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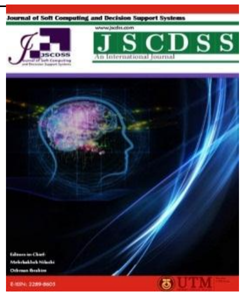

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System Identification and Intelligent Control of Flexible Manipulator System

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Abstract

Position control of flexible manipulator system is normally accompanied with tip vibration that results in degradation of performance. This paper investigates an active control strategy by applying classical PID controller to suppress unwanted vibration of flexible manipulator in presence of disturbances. The parameters of PID controller are tuned by genetic algorithm (GA) and particle swarm optimization (PSO) in the intelligent (self-tuning) manner. The results of these two optimization methods are compared toward vibration control capability, moreover; modeling of flexible manipulator is conducted by applying system identification method in which autoregressive with exogenous input (ARX) model is intended as linear model. This research can be regarded as guidance for further elaborate research on implementing optimization method particularly integrated with PID controller for flexible manipulator system modeled by system identification approach.

Keywords: Flexible manipulator, System identification, Genetic algorithm (GA), particle swarm optimization (PSO), PID controller

1. Introduction

Manipulator systems have been playing essential role in today's technology. They are attached with other automatic appendage to carry out accurate and heavy operation such as automotive industry, space robotic system (Zarafshan et al., 2013) biomedical engineering (Sekiguchi et al., 2001), even in the electronic application (Brouwer et al., 2010). Owing to drastic characteristic such as light weight, low energy consumption and satisfactory speed, flexible manipulator becomes eligible candidate than its rigid counterpart.

However, flexibility in terms of low stiffness has some undesirable effects namely, chaotic motion that takes system into instability state and time delay. Thus designing an active controller in order to cope with potential drawbacks and suppress such destructive vibration has been gaining importance in recent years. Basically, Control of flexible manipulator dealing with trajectory tracking and vibration control simultaneously which in the most of the cases two distinct control strategies are implemented to keep desired hub angle and cancel sever tip vibration. A challenging aspect of flexible manipulator control resemble to other control systems is to formulate an appropriate model of flexible manipulator before implementing any control scheme.

In the literature, several theories have been proposed to present a distinguished ways for modeling and suppressing the vibration of flexible manipulator. Qiu et al. (2012) proposed dynamic model of flexible manipulator using assumed mode method (AMM) and applying composite PD and direct adaptive fuzzy controller for control system. Developing input shaping controller in to cancel the vibration of single flexible link, in which modeling of system is done by finite element method (Zain and Tokhi, 2006). Cancelling the vibration in presence of nonlinearities such as motor friction (coulomb friction) is carried out by model predictive controller (MPC) (Abdolvand and Fatehi, 2012). Another solution described by Shawky et al. (2013) in which control of tip vibration and tracking control of flexible manipulator is performed by using the nonlinear state dependent Riccati Equation (SDRE) method, moreover; assumed mode method is intended in modeling part. In the recent years of research on flexible manipulator besides developing control strategy, modeling with the system identification draws the attraction of researcher considerably. Ramos and Feliu, (2008) investigated the online payload identification of (MIMO) single-link flexible robot base on captured signals from motor position and the coupling torque. The