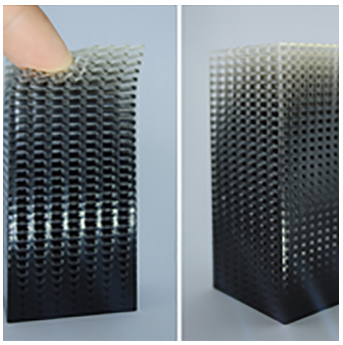
Lancaster University Pushes Design Limits with GrabCAD Voxel Print Technology

4D PRINTING AND SHAPE-SHIFTING TECHNOLOGY ON THE HORIZON

"With voxel printing that has the capability of a trillion voxels in the space of the printer and six different materials, the number of possible combinations is six to the power of a trillion, which is an astronomical number."

– Dr. Daniel Richards, Lancaster University

CASE STUDY

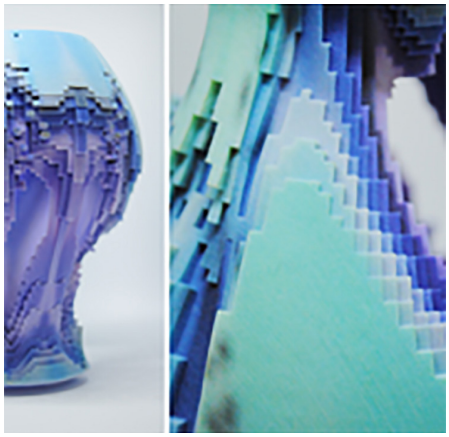


Functionally graded lattice structure with seamless blends of multi-materials.

CREATIVE CONSTRAINTS

ImaginationLancaster, part of The Institute for the Contemporary Arts at Lancaster University in the U.K., focuses not just on art and design but on those paths that will foster design skills to tackle future real world issues. This creative research center enables people and organizations to engage with academia in creative ways. Their broad mission can leave a gap between creative vision and the tools available to fulfill that vision. For Dr. Daniel Richards, a lecturer at Lancaster University, whose research area is computational design or how complex objects can be fabricated with new technologies, the question driving his research is: what is the future of Computer Aided Design (CAD) for advanced manufacturing?

Richards believes there is a need to radically rethink how designers, artists and engineers conceive, model and edit complex multi-material structures, and then efficiently output them. While additive manufacturing, or 3D printing, has virtually unlimited design capabilities, Richards says there are “actually some really severe limitations in terms of the available software.” His research is not looking at small, incremental changes to existing, well-established CAD packages, but rather he is trying to create entirely new CAD environments for emerging manufacturing methods. “I wanted to see what would happen if I start to mix in really fundamental disruptive changes to these. What would that allow me to do?”

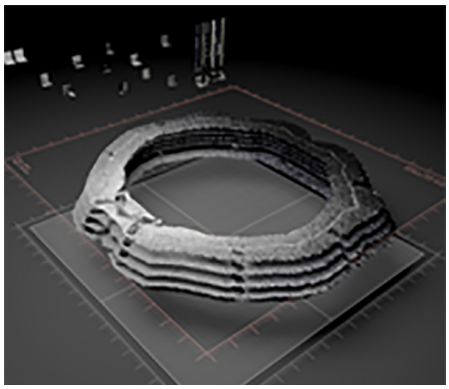


Low resolution 3D printable volumetric texture. Vector-based volumetric textures can be designed and applied to objects allowing them to be fabricated in any resolution with GrabCAD Voxel Print.

Richards began to integrate some complicated algorithms into the software and “the benefit is I can start to do some really interesting manipulations of the information that produce physical forms that I can optimize in so many ways,” said Richards. “But there are trade-offs. Designers don’t really want to operate on that level of complexity. They want software to be relatively simple. And so the mission became ‘how can we do that?’” In the end, says Richards, “the real problem is how do you enable people to use it? And it’s a lot more difficult than I thought it was going to be.”

Six to the Power of a Trillion Design Possibilities

Richards’ academic inquiry into 3D design manipulation preceded his tenure at Lancaster, but gained traction once he accepted the position and saw they had a Stratasys J750™ 3D Printer on site. It’s then that Richards began to push state-of-the-art CAD to the breaking point in order to explore applications of advanced multi-material additive manufacturing in industry. The critical breakthrough for Richards came when his inquiries caught the attention of Stratasys, who invited Richards to participate in their GrabCAD Voxel Print™ Research Program.



Concept interface design for creating volumetric textures with Compositional Pattern Producing Networks.

“The GrabCAD Voxel Print software tool has completely transformed how we can make things,” said Richards. “I was blown away when I realized how many voxels you have available with this. Imagine sitting down to a trillion pieces of Lego and what you could make with that. The next question is how you do it,” said Richards. The answer for Richards is developing printable and evolvable volumetric texture maps as a new way of modeling complex objects for voxel printing.

Traditional voxel modeling techniques are derived from medical imaging, the type done with MRI and CT scans using a Cartesian grid on the x, y and z axis. “You define your object within a conventional Cartesian grid of voxels. Anywhere that part of the design touches a voxel, you switch that voxel on, define the properties of that voxel, then take your object out and you’ve got a voxelized model ready for printing with Voxel Print technology.”

Richards’ research is more like coloring outside the lines and inside the model. “What if we weren’t limited by a Cartesian voxel grid? What if we used a weird neural network-based approach to actually create the voxel space that warps and shapes an existing piece of geometry? We could then define all the internal properties within that, as a function of itself, and then work out a way of slicing that irregular voxel grid into a new voxel grid for printing,” said Richards.

The research Richards and his team are conducting takes surface designs and wraps them in unconventional voxel grids. “If traditional voxel modeling approaches take an object and place it in a world made up of neatly arranged 3D pixels, this approach takes an object and wraps a ‘world’ of potentially irregular 3D pixels, turning it into a ‘deep surface,” said Richards. “The idea that started this is what if you could somehow have this voxel which not only knew where it was within the x,y,z space, but it also knew where it was in relation to something else – some other geometry. And then, how you could start to use that information,” said Richards. This change to the existing methodology might sound complicated but it enables “some really useful algorithms from artificial intelligence (AI) and data science research to be used to discover complex multi-material designs.”

This research goes well beyond the theoretical. “The idea is that we’re going to start to explore applications that have seamless graduation between materials. The combination of our method with Voxel Print opens up applications beyond prosthetics, the medical arena and aerospace. There are probably applications which we haven’t even thought of,” said Richards. “The ultimate goal is to explore applications in high-value manufacturing.”

The next frontier in this process is 4D printing and shape-changing materials, says Richards. “You’re no longer just designing a static object; perhaps you’re designing something which can either bend in certain ways or has certain material properties that can completely transform and change shape. With voxel printing that has the capability of a trillion voxels in the space of the printer and six different materials, the number of possible combinations is six to the power of a trillion, which is an astronomical number,” said Richards.

The design space is limitless, says Richards, and the applications are as well. “Robots without hinges. The ability to print a working robot that could be a shape-changing or moving object.” Richards says aerospace companies are already looking at designing wings that can bend, so that it’s not just flaps that lower but actually the whole wing that morphs. “There are some major benefits for military plane designs or high-performance planes,” said Richards, and this is only the beginning.

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