Chapter 12
Mission Planning of Mobile Robots and Manipulators for Service Applications

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ABSTRACT

The purpose of this chapter is to present a mission planning approach for a service robot, which is moving and manipulating objects in semi-structured and partly known indoor environments such as stores, hospitals, and libraries. The recent advances and trends in motion planning and scheduling of mobile robots carrying manipulators are presented. This chapter adds to the existing body of knowledge of motion planning for Service Robots (SRs), an approach that is based on the Bump-Surface concept. The Bump-Surface concept is used to represent the entire robot's environment through a single mathematical entity. Criteria and constraints for the mission planning are adapted to the service robots. Simulation examples are presented to show the effectiveness of the presented approach.

INTRODUCTION

In recent years, robot applications are moving from industrial environments to unstructured and/or semi-structured environments such as domestic and shop floors. Therefore, the service robot development is based on the rich heritage of the industrial robot research. However, the service robots should acquire new capabilities to perform in unstructured and/or semi-structured and partly-known environments with high-safety requirements since the robots are sharing the same workspace with people and other sensitive objects designed for human handling.

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Service robots are called to perform fetch and carry tasks in domestic environments or professional environments varying from simple orders, e.g., "go to the refrigerator and fetch a bottle of milk," or more complicated tasks like serving food in a restaurant. In other professional environments, like market stores, libraries, and hospitals, transportation and courier tasks are usually required. These robots among other advanced capabilities should be able to plan their missions autonomously. This is the subject of this chapter.

The spectrum of service applications relevant to mission planning is growing continuously with the trend to take over the demand for industrial robot applications. In professional or domestic environments, the most promising robot applications that include mission-planning tasks are the following:

- Delivering medicine, food, and medical consumables in hospitals.
- Delivering or distributing books in libraries.
- Stores and pharmacy automation.
- Surveillance in dangerous areas.
- Materials distribution and delivery in construction sites.
- Helping people in domestic environments.
- Providing transport and delivery tasks in urban environments.

The missions of the service robots 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 partly known environments. In indoor environments, the objects are not located in a constant and predefined position and the demands can vary very often; therefore, the robots should be capable of planning and scheduling autonomously their collision free optimal routes. Since, most of the service applications include handling of objects; the motion planning of a manipulator, which is mounted, on a mobile platform represents one of the key issues in the research and development of service robots.

In this context, mission planning is identified as a fundamentally critical factor for an autonomous service robot among other capabilities such as sensing and recognizing the environment, position determination, and task execution. The mission planning is considered as the highest level of a hierarchical or layered intelligent control system for an autonomous service robot.

In the following, the state of the art in the motion planning and scheduling of mobile robots as well as for manipulators is presented with particular attention to the advances in mission planning for service robots. Then an integrated approach is presented as a paradigm of optimal multi-target mission planning of a mobile platform in partly known environments with known static obstacles and unknown moving ones, as well as the motion planning of a manipulator mounted on the platform and performing manipulations at the target locations.

ADVANCES AND TRENDS IN MISSION PLANNING OF SERVICE ROBOTS

For systematic and historical reasons the present review starts by presenting motion planning methods for mobile robots and manipulators in known and partly unknown static/dynamic workspaces, followed by scheduling techniques for multi-target routes. This section concludes with methods considering motion planning and scheduling together particularly for service robots. A detailed and systematic presentation of the motion planning problems and the most promising methods that appeared in the relevant literature can be found in two books (LaValle, 2004; Latombe, 1991).

The Motion Planning Problems (MPP) can be distinguished in two main types: (a) static mission planning, that allows a robot to move through stationary obstacles, and (b) dynamic mission