

Chapter 65

Mission Design of Mobile Manipulators in Cluttered Environments for Service Applications

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ABSTRACT

The purpose of this paper is to present a mission design approach for a service mobile manipulator which is moving and manipulating objects in partly known indoor environments. The mobile manipulator is requested to pick up and place objects on predefined places (stations). The proposed approach is based on the Bump-Surface concept to represent robot's environment through a single mathematical entity. The solution of the mission design problem is searched on a higher dimension Bump-Surface in such a way that its inverse image into the actual robot environment satisfies the given objectives and constraints. The problem's objectives consist of determining the best feasible paths for both the mobile platform and for the manipulator's end-effector so that all the stations are served at the lowest possible cost. Simulation examples are presented to show the effectiveness of the presented approach.

INTRODUCTION

Mobile manipulator is a robotic system built from a robotic manipulator arm mounted on a mobile platform. Such systems offer a dual advantage of mobility and dexterity. The mobile platform offers unlimited workspace to the manipulator. The extra degrees of freedom of the mobile platform extend the workspace of the arm, whereas an arm offers several operational functionalities. However, the large number of degrees of freedom can be a challenging problem for the operation of such a system.

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

Service robots are of immense interest due to their capability to perform complex tasks in many fields such as automated transportation systems in offices, hospitals, libraries and building management (Xidias et al., 2012). The purposes of automation are both to save time and manpower and to improve the service quality. In a market store or a library, several tasks should be done by a service robot. For example, a service robot should distribute goods or books to the shelves with an optimum way in order to save time and related costs.

In this paper, we consider a mobile manipulator (hereinafter it is called as *service robot* or SR) which is moving in a 3D indoor environment with various demands for picking objects from a depot (e.g., a library desk) and placing them on predefined stations (e.g., the bookshelves). The service robot starts from its depot, passes through all the stations (the order is not predefined) and returns back to its depot for the next task assignment. The objective is to determine a safe-route (collision-free) so that all stations are served at the lowest cost (i.e., in minimum time and in optimum order).

The attainment of this objective necessitates the solution of two known combinatorial optimization problems: (a) the motion planning problem for both the manipulator and the mobile platform (MPP) (LaValle, 2004), and (b) the vehicle routing and scheduling problem (VRSP) (Qiu et al., 2002). Both of them are known to be intractable. Motion planning and task scheduling issues are often studied separately. So far, the integration of these problems has been studied by few researchers in (Xidias et al., 2009), (Herrero-Pérez & Martínez-Barberá, May, 2010), (Xidias & Azariadis, 2011) and (Jin and Ray, 2014) for industrial applications. In (Xidias et al., 2009), an Autonomous Guided Vehicle (AGV) is demanded to serve timely (providing delivery tasks) as many work stations in a 2D industrial environment as possible. First, the vehicle's environment is mapped onto a B-Spline surface embedded in 3D Euclidean space using a robust geometric model. Then, a modified genetic algorithm is applied to the generated surface to search for an optimum path that satisfies the requirements of the vehicle's mission. However, this work considers only one moving AGV and does not take into account the corresponding kinematic constraints.

In (Herrero-Pérez & Martínez-Barberá, 2010) a methodology is presented for modeling and controlling a flexible material handling system (MHS), composed of AGVs, suitable for flexible manufacturing systems. The AGVs incorporate artificial intelligence and mobile robotics techniques in order to determine their paths. The MHS makes use of a decentralized navigation control and a distributed Petri net in order to achieve higher flexibility and autonomy. However, the method is not globally optimal because

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