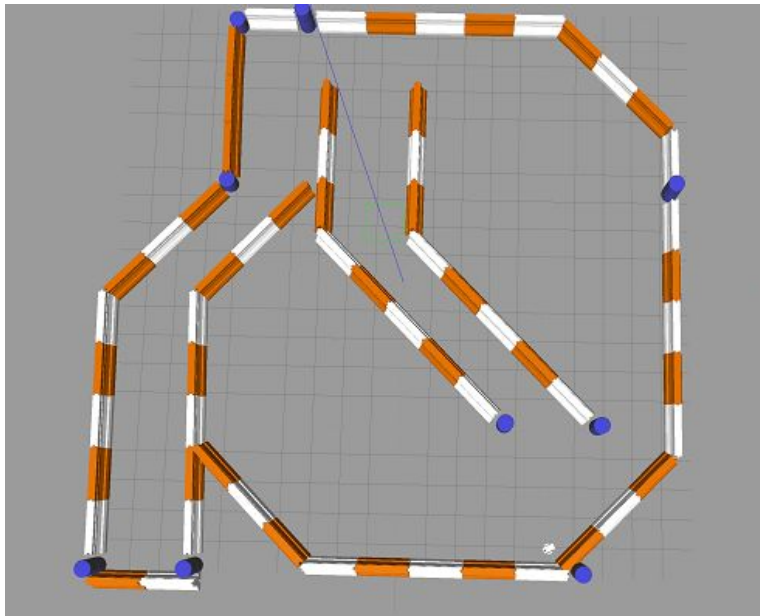


# Udacity RoboND

## Project Report:

### Where am I ?

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# Abstract

The goal of the project is to make use of ROS (Robotics Operating System) packages to accurately localize a mobile robot inside a provide map in the Gazebo and RViz simulation environments. A custom differential wheel mobile robot model will be created in a Gazebo world. ROS navigation stack is applied in this project, packages such as AMCL (Adaptive Monte Carlos Localization), Map\_Server and Move\_Base. Depend on compute platform and sensor accuracy, performance tuning is required to achieve the best localization results.

# Introduction

The objective of this project is to use ROS packages to localize a mobile robot inside a provided map in the Gazebo and RViz simulation environments. This article will present an overview of a navigation stack in ROS.

- Create a custom ROS package
- Write a custom robot model in a Gazebo world
- Write launch script to bring up the custom robot in the Gazebo world
- Write launch script to launch AMCL and MOVE\_BASE packages
- Tune the AMCL parameter to achieve the best possible localization results

# Robot Model

A custom differential wheel mobile robot is built in URDF file. For this type of wheel drive, it requires two independent motor driven wheels to enable this type of driver to work. It can have either one or two caster wheels to support the robot. It consists of a hokuyo laser scanner, camera and differential wheel sensor.

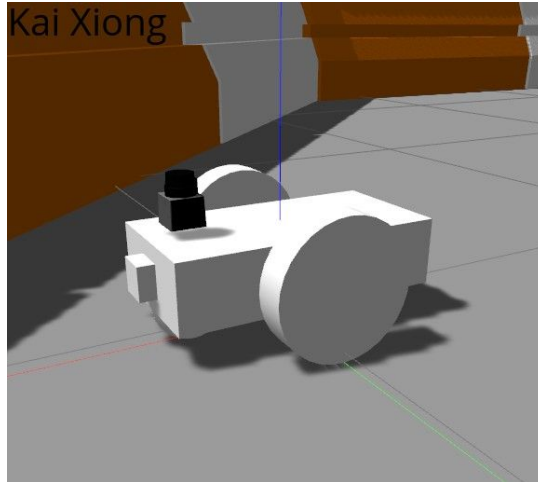


Figure 1. Robot Model

## Localization

Localization is the basic function of a mobile robot. Before the robot can execute any movement, it need to determine its own position with respect to the map. With the ability of localization, the robot can navigate from point A to B. Mobile robot also must be able to avoid dangerous situations such as collisions and unsafe environment.

## EKF vs MCL

The main two types of localization methods are “Extended Kalman Filter” and “Monte Carlo Localization”. MCL is a type of particle filter algorithm. Compare EFK with MCL, MCL is more robust and it capable of global localization.

