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ADVANCED OPTIMAL DESIGN USING ARTIFICIAL IMMUNE SYSTEM

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ABSTRACT

1. Introduction

The paper deals with an application of the artificial immune system (AIS) and the finite element method to the optimization problems of 2-D and 3-D structures. The optimization method concerns the simultaneous optimization of topology, shape, and material. This approach is based on the mechanism discovered in biological immune systems. The main advantage of the AIS is the fact that this approach does not need any information about the gradient of the fitness function and gives a strong probability of finding the global optimum.

2. The artificial immune systems

The artificial immune systems are developed on the basis of a mechanism discovered in biological immune systems. An immune system is a complex system which contains distributed groups of specialized cells and organs. The main purpose of the immune system is to recognize and destroy pathogens - funguses, viruses, bacteria and improper functioning cells. The lymphocytes cells play a very important role in the immune system. The lymphocytes are divided into several groups of cells. There are two main groups B and T cells. The B cells contain antibodies, which could neutralize pathogens and are also used to recognize pathogens. The artificial immune systems take only a few elements from the biological immune systems. The most frequently used are the mutation of the B cells, proliferation, memory cells, and recognition by using the B and T cells. The presented approach is based on the Wierzchoń S. T. algorithm [1], but the mutation operator is changed. The Gaussian mutation is used instead of the nonuniform mutation in the presented approach.

3. Formulation of the problem

The immune process proceeds in the environment in which the structure fitness is described by the minimization of the mass of the structure with constraints imposed on

equivalent stresses and displacements of the structure. During the immune optimization process the domain of the structure, its boundary and the field of mass densities can change for each iteration. The distribution of mass density $\rho(X)$, $(X)\in\Omega_t$ or thickness $g(X)$, $(X)\in\Omega_t$ in the structure is described by a surface $W_\rho(X), W_g(X), (X)\in H^2$ (for 2-D) or a hyper surface $W_\rho(X), (X)\in H^3$ (for 3-D). The surface (hyper surface) $W_\alpha(X), \alpha=\rho,g$ is stretched under $H^d\subset E^d, (d=2,3)$ and the domain Ω_t is included in H^d, i.e. $(\Omega_t\subseteq H^d)$. The shape of the surface (hyper surface) $W_\alpha(X), \alpha=\rho,g$ is controlled by parameters of B-cell receptor dj, j=1,2,…,G, which create a B-cell $bc=\langle d_1,d_2,...,d_j,...,d_G\rangle$, $d_j^{\min}\le d_j\le d_j^{\max}$ where $d_j^{\min}$, $d_j^{\max}$ - are minimum and maximum values of the parameters of B-cell receptor, respectively. B-cell receptors are the values of the function $W_\alpha(X)$, $\alpha=\rho,g$ in the control points $(X)_j$ of the surface (hyper surface), i.e. $d_j=W_\alpha\left[(X)_j\right]$, j = 0,1,2,...,G.

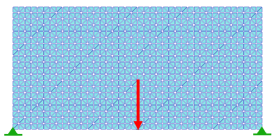
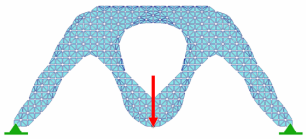
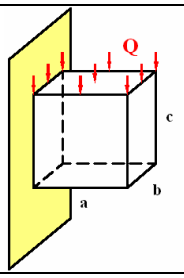
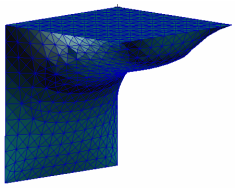
The material properties of finite elements change by means of the proposed method and some of them are eliminated. As a result the optimal shape, topology and material of the structures are obtained.

4. Numerical examples

Two numerical examples are considered, i.e. the optimization of the shape, the topology and the mass density of a plate in plane stress and a 3-D solid body.

The structures are considered in the framework of the theory of elasticity. The results of the examples are obtained by using an optimization method based on the artificial immune system.

Table 1. The results of the optimization

	Geometry and the loading	The optimization results
2-D structure		
3-D structure		

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REFERENCES

[1] S. T. Wierzchoń, Artificial Immune Systems, theory and applications, EXIT, 2001 (in Polish).