Chapter 20

Adaptive Integrated Control for Omnidirectional Mobile Manipulators Based on Neural-Network

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ABSTRACT

An omnidirectional mobile manipulator, due to its large-scale mobility and dexterous manipulability, has attracted lots of attention in the last decades. However, modeling and control of such systems are very challenging because of their complicated mechanism. In this paper, an unified dynamic model is developed by Lagrange Formalism. In terms of the proposed model, an adaptive integrated tracking controller, based on the computed torque control (CTC) method and the radial basis function neural-network (RBFNN), is presented subsequently. Although CTC is an effective motion control strategy for mobile manipulators, it requires precise models. To handle the unmodeled dynamics and the external disturbance, a RBFNN, serving as a compensator, is adopted. This proposed controller combines the advantages of CTC and RBFNN. Simulation results show the correctness of the proposed model and the effectiveness of the control approach.

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INTRODUCTION

A mobile manipulator, which generally consists of a mobile platform and a robot arm, provides a new direction in robot researches and applications due to its large-scale mobility and dexterous manipulability. The mobility of the mobile platform substantially increases the size of workspace, and it enables the end effector of the manipulator to reach a relatively better position to operate dexterously. The manipulability of the robot arm, which is mounted on the mobile platform, greatly improves the functionality of the mobile manipulator. Because of these distinct advantages, mobile manipulators have been applied more and more extensively.

A number of related works have been developed in this field in the last decades. In literatures (Campion and Bastin, 1996; Betourne and Campion, 1996; Siciliano, Wit, & Bastin, 1996), modeling and control of omnidirectional mobile robots were analyzed in details. The dynamic model and kinematic model of an omnidirectional mobile robot with three castor wheels were presented in (Chung, et al., 2003; Yi and Kim, 2001). Tan and Xi (2001) proposed a unified dynamic model for a mobile manipulator consisting of a Nomadic XR4000 and a Puma 560 robot arm. Holmberg and Khatib (2000), Khatib, et al. (1996), Khatib (1987) developed a holonomic mobile robot and presented a dynamic control method for a parallel redundant system. On the whole, existing works can be approximately divided into two groups: One is separate control of the mobile platform and the robot arm, i.e., the mobile manipulator is regarded as two subsystems. In this way, Liu and Lewis presented a decentralized robust controller in (Liu and Lewis, 1990). Chung and Velinsky (1998) also derived the dynamic model of the holonomic mobile platform and the manipulators separately. The other is control the mobile manipulator as a whole, that is, we consider the mobile platform as a multiple-DOFs joint. For example, Yamamoto and Yun (1994) studied a two-linked planar mobile manipulator subject to nonholonomic constraints. Considering the characteristics of our experimental setup, we adopt the latter control strategy in this paper.

Existing control strategies of the omnidirectional mobile manipulator can be approximately divided into two groups: One is separate control of the mobile platform and the robot arm, i.e., the mobile manipulator is regarded as two subsystems. In this way, Liu and Lewis presented a decentralized robust controller in (Liu and Lewis, 1990). Chung and Velinsky (1998) also derived the dynamic model of the holonomic mobile platform and the manipulators separately. The other is control the mobile manipulator as a whole, that is, we consider the mobile platform as a multiple-DOFs joint. For example, Yamamoto and Yun (1994) studied a two-linked planar mobile manipulator subject to nonholonomic constraints. Considering the characteristics of our experimental setup, we adopt the latter control strategy in this paper.

As for these methods, CTC is an effective motion control strategy. However, requirements of precise model are very rigorous in practical applications. Furthermore, this kind of controllers becomes unstable when the unmodeled dynamics or the external disturbance is significant. To handle these difficulties, Song and Yi (2005) adopted a fuzzy approach to compensate the uncertainties. In literatures (Kwan, et al., 1998, Wai, 2003), generalized fuzzy neural network, wavelet neural network motions to improve the workspace and overall dynamic endpoint properties, and the redundant degrees of freedom can be used to accomplish accessory tasks.

However, while the omnidirectional mobile manipulator provides a lot of advantages, we suffer a lot from its complicated mechanical structure. Firstly, it is very difficult to derive the model of an omnidirectional mobile manipulator, especially the dynamic model. Secondly, more redundant degrees of freedom also implies more motors need to be controlled, therefore, path planning and motion control of such a system are very challenging. Moreover, many intelligent control methods are unable to be applied online due to the computational complexity of the model.

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