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MULTI-PARTICLE COLLISION ALGORITHM WITH HOOKE-JEEVES FOR SOLVING A STRUCTURAL DAMAGE DETECTION PROBLEM

Reynier Hernández Torres(1), **Leonardo Chiwiacowsky**(2), **Haroldo Campos Velho**(3)

(1)Instituto Nacional de Pesquisas Espaciais, Brazil
reynier.torres@inpe.br
(2)UNISINOS, Brazil
ldchiwiacowsky@unisinos.br
(3)INPE, Brazil
haroldo@lac.inpe.br

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Summary: A structural damage detection problem is handled using a recent meta-heuristic algorithm (Multi-Particle Collision Algorithm -- MPCA) associated with a deterministic approach -- the Hooke-Jeeves approach. Under a forcing term, the structural response is measured. Therefore, the time observed displacement measured is used as experimental data. This inverse problem is formulated as an optimization problem. The objective function is given by the square difference between the measured displacement and output computed by the forward model.

MPCA is a meta-heuristic algorithm based on the physics in the nuclear reactor, with a particle (neutron) travels in the reactor. Two phenomena can be pointed out during the travel trajectory: absorption, and scattering. The latter process is the mechanism to scape of local minima. Three principal functions in the algorithm control all the process: perturbation, exploration, and scattering. Particles in the whole population behave cooperatively: after some objective function evaluations (determined by the user), the best particle is over-copied for all other particles, through a blackboard strategy. A parallel version of MPCA using Message Passing Interface (MPI) is implemented as well as it reduces the computation time.

The pattern search method of Hooke-Jeeves (HJ) is a simple but efficient local optimization method. It uses a sequence of exploratory movements on a base point, considering a certain radius. If, during the exploration, a better solution is computed, the base point change for this better point. Otherwise, the exploration radius is changed for a smaller value.

Three problem are employed for testing the methodology: spring-mass system, truss, and beam structure models. Several Degrees of Freedom (DOF) were used for the numerical experiments. Finite element formulation is used to solve the forward model. All data were created "in silico" (synthetic experimental data). Time-invariant damages were assumed to generate the synthetic displacement data. Experiments with noiseless and noisy data were carried out. Level of noise on two and five percent were considered. Good recoveries of the damages have been achieved.