Investigation of ROS Based Environment Modelling and Mobile Robot Position Estimation with Dead Reckoning and Uncertainties

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***Abstract*— This paper aims to investigate Robot Operating System (ROS) based environment modelling and mobile robot position estimation considering dead reckoning and uncertainties. A mobile robot movement is analyzed in a few environment conditions by using Extended Kalman Filter with ROS to identify and examined the mobile robot estimation performance on its surroundings. The heading angle and initial state covariance performance are assessed with different mobile robot movement. The paper is organized mainly to describe the results from both simulation and experiment using Extended Kalman Filter that consists of undetermined and unpredictable environment states. For experimental verification, a Turtlebot3 equipped with a 360-degree LiDAR and IMU is being applied to demonstrate the performance of estimation in a situation that has unknown uncertainties in several conditions. Both simulation and experimental results indicates that state covariance is converging lesser than the initial state covariance in any environmental cases which is in contrast with the literatures. Besides, it is also found that the mobile robot heading angle is important to be accurate at all times for better estimation results.**

Keywords—Extended Kalman Filter, Dead Reckoning, Estimation, Navigation, State Covariance

I. INTRODUCTION

The market demands on autonomous vehicle especially on electric vehicles is increasing recently and has becomes one of the fascinating and promising research areas. On top of its eco-friendly and cost-effective system advantages, electric vehicles require a lot of system to be fully functional such as its navigation features[1]-[3]. Navigation is in fact a very important feature to be available in any autonomous system which determines the vehicle capabilities to describe its surrounding area when moving through the environment. This will also include the study and issues of mathematical modelling, abilities of obstacle detection and avoidance, path planning, controllability, information management, positioning and other problem needs to be solved[4][5]. To model a whole vehicle structure would indeed needs a lot of investigation on the kinematics and dynamics, materials to be applied, and selection of sensor. Hence, all these requirements have ended up with time-consuming processes. Therefore, researcher starts to analyze the system performance through the application of mobile robot, which is simpler, yet effective to represent the vehicle behaviour in any demonstrated situation. The earliest application of a mobile robot for navigation was recorded when it is applied as an autonomous guided vehicle (AGV).

Streaming down on the issues on navigation, dead reckoning is one of the popular themes which defines how well the mobile robot is capable to identify its location based on previous measured information from its proprioceptive sensors such as encoder, Inertial Measurement Unit or any odometry-based sensors[6]-[8]. To solely depends on dead reckoning for navigation is a risky option as measurements normally includes error every time the mobile robot updates its location[9]. Therefore, it is essential to apply both exteroceptive and proprioceptive sensors to obtain better results. However, those sensors are prone to certain factors and depends on the environment conditions. These shortcomings can be overcome by using estimation techniques such as Kalman Filter to infer the mobile robot and its surroundings conditions.

Simultaneous Localization and Mapping (SLAM) offers solution to the navigation by determining the mobile robot location and mapping of the mobile robot surroundings by using any method. Undeniably, there are many techniques available in SLAM which has been proposed by researcher. Extended Kalman Filter(EKF) dominates mostly as the main solution to SLAM due to its advantages; faster and efficient. Until today, the study on EKF has covered most of the critical aspects such as its convergence, consistency[10], computational cost, controllability and observability in various applications[11][12]. As a result, the technique has become more attractive than others. In EKF based navigation, the main concern is to assess the estimation errors and state covariance efficiency. The smaller the error and state covariance, the estimation provides better performance. The EKF performance is also affected by its initial state covariance. In fact, the mobile robot initial state covariance defines the efficiency of the estimation[10]-[14]. In practical condition, this needs to be further study as very few reports can be found on this matter. The mobile robot heading angle