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UNCERTAIN COUPLING BETWEEN SUBSTRUCTURES: A NONPARAMETRIC STOCHASTIC MODELING

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ABSTRACT

Complex mechanical and aerospace systems, e.g. cars, airplanes, submarines, are often constructed as an assembly of various components using fasteners (rivets, bolts,..) and/or bonding techniques (welding, gluing,...). The accurate modeling of the boundary conditions induced by these fasteners and bonds on the substructures assembled is a delicate process but it is often approximated by a classic boundary condition, e.g. a perfect clamp. Thus, the computational model developed from such a simplified boundary condition exhibits *model uncertainty* with respect to the physical system. Note further that the actual boundary conditions induced by two seemingly identical fasteners or bonds will in general be different thus implying that there exists as well *data uncertainty*. Accordingly, the consideration of uncertainty in the assembly of structures must be carried in a framework that permits the inclusion of both model and data uncertainties. Such a framework is the nonparametric stochastic modeling technique [1,2] which is adopted here.

The first step in the introduction of uncertainty in the coupling between substructures is a partitioning of the overall computational model that reveals the degrees-of-freedom associated with the coupling. This effort can be accomplished by traditional substructuring techniques, a Craig-Bampton strategy is employed here. The introduction of uncertainty in this partitioned system is then achieved by randomizing the blocks of the mass, damping, and/or stiffness matrices associated with the coupling degrees-of-freedom alone.

The nonparametric stochastic modeling of random positive definite matrices has originally and extensively been developed for the mass, damping, and stiffness matrices of reduced order models of full dynamical systems. In the present context, however, it may not be appropriate to proceed with a reduced order modeling of the coupling degrees-of-freedom without unduly softening this coupling and thus an alternate formulation is warranted. Specifically, the recent modification of the method [3] in

which full size random matrices are generated is adopted here and leads to the desired stochastic model of uncertain coupling between substructures.
Note that the introduction of additional uncertainty originating from the substructures properties and/or on their boundary conditions can also easily be achieved, e.g. with the nonparametric method, [1,2] and [4,5] for the uncertainty on boundary conditions.

This approach is exemplified in detail on a structural dynamic model of a folding (morphing) wing with the uncertainty located at the hinge between the two components (inboard and outboard) of the wing.

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