Hochschule
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Software Development Project

Final Presentation

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Introduction

Basic Navigation Test

- Environment: Workspaces, waypoints and obstacles.
- Task specification: Sequence of poses.

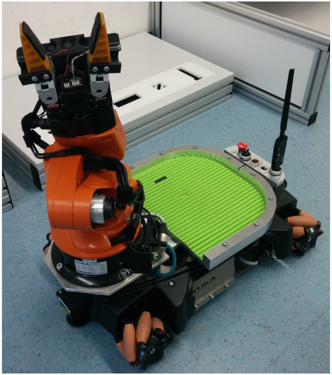
Challenges

- **Perception:** Accessing and processing sensor data.
- **Mapping:** Building map of the environment.
- **Localization:** Pose inside map.
- **Path planning:** Determine sequence of poses between waypoints.
- **Motion control:** Execution of path.

KUKA youBot

The youBot is a mobile manipulator designed for education and research purposes. It comes with fully open interfaces and API.

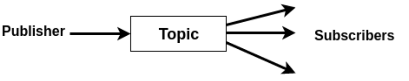
- Omnidirectional, four-wheeled
- 5-DOF manipulator with a two-finger gripper
- On-board PC with CPU, 2GB memory, 32GB SSD drive
- Sensors: vision sensors, rangefinders



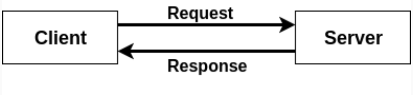
Robot Operating System (ROS) I

Set of software and libraries.

- **Node**: A process using ROS.
- **Topic**: Message queue, used for communication between nodes.



- **Service**: Offers synchronous service calls.



Robot Operating System (ROS) II

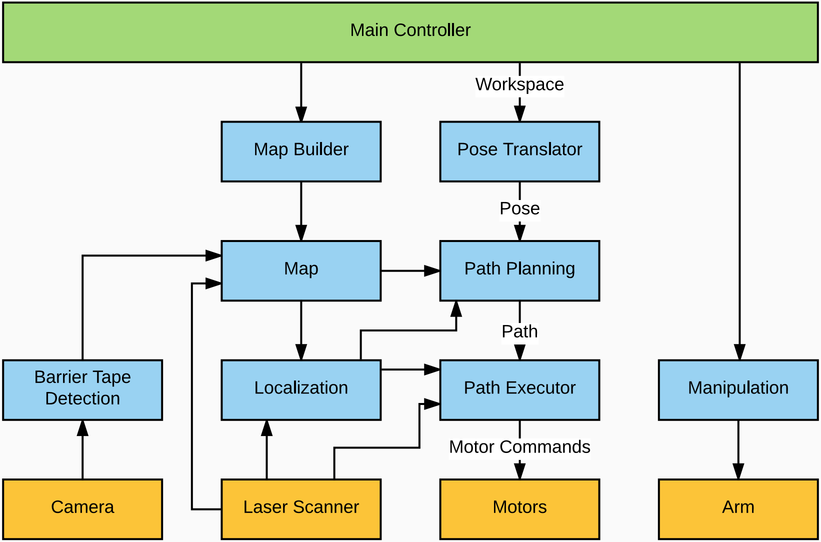
- **Actionlib**
  - Provides client interface to send requests to server
  - Client and server communicate with messages:
    - Goal
    - Feedback
    - Result

Approach

Approach

- Divide problem into smaller parts.
- Each part is defined by
    - It's function and
    - Interface
- Parts are replaceable.
- Try to use as many available components from ROS as possible.

Software Modules



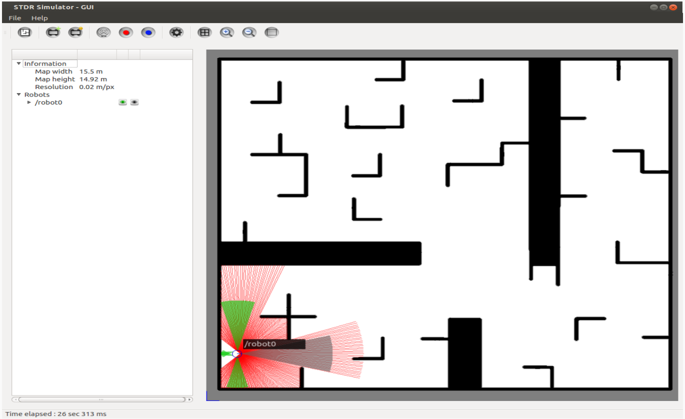
Realization

Realization

Simulation

Simulation

- Simple Two Dimensional Robot (STDR) simulator
- Tasks performed:
  - Map Building
  - Localization



