Feedforward Model Based Active Force Control of Mobile Manipulator using MATLAB and MD Adams

SHARIMAN ABDULLAH, MUSA MAILAH, COLLIN TANG HOWE HING
Department of Applied Mechanics & Design
Faculty of Mechanical Engineering
Universiti Teknologi Malaysia
81310 Skudai, Johor
MALAYSIA
shariman@utem.edu.my, musa@fkm.utm.my, tanghh@fkm.utm.my

Abstract: - The paper highlights the potentials of using a feedforward model based Active Force Control (AFC) as a disturbance rejection scheme in the motion control of a mobile manipulator (MM). The AFC part creates a force or torque feedback within the dynamic system to allow for the compensation of the sudden disturbance introduced into the system prior to relaying the signal to the conventional outerloop position controller employing a resolved acceleration control (RAC) configuration, thereby increasing the robustness of the MM system. The proposed AFC-based model also shows a faster computational performance by manipulating the estimated inertia matrix (***IN***) of the system instead of considering the entire system dynamic model. A feedforward element in the form of a simplified model of the dynamic system is implemented to complement the ***IN*** for a better trajectory tracking performance of the system. The simulation was performed and the results were compared with the computed torque control (CTC) with RAC scheme to benchmark the performance and robustness of the AFC-based counterpart. The MM consists of a skid steering four wheel nonholonomic mobile platform with a three degree-of-freedom (DOF) articulated manipulator attached on top. With the proposed controller incorporated into the system, the tracking performance of the MM is considerably enhanced with increased workspace capacity and better operation dexterity.

Key-Words: - Active force control, Feedforward model based control, Mobile manipulator, Robust control, Tracking Performance

1 Introduction

Mobile manipulator is better understood as a combination of a mobile platform and an arm manipulator attached to it. There is significant research on mobile robot or mobile platform in recent years and developments have been made in areas related to localization, control and others. However, the actual implementation of a mobile robot in real world is rather limited. Perhaps the lack of task that a mobile robot can perform is the limiting factor towards the possible implementation of a mobile robot in real world. Therefore, the addition of a robotic arm or manipulator to a mobile robot is the most natural thing to do. However, adding a manipulator with several DOF to a mobile robot increases the complexity of the system.

The precision and reliability of a typical industrial robot have become increasingly an essential part in modern manufacturing processes. These industrial robots have a wide application range, expanding from a simple process like point-to-point material transfer to a more complicated operation, like continuous trajectory tracking, spray painting, and welding. The fixed base of the industrial robot arm limits the working range and flexibility of the system. By adding mobility to the robot arm, it can significantly increase the working range and flexibility of the robot, but at the same time increase the control system complexity. Most of the recent industrial manipulators are still using proportional-integral-derivative (PID) position controller by neglecting the dynamics of the manipulator. This approach is sufficient, since most of the parameters surrounding the manipulator are in fact controllable [1, 2]. Adding the mobility to the manipulator, however, changes the system dynamics and exposes the system to more environmental noises; hence, a more robust and effective control system is required.

A research project from Aalborg University demonstrated a MM concept that can operate in a flexible manufacturing environment [3]. The MM nicknamed “Little Helper” was developed to promote the idea of an autonomous manufacturing