Investigation on Intermittent Observation in Mobile Robot Localization with Fuzzy Logic Technique

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Abstract— This paper deals with an analysis of intermittent observations for mobile robot localization with Fuzzy Logic approach. Mobile robot can easily lost its sight during environment observations due to several factors such as sensor faulty, and dynamic conditions. This can lead to erroneous estimation and the mobile robot become uncertain about its position. As a solution to this issue, this paper proposed a study on Fuzzy Logic technique to overcome such problem considering the Extended Kalman Filter(EKF) measurement innovation characteristic. The rules and fuzzy sets are designed such that it preserved good estimation whenever the relative angle and its relative distance measurements suddenly becomes larger than the previous measurements. The simulation results discusses two different cases observing the performance of the proposed technique. The results show that EKF with Fuzzy Logic technique is able to deal with intermittent observations if the design takes proper analysis and consideration on the measurement innovations.

Index Terms— Intermittent Observation, Extended Kalman Filter, Localization, Fuzzy Logic, State Covariance

I. INTRODUCTION

Mobile robot navigation is one of the research field that truly support autonomous robot behavior[1]. One of its task, known as localization has gained numerous interest in research with various technique and analysis covering different issues such as uncertainties[2][3][4], dynamic environment[5], computational cost[6][7], intermittent observation[8] and data association[2]. Most of the techniques apply the probabilistics approach that utilize the previous gained information from measurement or observations to estimate the mobile robot locations as well as the environment conditions. Based on Bayes rule, the probabilistic approach has an excellence performance than the other available methods; mathematical or the behavioral based models thanks to its less-complexity and cost-efficient.

In many of available research, Extended Kalman Filter(EKF)[9] has been the main interest to estimate the mobile robot locations. Even though Particle Filter and other new techniques can be better in terms of accuracy, EKF which offers low computational cost in operation is proven to be practical in most of current applications[4]. Many studies of EKF in mobile robot can be found tolerating various problems and some of it is available in the literatures. This paper focusses on the intermittent observations[8] which occurred when the mobile robot has sensors faulty, problems on sensor fusion when processing information and operating in a dynamic environment. This intermittent observation can

lead to bigger problem such as kidnapped robot problem, increasing uncertainties in measurement, and mobile robot breakdown. Hence, a solution to avoid such issue can be a wise decision in achieving better estimation results for various applications. Only then, further improvement on the estimation can be done such as in reducing computational cost and uncertainties of the system. This paper attempts to identify and analyze the capabilities of Fuzzy Logic technique to overcome the problem. Fuzzy Logic is known as a technique that able to act intelligently for a specific problem through experience and information obtained prior to the problem. It works through combination of fuzzy rules and fuzzy sets design which determines the best configuration for better performance. A number of paper investigating the application of Fuzzy Logic in EKF can be found such as examined by Kramer et al[10]. Four different methods are analyzed in their work, and it was found that Fuzzy EKF surpassed the normal EKF performance in mobile robot localization. Further works demonstrated by Hai-Yun Wang et al[11] designed Fuzzy Logic that able to adjust the measurement innovation to gain better estimation. The results shows Fuzzy EKF has lower error and secured a good estimation results as well. Our preliminary study[12] also suggest that Fuzzy EKF surpassed normal EKF performance with a slight difference to the rules and application to what has Hai-Yun Wang et al reported.

A number of papers in intermittent studies can be found in literatures but very few of it examines the condition in mobile robot applications. In earlier research, most of the analysis focusses on the packet lost in sensor network[13], [14]. Mainly, the study covers mathematical analysis and characteristics during intermittent observations, including the boundaries of state covariances, and the behavior of state covariance[15], [16]. Until now, in our best knowledge, surprisingly none of the current research attempts to correct or reduce the error generated during intermittent observation especially on mobile robot navigation. The possible reason especially for EKF is due to the estimation can still preserved a good estimation with acceptable error. However, rather than depending on this reason, avoidance is more preferable as it can reduce the possibilities of having different problem mentioned earlier in this section. Therefore, this paper looks into this aspect by proposing Fuzzy Logic technique in EKF estimation.

Throughout this paper, EKF based mobile robot localization with Fuzzy Logic in intermittent observation is examined. The EKF measurement innovations is analyzed first before the Fuzzy Logic is designed. The analysis is also

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