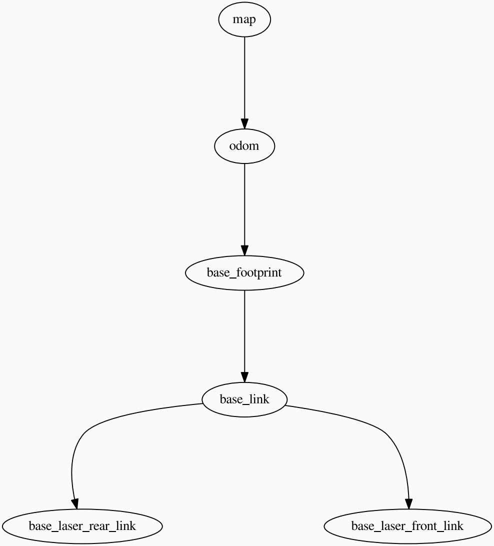
Information
Map width 15.5 m
Map height 14.92 m
Resolution 0.02 m/px
Robots
/robot0

Time elapsed : 26 sec 313 ms

Map building I

- Gmapping is used to build 2D occupancy grid map
- Uses laser sensors to build the map
- Map Server
    - Provides map saver utility, to save generated map in files(yaml and pgm)
    - Offers map data as a ROS Service

Map building II



Localization I

- Adaptive Monto Carlo Localization(AMCL) is used to localize the robot
- Uses particle filter to track the pose of robot
- Problems:
  - AMCL could not find laser data on /scan topic
  - AMCL node crushes after some time
- Solutions:
  - Remap /scan_front and /scan_rear to /scan topic
  - Because of transformations provided by STDR simulator

Realization

KUKA youBot

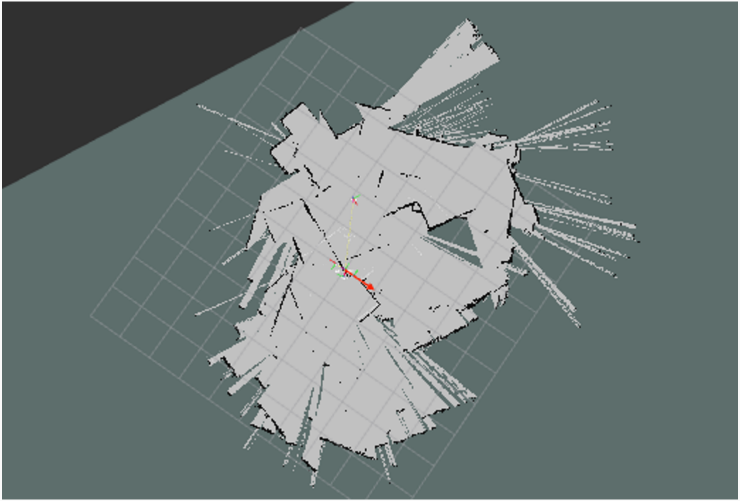
youBot Driver

- Driver for the KUKA youBot robot
- youBot API represents robot system as a combination of sub-systems
- Contain three main classes
  - youBot Manipulator
  - youBot Base
  - youBot Joint
- Uses ROS wrapper for translation to ROS

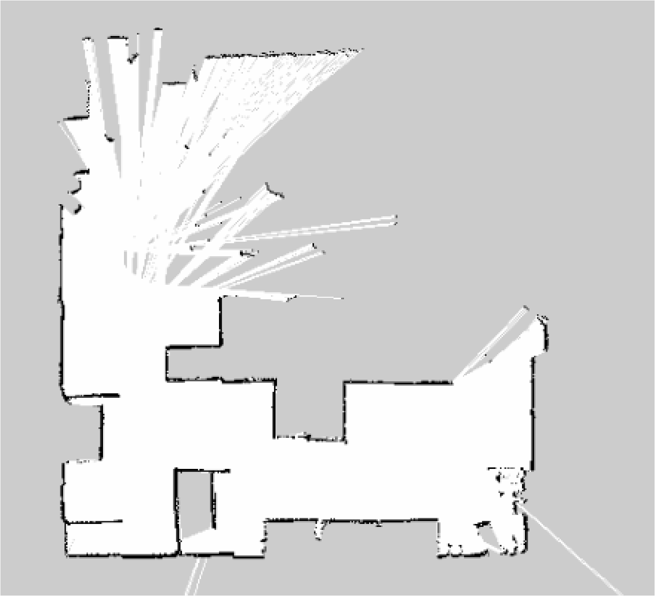
Map building III

- **Problems**
    - Messy Map
- **Solutions**
    - Because of different translations in simulation and real world
    - Configuration of laser scanners in simulator is upside down

