Design of General Lattice Structures for Lightweight and Compliance Applications

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Abstract
The primary goal is to design parts with lattice mesostructure and demonstrate that they have better structural and/or compliance performance, per weight, than parts with bulk material, foams, or other mesostructured approaches. Mesostructure refers to features within a part that have sizes between micro and macro-scales, for example, small truss structures, honeycombs, and foams. The versatility of additive manufacturing allows for the fabrication of these complex unit cell lattice structures which can be used as building blocks for macro-scale geometries. A method and software system have been developed to synthesize lattice mesostructure parts and compliant mechanisms in 2D and 3D. Underlying the synthesis method is a new analytical model of unit lattices, used to compose larger structures. Axial, bending, shearing, and torsion effects are included in the analysis for each strut in the lattice structure which is then related to the mesostructure level (unit cell). A unit lattice finite element analysis method allowing nonlinear deformation is employed to analyze a unit cell comprised of n[3] unit structures for their stiffness and displacement compared to their relative density under loading. Aerospace and biomedical applications are demonstrated.

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As light-weight applications entail the use of strong but low-density materials, aluminium alloys are generally used. Light-weight steel-aluminium alloys have its share in the automotive and civil industry However, new approaches in fabrication techniques are leading to the increased use of fibre reinforced plastics. Lattice structures are recognized for their advantages in providing lightweight, stiff and shock-resistant structures. In this work, they are used to create a strong, lightweight metal antenna, which is even comparatively lighter than the metal-coated 3D printed polymer antenna, and with higher structural strength.