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FUZZY-BASED ADAPTIVE MULTI-MODAL VIBRATION CONTROL WITH IMPERFECT STRUCTURAL DATA

Abstract

In this paper, we propose an innovative method of "fuzzy-based adaptive" multi-modal vibration suppression for structures with imperfect structural data. This proposed adaptive control is made of the fuzzy inference and Mamdani's methodology. Our control is applicable both to multi-modal vibration suppression and to vibrating structures with incomplete structural data. So far, adaptive vibration controls have been proposed under the assumption that an accurate structural model can be obtained beforehand. However, it is quite difficult to obtain a precise mathematical model of structures, especially in space. Firstly, preliminary experiments for space structures are difficult to carry out on earth. Secondly, space structures are built in space with their sections launched one by one with rockets or space vehicles. If the worst happens, errors of mathematical models lead to the divergence of vibration due to control spillover. To effectively suppress multi-modal vibrations with imperfect structural data, we feature a threshold approach for switching semi-active vibration suppression. What it comes down to is that the following three notions are integrated; Mamdani's fuzzy inference, a threshold approach, and a switching semi-active control. The first step of designing a fuzzy control is to create the input and output logical rules of the system. Next, the fuzzy membership functions are drawn up on the basis of these logical rules. Then, the fuzzy control system automatically calculates the suitable threshold coefficient that is essential for our switching scheme. Importantly, our fuzzy-based system varies the coefficient value with time, which results in an adaptive control architecture, whereas conventional systems using the threshold approach keep the coefficient value always constant. Experiments of adaptive vibration suppression using our fuzzy-based control were carried out to verify the proposed adaptive system in a real structure. A CFRP plate was selected as a vibrating structure, because it has very close multiple frequencies. Firstly, we intentionally changed the magnitude ratio of each multi-modal vibration from the nominal value. The fuzzy-based system showed that the robustness over the ratio change, compared with conventional systems. We confirm that our adaptive control is adaptive to the change in vibration condition. Next, we demonstrate that the proposed system is adaptive to the change in values of electric components. Moreover, we carried out an experiment of adaptive vibration suppression against random force input. In such a severe vibration condition, the fuzzy-based control system suppressed random vibrations effectively.