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Vibration suppression using nonlinear control of active absorber

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Vibration suppression is still very demanding problem, specifically for fast and exact motion request demands. Extensive research in this filed shows mainly approaches based on linear models or their linearized forms in connection with a linearized absorber.

This paper deals with an active absorber mounted on a robotic arm which dynamics is generally nonlinear. A robot arm is considered nonrigid. The nonrigidity is considered as a flexible robot link which review is discussed and summarized in [4] and possible control algorithms of two-link flexible manipulators are summarized in [2]. The main considered properties of the robot arm are chosen as close as possible to the reality and a dynamic model of the robot arm is assembled. The modal and inertia properties are investigated using the finite element method (FEM). The simulation results are then used as inputs for a simplified dynamic model.

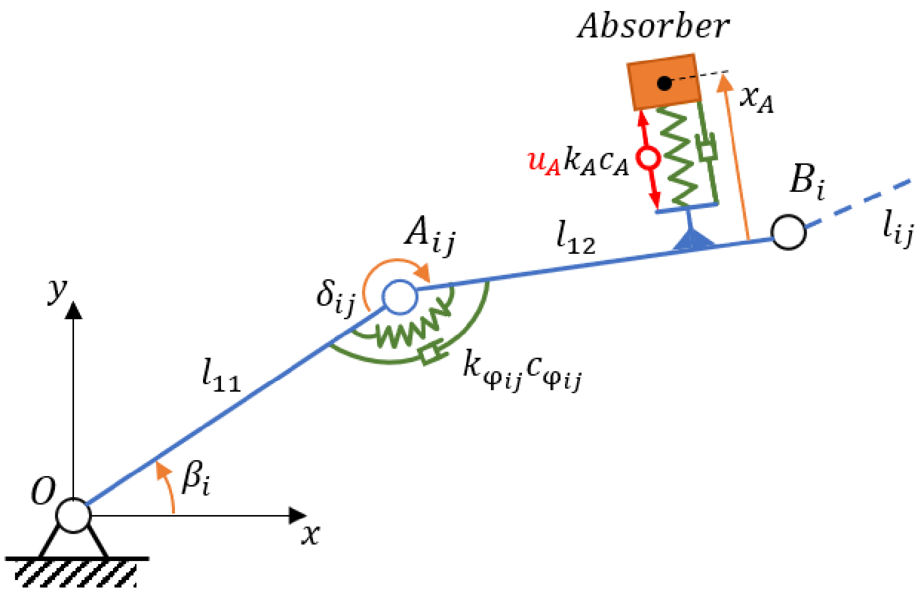

Fig. 1. A scheme of a flexible robot link with active absorber

A flexible robot link OB_i (or $B_{i-1}B_i$ for $i > 1$) is modeled as a rigid serial chain with joints A_{ij} with torsional spring $k_{\varphi ij}$ and damping $c_{\varphi ij}$. An active absorber is added as is shown in Fig. 1. The u_A, k_A and c_A are the active force, stiffness and damping of the absorber, respectively. The similar approach is shown in [1], where the joints A_{ij} are replaced by the two springs k_x and k_y.

The control scheme is based on the computed torque method (CTM) which uses the inverse dynamic to linearize the model of the robot. The inverse-dynamics procedure for flexible-robot manipulators is also used in [3] where its leads to driving forces associated with the deformation modes. This idea is similar in this paper, however, besides the driving forces the concept is extended to the active absorber added to the structure. In connection with large motion demands the active absorber deals with the nonlinear dynamic of the robot arm. The investigated structure in this paper (Fig. 1 where $i, j = 1$) is considered in a few steps. Firstly, the rigid arm with fixed absorber inertia properties is considered as a starting point. For this structure the CTM method is optimized in control parameters which is taken as a default state of control performance. The simplified control scheme with the feedback linearization loop is shown in the Fig. 2. This procedure is tested for trajectories which represent fast and large motion request demands. Secondly, the robot arm is considered rigid with active absorber. This leads to performance comparison and searching for control law of the absorber with stability analysis. Finally, the robot arm is modelled flexible and considers the first deformation mode of the link.

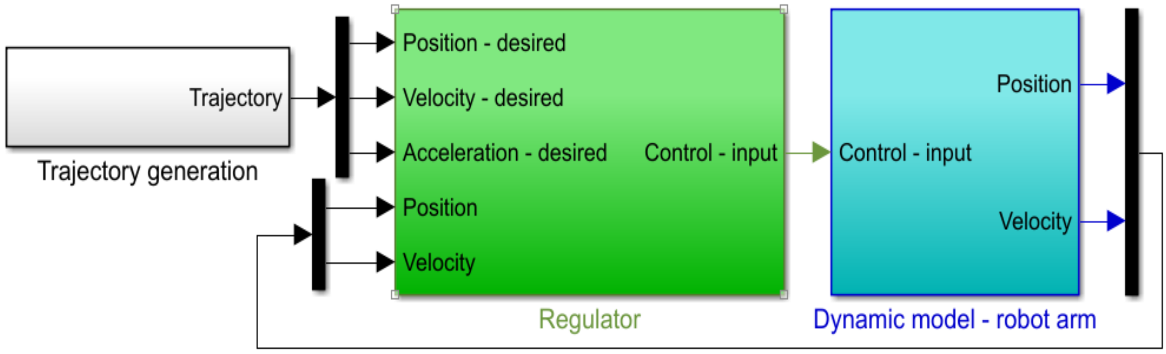

Fig. 2. Simulation scheme with CTM control strategy

In conclusion, the brief investigation to the flexible manipulator model in connection with the nonlinear control of active absorber is shown. The flexible robot link is considered and CTM control with the nonlinear control of absorber based on deformation modes is investigated.

The future work considers the extension of the deformation modes ($j > 1$). This should lead to the more complex adaptive control law of the absorber.

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