An Adaptive Estimation Technique for Finite Escape Time Issue in Mobile Robot Navigation

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***Abstract*—This paper deals with the analysis of H infinity Filter for mobile robot navigation considering the Finite Escape Time problem. H infinity Filter has disadvantages in navigation as the current states of estimation may lead to erroneous results due to the finite escape time issue. This is a case where the estimation may become erroneuous due to huge amount of state covariance produced by the updated state covariance during mobile robot observations. Therefore, the state covariance is modified to avoid the occurrence of finite escape time when mobile robot moves in a surrounding area. The updated state covariance is changed by checking the state covariance matrix through the Cholesky function to provide a reliable positive semidefinite matrix during the observation process. Simulation results have described that the performances are better compared to the normal H infinity Filter which illustrates a number of finite escape time during mobile robot movements.**

Keywords— Mobile Robot, Navigation, H infinity Filter, Finite Escape Time, State Covariance)

I. INTRODUCTION

Making an autonomous vehicle or autonomous mobile robot has been one of the challenges in navigation problem. Since two decades ago, a number of researchers attempts to proposed a variety of approaches to solve the navigation problem that can be categorized into mathematical modelling or kinematic analysis, probabilistic and also behavioural models[1]. As most of the conditions in navigations are mainly involving working in unknown environment that contains a lot of uncertainties, the probabilistics technique becomes essential to estimate the mobile robot or vehicle locations indefinitely. Some of it, namely as Kalman Filter[2]-[4] and its associated variants such as Unscented Kalman filter[5], sigma point Kalman filter[6], Particle Filter[7]-[9], and others have been around for more than a decade to offer solution. There have been different kinds of issues solved based on their findings that mainly pointing out on how uncertainties can be defined at certain level. Particle filter for examples have gained a lot of attention as it provide better efficiency and accuracy especially in dynamic environment[9].

One of the issues in navigation can be defined as Simultaneous localization and mapping (SLAM) that describes a situation where the location and pose of mobile robot needs to be update continuously when moving inside an environment while at the same time building the surroundings map based on its sensors measurements. The measurements are based on both exteroceptive and proprioceptive sensors attached to the mobile robot. From the perspective of the sensors type, sensors such as sonar sensors[10], LiDAR[11][14], laser range finder[15][16] and vision sensors have been famously applied to the mobile robot due to its accuracy and adaptability to the environment being observed. However, the selection of sensors would be easier with the help of probabilistic technique as it requires less information from those sensors to infer the surrounding area conditions[1].

The research on celebrated Kalman Filter as one of the influential methods to solve SLAM problem till today, is still progressing due to its known shortcomings such as only assured to perform well when gaussian noise are considered[17]. Due to this reason, its family, the H_∞ Filter was introduced for an alternative solution to SLAM problem that can tolerate with non-gaussian noise. Theoretical studies on the method have been conducted and continued to experimental analysis[18][19]. The finite escape time was one of the limitations that restricted the filter performance and application in real environments[20][21]. The state covariance matrix which demonstrates the level of uncertainties or confidence of estimation is affected by the finite escape time. This phenomenon described a state where the state covariance matrix calculated based on the recursive update suddenly exhibit infinite state. This situation is not expected to be visible during mobile robot estimation and eventually defines that the estimation is not reliable.

Several attempts are suggested such as by using γ-switching strategy, modifying the updated state covariance and examining the conditions of noises parameters in the area. Interestingly, even though the finite escape time are observed during H_∞ Filter estimation, at certain level of noises and conditions, the location and mobile robot pose can still be identified sufficiently. In fact, the results can be better than Kalman Filter itself on the pose estimation for most of the cases if only the state covariance are not considered. Therefore, the investigation on H_∞ Filter is still required to analyze further the filter capability in SLAM problem.

In pursuit of getting better H_∞ Filter performance, this paper deals with the analysis of H_∞ Filter by defining some of the parameters and investigate its estimation through certain cases of environmental conditions based on results obtained by previous findings. Few cases of environmental conditions