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A New Hybrid Approach for Simultaneous Localization and Mapping

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Abstract: **This paper describes a novel proposal of metric-topological approach to simultaneous localization and mapping (SLAM) which achieves efficient mapping of large-scale environments. For the local metric map, we adopt a common approach to the SLAM problem - the feature-based stochastic mapping using an extended Kalman filter (EKF). At this level of abstraction, distinguished landmarks are detected from the scan data provided by a laser range finder using a recently proposed framework. These features can be repeatability detected and matched from different viewpoints. Each set of features which shares the same environment space constitutes a node in a topological representation of the whole environment. This scheme implies the development of a robust mechanism to determine when the robot has moved from a local map to a new one and a fast approach to match the recently perceived landmarks with the rest of nodes of the topological map. This last issue provides the approach with the loop-closing ability. Several experiments have been conducted to test the efficiency of the different modules of the whole navigation system. They show that the proposed approach will be able to correctly deal with large environments.**

Key-Words: - **Mobile robotics, navigation, extended Kalman filter, hybrid metric/topological maps, simultaneous localization and mapping**

1. INTRODUCTION

Autonomous navigation is a fundamental ability for mobile robots which requires the integration of different modules. Among them, self-localization and environment mapping are two essential ones, as they are needed at different levels, from low-level control to higher-level strategic decision making or navigation supervision. It is well known that to guarantee bounded errors on its pose estimates, the robot must rely on sensors which can perceive stable environment features. Thus, if the robot manages a spatially consistent map of the environment, it could apply a map-based localization approach to obtain a correct estimation of its pose [1]. On the other hand, if the robot pose is exactly known, it could build a consistent environment map with the perceived data. The mapping and localization tasks are then intimately tied together [2], and they must be concurrently solved. The problem of the simultaneous localization and mapping (SLAM) has been extensively addressed by the robotic community in the last years.

Conventional SLAM approaches have usually built metric maps, both grid and feature based maps, which identifies each environment location with a set of geometrical relationships. The implementations of such approaches typically include variations on the Kalman filter [3] or particle filters [4], whose aim is to manage all information increasing the efficiency and robustness of the localization and mapping processes [5]. Currently, one of the main limitations of all these implementations is that the complexity grows when the size of the map increases. Although different techniques have been proposed to alleviate this problem, such as the Compressed EKF (CEKF) [6] or the fastSLAM [4], it is inherent in maintaining a global map. Since the complexity of the global map associated to a large environment cannot be avoided, several researchers have proposed to divide it into submaps, within which the complexity can be bounded [7-9]. Therefore, this process can be improved by including a topological level for which each node is a metric submap [10], in order to take advantage of properties inherent in topological map, as a natural environment description, global consistency

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