	<b>EKF</b>	<b>MCL</b>
Observation	Landmarks	Raw measurement
Observation noise	Gaussian	Any
Posterior	Gaussian	Particles
Efficiency (Memory)	☆☆	☆
Efficiency (time)	☆☆	☆
Ease of Implementation	☆	☆☆

Resolution	☆	☆☆
Robustness	X	☆☆
Memory & Resolution Control	No	Yes
Global Localization	No	Yes
State Space	Unimodel Continuous	Multimodel Discrete

Table 1. EKF vs MCL comparison table

## AMCL

AMCL (Adaptive Monte Carlo Localization) is a probabilistic localization package for 2D navigation. It implements the adaptive (or KLD-Sampling) Monte Carlo Localization approach which use a particle filter to track the pose of a robot with a known map.

The AMCL pose output frequency is depended on the frequency rate of the laser scans. If the laser scan frequency is 10 Hz, the maximum output of the AMCL\_pose will be 10 Hz. In order to make the particle converge quicker, by reducing the “update\_min\_d” and “update\_min\_a”.

Parameters	Value
odom_frame_id	odom
odom_model_type	diff-corrected
base_frame_id	robot_footprint
global_frame_id	map
min_particles	10
max_particles	500
transform_tolerance	0.1
resample_interval	1
odom_alpha1	0.05
odom_alpha2	0.05
odom_alpha3	0.05

odom_alpha4	0.05
update_min_a	0.01
update_min_d	0.01

Table 2. AMCL parameters

## Move\_base

The move\_base package provides an implementation of an action (actionlib package) that, given a goal in the world, it will attempt to reach it with a mobile base. The move\_base node links together a global and local planner to accomplish its global navigation task. It supports any global planner adhering to the nav\_core::BaseGlobalPlanner interface specified in the nav\_core package and any local planner adhering to the nav\_core::BaseLocalPlanner interface specified in the nav\_core package.

Parameters	Value
base_global_planner	navfnNavfnROS
base_local_planner	TrajectoryPlannerROS
max_vel_x	0.5
min_vel_x	0.1
xy_goal_tolerance	0.05
yaw_goal_tolerance	0.05

Table 3. Move\_base parameters

## Map\_server

Map\_server provide the map\_server ROS Node, which offers map data as a ROS Service. It also provides the map\_saver command-line utility, which allows dynamically generated maps to be saved to file. It is used for loading static map.

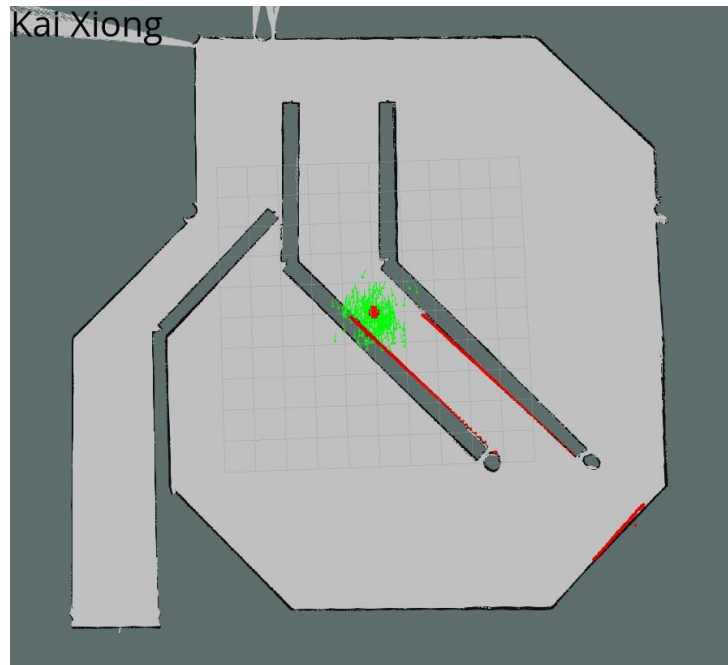


Figure 2. Jackal race Grid Map

## Localization Accuracy

The AMCL output `AMCL_pose` message. The message type is `geometry_msgs/PoseWithCovarianceStamped`. The localization accuracy is represented in the pose covariance. The 6x6 covariance matrix represent in x, y, z rotation about X axis, rotation about Z axis. The higher the value, it represent higher uncertainty.

