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AI-Driven Design of Lattice Structures for Enhanced Endoprosthesis Performance

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Abstract:

Open-pore lattice structures offer versatile design possibilities for various applications including arthroplasty, where they have demonstrated the potential to enhance bone ingrowth. However, the vast range of geometric configurations and customization options complicates the selection of the optimal lattice structures. This study introduces an AI-supported design workflow for generating lattice structures to enhance the performance of endoprostheses manufactured from Ti-6Al-4V. The AI-driven approach allows for the customizability of endoprostheses and is expected to promote bone ingrowth and natural load distribution between bone and prosthesis. Initially, a comprehensive database is established, comprising a variety of unit cell structures including those inspired by aquatic plankton organisms such as diatoms and Radiolaria. From these, regular, uniform, open-pore lattices are generated. The design parameters including unit cell selection, material thickness, and cell orientation are fully customizable, allowing the adaptation of the generated lattice to meet the functional requirements of endoprostheses. This flexibility enables structural optimizations in terms of the weight of a patient, bone porosity, mechanical strength, and manufacturability. Using advanced algorithms and neural networks, the AI analyzes a database of over 40,000 configurations to recommend optimal lattice designs based on user-defined inputs. This tool streamlines the design process by aiding in the selection of appropriate lattice configurations for endoprostheses, resulting in highly optimized structures.

Keywords:

Deep learning, Optimization, Healthcare, Hip Implant, Lightweight design.