Improved Evolutionary Algorithms and MFDM Applied to Large Non-linear Optimization Problems of Mechanics

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Improved Evolutionary Algorithms (EA) applied to a wide class of large non-linear constrained optimization problems are considered in this paper. The long-term objective of this research is a significant acceleration of the EA based solution approach and its application to chosen engineering problems of mechanics, including residual stress analysis. In the problems considered, a function given in the discrete form, e.g. expressed in terms of its nodal values, is sought. In order to obtain discrete formulation, any discretization method may be applied, including Meshless Finite Difference Methods (MFDM) [3, 4] considered here.

The standard EA are understood here as real-value coded Genetic Algorithms using three operators: selection, crossover, and mutation [1]. Dedicated approach proposed includes several additional speed-up techniques, namely: smoothing and balancing, step-by-step mesh refinement, a'posteriori solution error analysis combined with non-standard parallel computations, estimation of the convergence point of population, efficient constraint handling techniques, and population averaging [5]. These very general ideas may be applied in many ways. Recent advances in development of all proposed techniques, including searching of the most efficient combinations and numerous parameters, are considered here.

Presented is the efficiency analysis of all speed-up techniques proposed. Simple but demanding benchmark problems are used, including residual stress analysis in chosen elastic-perfectly plastic bodies under various cyclic loadings [2], and problems resulting from the Physically Based Approximation (PBA) of experimental and/or numerical data. Such approximation may simultaneously use all information available for the problem considered: all experimental data obtained by means of various measurement techniques, their statistics, as well as theoretical and/or heuristic knowledge. Chosen benchmark boundary value elliptic problems, with various geometrical shapes are considered as well. All these benchmarks allow to choose almost any number of decision variables involved. The largest executed numerical tests involved more than 3000 decision variables. Results obtained indicate a possibility of practical application of the improved EA to the large optimization problems considered. Each one of the techniques considered allowed for significant acceleration of computations. The final engineering objective of this research includes real complex problems, e.g. residual stress analysis in railroad rails, and vehicle wheels.

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