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ABSTRACT

A methodology is proposed for uncertainty quantification and validation to accurately predict the mechanical response of lattice structures used in the design of scaffolds. Effective structural properties of the scaffolds are characterized using a developed multi-level stochastic upscaling process that propagates the quantified uncertainties at strut level to the lattice structure level. To obtain realistic simulation models for the stochastic upscaling process and minimize the experimental cost, high-resolution finite element models of individual struts were reconstructed from the micro-CT scan images of lattice structures which are fabricated by selective laser melting. The upscaling method facilitates the process of determining homogenized strut properties to reduce the computational cost of the detailed simulation model for the scaffold. Bayesian Information Criterion is utilized to quantify the uncertainties with parametric distributions based on the statistical data obtained from the reconstructed strut models. A systematic validation approach that can minimize the experimental cost is also developed to assess the predictive capability of the stochastic upscaling method used at the strut level and lattice structure level. In comparison with physical compression test results, the proposed methodology of linking the uncertainty quantification with the multi-level stochastic upscaling method enabled an accurate prediction of the elastic behavior of the lattice structure with minimal experimental cost by accounting for the uncertainties induced by the additive manufacturing process.