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Multiobjective topology optimization of trabecular Bone Structure in the spine and the femur: Implications for biomimcry[1] AHMED ELBANNA, DARIN PEETZ, University of Illinois Urbana Champaign — Bone is classically considered to be a self-optimizing structure in accordance with Wolff's law. However, while the structure's ability to adapt to changing stress patterns has been well documented, whether it is fully optimal for compliance is less certain (Sigmund, 2002). Given the complexity of many biological systems, it is expected that this structure serves several purposes. We present a multi-objective topology optimization formulation for trabecular bone in the human body at two locations: the vertebrae and the femur. We account for the effect of different conflicting objectives such as maximization of stiffness, maximization of surface area, and minimization of buckling susceptibility. Our formulation enables us to determine the relative role of each of these objective in optimizing the structure. Moreover, it provides an opportunity to explore what structural features have to evolve to meet a certain objective requirements that may have been absent otherwise. For example, inclusion of stability considerations introduce numerous horizontal and diagonal members in the topology in the case of human vertebrae under vertical loading. However, the stability is found to play a lesser role in the case of the femur bone optimization. Our formulation enables investigation of bone adaptation at different locations of the body as well as under different loading and boundary conditions (e.g. healthy and diseased discs for the case of the spine). We discuss the implications of our findings on developing design rules for bio-inspired and bio-mimetic architectured materials.

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