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INTELLIGENT COMPUTING IN MULTISCALE MATERIALS DESIGN

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This work is devoted to development of an original intelligent computing approach to rational design of materials structures taking into account their actual multiscale state.
The intelligent computing approach is a hybrid system which consists of a 'hard' deterministic FEM solver which is controlled by some soft computing techniques based on bio-inspired methodology as evolutionary, immune or swarm paradigms.

The most important advantages of bio-inspired methodologies are their robustness, great probability of finding the global optimum and easy adaptation to new problems. The main disadvantage is long computation time due to the need of solving hundreds or thousands direct problems during optimization. To speed-up computations parallel and multi-subpopulation approaches are proposed.
Such a hybrid intelligent computing system has some interesting features which enable to reach the global minimum for prescribed objective functional for considered materials bodies.

The intelligent optimization process allows us to find a material structure with best performance or strength in one scale with respect to some design variables in another scale.

The identification problem in which evaluation of some geometrical or material parameters of structures in one scale having measured information in another scale is formulated in the similar way. This task is considered as a special task of the optimization problem.

Problems considered in the paper tackle optimization and identification of microstructure parameters on the base of objective functionals and measured data (displacements, strains or natural frequencies) obtained for the macroscale level.
The proposed approach of identification is one of the most important stage of multiscale modelling because it enables to find some geometrical and/or material parameters of a micro-model in the rational and efficient way. Such parameters are necessary to formulate and solve the direct problems, in framework of the multiscale methodology, for engineering analysis of existed structures.

Optimization and identification performed with the use of the evolutionary, immune and swarm algorithms and multiscale FEM models based on the computational homogenization are considered.
Several numerical examples of optimization and identification of composite and functionally graded engineering materials are presented.