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A Graceful Motion of Robot using SLAM and Kalman Filter

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ABSTRACT

Although progress in 2D mobile robot piloting has been significant but the goal of this paper focus on to explore the use of SLAM using kalman filter and with the help of various sensory gadgets. To estimate the robot position and feature (a point in environment) locations, Kalman Filter for moving robot is used in tabular format which depicts diversion of robot with respect to origin at starting and ending point and calculating reflexive angles at different points of experimental pathway. Main focus of this paper is to minimize the standard deviation in new estimation of moving robot

Introduction

A mobile robot may consist of motor, camera and actuators. To determine the area in which the robot is known as mapping and establishing the current position of robot in the map provided, is known as localization. Combined approach of localization and mapping in real-time is called Simultaneous Localization and Mapping (SLAM). Solution to a SLAM can easily be mapped through robot with help of minimal sensory gadgets of mobile robotics like motor, camera and actuators without human intervention. Various components used like

Feature

It is a specific point in environment which can be detected as milestone or previously known artifact by mobile robot.

Map

It's a feature location which estimates robot's path and these are identifiable. If robot can locate any one feature, then it is capable to estimate the distance and direction between feature and robot itself for localization. Distance can be estimated if physical dimension are known and to estimate depth, multiple cameras are used [2][3].

In the development of SLAM we discuss localization and mapping individually in the very next section of related work to understand why we should find simultaneous solution. Latterly we discuss about kalman filter for moving robot.

Related Work

SLAM is a major and new field of robotics, in the mid 1980's Smith and Durrant- Whyte developed a representation in feature location (Durrant – Whyte,[1]). Localization model as shown in Fig 1 is classified among extract milestone and calculation type and past, present and future type. In former one, robot extracts various milestone/check post based on which robot localized itself and the latter one indicate that current location of robot while it rotate its axis. Consider a mobile robot which contains beacons- points with exact locations and robot can calculate its distance and direction. Suppose location of robot is not known then it computes its information from beacons, hence location of robot can easily be navigated. To determine location of new robot position beacons are needed.

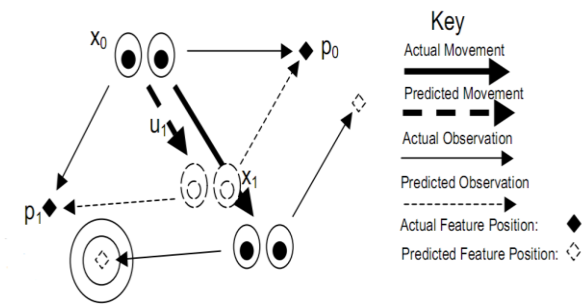

Figure 1. Localization Model

A number of researchers had been looking that probabilistic Mapping Model as shown in fig 2was an issue in robotics, over next few years a number of key papers were produced. Work done by Cheeseman[4] and Durrant Whyte[1] are the major milestone to show degree of correlation between estimation of locations in map.

In this model agent can locate the features to build a map which is based on Z0= {z00, z01….z0n}, when agent moves the map can be made more accurate. This model is same as that of localization model, but in this model location of feature will have shifted from their expected locations. Robot will made new map Z1, which consists of new location of feature in Z0 shown in fig.2

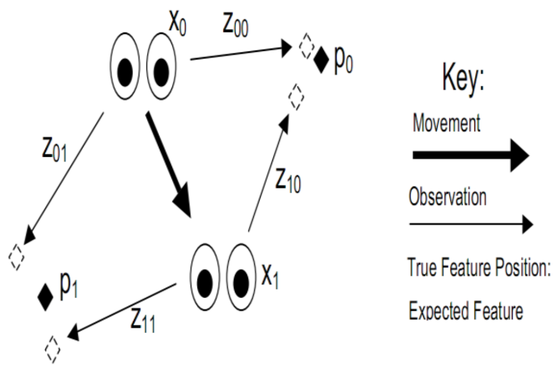

Figure 2. Mapping Model

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Work by Maybeck[4], Nebot[5] and Csorba[6] all done a great contribution in Simultaneous Model as shown in fig 3 in order to navigate a robot without GPS, for that we need to combine both the localization algorithm and mapping algorithm in single rotation for accurate feature location and position as input respectively. Suppose robot starts from origin and through mapping model, it constructs the map, then move to new location and through localization model robot updates its expected location. Lastly, newly position is used to generate new map. This is possibly a solution to Simultaneous Localization and Mapping problem.

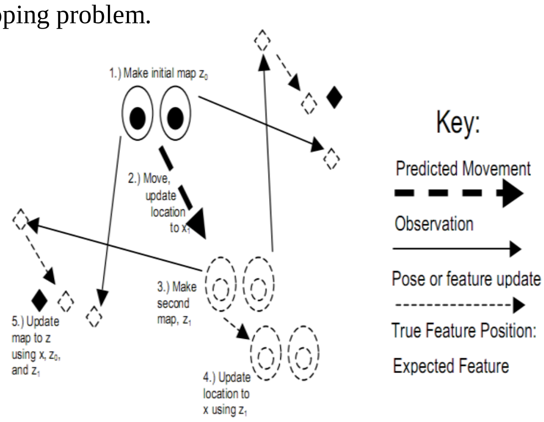

Figure 3. Simultaneous Model

Ayache and Faugeraus[7] were undertaking early work in visual navigation, Crowley[8] and Chatila and Laumond[9] were busy in navigation of robot using kalman based algorithms. The landmark paper given by Smith, Self and Cheeseman[10] showed that a robot's motion is based on unknown environment and taking the relative observations of landmarks but the implication of this has great intensity as it combine both the localization and mapping model that would require a state estimate and state update for moving robot.

