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Optimal location of piezoelectric sensors by a genetic algorithm

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ABSTRACT

In active vibration control of structures, some parameters such as the location of actuators and sensors, have a major influence on the performance of the control system. It is well known that misplaced sensors or actuators lead to problems such as the lack of observability or controllability. The problem is to find the locations on the structure where the controllability and observability measures of important eigenmodes are optimized. However, placing a sensor (or actuator) in a location where the observability (or controllability) of one eigenmode is high does not necessarily imply high observability (or controllability) of the other modes.

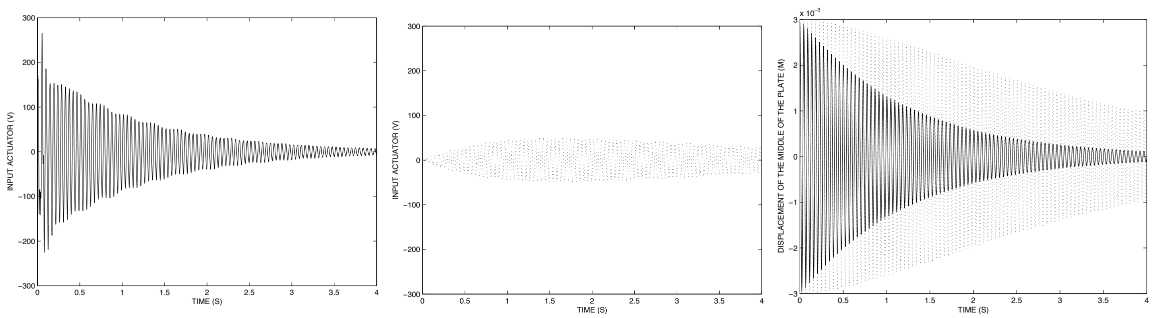
Given the importance of optimal location, a number of researchers have adressed this issue in the past. In most of papers, observability and controllability properties are used in the optimization criteria. In this case, the optimization problems of actuators and sensors are similar and the optimization methodology is the same.

In the case of sensors locations, the most usual performance uses the energy of the state output so as to maximize the information given by the sensors. In [1], the authors propose to maximize the measures of the gramian observability matrix in order to obtain optima without depending on the initial conditions or external forces. [2] suggests to maximize the minimal components of the output matrix. In [3] residual eigenmodes are used to avoid spillover effects. In [4], a modified optimization criterion is proposed based on measured output energy, in order to find the optimal location of sensors. This criterion ensures a good observability of each eigenmode of the structure, and permits by considering the residuals modes to limit the spill-over effects. A degree of observability for each eigenmode is also defined, leading to informations on optimal sensors numbers.

These optimization problems are reduced to nonlinear programming problems and their solutions are the minima of nonlinear non convex functions. For such problems the traditional algorithms (conjugate gradient, Newton-Raphson . . .) are not applicable or tend to be trapped in local optima. In order to overcome these limitations, a stochastic optimization method [5], based on a genetic algorithm, is used in several papers, for example in [3]. One of the main advantages of these algorithms is that they do not have much mathematical requirements about the optimization problem (only an evaluation of the

objective function is needed). The genetic algorithms are conveniently presented using the metaphor of natural evolution: a randomly initialized population of individuals (i.e. a set of points of the search space) evolves following the principle of the survuval of the fittest. New individuals are generated using simulated genetic operations such as mutations and crossover. The probability of survival of the newly generated solutions depends on their fitness (how well they perform with respect to the optimization problem): the best are kept with high probability and the worst are rapidly discarded.

This presentation is focused on optimal locations of sensors. The effect of sensors locations on the active control efficiency is shown in figure (1), in the case of a simply supported plate. In this paper, we study the family of the modified criterions proposed in [4] for the optimal placement of piezoelectric sensors. Consideration is given to the reduction of the spillover effect by taking into account the residual modes in the optimization function. A simple Genetic Algorithm well suited to find the optima of the previous defined objectives functions is developped.



(a) input actuator

(b) input actuator

(c) displacement at the middle of the plate

Figure 1: active control of a plate with one actuator located at the middle of the plate. Comparison between two sensor locations : at the middle of the plate (black line) or near the edge (grey line)

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