Distributed modular semi-active controller for suppression of vibrations and energy harvesting

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Distributed controllers have been widely developed for a variety of engineering applications, taking advantage of their robustness, functionality and computing capabilities. The purpose of this work is to design a distributed state-feedback controller that can be perceived as a 'plug and play' device, allowing effortless integration with a structure and providing simplicity in assembly, replacement, or reconfiguration. Our controller is based on a set of individual subcontrollers each one of which is associated with a subsystem representing part of a vibrating structure. Each subcontroller relies on state measurements of the adjacent subsystem's sensors to carry out global vibration suppression and energy harvesting tasks. Additionally, we assume that the neighboring subcontrollers exchange some state information to estimate a prediction of the coupling forces. The incorporated computational procedures for the subcontrollers are uniform which allows for designing a modular architecture that is cheap to build and easy to maintain. One of the essential benefits of the proposed distributed controller is that the subcontrollers perform the computing in parallel, which compared to standard centralized approaches significantly reduces the computational burden and allows for an adaptive implementation to large-scale structures subjected to changes in the parameters and excitation.

The majority of the distributed controllers designed for structural control have been based on the idea of isolated subsystems conforming to the parts of a vibrating structure and designing a set of local state-feedback controllers, where each relies solely on the state information of its adjacent subsystem [1, 3, 5, 6]. In our work, we suggest using the communication between the neighboring subcontrollers and building an evolutionary model that allows for short-time prediction of the coupling forces between subsystems. For the control we assume a stabilizing state-feedback switching law [4]. The selection of the parameters of this control law enables compromising antagonistic vibration suppression and energy harvesting objectives [2]. The validation of the method is carried out by experiments on a specially designed semi-active modular vibrating platform equipped with a set of electromagnetic control devices, displacement laser sensors and a real-time control system. We investigate a series of free-vibration scenarios assuming different selections of the distributed controller's architecture. The performance of the proposed method is tested by comparisons with standard centralized controller and passive damping strategy.

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References

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