Raspberry Pi GoPiGo Robot EKF SLAM Implementation

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***Abstract*—Robot motion is stochastic and not deterministic. A robot does not faithfully execute movement commands due to inaccuracies in its motion mechanism, approximations made in modeling its environment and incomplete modeling of the physics of its operating environment. Due to these reasons, the robot may not end up exactly at the location where it should have been if the movement command had been faithfully executed. The robot position may be thought of as a two dimensional probability distribution. This probability distribution will have a mean that will be equal to the expected robot location based on the movement command. The covariance will be the measure of how faithfully it executes commands. Due to this uncertainty in movement, with each motion command, the location uncertainty increases and after a while the robot gets lost. In some applications, robots need to be able to go into an unknown environment and explore it. This is a difficult problem due to the issue described above. If a map of the environment is available, the robot can use sensors to find its location in the environment. Conversely, if the robot knows where it is, it can generate an environment map. This is a sort of chicken and end problem. Simultaneous Localization and Mapping (SLAM) solves this problem. An Extended Kalman Filter (EKF) can be used to reduce robot location uncertainty. This document describes the implementation of EKF SLAM using a robot.**

I. Introduction

A. The platform

The robot used for this implementation is based on a Raspberry Pi and is manufactured and sold by Dexter Industries [1]. The robot is equipped with an ultrasonic sensor that is capable of measuring distances accurately to 250 cm. The sensor is mounted on a servo mechanism that can point the sensor in any direction ahead of the robot. The robot moves through use of two wheels that can be independently controlled by motors. Each wheel has an encoder using which the robot can issue commands for a wheel to move a fixed number of steps. The robot also has a third castor wheel that can move in any direction, but is not powered. The robot will be given commands to make it move and it can sense its surroundings using the ultrasonic sensor.

B. EKF SLAM

A Kalman filter is a gaussian filter algorithm that can use two gaussian distributions for a computed value and merge them together to form a distribution that has lesser variance than either of the two distributions. A Kalman filter however only works in the case of systems where the mechanics are linear. This is where the Extended Kalman Filter (EKF) comes in.

The robot state transition function and landmark measurement probabilities are governed by nonlinear functions g and h respectively[4]:

$$x_t = g(u_t, x_{t-1}) + \epsilon_t \quad (1)$$

$$z_t = h(x_t) + \delta_t \quad (2)$$

Here x_t is the robot location at time t, u_t is the robot command that causes it to reach position x_t, z_t is the landmark measurement at time t, ϵ_t is the robot motion uncertainty that depends of the mechanical properties of the robot and δ_t is the sensor measurement uncertainty.

The Kalman Gain or the reduction in the robot position uncertainty is inversely proportional to the sensor uncertainty. The better the sensor, the higher will be the Kalman Gain and the less uncertainty there will be in the robot position[5].

II. Problem description

III. Approach/Methods

IV. Results

V. Discussion

VI. Future work

References

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