About the Cover

CultLab3D

Digitizing Cultural Heritage

Gary Singh

For many years, various national and international initiatives have tried to implement strategies to digitally capture and archive cultural-heritage artifacts. With hundreds of millions of artworks and treasures in museums and institutions around the world, an effective strategy is needed to adequately preserve the works in the digital domain. You never know when the next fire will occur or the next historical building might collapse. What's more, many institutions simply don't have enough room to display all of their collections.

As an alternative to the more time-consuming and expensive 3D-digitalization methods of the past, researchers at the Fraunhofer Institute for Computer Graphics Research, in Darmstadt, Germany, designed CultLab3D, a mobile digitization lab, from scratch. Nothing similar had existed anywhere. (For a look at related research, see David Arnold's article, "Computer Graphics and Cultural Heritage," on page 76 of this issue.)

CultLab3D automates and industrializes the digitization of museum artifacts quickly and inexpensively. Besides capturing the artifacts' geometry and texture, the system captures their optical properties, such as reflection and absorption characteristics. So, any subsequent photorealistic representations of their appearances can be accomplished under any future lighting conditions. Because CultLab3D is mobile, the entire system can be transported to almost any museum, anywhere.

The System

Even on YouTube (www.youtube.com/channel/UCuPdbUOvjLTgjT7fbTxG_8g), CultLab3D is a marvel to watch. While on a conveyor belt, the artifact—mini-sculpture, statuette, or what have you—passes through two nested aluminum scanning arcs holding nine high-resolution cameras and nine ring lights, respectively (see the magazine cover). Each arc can describe a full hemisphere, and each moves around the artifact, using photogrammetric, image-based reconstruction to capture the geometry, texture, and optical properties, reaching submillimeter accuracy. Humans don't need to constantly reposition the scanners or artifact, adjust the room lighting, and so on.

Next, a structured-light scanner on a compliant robotic arm resolves any remaining occlusions or gaps in the virtual model. The finished 3D model can then be semantically annotated with cultural, historical, or provenance information, such as the period of origin or its relation to other artifacts and geography. Proprietary software, CultSoft3D, controls the scanning and hardware automation. The process takes just a few minutes, as opposed to the tens of hours for previous manual systems. When an artifact—say, a human-sized statue—is too large for the conveyor belt, an omnidirectional robot with four-wheel drive is used. The robot contains another structured-light scanner mounted on a next-generation, lightweight, compliant robotic arm. Figure 1 shows the results of scanning a bust of Nefertiti.

Pedro Santos heads Fraunhofer's Competence Center for Cultural Heritage Digitization, which developed CultLab3D. He says the project functions on multiple fronts. The issues are much larger than just scanning sculptures.

"It is not only about going for fast and economic 3D mass digitization of cultural-heritage artifacts," he declares. "It is about creating a whole ecosystem around that topic."

And the topic is complex, says Santos. "[It] involves fast and precise content annotation, classification and storage connecting with meta- and provenance data, data formats which are readable 500 years from now, long-term data storage so that data is readable 500 years from now, stan-

 Published by the IEEE Computer Society

dardization of formats for optical material properties, minimum quality standards for digitization including controlled lighting environments, [and] certification of 3D models, under which technical conditions they were created, and by whom."

Santos says that to his knowledge, there isn't yet any default legislation on who owns the created 3D model, so intellectual-property (IP) rights lead to other challenges. For example, does the IP reside with the museum that owns the physical artifact or to the hardware engineers, the machine operators, or those who actually crunched the code? It's a thorny issue.

"To this end, we have created a forum, meeting twice a year," Santos says. "[We] will gather all relevant stakeholders to discuss and push those topics forward."

In any event, the project is off to a whirlwind start. Just last year, Santos and his team presented the first working prototype of CultLab3D at the 2013 Digital Heritage International Congress in Marseille, where the system took the 2013 Digital Heritage International Congress and V-MUST.NET award for the best technology exhibit. As if that wasn't enough, end users already include Stiftung Preußischer Kulturbesitz (the Prussian Cultural Heritage Foundation), which operates many museums in Berlin, including the world-renowned Pergamon Museum. The Liebieghaus in Frankfurt, which accommodates a collection of 5,000 sculptures, is also on board. Meaning, there's plenty of work to be done.

Applications

Especially in Berlin, where more than six million artifacts exist across many institutions, with another 120,000 pieces acquired every year and nowhere to possibly display everything, CultLab3D's capabilities will probably add an entire new dimension to interactive or hybrid exhibits. With everything digitized in 3D models accurate to submillimeter levels, museum visitors could, besides looking at physical artifacts, independently choose which artifacts from storage to view, on the basis of similar characteristics or origins. You can also envision CultLab3D extended to warehouses, bank vaults, or previously inaccessible corners of storage facilities—all without the massive human hours that such cases normally require. The possibilities here are virtually endless.

It doesn't stop there. Such highly precise 3D models might also replace expensive loans of originals for scientific research. This would save enormous amounts of money. Insurance costs would be unnecessary.

Figure 1. Scanned copies of a bust of Nefertiti by CultLab3D, (a) without and (b) with texture. The process captured the bust's geometry and texture but not its optical properties. (Source: Fraunhofer Institute for Computer Graphics Research; used with permission.)

At the moment, the technology employed in this project—software, hardware, and robotic implementations—is under wraps. Scientific papers haven't emerged just yet.

"We have not yet published anything in the first year due to the fact that we needed to plan and build everything from scratch, since there was no such thing before," Santos says. "And we [have to] safeguard some of our developments and file them in for a patent, such as the scanner arcs."

Santos says that in March or April 2014, his team will conduct evaluations at various museums in Berlin and Frankfurt. They aim to obtain hard evidence as to just how much faster CultLab3D performs than more traditional approaches.

"However, we already have data on that, of course," he quips.

Gary Singh *lives and writes in San Jose, California. Contact him at gsingh@avantguild.com.*