Paper ID: 64106
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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Smart Materials and Adaptive Structures (9)

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MODEL PREDICTIVE CONTROL FOR SWITCHING VIBRATION SUPPRESSION USING FUTURE TRAJECTORY

Abstract

These days, the required pointing performance of observation satellites is very demanding, so vibration suppression or isolation become an important issue for observation missions. In order to orientate observation devices to the target direction, a momentum-wheel is installed to provide attitude-control torque. However, it also produces undesirable force and torque because of wheel-imbalance and the imperfection of the ball-bearing. Since these disturbances may seriously damage observation activities, the use of vibration suppression systems for space applications has become standard practice Among several control schemes, model predictive control (MPC) is an active control method to decide an optimal control input by predicting the future state based on the system model with disturbance. MPC can handle constraint conditions more easily than conventional control methods and can easily handle time delay. So far, predictive control was proposed independently by several researchers at almost the same time. In terms of practical application, MPC is used in the operations of slow-moving plants with the considerable increase in the amount of calculation. The MPC application to switching vibration control has not been considered so far. Recently, a predictive control for controlling vibrations was proposed. However, the control is implemented only on active control. Furthermore, the previous control scheme cannot be applied to a multiple DOF system because it is considered only for a one-DOF system. This paper proposes a new control method that incorporates model predictive control and switching vibration suppression by using future trajectory. With the degree extension of the MDOF system, parameter tuning might be complicated in the conventional switching methods. Therefore, in order to extend the diversity of the input decisions, MPC and switching control are integrated. MPC can design control input trajectories arbitrary. A predictive controller has an internal model and predict future states of a system among a prediction horizon. The future states are optimized by selecting the most desirable input trajectory. Future states of a system are predicted based on two assumptions. The first assumption considers future control inputs are expressed as summations of harmonic functions. The second considers that periodic disturbances that cause resonance are applied to a structure. Switching based on the prediction can achieve more effective vibration suppression and easier tuning than switching methods. Computational loads are reduced by appropriately designing input trajectory. The beneficial features of the proposed method are demonstrated in simulations and experiments.