Genetic Algorithm with Prediction of Unsuitable Variants Based on Existing Solutions

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Abstract **A modified genetic algorithm is proposed for optimization of the systems of mathematical models described by partial differential equations. This algorithm makes use of automatic prediction of problematic variants from technical and also numerical viewpoints. The algorithm is implemented in the framework OptiLab that represents a part of application Agros2D developed by the authors.**

Keywords **genetic algorithm, constrained optimization, shape optimization**

I. Introduction

Full utilization of genetic algorithms (GAs) for optimization of real engineering problems is conditioned by a correct and accurate formulation of the task. This holds even for the shape optimization that is often uneasy to define (complicated geometrical shapes, solvability of the task and so forth).

The paper presents a modified genetic algorithm whose power was tested on several strongly nonlinear tasks. The principal aim of the proposed implementation is to show the application of the optimization technique which extends standard formulation of optimization task. This technique makes use of constrains dependent on solved variants for prediction of unsuitable combinations of parameters. The algorithm leads to a simplified formulation of the constrained optimization problem and accelerates the process of finding the optimum solution.

II. Proposed Algorithm

With respect to the fact that finding parameters during optimization by GAs represents a random process, a great attention has to be paid to the selection of their limits and constraints to avoid their unacceptable combinations and also stabilize numerical solution of the models. This is reached by applying the parameter limits and standard constrains.

The standard optimization problem can be formulated as

$$\text{minimize} \quad \boldsymbol{F}(\boldsymbol{x}), \quad \boldsymbol{x} = (x_1, \ldots, x_i, \ldots x_n) \in \mathrm{R}^n, \qquad (1)$$

where $\boldsymbol{F}$ denotes vector of functionals and $\boldsymbol{x}$ vector of parameters. Search space is limited by lower and upper bounds of parameters defined by relation

$$l(i) \leq x_i \leq u(i), \; 1 \leq i \leq n, \qquad (2)$$

where $l(i)$ and $u(i)$ are the functions representing the lower and upper bounds, respectively. The standard optimization constraints can be described by formulae

$$h_j(\boldsymbol{x}_i) = 0, \; j \in (q+1, \ldots, m), \qquad (3)$$

$$g_j(\boldsymbol{x}_i) \leq 0, \; j \in (1, \ldots, q), \qquad (4)$$

where h_j is equality constraint function and g_j inequality constraint function. The proposed algorithm uses also constraints given by the following relations

$$h_j(\boldsymbol{x}, \boldsymbol{x}_k, \boldsymbol{y}_k, \boldsymbol{F}_k) = 0, \; j \in (q+1, \ldots, m), \; k \in (1, \ldots, i-1),$$

$$g_j(\boldsymbol{x}, \boldsymbol{x}_k, \boldsymbol{y}_k, \boldsymbol{F}_k) \leq 0, \; j \in (1, \ldots, q), \; k \in (1, \ldots, i-1),$$

where $\boldsymbol{x}_k$ is the vector of parameters of already solved models, $\boldsymbol{y}_k$ represents their solutions and $\boldsymbol{F}_k$ is the vector of objective functionals. The basic scheme of the proposed algorithm is shown in Fig. 1.

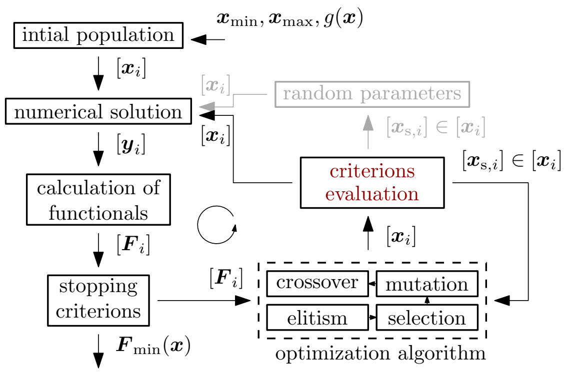

Fig. 1. Principal scheme of proposed algorithm

III. Conclusion

The main goal of the proposed algorithm is to improve constrained GAs and include there further constrains dependent on existing solutions of the models. From several numerical tests with standard testing optimization functions it is obvious that the modification makes the formulation of the problem easier and leads to a substantial acceleration of computations.

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