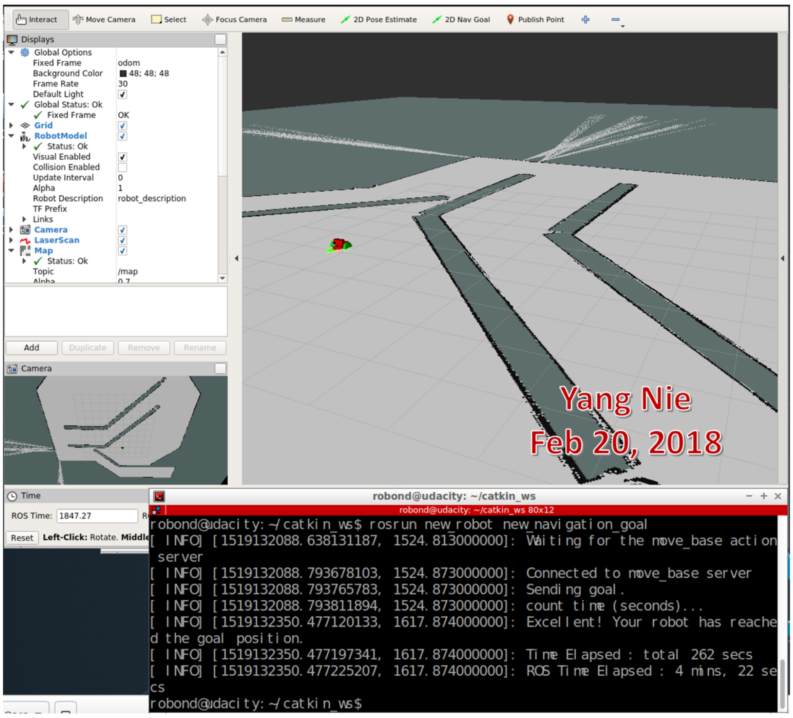
Udacity Robotics Software Engineer Project

Term2 Localization Lab

Abstract

The two robots were created in the project, both robots started from a initial starting point, then utilized ROS packages to accurately localize a mobile robot inside a provided map in the Gazebo and RViz simulation environments. The sensors and AMCL (Adaptive Monte Carlo Localization) algorithm were used to locate current position, and search the path to navigate automatically to a predefined target position. The results for both the Classroom robot and the developed robot will be compared in this article.



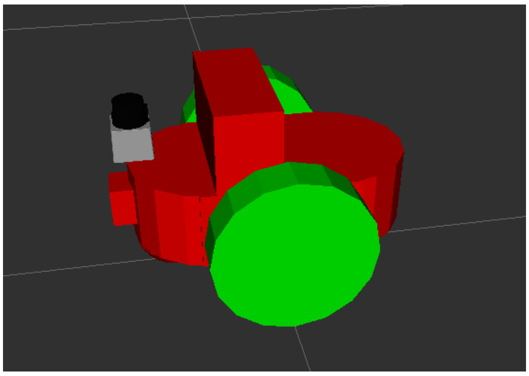
Introduction

The project forcus on following several aspects of robotics:

- Building a mobile robot for simulated tasks.
- Creating a ROS package that launches a custom robot model in a Gazebo world and utilizes packages like AMCL and the Navigation Stack.
- Exploring, adding, and tuning specific parameters corresponding to each package to achieve the best possible localization results.

The project created two robots:

- One is benchmark robot (called: udacity_bot) given as part of the project,
- The second one (called: new_robot) was created by auther.



Both robots need to use sensors such as a camera or Lidar (Light Detection and Ranging) and AMCL algorithm package.

A predefined maze map was provided, and a C++ navigation goal program was coded to give a navugation goal position.

Background

The robot performance is related a running environment directly, it is so important which hardware and virtual machine configuration were used in this project.

