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OPTIMIZATION OF INPUT MATERIAL PARAMETERS FOR NANOINDENTATION MODEL

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ABSTRACT

Material parameters optimization for a finite element nanoindentation model is discussed in this paper. Nanoindentation is a relatively new experimental method, which allows testing the physical properties of materials on the scale of micrometers, i.e. at the typical dimension of individual components. Because this testing is very financial demanding, numerical models are used. Then, the problem is to determinate the input material parameters for the model to achieve the same response from the experiment and from the numerical model. A forward mode of the inverse analysis is applied for optimization.

The numerical model of nanoindentation is very time consuming, hence it is useful to use its approximation instead of the real model. Here, the Radial Basis Function Network (RBFN) is used for the approximation. This approach comes from the domain of a general approximation, usually called the Response Surface methods [1], Diffuse Approximations [2] or Surrogate models [3]. RBFN is based on artificial neural networks, but has some specific properties: the neural net is created only with one layer of neurons, it has a specific type of a transfer function and the training of this net leads to the solution of a linear system of equations. Our particular implementation is based on the variant introduced in [4].

Firstly, single objective optimization is used. The methodology consists of the direct optimization of the least square error function between an experiment and results from the numerical model. As an optimization algorithm, the evolutionary algorithm GRADE with its

extension called CERAF is used [5]. This extension allows solving the multi-modal problems.

Then, the multi-objective optimization is used. Objective functions are based on a difference between an experimental curve and a result from the model. As the first objective the function from the previous part is used. The second one presents a difference between slopes of stress-strain curves. Further, differences between these curves in significant points were tested. All objectives are to be minimized. As an optimization algorithm the evolutionary algorithm mentioned previously together with Pareto Archived Evolution Strategy [7] is used.

The proposed methodology is examined on a set of illustrative problems using both experimental as well as computer-generated data. From the point of view of efficiently and accuracy, this methodology provides a promising alternative to the existing approaches.

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