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Exploring the Potential of Bio-Inspired Lattice Structures for Dynamic Applications in Design

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Abstract : For centuries, the forming processes in nature served as a source of inspiration for both architects and designers. It seems as most human artifacts are based on ideas which stem from the observation of the biological world and its principles of growth. As a fact, in the cultural history of Homo faber, materials have been mostly used in their solid state: From hand axe to computer mouse, the principle of employing matter has not changed ever since the first creation. In the scope of history only recently and by the help of additive-generative fabrication processes through Computer Aided Design (CAD), designers were enabled to deconstruct solid artifacts into an outer skin and an internal lattice structure. The intention behind this approach is to create a new topology which reduces resources and integrates functions into an additively manufactured component. However, looking at the currently employed lattice structures, it is very clear that those lattice structure geometries have not been thoroughly designed, but rather taken out of basic-geometry libraries which are usually provided by the CAD. In the here presented study, a group of 20 industrial design students created new and unique lattice structures using natural paragons as their models. The selected natural models comprise both the animate and inanimate world, with examples ranging from the spiraling of narwhal tusks, off-shooting of mangrove roots, minimal surfaces of soap bubbles, up to the rhythmical arrangement of molecular geometry, like in the case of SiOC (Carbon-Rich Silicon Oxicarbide). This ideation process leads to a design of a geometric cell, which served as a basic module for the lattice structure, whereby the cell was created in visual analogy to its respective natural model. The spatial lattices were fabricated additively in mostly [X]3 by [Y]3 by [Z]3 units' volumes using selective powder bed melting in polyamide with (z-axis) 50 mm and 100 µm resolution and subdued to mechanical testing of their elastic zone in a biomedical laboratory. The results demonstrate that additively manufactured lattice structures can acquire different properties when they are designed in analogy to natural models. Several of the lattices displayed the ability to store and return kinetic energy, while others revealed a structural failure which can be exploited for purposes where a controlled collapse of a structure is required. This discovery allows for various new applications of functional lattice structures within industrially created objects.

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