Hardware:

```
Computer model: Surface Pro 4
```

```
Processor: Intel i7-6650U CPU @ 2.20GHz @2.21GHz
```

```
RAM: 16GB
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```
Operation System: Window 10 Pro
```

Virual Machine:

```
VMware Workstation 12 Pro, version 12.5.6
```

```
Processor: 2
```

```
Memory: 8GB
```

```
Hard Disk: 40 GB
```

Software

1. Using an Udacity ROS (Kinetic) package to create a robot simulation environment on VMWare machine. This ROS includes Python (2.7), Gazebo (7.10.0) and RViz (1.12.15) packages.
2. To build a testing simulation environment, these package need to install in ROS:

- ros-kinetic-navigation
- ros-kinetic-map-server
- ros-kinetic-move-base
- ros-kinetic-amcl

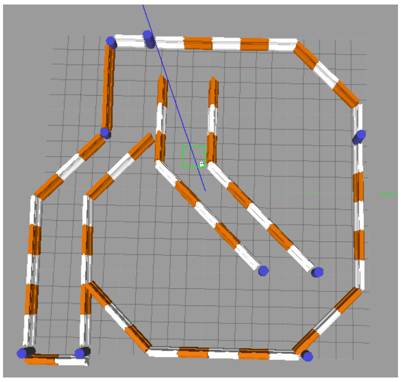
3. Using URDF (Unified Robot Description Format) to create the robot model which includes pose, inertial, collision and visual data.

   Two sensors - a camera and a laser rangefinder (Hokuyo) was added in this URDF model.
4. Three Gazebo plugins were used to help utilize all available gazebo functionality in order to implement specific use-cases for specific models. They are:

- A plugin for the camera sensor.
- A plugin for the hokuyo sensor.
- A plugin for controlling the wheel joints.

  A xacro file under urdf folder, udacity_bot.gazebo, includes these three plugins

5. A map created by Clearpath Robotics was used for both robots in the project.

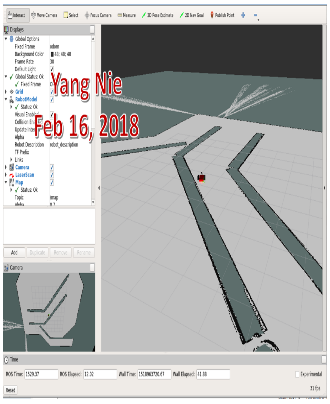
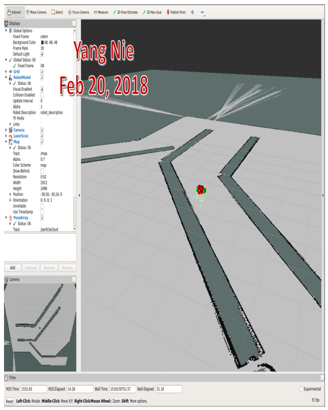


6. AMCL (Adaptive Monte Carlo Localization) algorithm was used to dynamically adjust the number of particles over a period of time.
7. A C++ code - navigation_goal.cpp file was used to send a target position to move_base action server.
8. There launch file: robot_description.launch, udacity_world.launch and amcl.launch under launch folder.

