# Optimization of structural topology using unstructured Cellular Automata

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**Abstract**

For a few decades topology optimization has been one of the most important aspects of structural design. One of the most important issues stimulating permanent development of this research area is implementation of efficient and versatile methods for generation of optimal topologies. Many modern computational techniques are nowadays invented so as to perform similarly to biological systems. They have gained widespread popularity among researchers because they are easy for numerical implementation, do not require gradient information, and one can easily combine this type of algorithms with any finite element structural analysis code. Among biologically inspired methods, which have recently aroused interest of designers one can find also Cellular Automata (CA). The idea of Cellular Automata is to replace a complex problem by a sequence of relatively simple decision making steps. In engineering implementation of Cellular Automaton the design domain is decomposed into a lattice of cells, and a particular cell together with cells to which it is connected form neighborhood. It is assumed that the interaction between cells takes place only within the neighborhood, and the states of cells are updated synchronously in subsequent time steps according to some local rules. In recent years the Cellular Automata concept has been successfully applied to structural topology optimization problems. The majority of results that have been obtained so far were based on regular lattices of cells. Practical engineering analysis and design require however using, in many cases, highly irregular meshes for complicated geometries and/or stress concentration regions. The aim of the present paper is to extend the concept of Cellular Automata towards implementation of unstructured grid of cells related to non-regular mesh of finite elements. Introducing irregular lattice of cells allows to reduce number of design variables without loosing accuracy of results and without excessive increase of number of elements caused by using fine mesh for a whole structure. It is worth noting that the non-uniform density of finite elements can be, but not necessary is, directly related to design variables which are related to cells of Cellular Automaton. The implementation of non-uniform cells of Cellular Automaton requires a reformulation of standard local rules, for which the influence of neighborhood on current cell is independent of sizes of neighboring cells.

**Keywords:** topology optimization, Cellular Automata, unstructured mesh.