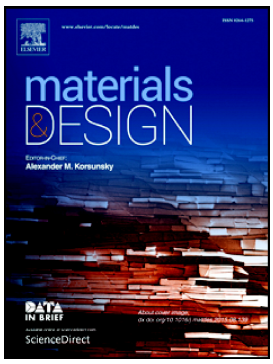
Accepted Manuscript



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PII: S0264-1275(17)31161-9
DOI: https://doi.org/10.1016/j.matdes.2017.12.047
Reference: JMADE 3598

To appear in: *Materials & Design*

Received date: 21 September 2017
Revised date: 21 December 2017
Accepted date: 25 December 2017

Please cite this article as: Yafeng Han, Wenfeng Lu , Evolutionary design of nonuniform cellular structures with optimized Poisson's ratio distribution. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Jmade(2017), https://doi.org/10.1016/j.matdes.2017.12.047

Evolutionary design of nonuniform cellular structures with optimized Poisson's ratio distribution

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Abstract:

For negative Poisson's ratio (NPR) cellular structures, most previous research focus on the design of unit cells, and then repeat the unit cell to construct uniform cellular structures. However, there is a disadvantage that these structures do not have much design freedom to achieve high-level functions, such as performing a desired deformation. As a solution, an evolutionary design method is proposed to develop nonuniform cellular structures. To conduct this method, the design domain is divided into finite unit cells with tunable Poisson's ratio (PR). With a given objective deformation, the value of each unit cell's PR is optimized using evolutionary algorithm (EA). In order to reduce the computational cost of the algorithm, discrete cosine transform (DCT) is applied to encode the structure for evolving. Considering the geometrical complexity of the optimized nonuniform cellular structures, additive manufacturing (AM) is chosen to build them physically. Both two-dimensional (2D) and three-dimensional (3D) design cases were developed and analyzed to validate the proposed method. The computational and experimental results showed good conformation with each other. Most importantly, this novel design method brings huge potential to NPR cellular structures with high-level functions and much wider applications.

Keywords:

Nonuniform cellular structure, Poisson's ratio, evolutionary algorithm, re-entrant structure, additive manufacturing.