Nonlinear effects in joints of multi-dimensional active absorbers for robotics

Zbyněk Šika*, Karel Kraus* and Jan Krivošej*

**Faculty of Mechanical Engineering, Czech Technical University in Prague, Praha, Czech Republic*

Abstract. Different imperfections and various nonlinear friction regimes in joints of mechatronic systems substantially deteriorate their behaviour. This also largely applies to multi-dimensional active vibration absorbers with actuators and sensors in feedback control laws. High functional accuracy is often required for the active absorbers, leading to conflicting demands on the design and thus to the necessity of advanced elimination and/or compensation of these unwanted nonlinearities. The research ranges from the optimization of absorber design, through friction compensation based on an adaptive model or an advanced observer, to modifications of absorber control strategies. Some of investigated elimination methods are experimentally tested on a demonstrator of a controlled planar vibration absorber with three degrees of freedom.

Introduction

Industrial serial robots are typically able to cover large workspace, but their mechanical properties don't allow combining high accuracy and high dynamic of operations. The same is valid also for new very light robot concepts. Widely spread usage of robots, even for tasks such as drilling [1], leads to high demands to accuracy and speed. The absolute measurement of the end-effector for fast position feedback as well as usage of inbuilt robot motors for vibration suppression is often problematic. The authors of the paper are therefore dealing with an alternative concept of using compact active multi-dimensional absorbers for robots [2]. Reducing the vibrations of the robots by means of active absorbers can be realized with the help of built-in and local sensors only. In addition, active absorbers allow the adaptation to variable dynamic properties of the robot. There are many control laws that can be used, one of them is the so-called delayed resonator concept [3].

Results and discussion

The operation of any real controlled mechanism is strongly influenced by imperfections and passive effects in the kinematic joints. Research and ways to compensate these nonlinearities are very current, for example, the use of LuGre models [4] and their combinations with advanced observers [5] can be mentioned. High demands are placed on the exact function of active absorbers for the given purposes in robotics, which leads to the need to solve the problem of imperfections of real kinematic joints. An experimental demonstrator was assembled for this purpose (Figure 1) including six AVM60-25 voice-coil actuators, linear ball bearings, built-in encoders and precise revolute/spherical joints. The first phase of the research consisted in the identification of variantly formulated nonlinear passive resistances effects models (LuGre, neural network based and others) during different motion regimes of the 3 DOF absorber demonstrator. Adaptation of the parameters took place using the parallel simulation of the mechanism model in the control system of the actuators. During these identifications, the repeatability of the results and the degree of uncertainty of the obtained models were also determined. The second phase investigated the integration of some obtained nonlinear models to the control laws specific for active vibration suppression. Generalization of computed-torque type methods and their combination with active vibration control strategies was the main goal of these experiments. The current results of both of these research phases will be presented, including open questions for further investigation.

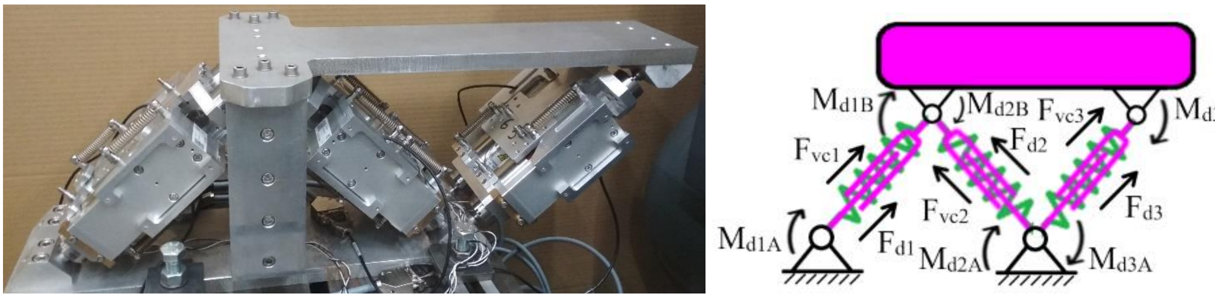

Figure 1: Demonstrator of an active planar 3 DOF vibration absorber and scheme of its mechanical model.

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