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Digitization, Documentation, and Democratization: 3D Scanning and the Future of Museums

On July 3, 2013, flaring tempers matched the scorching heat of the Sahara Desert in Egypt, where the military arrested President Mohamed Morsi just a year into his presidency in response to widespread civil unrest.

King Tut's gold funerary mask.

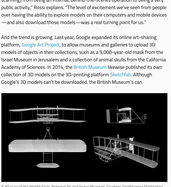
The military coup catalyzed a wave of violence across the country as Morsi supporters clashed in the streets with Morsi opponents. Along with hundreds of lives, the casualties included more than 1,000 historic artifacts that were stolen or destroyed when looters pillaged the Malawi National Museum, an archaeological museum in the Nile River city of Minya, south of Cairo. A 3,500-year-old limestone statuette of King Tutankhamun's sister was lost, along with ancient animal mummies, jewelry, pottery, coins, and coffins—objects that had survived thousands of years only to disappear in an instant.

It was a stark reminder: Although they exist to protect and preserve the priceless objects inside them, museums are not invincible.

That's not the only threat. Artifacts also can be lost to time, terrorism, vandalism, weather, and even accidents. Egyptian artifact, King Tut's gold funerary mask, was damaged last year by a botched cleaning job.

Physical preservation isn't enough. To truly safeguard humanity's treasures, museums have also been leveraging digital preservation techniques like 3D scanning, modeling, and documentation, according to Adam Metallo and Vincent Rossi, 3D program officers in the Digitization Program Office at the Smithsonian Institution in Washington, D.C. Since 2010, the Digitization Program Office has been working to digitize the more than 138 million objects in the Smithsonian's collection using a range of 3D scanning technologies, including laser scanning, CT scanning, structured-light scanning, and photogrammetry.

"Not too long ago, we had an earthquake here in D.C., so things happen," Metallo says. "No amount of documentation can ever replace our collections—we will always maintain the collections. But documenting our first priority—but using 3D technologies to digitize objects can help mitigate the impact of events that could put them at risk."

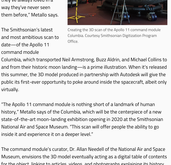


Lincoln Life Mask, National Portrait Gallery. Courtesy Smithsonian Digitization Program Office.

Indeed, historians can skew better at night knowing that museums such as the Smithsonian are using technology to create digital "backups" of their collections. Documentation is only step one, however. According to Metallo and Rossi, known affectionately to their colleagues as the "laser cowboys," step two is democratization.

"The founding principle of the Smithsonian is the diffusion of knowledge," Metallo says. "Two hundred years ago, that meant diffusion of knowledge through a school or museum. If you think about what it means that the Smithsonian were founded today, obviously, you would think about harnessing the internet and new digital architectures available digitally."

"Our fairly monumental task today is making good on our founding principle in a way that allows us to deliver the amazing stories surrounding our collection on the web, which is an incredible way to provide access," he continues. "If you think about the limited number of people in the long run who are able to actually visit the museum in person, it pales in comparison with the number of people who have Internet access in the United States and worldwide."



Digital reconstructions of a new fossil dolphin from Panama bookend a photograph of the actual specimen. These 3D models can be visualized, downloaded, and printed from the Smithsonian X 3D website. Courtesy Nicholas D. Pyenson / SMNH Imaging / Smithsonian Institution.

The Smithsonian's Digitization Program Office took an important step toward realizing its goal in 2015, when it launched the Smithsonian X 3D Explorer, a WebGL 3D application created in partnership with Autodesk to enable virtual exploration of Smithsonian artifacts via interactive 3D models in any web browser. Available objects include the Wright brothers' first airplane, Amelia Earhart's flight suit, a woolly-mammoth skeleton, the Gunboat Philadelphia, and casts of President Abraham Lincoln's face made during the Civil War—all of which can be not only viewed online but also downloaded for the purpose of creating user-generated renders, animations, or even small 3D-printed replicas.

"Collaborating with Autodesk to create our WebGL 3D viewer took our [3D scanning] from being an internal, behind-the-scenes operation to being a very public activity," Rossi explains. "The level of excitement we've seen from people over having the ability to explore models on their computers and mobile devices —and also download those models—was a real turning point for us."

