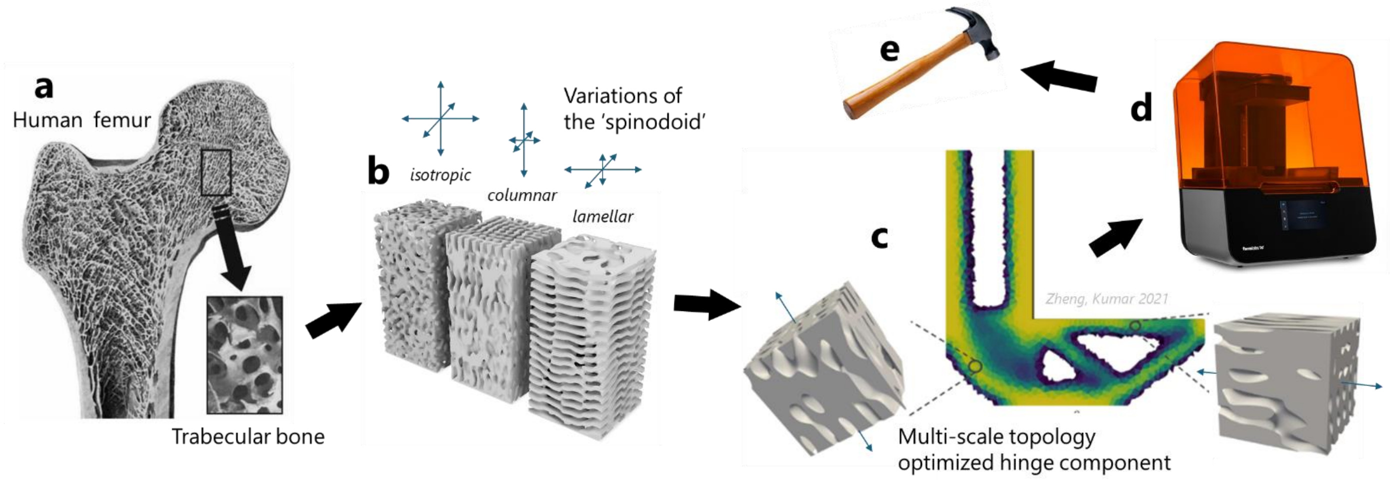
Faculty of Aerospace Engineering
Deptartment of Structures and Materials

BSc/MSc thesis, semester project or internship opportunity

Multiscale topology optimization and additive manufacturing of porous materials for tuneable, strong and light structural components

Porous materials feature high specific strength, damage resistance and tolerance to off-axis loading. For these reasons, such materials are often found in nature. Many biological materials also exhibit local variations in the degree of porosity and its orientation, resulting a gradual change in mechanical properties throughout the structure. This allows structures like the human femur (a) to conform optimally to stresses on two levels: their overall shape and the microstructure distributed within that shape. This hierarchical materials design is very efficient.

A recently developed, tuneable material known as the spinodoid is a porous, bi-continuous structure closely resembling trabecular bone (b). Multi-scale topology optimization algorithms have been developed for this material, enabling the design of graded, bone-like structures (c). However, their manufacturability and real-world mechanical performance have not yet been rigorously validated or compared to other approaches, such as the optimized porous infill by Wu et al. (TVCG 2018) or conventional generative design without porosity. This thesis aims to address that gap.



Research activities:
During this thesis, you will have the opportunity to design, fabricate, and test multiscale structural components with optimized spinodoid microstructures. Using an existing topology optimization algorithm, you'll generate and 3D print optimized designs using advanced additive manufacturing tools (d). You will investigate their mechanical performance (e), their tuneability range as well as their manufacturing constraints. You can also compare the performance of the optimized spinodoid microstructure to other approaches, such as the 'optimized infill' approach and traditional generative design. You could also expand the algorithms to multi-objective optimization by including manufacturing constraints into the algorithm.

Requirements:
This project combines theory and practice across multiple disciplines. Ideally, you have some experience with topology optimization or FEM simulations, 3D printing, coding and some knowledge of mechanics as well as an interest in materials science. We can of course tailor the exact project requirements based on your profile. If you're interested, send an email to: **c.lankhof@tudelft.nl** and read about our group at **shapingmatterlab.com**