

Energy conversion in a distributed actuators vibrating structure

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Context: Actuators are becoming smarter, lighter and more energy efficient. They can be multiplied in order to better control a system and achieve advanced displacement fields. For instance in industrial applications, several piezoelectric actuators are bonded on plates to create ultrasonic vibration to allow for membranes de-fouling in chemical processes, for efficient de-icing in avionics applications [1] or to create localized vibrations in haptics [2, 3].

These actuation architectures pose several challenges however. Indeed, compared to solutions with less but bigger actuators, achieving high efficiency energy conversion in smaller power supplies becomes more complicated. Moreover, the actions of each actuator must be orchestrated with the others so as not to produce negative interference in the system. The fact that the optimal operating conditions have to adapt to the external load, which vary in time, complicates complicate matters.

In this context, the L2EP developed a methodology which is based on the closed loop control of each actuator. This mechatronic approach allows for optimized control architecture yet ensuring outstanding performances. Moreover, the effect of the mechanical load on the system can be observed and estimated through the system's inverse model. However, the approach has not been extended to very large number of actuators (>25) and the theoretical stability conditions has not been described.

Objectives: The objective of this thesis is to control a large number of actuators coupled to a common vibrating structure in order to generate predefined vibration patterns. Stability conditions will be derived for the combined action of multiple actuators acting on the same structure. The versatility of the proposed approach will be demonstrated through applications to both high-frequency and low-frequency vibration scenarios. Given the laboratory's strong expertise and recognition in the field of haptics, this emerging application area of vibration control will be used to implement and evaluate the proposed solutions across several use-case scenarios. Estimation of the load will be implemented in real time in order to follow the operating conditions.

References:

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