SLAM: Map My World

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1 Introduction

Consider a robot in an unknown environment, with no known map. The robot takes sensor readings and experiences control actions. Based on these observations and actions, the robot must construct a map and localise itself within the map. In robotics, this scenario is known as the *simultaneous localisation and mapping problem*, or SLAM. In simpler terms, using sensor readings and control data, SLAM concurrently constructs an environment map, and determines the robots location and orientation within that map. This is an important problem since odometric data is subject to small perturbations which are introduced from wheel slippage and sensor noise - often refered to as odometric drift. Mapping allows a robot to revisit previously mapped terrain and reset any localisation error. Also, location and orientation within a given map are normally used as inputs for higher order functions like path planning. The problem is more difficult to solve than localisation with known poses since high dimensionality of map spaces can often lead to computational intractibility. This paper explores two approaches to solving SLAM. The first of these solutions is called FastSLAM which employs a combination of Extended Kalman Filters(EKF) and Monte Carlo Localisation (MCL) to solve the problem. The second approach is called GraphSLAM, which solves the problem by optimising a graph structure built by the algorithm. The paper concludes with an application of GraphSLAM in a Gazebo simulation using an off-the-shelf implementation called RTAB-Map in ROS. The GraphSLAM implementation is tested across two different environments providing opportunities for discussion of the algorithm robustness.

2 Background

Robot localisation aims to determine, for some discrete time step t, a distribution of the robot's pose, x_t, given a series of observations, $z_{1:t}$, control actions, $u_{1:t}$, and a map, m. The localisation problem is often expressed, using conditional probability notation, as follows:

$$p(x_t|z_{1:t}, m, u_{1:t}) \tag{1}$$

Mapping of an environment is the problem of determining a distribution over all possible map configurations, m, given a series of observations, $z_{1:t}$, and known robot poses, $x_{1:t}$. The mapping problem is often expressed, using conditional probability notation, as follows:

$$p(m|z_{1:t}, x_{1:t}) \tag{2}$$

Generally, a robot has neither the map, nor known poses, meaning that posteriors for both the map space and the robot's pose need to be determined. Equations (1) and (2) show these distributions are dependent on each other - evaluation of pose posterior requires the map, and evaluation of map posterior requires pose. This is often referred to as the chicken and egg problem. The main implication is that approaches designed to solve equations (1) and (2) cannot be readily applied in their current forms. Further, the problem can no longer be sufficiently expressed using these equations. SLAM, as the name suggests, determines these the map, m, and pose, x_t, simultaneously given sensor observations, $z_{1:t}$, and control actions, $u_{1:t}$. Mathematically, this is expressed as:

$$content... \tag{3}$$

2.1 FastSLAM

2.2 GraphSLAM

3 Scene and robot configuration

explains how the gazebo world was created by providing an overview of the layout of items in his/her customized Gazebo world. Student also describes the robot's parameters, sensor features, and reasoning on the package structure.

4 Results

Results - The student should include the images for mapping process, final map (2D/3D) for both Gazebo worlds.

5 Discussion

Discussion - The student explains how the procedure went and methodologies to improve it. The student should compare and contrast the performance of RTAB Mapping in different worlds.

6 Future Work