Results

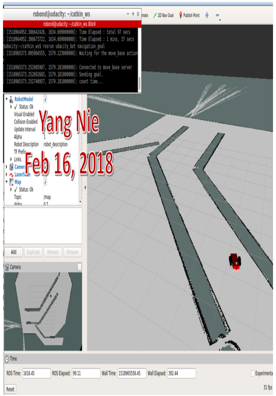
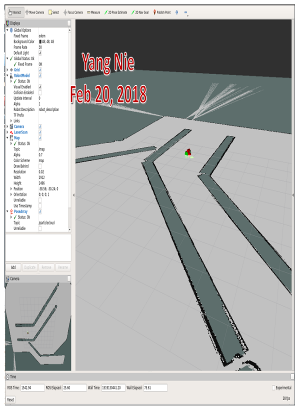
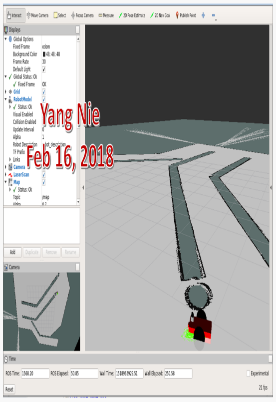
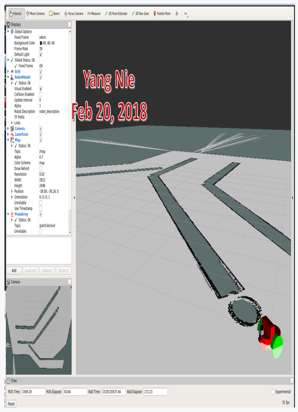
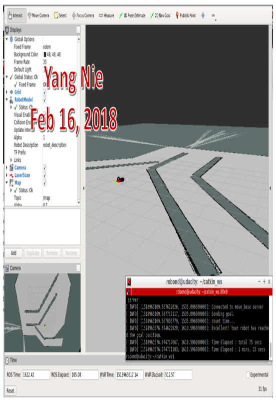
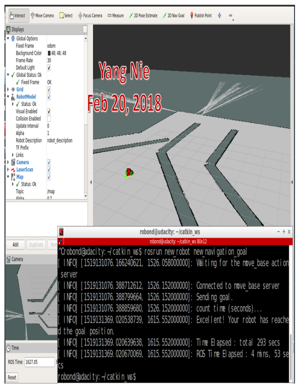
Testing scenario:

Both robots used the same map with same starting (0 0 -0.785) and target (0.995 -2.99 0) position.

udacity_bot	new_robot
	

Testing results

Both robots can arrive to the target position within reasonable time.

	udacity_bot	new_robot
Go a head		
Make a turn		
Arrived target		
Average Time	6 -7 munites	4 -5 munites