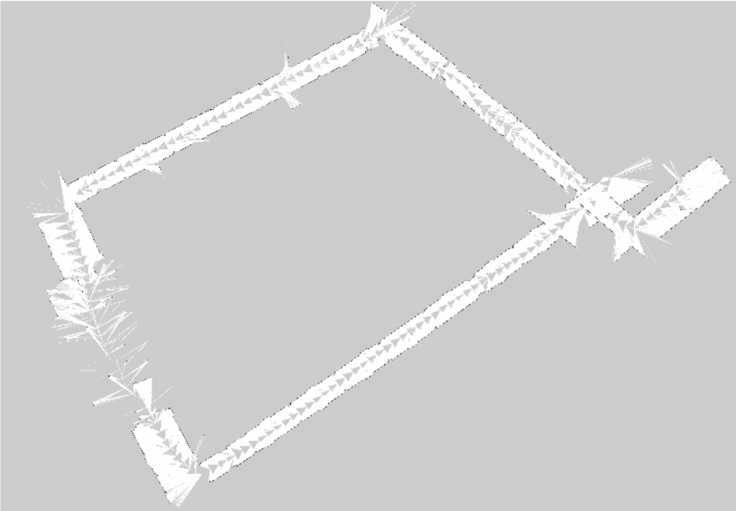
Map building IV



Map building V



Map building VI



Navigation I

- Planners: global, local
- Costmaps: global, local
- Local planner: dwa_local_planner
  - Given: plan, costmap, odom
  - Generates costs of transversing through map grids
  - Output: Velocity command
- Output: Velocity command (cmd_vel)

Navigation II

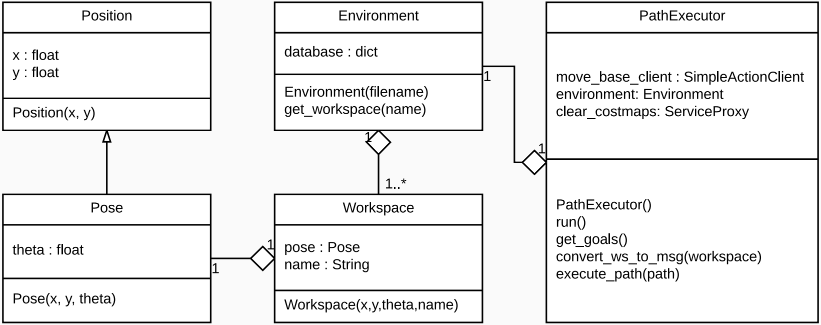
- **Problem**
  - Differential drive motion
- **Solution**
  - dwa_local_planner

Path executor

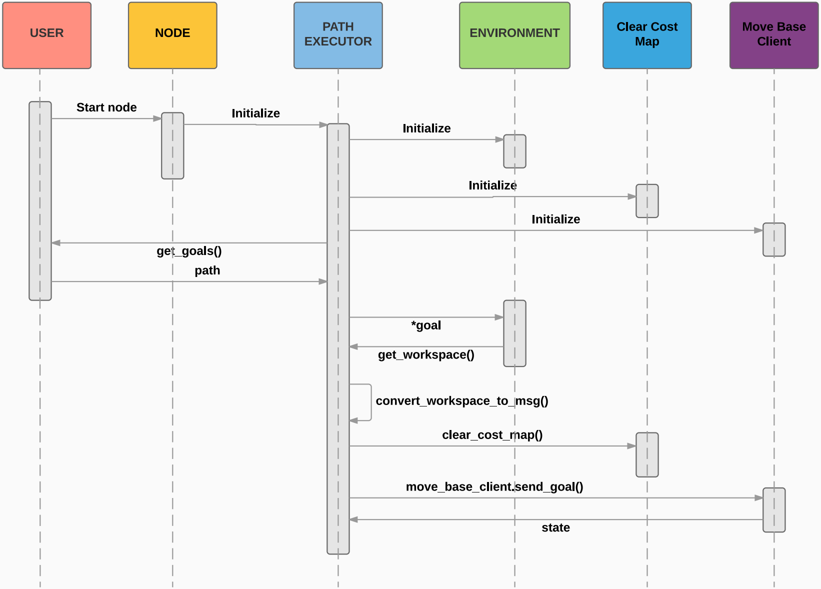
Path executor reads a set of user inputs and convert them to move_base_msgs.

