Improving 2D SLAM results on uneven terrain by utilizing inertial sensor data

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Abstract

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Chapter 1

Introduction

Explains why this research is interesting.

The Simulatenous Localization And Mapping (SLAM) method employed by the AJORF (Amsterdam-Oxford Joint Rescue Forces ¡¡cite team description paper¿¿ is not robust against severe tilting of the laser scanner.

In this report, an extension to the algorithm is proposed which prevents the addition of patches to the map when the laser scanner data is in a plane too far from the horizontal

Chapter 2

Background

2.1 USAR Sim

* The Urban search and rescue challenge

2.2 Slam

One of the goals of the USAR challenge was to create a useable map of the environment.

The problem an agent faces when it needs to find it's way in an unknown environment is called SLAM, for Simulatenous Localization and Mapping. The agent has no map of the environment, and also no way of knowing it's exact location. It needs to infer the map and it's position on the map from the information it gathers from it's sensors throughout time.

Thus, SLAM is a chicken-and-egg problem: without a map it is hard to estimate the agent's position, and without the agent's position it's hard to estimate the map!

In this section we will first examine how the robot keeps track of the state of the world, and then how the SLAM problem can be solved with Extended Kalman Filters.

2.2.1 State

The state of the world as it is known to the agent is denoted x. The value of this set of variables may change over time, as the agent collects sensor data from the environment. The state at time t is denoted x_t.

Many variables may be included in the state variable x. For the purpose of this work, we will assume that it contains at least the agent's *pose and a* map of the environment.

In most SLAM approaches, two types of sensor data is collected: *environmental measurement data and* control data. Environmental measurement data collects information about the environment, while control data collects information about the robot within the environment. Environmental measurement data is denoted z (at a specific point in time z_t). Examples of environmental sensors available to an agent are laser scanners, sonars and video cameras. Control data and GPS signals. Control data sensors collect information intrinsic to the agent: it's velocity and position. Examples of control sensors are odometry sensors, inertia sensors and global positioning systems.

For the purpose of this paper we are mainly interested in the online SLAM problem, in contrast to the full SLAM problem. Online SLAM seeks to estimate the current pose x_t and map m:

$$p(x_t, m|z_{1:t}, u_{1:t}) \tag{2.1}$$

In contrast, the full SLAM problem estimates all poses x and map m:

$$p(x_{1:t}, m|z_{1:t}, u_{1:t}) \tag{2.2}$$

2.2.2 Gaussian filters

2.2.3 Localization

2.2.4 Extended Kalman Filters

2.2.5 ManifoldSLAM

2.2.6 2D slam in 3D environment

Only a slice of the world is returned - so we need to make sure we are horizontal. Otherwise, the scanner returns wrong readings.

Chapter 3

Method

3.1 SLAM confidence measure

The confidence measure based on the determinant of the covariance matrix of the pose uncertainty. The hypothesis is that if this measure is larger, then the confidence is lower (the uncertainty is bigger).

The determinant of the covariance matrix is used as metric:

is the sample variance-covariance matrix for observations of a multivariate vector of p elements. The determinant of D, in this case, is sometimes called the generalized variance. (http://www.itl.nist.gov/div898/handbook/pmc/section5/pmc532.htm)

3.2 Inertial sensor data

Gives the rotations on three axis, enables you to detect