A new approach for coupled materials parameter identification and probabilistic state estimation of a dynamic system

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The aim of this work is to estimate the state of a standard dissipative dynamic mechanical system and to identify its constitutive parameters, simultaneously. This concept uses techniques of parameter identification in stochastic form and data assimilation techniques that applied fairly successfully to meteorology and oceanography. This so-called "coupled" technique is based on the exploitation of uncertain experimental "a priori" data from which informations about the "a posteriori" state of the system are obtained via techniques of data assimilation and which are then used as data for our method of stochastic identification. A new composite functional is thus introduced in order to combine a identification functional put in a stochastic form together with terms coming from sequential or variational estimation techniques.

A parameter identification method is first designed, grounded on the minimization of an energy like error functional, extending preceding approaches [1][2]. The energy error incorporates simultaneously a free-energy error and a dissipation error. Control, via this error functional, of the free energy and the dissipation makes possible to obtain a better behavior of the functional when the material parameters to be identified concern entirety about the standard dissipative behavior law. In order to update parameters of the stochastic model from dubious experimental measurements, the next step is to extend our error-functional calculus carried out within a deterministic framework towards a stochastic framework which make then possible to use simultaneously estimation techniques in a global variational approach. Our technique is based on the method of resolution of inverse problems by the theory of estimation [4].

Data assimilation methods often enable to obtain reliable forecasts by integrating the differential equations governing the considered system, not perfect, starting from the uncertain observations available at present time [3]. This technique can generally be filed in two categories: the first gathers the techniques of sequential data assimilation derived from the theory of the statistical estimate (the optimal interpolation); the model is integrated with respect to time over all the period of assimilation by its type predictor-corrector concept; these algorithms rest on the principle of the filter of Kalman. The other category results from the theory of optimal control where one seeks the solution which minimizes a preset function cost. The idea consists in explicitly seeking a last state to which the trajectory resulting remains close to available observations all along the period of assimilation (in a least-square sense). Our "estimate-identification" strategy does not favour any category. The two types of methods can be applied successfully.

Numerical results through a simple model are provided to validate this new formulation. For these simulations, we applied to estimating the state (displacement in our case) of a linear viscoelastic system and identifying its stiffness and viscosity parameters from measurements of displacement.

References

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Keywords : data assimilation, dynamic system, stochastic inverse problem, parameter identification.