On Accelerating Evolutionary Algorithms Applied to Physically Based Approximation of Experimental and Numerical Data

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ABSTRACT

This work considers development of highly efficient, dedicated Evolutionary Algorithms (EA) for a wide class of large non-linear constrained optimization problems. Particularly discussed are chosen problems of mechanics, including smoothing of experimentally measured data using the Physically Based Approximation (PBA) [2]. Such approximation presumes simultaneous use of the whole experimental, theoretical, as well as heuristic knowledge of the analyzed problems. Though very general character of the improved EA method, the objective of our current research is its application to residual stresses analysis in railroad rails and vehicle wheels [2]. However, due to the size and complexity of the considered problems, this research is focused, first of all, on the efficiency increase of the applied algorithms. In contrast to most deterministic methods, the EA [1] may be successfully used to non-convex problems, but their general efficiency is rather low. Therefore, we have already proposed several new acceleration techniques, including smoothing and balancing, a'posteriori error analysis and related techniques, adaptive step-by-step mesh refinement, as well as non-standard distributed and parallel computations. Standard acceleration approaches for the EA were considered as well. In this paper we present advances in development of the proposed acceleration techniques, and recent numerical results for various benchmark problems.

In order to evaluate the correctness and efficiency of considered techniques several benchmark problems were chosen, including residual stresses analysis in elastic-perfectly plastic bodies under various cyclic loadings. Several benchmark problems of the PBA were also investigated, including smoothing of simulated, as well as true measured beam deflections, and residual stresses reconstruction in the thick-walled cylinder using simulated pseudo-experimental data. The main objective of numerous executed tests was to evaluate the ability of the proposed methods to deal with large optimization problems. Numerical results obtained so far are very encouraging and indicate a clear possibility of practical application of the improved EA to the analysis of such problems. The greatest acceleration was obtained for solution approach using a step-by-step mesh refinement combined with the other techniques. The overall speed-up factor about 120 was reached. It is also worth noticing, that the improved EA allowed obtaining solutions in cases when the standard EA failed due to large number of decision variables.

Future research includes further development of various acceleration techniques, and application of the improved EA to large engineering problems, including theoretical and hybrid experimental-theoretical analysis of residual stresses in railroad rails, and vehicle wheels. Effective application of the improved EA and the PBA approach for smoothing discrete data obtained from any rough numerical solution of the boundary value problem, as well as for solving inverse problems, is also possible.

REFERENCES

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