Mitigation of impact-born vibrations

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Extended abstract

This contribution proposes, reviews and discusses two approaches to the problem of damping of impact-excited vibrations of structures. The impact is defined here either as a short-term, localized impulse of force or as a localized inelastic impact by a given mass with a certain initial velocity. The damping process, as understood here, encompasses two phases:

1. the initial phase of impact reception and then
2. the resulting free vibrations of the structure.

The first approach relies on initial (topological) optimization of passive damping distribution in the structure, which in the basic form is equivalent to the optimization of material damping coefficients of structural elements, but which can also include optimum distribution of passive dampers of various characteristics (e.g., frictional) and/or an additional optimization of structural topology. Our initial method of choice for handling such a problem is the virtual distortion method [1], which has already been used in frequency domain for reanalysis and identification of local material damping [2,3].

The second approach is semi-active and based on controlled activation of a number of semi-active actuators, which can be performed either before an imminent impact, in order to adapt the structure to the known-at-the-time impact characteristics, or continuously during the impact reception and vibration phases, that is in a fully semi-active control strategy [4]. It is required that the actuators are semi-active, that is their activation amounts to the modification of local mechanical/damping characteristics of the structure. Such an approach is much safer and less energy-consuming than active structural control, which usually requires significant additional forces to be applied to the structure and which is thus hazardous in case of any fault. Figure 1 illustrates an astonishingly high efficiency of a semi-active control strategy of vibrations in a deployable cantilever structure [5] (a Prestress Accumulation - Release strategy [6]).

In approaches, various formal aims of optimization are possible, including minimization of total energy of the structure, peak or root mean square strains, displacements or accelerations at selected crucial points, etc.

Note also that the impact characteristics may not be fully known at the optimization time, or the structure can be exposed to a number of impacts of various characteristics. In such a case, optimization must be performed with respect to a whole family of potential impacts, taking into account either the worst-case scenario or the statistical measures of the mean and the standard deviation of the response [4].

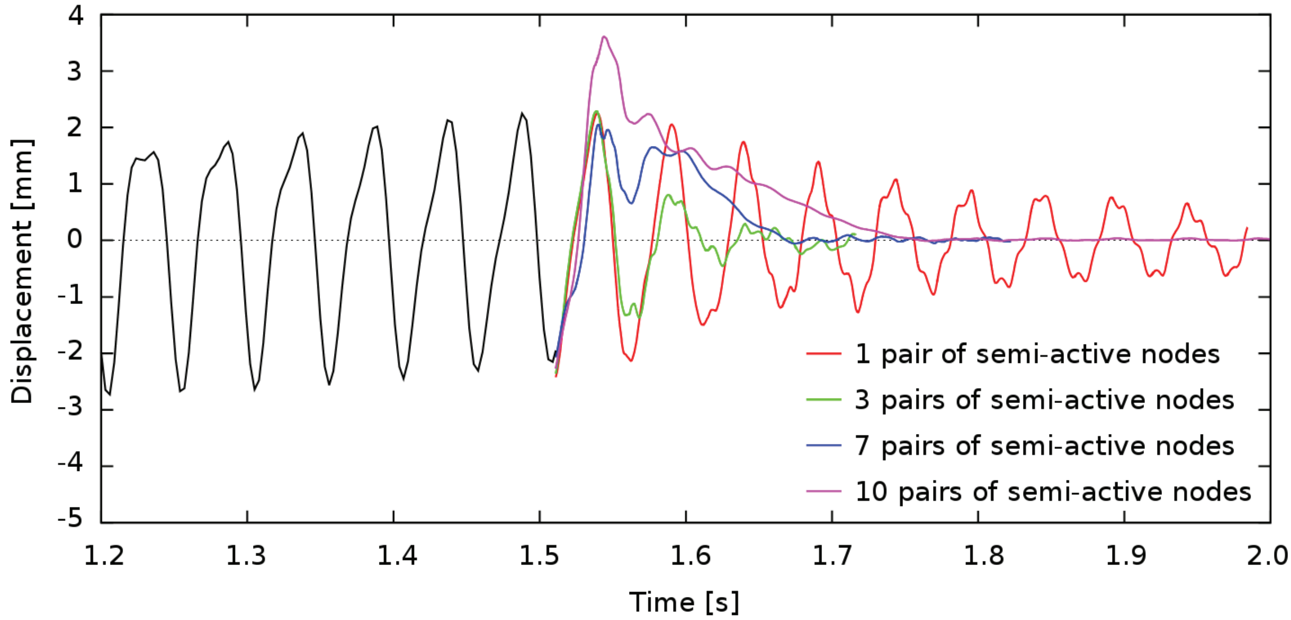

Figure 1. Vertical displacements of the tip of a cantilever structure prior to and after the activation of an ad hoc semi-active control strategy [5]

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