Abstract

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Detailed Environment Representation for the SLAM Problem

This thesis addresses the environment representation problem for Simultaneous Localisation and Mapping (SLAM) algorithms.

One of the main problems of SLAM is how to interpret and synthesize external sensory information into a representation of the environment that can be used by the mobile robot to operate autonomously. Traditionally, SLAM algorithms have relied on sparse environment representations. However, for autonomous navigation, a more detailed representation of the environment is necessary, and the classic feature-based representation fails to provide a robot with sufficient information. While a dense representation is desirable, it has not been possible for SLAM paradigms.

This thesis deals with the problem of obtaining detailed environment representations for the Simultaneous Localisation and Mapping problem. The thesis introduces the concept of DenseSLAM, which is defined as the process of simultaneous localisation and dense mapping. A solution for DenseSLAM named Hybrid Metric Maps (HYMMs) is presented. HYMMs combine feature maps with other dense metric representations such as occupancy grids. The global feature map is partitioned into a set of connected local regions, which provide a reference for a detailed multi-dimensional description of the environment. The combination of dense metric maps with feature maps has complementary properties. The stochastic feature map ensures the dense map remains consistent, and the dense map provides auxiliary information to assist navigational capabilities, such as data association, landmark extraction and path planning.

In addition to maintaining dense environment representations, the new algorithm is able to obtain multi-layered maps, where each layer represents different properties of the environment, such as occupancy, traversability, elevation, etc.

The classic feature-based representation relies on simple geometric models to define the landmarks. This limits EKF-SLAM to environments suited to such models. In order to overcome this restriction this thesis presents an algorithm which, rather than using geometric models to define landmarks, uses templates of raw sensed data. Complex landmarks can be identified and extracted as they are observed from multiple vantage points. The algorithm uses scan alignment in order to create observations.

This thesis presents simulation and experimental results in outdoor environments using data collected with a vehicle equipped with odometry and laser sensors.