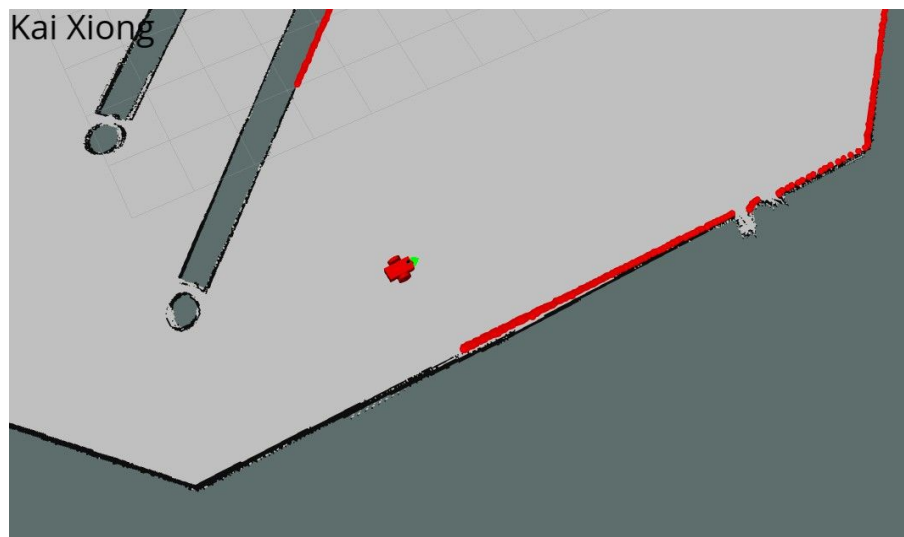


Figure 3. Localized map

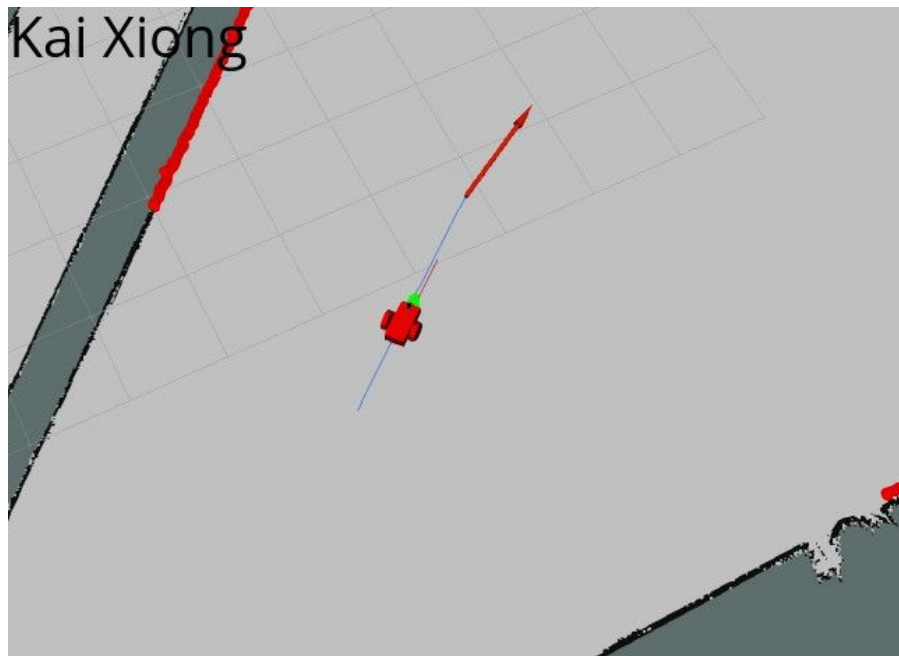


Figure 4. Robot move to goal

## Discussion

The AMCL performance depended on the CPU performance, laser scan accuracy and AMCL parameters. AMCL may perform badly in location such as long corridor, where there is less distinct feature in the map.

## Conclusion / Future Work

In conclusion, the custom mobile robot capable of accurately localized in a known map. Sensor fusion can help to improve the accuracy. Sensors such as IMU, RGBD camera and GPS. Robot\_pose\_ekf packages can perform sensor fusion by taking in sensors output. It can help to output more accurate position, even if one of the sensors is failed.