Mission Management for Mobile Robots

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1 Introduction

Despite of more than 15 years of research to bring mobile robots into the undeterministic surroundings of our offices and livingrooms, they are still restricted to simple applications such as vacuuming and lawn mowing. Well established frameworks as Player(Gerkey et al., 2001), CARMEN (Montemerlo et al., 2003) and the DTU developed MobotWare (Beck et al., 2009) all offer a good interface for research in advanced navigation algorithms and implementation of simple motion control. Unfortunately much time is wasted by researchers on ad-hoc implementation of mission control, limiting the progress into developing actual robot applications.

DTU MobotWare is a mobile robot control framework, where the first modules date back to 1999, A constant development has now led to a core framework, which provides a strong core foundation for research and development of new mobile robot applications. The supported range of robot platforms spans from indoor classroom robots, several outdoor platforms and agricultural platforms as the HAKO HakoTrac3000 and the heavy Claas Axion 700.

The MobotWare framework has three core modules:

- *Robot Hardware Daemon (RHD).* Flexible hardware abstraction layer for real-time control.
- *Mobile Robot Controller (MRC).* Real-time Closed-loop controller of robot motion and mission execution.
- *Automation Robot Servers (AURS).* Advanced framework for processing of complex sensors and non real-time planning.

2 Managing Navigation Missions

This article proposes a system for mission management of navigation missions for the DTU MobotWare framework. The Mission Manager is a navigation framework, that offers a unified approach to develop robot applications through a reusable toolbox of navigation behaviors. The modular architecture, makes it simple to change and expand application environment or improve system capabilities by adding new or improved perception and navigation algorithms.

The essential reliability and redundancy in mission execution is accomplished through a global feedback system, that allows error detection and handling at real-time, behavior and planning levels. This ensures safe and reliable mission execution and brings the robustness required to develop mobile robot applications for real-world environments.

The operator target group is focused towards non-developers, making the operator interface simple and not requiring any knowledge about motion control and sensor systems. Operators are allowed to keep their focus on operating the robot application and are able to comfortably plan and monitor mission execution through a point-and-click GUI.

3 Mission Planning

A prerequisite for reducing required operator input and establishing mission level feedback is an efficient mapping and planning system. The Mission Manager utilizes a topological graphbased map for simple but scalable world modeling and a efficient graphbased planner. The mapping system introduces a hierarchial graph-structure that improves map scalability and makes true geographic representation possible.

4 Mission Execution

The mission execution system is responsible of converting mission plans into robot actions. A script-based toolbox of navigation behaviors generate motion control code from available sensor and perception data. An asynchronous deliberation and execution system ensures that the execution system is executing the most recent motion control code without being limited by the computationally intensive navigation and perception algorithms.

Execution systems for mobile robots face the challenge of handling events and errors requiring response in hard real-time in architectures that are large, complex and hierarchical organized. The Mission Manager handles this challenge efficiently by enabling the hard real-time controller *MRC* to switch between redundant behaviors and respond immediately to real-time events. All pre-generated motion control code is assembled into a efficient selection tree, enabling *MRC* to handle navigation errors and event detection in hard real-time and efficiently reducing the real-time constraints to the high-level execution system.

5 Results

The Mission Manager has been demonstrated through a messenger service case application between offices at DTU Electrical Engineering, Institute of Automation and Control. The application proved the scalability strength, real-time performance, and error-handling capabilities of the system.

Further application areas has been investigated through simulation, including autonomous navigation through parks and trails, indoor cleaning, and autonomous field robot tasks as lawnmowing.

6 Conclusion

The Mission Manager is a powerful framework, exhibiting an unique combination of capabilities, that relieves researchers, application developers and operators from loosing development focus and precious time into struggling with ad-hoc implementation of inflexible and unreliable mission control systems. Using the Mission Manager, roles and entry-points are clearly defined and delimited.

Researchers can focus on developing algorithms for navigation, perception and signal processing and easily test their results by extending the navigation behavior toolbox of any new or even existing mobile robot application. Application developers can focus on designing mobile robot applications and to supply world models and navigation behaviors to navigate the application environment.

Operators could be agronomist or cleaning professionals, that can keep their focus on executing the robot applications and the results created by the mobile robot.

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