interfaces

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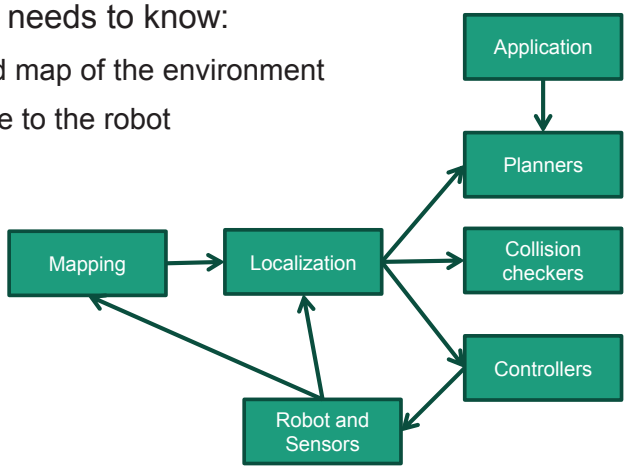
Mobile robot navigation with ROS
Architecture of a navigation system

- Navigation systems consist of planners that move the robot from a start to a goal without creating collisions with the environment
- For creating such plans the robot needs to know:
  - Where he is based on a defined map of the environment
  - Where the obstacles are relative to the robot



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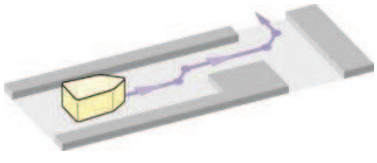
Mobile robot navigation with ROS
Existing systems

- AGV systems with different kinematics
  - Differential kinematics
  - Car-like kinematics
  - Omni-directional kinematics
- Localization with required changes to the environent
  - Optical lines on floor
  - Magnetic tags in floor
  - Laser markers in environment
- Planning on predefined path
  - Reactive obstacles produce stops of AGV



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Mobile robot navigation with ROS
Overview

- ROS provides a modular navigation system based on landmarks that can be used for arbitrary robots
- Separation of the modules for localization and navigation:
  - amcl and gmapping are components for localization
  - move_base is a component that integrates path planning, collision checking and controllers as plugins

- Process for utilizing the ROS navigation system for a robot:

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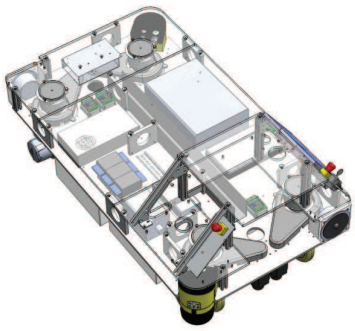
Mobile robot navigation with ROS
Prerequisites

- Mobile robot with driver in simulation (e.g. gazebo) or real robot hardware
- URDF description with at least a base_link and the sensor links with defined positions
- Sensors:
  - Laser scanners
  - Optional 3D cameras
- Actuators:
  - Kinematics module that controls cartesian twists
  - Cartesian odometry



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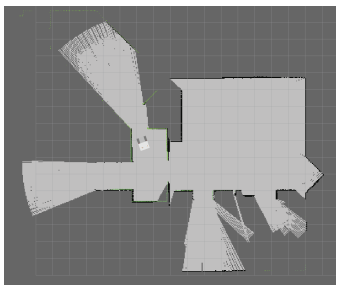
Mobile robot navigation with ROS
Mapping

- Gmapping: open source particle filter based slam algorithm (openslam.org)
  - Creates a gridmap of the environment that can be used by localization algorithms lateron
  - Robot moves around (e.g. by joystick) and gmapping registers scan data that are matched into a overall map
  - The existing part of the map is used for localization already during map creation
- Map is represented as occupancy grid and is distributed by the map_server node



Create a map of the environment | Start a localization for the environment | Configure and run motion planners | Send navigation goals to the motion planner

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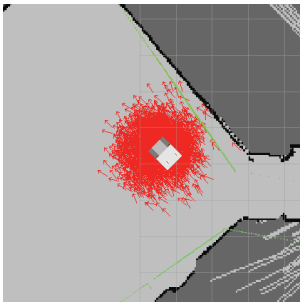
Mobile robot navigation with ROS
Localization

- AMCL (adaptive monte carlo localization)
  - 2D localization of robot moving in a known environment
  - Particle filter on occupancy grid map
  - Not a global localization → needs to be initialized to a known pose on start
- Localization produces a tf tree:
  - /map: origin of the map and global coordinate system for the application
  - /odom_combined: estimation of robot localization only based on odometry
  - /base_link: origin of the robot model (usually at the center of the robot on the floor)



