

Computational challenges in optimum structural design

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ABSTRACT

The optimum design of large-scale structures modeled with several thousands degrees of freedom (d.o.f.) is a computationally intensive task. When Evolutionary Algorithms (EA) are applied for this purpose, the solution of the Finite Element (FE) equilibrium equations is of paramount importance and requires the use of efficient computational techniques, in order to accelerate the overall optimization process and make it an application tool for practical problems. This is even more important for structural optimization under uncertainty, where procedures like Monte Carlo Simulation need to be executed for each candidate optimum design.

In the present study a structural optimization methodology based on Evolution Strategies (ES) is efficiently applied in the framework of sequential and parallel computing environments. This is achieved with improved algorithms in terms of the proper selection of the new generation of design vectors as well as with the incorporation of Neural Networks (NN) for the prediction of results in computationally intensive operations. The NN implementation is adaptive in the sense that the utilized NN configuration is appropriately updated as the algorithmic process evolves by performing NN retrainings using gradually accumulated information. The computational advantages offered by the proposed methodologies are further enhanced by the implementation of advanced solution algorithms, in both sequential and parallel computing environments, for handling the repeated finite element equations encountered within the optimisation procedure. These algorithms are based on Domain Decomposition (DD) methods and are executed on clusters of networked computers.

The proposed algorithms, which combine the effectiveness provided by soft computing techniques with the speed of computations achieved through efficient solution methods and parallel processing, allow the optimum design of large-scale engineering problems to be performed in affordable computing times. This way the range of applicability of optimization approaches and algorithms is extended to extremely computationally intensive optimization problems such as designs under multiobjective conditions, dynamic or seismic loading, as well as performance based designs with stochastic variables and reliability based optimization of real world engineering problems.