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GLOBAL TOPOLOGY OPTIMIZATION OF TRUSS SYSTEMS USING MODIFIED GENETIC ALGORITHM

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ABSTRACT

Genetic algorithms (GA) are global optimization algorithms simulating a natural evolution mechanism. GA are particularly useful for discrete optimization problems, among them for topology optimization of truss or frame systems. However, GA do not always yield a faster solution compared with other solution methods [1], therefore during the last decade researchers proposed various modifications of GA [2], [3].

The aim of this paper is to present the modified GA, providing better results for the topology optimization of truss systems than the classical GA [4]. In essence, in the modified GA instead of introducing into the set of problem's constraints some physical requirement, an additional stage of algorithm is included: the purification of genotype. For example, instead of the requirement that stresses in the trusses of the system exceed some minimum threshold value, the trusses after the selection, crossover and mutation operations are additionally analyzed, and the values of genes representing under-stressed trusses are reverted (graphically it is illustrated in Fig. 1).

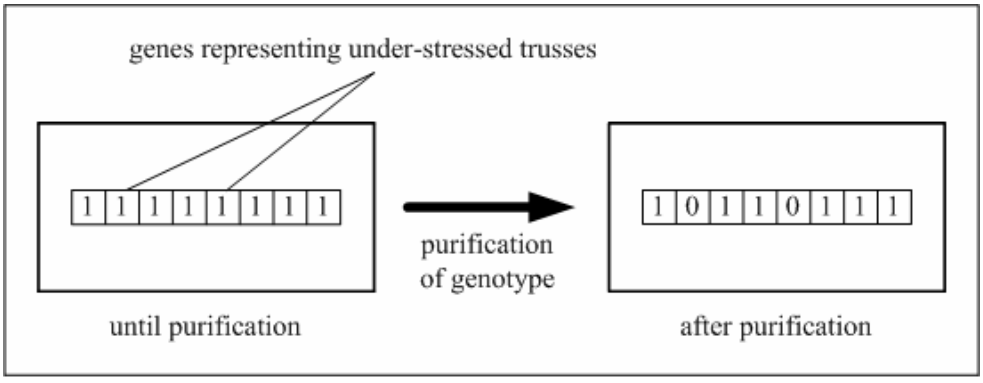

Fig. 1 Purification of the genotype

The problem of truss topology optimization is solved using bespoke software, which comprises the monitor program, library of genetic algorithms, and finite element program supplying the value of objective function. The system of constraints involves equilibrium, stability and maximum allowed stress requirements. The solution results are exported to the database, which allows for comprehensive statistical analysis of results using SQL queries.

The advances of proposed GA are shown in small-scale numerical example, where the global solution with the full search algorithm is feasible. This 8-node truss system was solved also using classical and modified GAs. Statistical analysis showing the dependencies of results of GA on the genetic parameters (crossover and mutation probabilities, population size) was performed. 360 different sets of GA parameters were examined in total; 30 independent numerical experiments with each set of parameters were accomplished – for each genetic algorithm the problem was solved 10800 times.

The results of numerical experiments clearly show that the modified GA renders better solution in a shorter time. Thus, the full search algorithm finds the global solution in 16.5 hr. The modified GA finds the same global solution in 30 % of all cases; the solution time varies in a range from 1 to 5 sec. The global solution, however, was not obtained with classical GA; the best solution exceeded the global one by 17.33 %.

Similar results were obtained also for other numerical examples.

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