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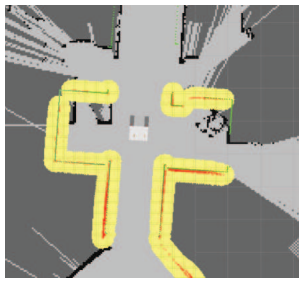
Mobile robot navigation with ROS
The costmap

- costmap_2d is the dynamic collision map that is used by move_base to plan a path
  - Live data of sensors (laser scans, 3D sensors) are mapped into a dynamic occupancy grid
  - Configured sensors can „mark“ grids to be occupied or „clear“ grids to be free
  - Costmap can be generated globally or in a defined local area around the robot



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Mobile robot navigation with ROS
Global path planners

- Global planners are implemented as plugins
- Searches for path from current position to the goal position
- Search is based on static information in costmap
- Navfn: standard implementation of global planner
  - Robot assumed as circular
  - Path search implemented using Dijkstra's algorithm

Create a map of the environment | Start a localization for the environment | Configure and run motion planners | Send navigation goals to the motion planner

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Mobile robot navigation with ROS
Local path planners

- Local planners are implemented as plugins
- Modification of path during execution to react to dynamic obstacles
- Dynamic costmap updates are used for collisions checks
- Different implementations are available:
  - Velocitiy filter: Implementation for differential platforms
  - Dynamic window approach: Implementation for omnidirectional platforms
  - Elastic Band: Omnidirectional behaviour can be tuned, Good performace in narrow environments

Create a map of the environment | Start a localization for the environment | Configure and run motion planners | Send navigation goals to the motion planner

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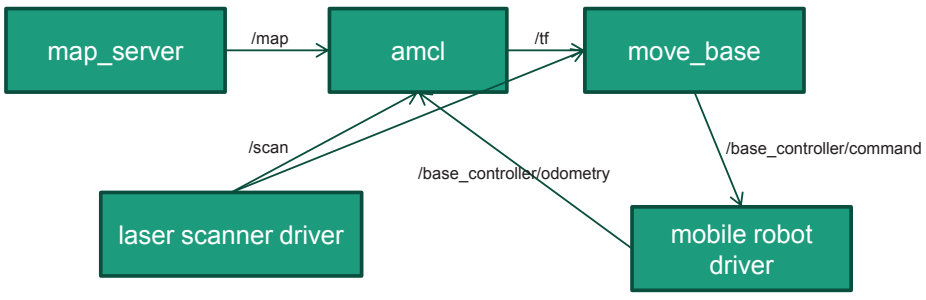
Mobile robot navigation with ROS
Deploying the navigation system

- Whole navigation system should be launched using a launch file configuring the nodes and the deployment
- Overall navigation system running looks like this:



Create a map of the environment | Start a localization for the environment | Configure and run motion planners | Send navigation goals to the motion planner

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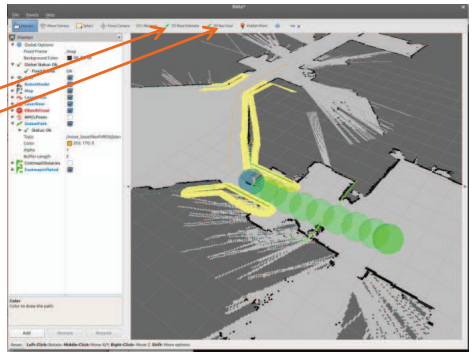
Mobile robot navigation with ROS
Interfaces to the navigation

- RVIZ can be used to:
  - Set the iniatial pose of the localization
  - Command a goal to the navigation



- TF can be utilized to integrate the localization information into an application (e.g. transform a detected pose into the global origin)
- Move_base action is used to command the navigation from applications

Create a map of the environment → Start a localization for the environment → Configure and run motion planners → **Send navigation goals to the motion planner**

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Mobile robot navigation with ROS
Summary

- ROS includes a navigation framework consisting of
  - Mapping: http://wiki.ros.org/gmapping
  - Localization: http://wiki.ros.org/amcl
  - Navigation: http://wiki.ros.org/move_base
- More detailed documentation can be found at http://wiki.ros.org/navigation
- Modular system allows to integrate extensions of mapping and planning algorithms (e.g. available from Fraunhofer IPA)

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Mobile robot navigation with ROS
Your navigation expert

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