The work in this paper is based on probabilistic Simultaneous Localization and Mapping using kalman gain to evaluate and minimize error in new estimation of moving robot.

Proposed Methodology And kalman filter

Kalman filter is an optimal estimator that derives parameters from inaccurate and uncertain observations. The KF was developed by R.E. Kalman and whose paper was published in 1960 (Welch and Bishop, [11]) is an extension of Kalman filter for estimating variable values which consist of robot pose in the distance travelled and feature locations. The data to be processed in kalman filter consist of robot location, actuator input, sensor readings, maps and motion sensors of mobile robot. Kalman filter is used to minimize the mean of squared error to estimate.

Consider a mobile robot moving in an environment and taking relative observations of landmarks a priori knowledge, in general, a solution to SLAM problem is desirable starting with the intermediate steps by initializing the state with number and a posteriori state estimation for moving robot

In SLAM terms, the values of variables to be evaluated will comprises of the feature locations and robot position—i.e. the data and world state that is to be worked and it consist of actuator input, location of vehicle, sensors that used to move robot and sensor readings.

Now to compare reality against prediction we have to move turtlebot on given experimental path, the robot has to sense the path (follower) and do needful motion and it based on LINUX based Robot Operating System (ROS).

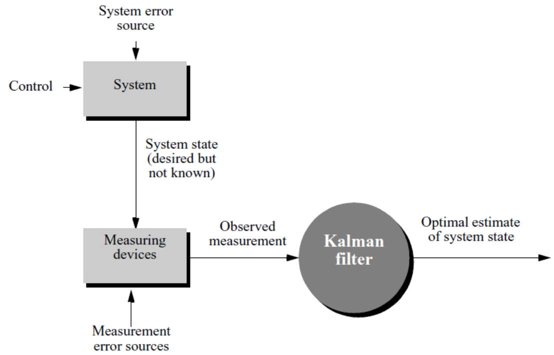

Figure 4. Typical kalman filter application

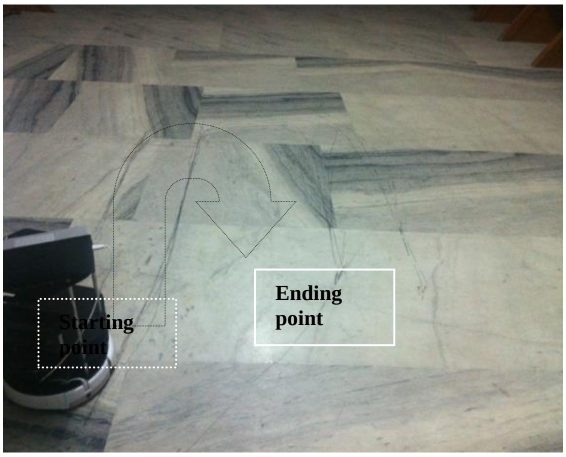

Figure 5. An experimental path having two turns with turtlebot on it

Conclusions and Results

This paper has described about SLAM and kalman filter which has summarized key implementations and demonstrations of method used. By selecting different 'x' values of diversion at starting point and ending point and gets the following results which are shown in table 1.

Table 1. Variation in motion at starting and ending point

Number of Iterations	Variation in motion with respect to starting point(x)	Variation in motion with respect to ending point (x)
1	0 (origin)	0 (actual)
2	5	3
3	10	0
4	10	0
5	3	2
6	0	3
7	12	9
8	8	8
9	0	7
10	5	11
11	10	6
12	3	2
13	2	12
14	0	6
15	0	5
16	1	1
17	6	4
18	3	3
19	9	1
20	1	4

Table I depicts the diversion of turtlebot when it was at starting point and estimation of this diversion will calculated till start of curvature after that estimation will again start when curvature ends till ending point of U shaped experimental pathway.

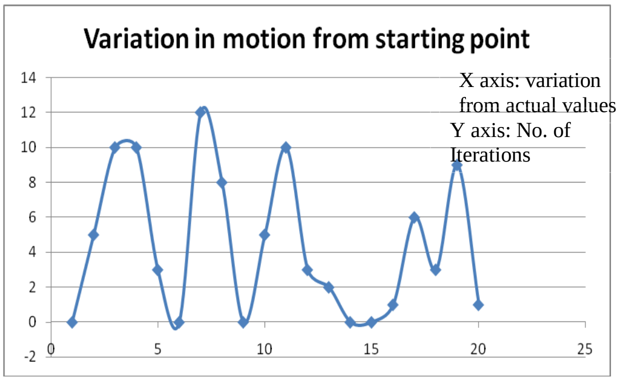

Figure 6. Variation in motion at starting point

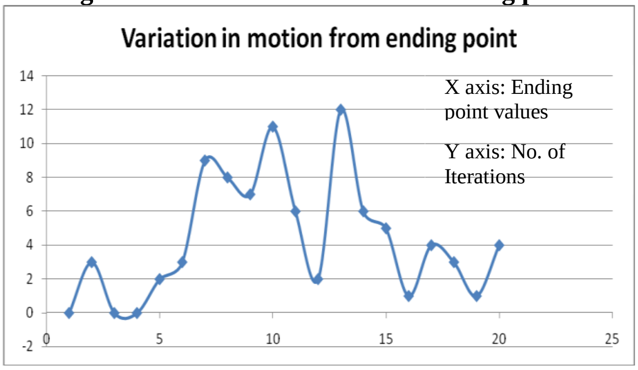

Figure 7. Variation in motion at ending point

From the above fig.6 and 7 one can see the diversion is not very much at starting and ending point as experimental path is linear and it can be proved mathematically also by taking the total sets and one can calculate standard deviation which comes around 5.326 mm. But this is not when turtlebot turns left and right, so one can estimate different reflexive angles when it turns.

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