

Chapter 23

Mission Design of a Team of Service Robots

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ABSTRACT

The purpose of this chapter is to present an integrated approach for Mission Design of a team of Service Robots that is operating in partially known indoor environments such as libraries, hospitals, or warehouses. The robots are requested to serve a number of service stations while taking into account movement safety and other kinematical constraints. The Bump-Surface concept is used to represent the robots' environment through a single mathematical entity and an optimization problem is formulated representing an aggregation of paths length and movement constraints. Then a modified Genetic Algorithm with parallel populations is used for solving the problem of mission design of a team of service robots on the constructed Bump-Surface. Three simulation examples are presented to show the effectiveness of the presented approach.

INTRODUCTION

Service robotics consist of a fast evolving domain. One of the main tasks of a service robot (SR) is to perform fetch and carry tasks in domestic environments or professional environments by achieving a high level of flexibility, autonomy, and efficiency in human-populated areas. Today, only few such systems are available for delivery tasks like serving drinks in a hotel, delivering mail, or offering transportation capacity in a hospital.

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In contrast to these single SRs' approaches, this chapter presents the problem where a team of SRs is requested to perform service tasks in a partly known indoor environment such as a library. They offer (the SRs) the possibility to simultaneously handle a large number of tasks in optimum time. Therefore, a large number of tasks have to be acquired, organized and scheduled by the SRs.

The tasks of the SRs cannot be programmed a priori, as it usually happens in the applications with industrial robots. High level of autonomy, flexibility and efficiency is required in partially-known environments. In indoor environments and especially in service stores the objects are not located in a constant and predefined position and the demands can vary frequently; therefore the SRs should be capable of designing (planning and scheduling) autonomously their collision free optimal paths.

In this context, Mission Design (planning and scheduling) is identified as a fundamentally critical factor for a team of SRs among other capabilities such as sensing and recognizing the environment, position determination and task execution. The mission design is considered as the highest level of a hierarchical or layered intelligent control system for a team of SRs.

In the following, an extensive review of works dealing with the Mission Design (MD) of a team of mobile robots is presented, with particular attention to the advances in motion planning and scheduling. Then an integrated approach is presented as a paradigm of optimal multi-target MD of a team of mobile platforms in partially known environments with known static and unknown moving obstacles.

ADVANCES AND TRENDS IN MISSION DESIGN OF A TEAM OF SERVICE ROBOTS

The domain of service robotics is a very fast growing area (Habib, 2006). Especially in the field of service robotics in environments such as hospitals, logistics (distribution centers) and post offices (Gürcan et al., 2009); service robots have been developed for several years and first commercial solutions are already available. In most cases, these robots have been single robots, developed for a single purpose with very restricted capabilities and without any "intelligence" (Thiel et al., 2011). Such an example is a robot used to transfer a book from the reception desk to a specific bookshelf. This leads to expensive systems that can hardly be afforded in greater quantities by the service stores. Furthermore, the personnel need to get special training in order to "cooperate" with the robots.

Traditionally, the materials are transferred into an industry or a warehouse by the Carousel technology which is used in industry the last 25 years, Figure 1. A Carousel is consisting of bins mounted to a frame that either spins horizontally or vertically. The orders are fulfilled manually and they are fairly restrictive in terms of allowable product shape and size. The mean transfer rate is lower than those of conveyors and the equipment suffers from the discontinuous motion. The equipment itself is loud, bulky, unreliable and inflexible and presents very low degree of scalability.

In today warehouses and logistics, robots and especially Autonomous Guided Vehicles (AGVs) or Mobile Robotic Units (MRU) are used to transport all type of materials from one service station (ST) to another moving along predefined fixed paths, Figure 2 and Figure 3. A flow path layout connects machines, STs and other fixed platforms along aisles. This layout is usually represented by a directed network of paths where intersections and pickup and delivery STs can be considered as nodes. In addition, each node is connected with any other node and the nodes are connected by straight lines and/or arcs.

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