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THE HYBRID METRIC MAP: A SOLUTION FOR PRECISION FARMING

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***Abstract*— This work presents a specific application of a novel map representation, the Hybrid Metric Map. This representation allows a consistent autonomous localization and simultaneously the synthesis of a detailed description of the environment where the robot or vehicle operates. There are many applications where an autonomous vehicle senses environment properties that are not necessarily used for the localization process. Precision agriculture is a special case of this. The proposed algorithm is able to fuse a large amount of information for the environment description and simultaneously estimate the vehicle position.**

***Keywords*— SLAM, Autonomous Navigation, Precision Agriculture**

I. INTRODUCTION

Reliable autonomous navigation in highly unstructured outdoor environments presents remarkable problems in terms of sensing, perception and navigation algorithms. Several papers address this problem with different approaches (Fox *et al.*, 1999; Sukkarieh *et al.*, 1999; Guivant and Nebot, 2002; Leonard *et al.*, 2001; Castellanos *et al.*, 1999; Masson *et al.*, 2002; Wang and Thorpe, 2002; Neira *et al.*, 1999). Vehicle localization based on a known map of the environment and the synthesis of a map when the vehicle position is known are problems that can be considered solved. In fact there are many effective solutions in research and industrial applications (Durrant-Whyte, 1996). Outdoor environments present additional challenges due to the lack of sensors and perception algorithms that can work reliably in a wide diversity of environments. A much more complicated problem is when both, the map and the vehicle position, have to be simultaneously estimated. This problem is usually referred as Simultaneous Localization and Mapping (SLAM) (Guivant *et al.*, 2000). Although the implementation of SLAM can be made very efficient in terms of computational complexity and memory requirements there are still fundamental problems that need to be solved. Depending on the quality of the vehicle models and the internal and external sensors, that are used in the estimation process, the autonomous operation could be extended to large areas.

There are important issues involved in an SLAM application.

Map representation: A detailed representation of a dynamic environment is usually needed.

Consistency of the robot localization and map building process: Estimations of the map for large environments are usually prone to present large uncertainties in the estimates. In such case stochastic filters based on linearizations are not appropriate. In those situations the filter (usually an Extended Kalman Filter-EKF) could generate over-confident and non-consistent results.

Finally, in every estimation problem, the measurements need to be associated with the underlying states that are being observed. This is usually referred as the data association process and it is a critical problem in localization or SLAM applications. Incorrect data association involves a failure of the estimation process.

These three issues take special relevance in applications where the working environment is outdoor, unstructured, large and without *a priori* description. Precision Agriculture is one of these applications. Traditionally the field robotics solutions to precision agriculture were based on the almost exclusive use of GPS and dead reckoning sensors (Stafford, 1998). However it is known that this class of sensors can not guarantee reliability. The satellite availability introduces limitations on the GPS sensor operation. Then the accuracy of centimeters that is claimed in GPS RTK (Real Time Kinematics) systems is only possible temporarily. This is due to the satellite availability, occlusions and multipath effects. That situation is not acceptable for an autonomous vehicle that needs to operate without interruption.

In the following sections the precision agriculture technique is introduced. Additionally a discussion about the degree of its acceptance in Argentina as an agriculture tool is presented. A section is dedicated to present the Hybrid Metric Map as a new paradigm in map representation. The usefulness of this technique