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INTEGRATING FUNCTIONALITIES USING 3D PRINTING: NATURE AS A MODEL

THE TASK

Nature provides ingenious solutions for many shapes and geometries with an almost perfect balance of strength, lightweight construction, and functionality. These structures optimized by nature inspired Leonardo da Vinci to translate them into engineering and to draft and design wings for flying machines.

Nature frequently uses recurring elements, such as networks of veins or the cellular structure at the core of bones, which in detail are distinct in terms of shape and size. Elements that are so rich in detail and geometrically indefinite, pose enormous challenges for technical design and manufacturing.

The variety of shapes found in nature and in existing components can be produced by means of advanced additive manufacturing techniques and optical reverse engineering tools. This not only lends freedom in design, but also allows for the integration of functions, such as hinged joints, and for changes in size by scaling.

OUR SOLUTION

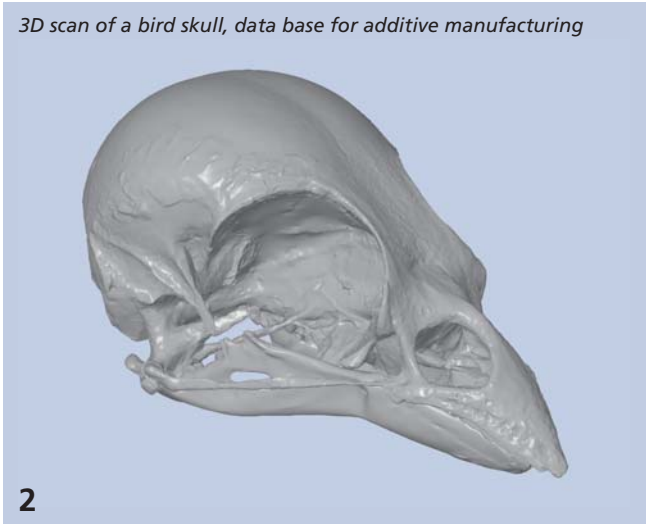
For additive manufacturing, the Fraunhofer IWS Dresden utilizes powder bed or nozzle based techniques to directly replicate natural and technical objects flexibly and without tools. The IWS is also equipped with various instruments for reverse engineering, used to digitally reconstruct objects through the generation of geometric data.

Laser buildup welding with powder or wire, and laser and electron beam melting, can be used for additive manufacturing. Design engineering can be simplified and sped up by reverse engineering thanks to the optical measurement systems for 3D scanning.

An object consisting of several components is to be buildup in one build job with minimal post-processing, i. e. without additional joining operations for hinges or spring elements.

The Fraunhofer IWS creates solutions to implement the process tailored to object size and complexity, considering all of the steps of the process holistically: geometry data acquisition, analysis of technology and strategy, CAD-/CAM manufacturing, process monitoring and control, post-processing and component inspection or analysis, etc.

3D scan of a bird skull, data base for additive manufacturing



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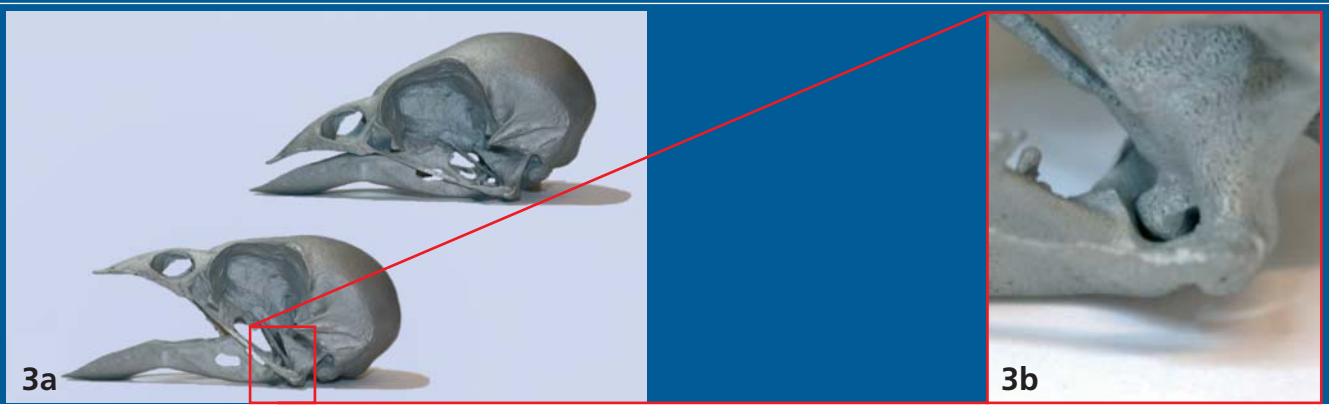


RESULTS

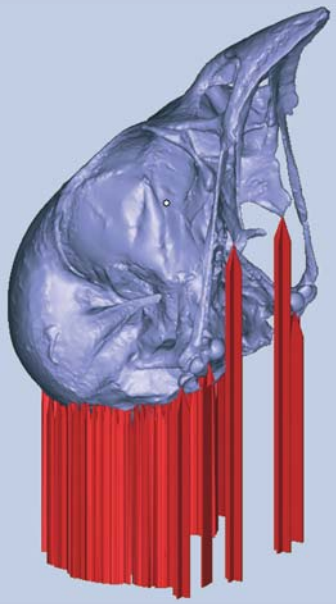
The process chain for the integration of functional elements by 3D printing is demonstrated for the replication of a common swift's cranial bone (Fig. 1). The original skull has cavities – eye sockets and the brain cavity –, as well as two hinges between the skull and the beak.

The replica, or the metal common swift, was laser melted in 1:1 and 4:1 scale. The building strategy was derived from the polygon-based 3D scan of the original skull (Fig. 2). The building direction and required support structure are illustrated in Figure 4.

Mobility of the beak hinge is shown in Figure 3. The hinge consists of an articulated cavity and head. These interlinked elements were built in one print cycle. As in the original, they make it possible to open and close the beak.

The replication of natural structures and functional elements by making use of technical materials can extend component design with many approaches optimized by nature. This also opens up potential applications in the field of rail transport and the aerospace sector, where highly stable, low weight components are needed.

Data conditioning for laser beam melting, positioning and building direction



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1 Original and replica of a bird skull

3a Functional integration, moveable beak

3b Detailed image of the printed hinge

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