And the trend is growing. Last year, Google expanded its online art-sharing platform, Google Art Project, to allow museums and galleries to upload 3D models of objects in their collections, such as a 9,000-year-old mask from the Israel Museum in Jerusalem and a 3,000-year-old statue from the California Academy of Sciences. In 2015, the British Museum likewise published its own collection of 3D models on the 3D-printing platform Sketchfab. Although Google's 3D models can't be downloaded, the British Museum's can.

A 3D scan of the Wright Flyer, National Air and Space Museum. Courtesy Smithsonian Digitization Program Office.

Whether they've viewed online or downloaded, manipulated, and refabricated using a 3D printer, the models promise to change the way museums interact with their audiences. For one, they allow museums to share more of their collections than physical space allows. Berlin's natural-history museum, for instance, is currently digitizing its vast insect collection, which comprises approximately 15 million individual specimens—more than it could ever hope to display in its exhibits.

"We want everyone to see them, the public and researchers, to see what's in the collection," imaging specialist Bernhard Sturdan, who is overseeing the project's technical aspects, told The New York Times.

Researchers are also an especially exciting audience, Metallo and Rossi agree. A 3D scan demands less physical handling that could damage objects, produces more and better data points, and generates an end product that is infinitely shareable via the Internet—all of which could yield new and deeper scientific insights when scans are analyzed by global scholars.

It's not just scientists who stand to benefit, however. It's also the public at large. "We want to take incredible showpieces like the Wright Flyer and document them with incredible fidelity to show people these objects they've always loved in a way they've never seen them before," Metallo says.

Creating the 3D scan of the Apollo 11 command module Columbia. Courtesy Smithsonian Digitization Program Office.

Creating the 3D scan of the Apollo 11 command module Columbia, Courtesy Smithsonian Digitization Program Office.

Another goal is the preservation of history. Metallo and Rossi agree. A 3D scan demands less physical handling that could damage objects, produces more and better data points, and generates an end product that is infinitely shareable via the Internet—all of which could yield new and deeper scientific insights when scans are analyzed by global scholars.

"The Apollo 11 command module is nothing short of a landmark of human history," Metallo says of the Columbia, which will be the centerpiece of a new state-of-the-art moon-landing exhibition opening in 2020 at the Smithsonian National Air and Space Museum. "This scan will offer people the ability to go inside it and experience it on a deeper level."

The command module's curator, Dr. Allan Needell of the National Air and Space Museum, envisions the 3D model eventually serving as a digital table of contents for the object, linking to articles, videos, and photographs explaining its history, design, and operation.

"It will be so detailed that it will be possible to make 3D models from the data that we're collecting," Needell says of the Columbia scan. "It will be possible to do virtual computational tours of nearly all positions of the interior. And we'll be able to spend some time using this capability to provide access to members of the public, scientists, engineers, or anyone else interested in this unique object. We haven't let anyone inside the artifact in 40 years, and we won't be able to let anyone inside as time goes on, but we will be able to provide extremely high-resolution data of what's in it."

A closer look at creating the 3D scan of the Columbia command module. Courtesy Smithsonian Digitization Program Office.

The Smithsonian's hope is that it will be able to use the data for various applications—both in the museum, in the form of touch-screen interfaces, as well as online.

"It's an opportunity for us to, on the one hand, preserve the symbolic, iconic importance of an object and to present it to our viewers in that way, but also recognize that an object sealed behind Plexiglass where nobody ever gets inside is losing some of its important values," Needell continues. "I think the advent of some of these new digital technologies provides us an opportunity to combine the educational and the preservation and conservation aspects of what we do as curators."

"It's an exciting prospect," Rossi adds. "We can see teachers and educators creating lesson plans [around the Apollo 11 mission] and using the 3D model as a tool to deliver them."

It might even be possible for Americans to one day "fly" the command module themselves using virtual reality. "The potential for something like this with a virtual reality experience is huge," Metallo says. "Imagine the renders that would be possible to create from the point of view of the astronauts using as-built CAD models that are more accurate than anybody has ever seen before. The possibilities are pretty endless."

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