Model Configuration

The new_robot parameter list as:

```
* /amcl/base_frame_id: robot_footprint
* /amcl/controller_frequency: 10.0
* /amcl/global_frame_id: map
* /amcl/initial_pose: 0 0 -0.785

* /amcl/laser_model_type: likelihood_field_...
```

```
 * /amcl/max_particles: 240
 * /amcl/min_particles: 30
 * /amcl/odom_alpha1: 0.002
 * /amcl/odom_alpha2: 0.002
 * /amcl/odom_alpha3: 0.001
 * /amcl/odom_alpha4: 0.001
 * /amcl/odom_frame_id: odom
 * /amcl/odom_model_type: diff-corrected
 * /amcl/recovery_alpha_fast: 0.1
 * /amcl/recovery_alpha_slow: 0.01
 * /amcl/resample_interval: 1.0
 * /amcl/transform_tolerance: 3.2
 * /amcl/use_map_topic: True
 * /move_base/TrajectoryPlannerROS/escape_vel: -0.1
 * /move_base/TrajectoryPlannerROS/gdist_scale: 1.0
 * /move_base/TrajectoryPlannerROS/heading_scoring_timestep: 0.8
 * /move_base/TrajectoryPlannerROS/holonomic_robot: False
 * /move_base/TrajectoryPlannerROS/latch_xy_goal_tolerance: False
 * /move_base/TrajectoryPlannerROS/meter_scoring: True
 * /move_base/TrajectoryPlannerROS/oscillation_reset_dist: 0.1
 * /move_base/TrajectoryPlannerROS/pdist_scale: 0.8
 * /move_base/TrajectoryPlannerROS/publish_cost_grid_pc: False
 * /move_base/TrajectoryPlannerROS/sim_time: 3.0
 * /move_base/TrajectoryPlannerROS/xy_goal_tolerance: 0.05
 * /move_base/TrajectoryPlannerROS/yaw_goal_tolerance: 0.05
 * /move_base/base_global_planner: navfn/NavfnROS
 * /move_base/base_local_planner: base_local_planne...
 * /move_base/controller_frequency: 5.0
 * /move_base/global_costmap/global_frame: map
 * /move_base/global_costmap/height: 40.0
 * /move_base/global_costmap/inflation_radius: 0.2
 * /move_base/global_costmap/laser_scan_sensor/clearing: True
 * /move_base/global_costmap/laser_scan_sensor/data_type: LaserScan
 * /move_base/global_costmap/laser_scan_sensor/marking: True
 * /move_base/global_costmap/laser_scan_sensor/sensor_frame: hokuyo
 * /move_base/global_costmap/laser_scan_sensor/topic: /new_robot/laser/...
 * /move_base/global_costmap/map_type: costmap
 * /move_base/global_costmap/observation_sources: laser_scan_sensor
 * /move_base/global_costmap/obstacle_range: 5.0
 * /move_base/global_costmap/publish_frequency: 2.0
 * /move_base/global_costmap/raytrace_range: 9.0
 * /move_base/global_costmap/resolution: 0.05
 * /move_base/global_costmap/robot_base_frame: robot_footprint
 * /move_base/global_costmap/robot_radius: 0.19
 * /move_base/global_costmap/rolling_window: False
 * /move_base/global_costmap/static_map: True
 * /move_base/global_costmap/transform_tolerance: 0.4
 * /move_base/global_costmap/update_frequency: 2.0
 * /move_base/global_costmap/width: 40.0
 * /move_base/local_costmap/global_frame: odom
 * /move_base/local_costmap/height: 20.0
 * /move_base/local_costmap/inflation_radius: 0.2

 * /move_base/local_costmap/laser_scan_sensor/clearing: True
```

```
 * /move_base/local_costmap/laser_scan_sensor/data_type: LaserScan
 * /move_base/local_costmap/laser_scan_sensor/marking: True
 * /move_base/local_costmap/laser_scan_sensor/sensor_frame: hokuyo
 * /move_base/local_costmap/laser_scan_sensor/topic: /new_robot/laser/...
 * /move_base/local_costmap/map_type: costmap
 * /move_base/local_costmap/observation_sources: laser_scan_sensor
 * /move_base/local_costmap/obstacle_range: 5.0
 * /move_base/local_costmap/publish_frequency: 2.0
 * /move_base/local_costmap/raytrace_range: 9.0
 * /move_base/local_costmap/resolution: 0.05
 * /move_base/local_costmap/robot_base_frame: robot_footprint
 * /move_base/local_costmap/robot_radius: 0.19
 * /move_base/local_costmap/rolling_window: True
 * /move_base/local_costmap/static_map: False
 * /move_base/local_costmap/transform_tolerance: 0.4
 * /move_base/local_costmap/update_frequency: 2.0
 * /move_base/local_costmap/width: 20.0
 * /rosdistro: kinetic
 * /rosversion: 1.12.12

NODES
  /
    amcl (amcl/amcl)
    map_odom_broadcaster (tf/static_transform_publisher)
    map_server (map_server/map_server)
    move_base (move_base/move_base)

ROS_MASTER_URI=http://localhost:11311
```

Several parameters were adjusted in the project and impacted robot performance:

1. /amcl/max_particles: If it is too low, the robot will take more time to navigate, and this error: "Clearing costmap to unstuck robot" pops up.
2. robot_radius: It it is too low, the robot will stuck on the wall without turning. If it is too high, the robot can turn into a cycle.
3. raytrace_range: Set it little higher that can help the robot keeps inside the navigation path to the target.
4. /move_base/controller_frequency: Set the lower value to eliminate the warning message "Control loop missed its desired rate of 20.0000Hz". This parameter doesn't impact robot performance, but it will reduce these unnecessary warning messages on the screen and in the log file.

Discussion

- Adjusting the parameter is a big challenge and time consuming job. Those parameters can be changed independently, but they are related eachother. It is impossible that one person tries all possible combination values for all parameters in limited time. A team work needs to assign for achieving the best result.
- AMCL would'n work well for the kidnapped robot problem, when this error: "Clearing costmap to unstuck robot" happened, the robot couldn't locate its current location to continue navigating to target.
- A moving robot with MCL/AMCl algorithm can be used warehouse industry to move and delivery good inside the warehouse. This job and working environment have clear start and end positions.

Future Work

- Both robots started forward to dead end direction, then turned back to reverse point. The algorithm can improve to avoid this issue.
- Adjusting and trying different parameters are very man power cost work, a database can be biult to store these test and result data to help develping a new rotot, and use Deep Learning technology to figure out and generate these parameters automatically.