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Optimal pump excitation frequency for improvement of damage detection by nonlinear vibro acoustic modulation method in a multiple scattering sample

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Abstract: We present a method to systematically optimize nonlinear damage detection in multiple scattering media by the nonlinear Vibro-Acoustic Modulation (VAM) technique. The latter consists here of exciting a medium simultaneously with a high frequency ultrasonic sinusoidal burst and with a low frequency continuous sinusoidal wave. Modulation of the high frequency (probe) by the low frequency (pump) is made possible by the presence of nonlinear scatterers, i.e. cracks, defects. A signal processing technique consisting of a closed loop system drives the automatic adaptation of the pumping frequency, yielding to the optimization of the nonlinear modulation (NM) of the output probing coda signal without a priori information on the medium and the scatterers. The correlation coefficient between a reference output probe signal without the pumping wave and an output modulated probe signal with a pumping wave was considered as our cost function. A multiple scattering solid beam where nonlinear scatterers can be controllably added or removed is designed and tested. The first step of this study is an empirical search of the correlation coefficient dependency on the pumping frequency to verify the performances of the proposed method. Then the implemented optimization algorithm based on genetic algorithm (GA) is used to find automatically the optimal pumping frequency. The obtained optimization results show a good agreement with the empirical study. Moreover, the genetic algorithm allowed to find the optimal pump frequency adapted to each configuration of nonlinear scatterers. This relatively fast search of the optimal nonlinear response could be extended to nonlinear scatterer imaging applications using the information on the resonant modes spatial shapes together with the associated optimal response.

Keywords : Optimal command, Genetic algorithm, Nonlinear- Vibro Acoustic Modulation, Crack detection