Abstract

Multi-robot systems are increasingly becoming the preferred approach to many real world applications such as search and rescue, exploration, surveillance and so on. However, in these applications teams of robots not only have to rely on local information and overcome the inherent problems with imperfect sensors, but they must also intelligently coordinate in order successfully accomplish the tasks at hand. Moreover, the dynamics of various environments, resource-constraints, malfunctioning robots and the ever increasing demands of user requirements add to the complexity of designing robot platforms, sensing models, communication schemes, control laws and self-organization strategies for these applications.

Our goal is to create a flexible self-organizing mobile robot swarm in support of multi-robot exploration, able to accommodate the different requirements for the development of such applications. To this end, our solution is a interdisciplinary approach where we design both the robotic mobile platform and a robust, flexible and scalable self-organization strategy that accounts for the limitations and resource constrains of physical embodied robots.

In addition, we develop tools for enabling seamless support for building, deploying and monitoring multi-robot applications, as well as a real-time visual sensing model required to create environment representations during the exploration process.

We introduce a new decentralized strategy that enables teams of non-holonimic robots to both aggregate and disperse in the environment when navigating in formation, whilst also guaranteeing swarm cohesiveness throughout the evolution of the team. Furthermore, we complement the strategy with new methods for dynamic generation of line shaped formations, while reducing the communication effort between robot team members.

Throughout the thesis we provide several comparisons, analytic analyses and experimental simulation results which show the benefits and flexibility of the our proposed solution to support the development of multi-robot exploration applications.