- Class: Position, Pose, Environment, Workspace, PathExecutor
- Functions:
  - Reads user inputs
  - Reads workspace from file
  - Converts workspace to move_base_msgs
  - Clears cost map
  - Sends goal message

Class Diagram

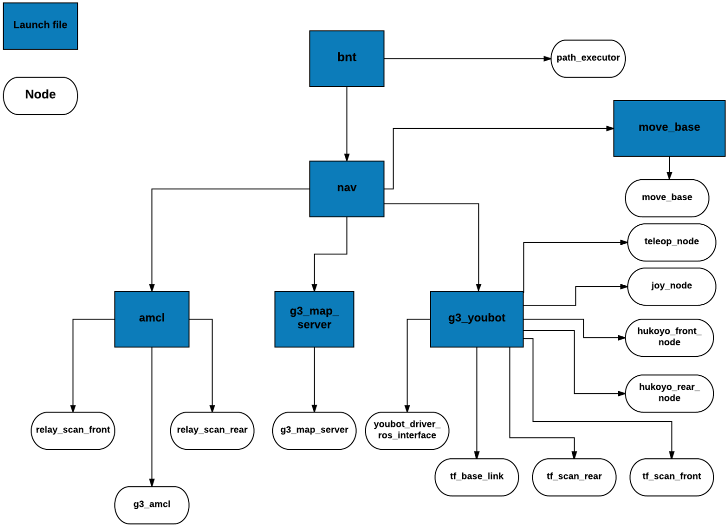


Sequence Diagram

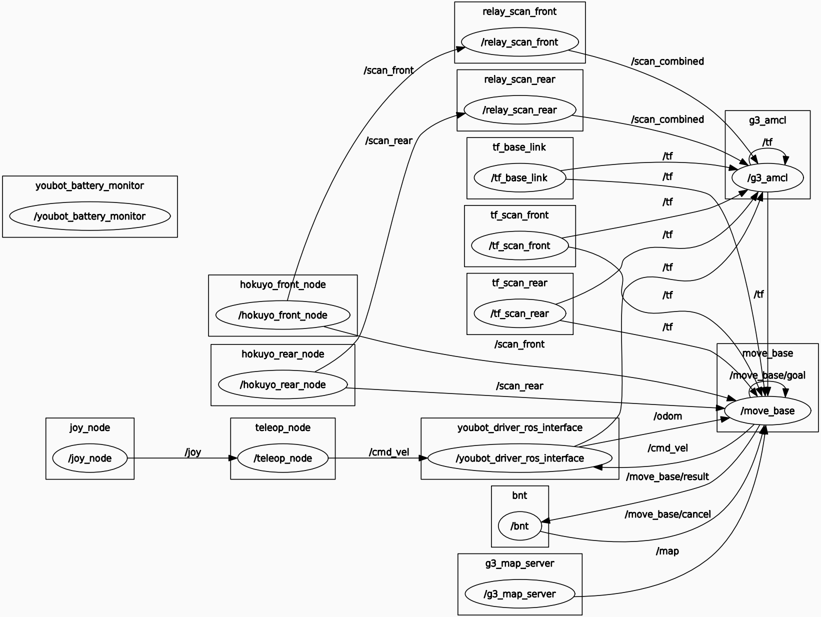


Results

Launch Files



RQT Graph



relay_scan_front
/relay_scan_front
relay_scan_rear
/relay_scan_rear
tf_base_link
/tf_base_link
tf_scan_front
/tf_scan_front
tf_scan_rear
/tf_scan_rear
g3_amcl
/g3_amcl
move_base
/move_base
/move_base/goal
youbot_battery_monitor
/youbot_battery_monitor
hokuyo_front_node
/hokuyo_front_node
hokuyo_rear_node
/hokuyo_rear_node
joy_node
/joy_node
teleop_node
/teleop_node
youbot_driver_ros_interface
/youbot_driver_ros_interface
bnt
/bnt
g3_map_server
/g3_map_server
/scan_front
/scan_rear
/scan_combined
/scan_combined
/tf
/tf
/tf
/tf
/tf
/tf
/tf
/tf
/tf
/scan_front
/scan_rear
/odom
/cmd_vel
/joy
/cmd_vel
/move_base/result
/move_base/cancel
/map

Conclusions

Conclusions

- Navigation was analyzed and applied to youBot.
- The task contains mapping, localization, path planning, motion execution.
- Mapping was realized using gmapping, which requires laser scans and correct transforms.
- Localization was achieved using AMCL, which relies on a map, laser scans, transforms, and initial pose.
- DWA local planner was employed for path-planning.
- A node was created as a path executor that requests user input.
- The robot was able to navigate around the lab by user input of a series of workspace.

Future Work

- User interface can be improved.
- The parameters can be retuned to improve the performace of robot.