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A genetic algorithm approach for the detection of corrosion in large-scale structures

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ABSTRACT

The problem here considered is related to a non-destructive test of material systems through an infrared thermographic inspection. The specific application is the detection of corrosion in an internal, unobservable surface of the system. The mathematical problem is an inverse problem. Precisely, it is here formulated as a problem of estimating the physical, spatially distributed, coefficients of the material from measurements taken at a portion of the boundary (the observable surface of the system).

The physical experiment consists of a thermal excitation of the material and continuous monitoring of its surface temperature. The problem has been successfully solved in the one-dimensional case [1], even with an analytic solution, and in the two-dimensional case of moderate size [2], where a numerical algorithm of nonlinear optimization has been employed to estimate the model parameters (i.e. the material coefficients) and an adaptive parametrization has been adopted to make the solution algorithm computationally efficient. In this case, the genetic algorithms seemed not to be the optimal choice for driving the process of adapting the parametrization [3] and are substantially preferable, instead, the standard techniques used in the adaptive finite element discretizations, i.e. the local refinement of the mesh used to represent the parameters.

Now, if we consider a large-scale slab and a sufficiently fine resolution for the measurement of the corrosion, a deterministic test of the structure becomes then computationally prohibitive. In particular, we refer to the case where the number of parameters is too high to execute the algorithm in reasonable times, if the model is parameterized in the overall space domain. Moreover, we consider also the case in which the surface is too wide to be conveniently measured everywhere and, therefore, only a limited set of sparse measures can reasonably be made.

Let us consider to represent the initial piece of information about the presumed corrosion and the estimates computed by processing the experimental data as stochastic quantities, i.e. no more deterministic. Then, to solve the problem we apply techniques deriving from the statistical inversion theory. The result of the analysis becomes therefore an hypothesis test that confirms the presence or the absence of corrosion at a predetermined confidence level.

We present a variation of the NSGA-II algorithm [4] and show its computational effectiveness at finding the optimal parameterization and the optimal (incomplete) sequence of measurements to be done at the system surface to guarantee a reliable corrosion estimate.

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