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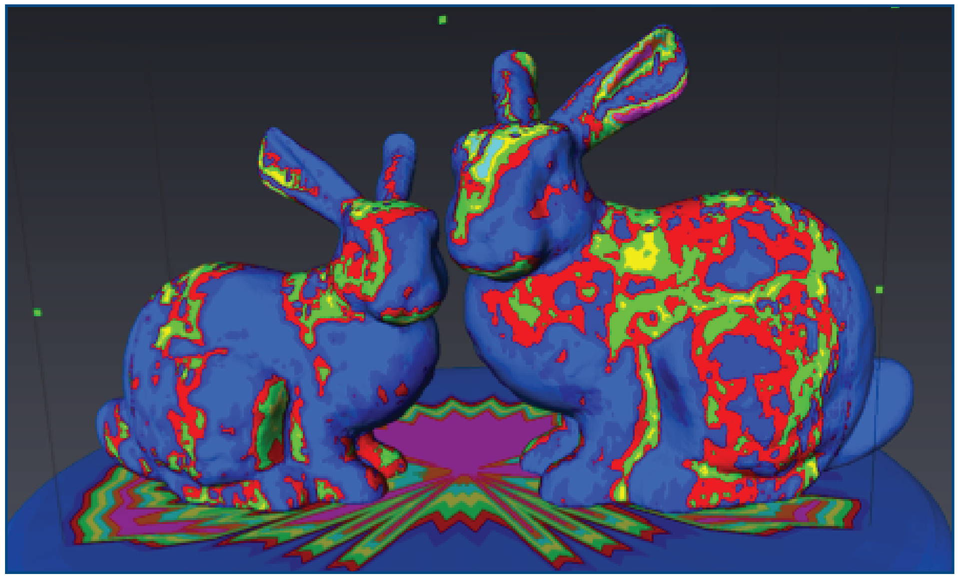
New X-ray Technology Improving 3D Printing Accuracy and Testing

The 3D printing industry is expanding rapidly into the mass market, allowing endless possibilities for inexpensive fabrication of commercial and consumer products.

To print an object, one first scans the object to create a datafile with points and triangles that mathematically define the exterior and interior surfaces of an object. It can take thousands of points to define the surface of an object in 3D. The 3D printer prints the object one "slice" at a time by laying down successive layers of plastic or metal ink, attempting to print up to, but not past, the mathematical surfaces. Since the polymer inks are heated to flow, there is a delicate balance between polymer flow, print speed, and print accuracy.

A tremendous advantage of 3D printing is reproducing specialized parts. For example, NASA researchers are developing 3D printers and highly specialized metal and polymer printing mediums that can be used by crew members aboard the International Space Station to print replacement parts. For this type of precision application, accuracy of the internal and external structures of these printed parts is of immense importance.

Being able to visualize the surface and interior of a 3D printed object will allow researchers and industry to develop 3D printing heads and software that create stronger and more accurately reproduced objects. Having the ability to compare machined parts with the printed parts inside and out is a vital part of this developmental process.



Two copies of the "Stanford Bunny," a 3D test computer model developed by researchers at Stanford, have been printed in plastic from a 3D printer. The image coloring represents the dimensional error between the print file and the plastic bunnies measured with X-ray tomography.

Dr. Les Butler, researcher with the NSF-funded Louisiana Alliance for Simulation-Guided Materials Applications (LA-SiGMA) consortium and Professor of Chemistry at Louisiana State University is leading a team of researchers who are developing an X-ray tomography and interferometry for the synchrotron at LSU's Center for Advanced Microstructures and Devices (CAMD).

Sometime in the near future, it will be possible to print out an electronic device, like a phone charger. Imaging objects containing both polymers and metals, like a simple phone charger, is difficult with conventional X-ray imaging, hence the need for interferometry to image structures and defects in these complex objects.

The X-ray interferometer system is unique because it will simultaneously create three images: 1) the traditional shadow X-ray image that measures the absorption of X-ray energies, 2) a phase-contrast image, which measures the phase shift changes of the X-ray beam as it bends while passing through the object, and 3) a dark field image showing the effect of X-rays scattered by extremely small defects in the object.

This combination of images will produce high quality sensitive detection of defects and complex structures within objects. For example, in the image above, researchers compared

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two computer test models taken by scanning a ceramic bunny with the 3D printed versions. To our eyes, the print model appears to be a larger, exact reproduction; however, the colormaps show dimensional errors on the order of a hundred microns.

A traditional X-ray image shows structures like bones very well, but it does not have good contrast resolution for structures that absorb X-rays at a similar rate, like soft tissues. The trio of images produced by the new X-ray interferometer has the potential to greatly transform the future of medical imaging.

Dr. Dan Hayes, Assistant Professor at the LSU AgCenter, is leading a research team conducting early experimental tissue engineering research with the X-ray interferometer. They are developing a unique medical device called a bioscaffold. These synthetic grafts are surgically applied to tissue, skin or broken bones to support them while they regenerate new tissue and heal.

The scaffolds, designed to dissolve over time, also contain silver nanoparticles that reduce bacterial growth and aid the growth of human adipose-derived stem cells.

Part of the instrument team at the LSU CAMD tomography/interferometry beamline. Pictured, left to right: Kyungmin Ham, Bolaji Olatinwo, Gerry Knapp, Les Butler, and Don Patterson.

Monitoring the bone and tissue growth and the integrity of the test bioscaffolds would be impossible with a traditional X-ray, so they are going to utilize the interferometer to test and monitor the bioscaffolds during the healing process in mice subjects.

Dr. Daniel Hayes

The medical community is intensely focused on developing this imaging technology into the next generation of CT scanners. Being able to see contrast in soft tissues would be immensely helpful for visualizing small tumors, tumor boundaries, tissue, cartilage and blood vessels. Not only would imaging be improved with this technology, but the radiation dose to the patient would be significantly reduced as well.

The development of this technology for human medicine is still in the early experimental stages, but mammography is touted as one of the best applications for the first future experimental medical devices.

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