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#7201 Summary

SUMMARY REVIEW EDITING

Submission

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Submission Metadata

EDIT METADATA

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Title and Abstract

Title: Two-Time Scale Model Predictive Control Design for Flexible Joint Manipulator

Abstract

This paper proposes a two-time scale control of a flexible joint manipulator (FJM) for accurate positioning and vibration suppressions as well. In particular, a composite model predictive control strategy is applied to an FJM. First, the dynamics of flexible joint manipulator is decomposed into slow and fast subsystems using singular perturbation approach. Then, for an accurate positioning of the FJM, a slow model predictive controller (MPC) is designed for the slow subsystem (rigid) whereas a stabilizing fast MPC is accomplished for the fast subsystem (flexible) Laguerre functions are used in MPC design for achieving both better consistency of model predictions and actual system behavior along with the desired attribute of reduction in computational burden. Simulation results depict the superiority of the proposed two-time scale model predictive control in terms of simpler/lower order dynamics, design simplicity and minimal computational efforts compared to a conventional MPC design for the original higher order dynamic system while achieving accurate positioning and vibration suppression of the FJM. *Keywords:* Flexible Joint Manipulator, Laguerre functions, Model predictive control, Singular perturbations theory.

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Contributors and Supporting Agencies

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Two-Time Scale Model Predictive Control Design for Flexible Joint Manipulator

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Abstract: This paper proposes a two-time scale control of a flexible joint manipulator (FJM) for accurate positioning and vibration suppressions as well. In particular, a composite model predictive control strategy is applied to an FJM. First, the dynamics of flexible joint manipulator is decomposed into slow and fast subsystems using singular perturbation approach. Then, for an accurate positioning of the FJM, a slow model predictive controller (MPC) is designed for the slow subsystem (rigid) whereas a stabilizing fast MPC is accomplished for the fast subsystem (flexible) Laguerre functions are used in MPC design for achieving both better consistency of model predictions and actual system behavior along with the desired attribute of reduction in computational burden. Simulation results depict the superiority of the proposed two-time scale model predictive control in terms of simpler/lower order dynamics, design simplicity and minimal computational efforts compared to a conventional MPC design for the original higher order dynamic system while achieving accurate positioning and vibration suppression of the FJM.
Keywords: Flexible Joint Manipulator, Laguerre functions, Model predictive control, Singular perturbations theory.

1. INTRODUCTION

In space applications, lightweight manipulators, solar satellite arrays etc. exhibit noticeable flexibility. Also in aerospace industry most of the metals are replaced by non rigid composite materials. Underwater cables and shipbuilding industries require flexible materials. All these applications require vibration free movement while maneuvering**.** With the advantage of light weight and lower energy consumption, flexible robot manipulators are utilized in space applications to handle the objects. Handling the flexible objects with robotic manipulation is a challenging and complex task and has attracted a lot of attention since 2009.

The two major aspects need to be addressed with flexible robot manipulators are its modeling and control. Various modeling techniques have been adapted to derive the dynamic model of FJM's in M. Pala Prasad Reddy et.al.(2012), W.J Book (1984), G.hastings et.al. (1987), P.B Usoro et.al.(1986), R.H Canon et.al.(1984), K H Low et.al. (1988. The flexible feature of manipulator produces complex dynamics and controller design difficult. A major concern encountered in robot manipulators control is related to fewer numbers of actuators compared to degrees of freedom causing the system to be under actuated. The under actuation problem is successfully resolved in the past by application of singular perturbation theory (SPT), which separate the model dynamics into slow-fast subsystems. The modeling of FJM involves both mechanical and electrical components; therefore two-time scale property exists, naturally.

Within this framework various control strategies have been developed in the past for singularly perturbed slow-fast subsystems. A detailed study on SPT to flexible manipulators is presented in B. Siciliano and W.J Book (1988), in which adaptive model following control is applied for positioning and full state feedback control law is applied to suppress deflections. B.Subudhi et al. (2003) applied neural network control to slow control and LQR controller for fast subsystem to account for the model uncertainty. A. Tavasoli et.al. (2009) designed an observer based composite slow-fast non linear controller for slow-fast subsystems based on two-time scale theory. Also, a composite robust PD-type nonlinear tracking control (S. González-Vázquez et.al. (2013)) and Lyapunov based adaptive back stepping controllers (H. T. S. A. A. K. MEHRNOOSH ASADI, 2016) are applied for robot manipulator based on SPT. An overview of Fuzzy sliding mode control approach to two-time scale systems is presented by G.V L et.al (2016). Jinyong Ju et al. (2016) have designed a virtual sensor based on SPT, which incorporates speed and vibration observers to control flexible-link manipulator. The past research work as listed above on two-time scale control does not guarantees the optimal solutions and cannot handle the constraints unlike the MPC. Hence, motivated from the SPT and MPC, in this paper a composite slow-fast MPC is proposed for simultaneous positioning and vibration suppression of FJM.

MPC becomes an efficient approach for industrial and process control applications due to its potential in providing optimal solutions. The MPC scheme is primarily employed in