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Development of a Graded Lattice Structure Design and Optimization Method with Complex Boundary Surface Constraints

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ABSTRACT

Graded lattice structures (GLS) are used widely in the areas of 3D printed sensors, personalized wearable devices, robotics, energy absorption, etc., and have a prospective future in the field of personalized medical devices. The large-scale applications of GLS-based personalized medical devices require a GLS design method that could handle the challenges caused by diverse boundary surface constraints and various requirements of graded mechanical properties [1,2], due to patient-specific care needs. In this work, the proposed automatic seed generation algorithm-based GLS design approach is a prospective solution to promote the wide application of GLS-based personalized medical devices [3,4]. The core idea of the proposed GLS design and optimization approach is (a) using an automatic point cloud generation algorithm to generate nonuniform seed distributions inside a domain with any shape; (b) raw GLS is then generated based on the seed distribution; (c) the radius of the raw GLS is further optimized based on finite element truss analysis. As seed distributions are generated according to the required boundary shapes of the target GLS and the graded mechanical properties are optimized based on finite element analysis, the resulting GLS is guaranteed to satisfy the requirements of boundary constraints and graded mechanical properties. Finally, several demos including a 3D-printed shoe sole, a bone scaffold, and an energy absorber are created, and the results indicate that the proposed GLS design and optimization method works very well.

KEYWORDS

Lattice structure; graded lattice structure; structure optimization; finite element analysis

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