Natural disasters or wars destroy cultural treasures. Fraunhofer researchers are presenting a mobile lab to three-dimensionally scan and digitalize artifacts at top speed.

Millions of cultural artifacts exist in our museums. But are these cultural treasures safe there? In the fire at the Duchess Anna Amalia library in Weimar in the year 2004 or when the historical city archive in Cologne collapsed in 2009, numerous works of art were destroyed completely. Preserving our cultural heritage in a digital way is a good way to mitigate the impact of such disasters. For around ten years, private, national and international initiatives have been trying to digitally capture and archive cultural treasures. However, these have mainly been limited to 2D artifacts such as book pages, paintings or photographs.

"With CultLab3D, we are presenting, for the first time, a quick, economical approach to digitalize cultural heritage in the next, the third dimension", says Pedro Santos of Fraunhofer IGD. His team is developing technologies for a faster
We have already grown used to the copying of two-dimensional documents and papers. But even three-dimensional things, such as a Roman vase from the museum, can be scanned and “printed” via a special printer. Unlike conventional printing, the printer hereby does not spit out a sheet of paper but a real object. Although 3D printing has been known and established for around 30 years, its possibilities are limited: A copy of the Roman vase, for instance, only roughly resembles the original.

Philipp Urban wants to change this and turn 3D printing into a more broadly used application. He is therefore setting up the new competence center “3D printing technology” at Fraunhofer IGD. He is getting a jump start via the Fraunhofer Attract Program enabling young researchers to develop their ideas at Fraunhofer in an application-oriented way. “So far, it has hardly been analyzed how material properties such as shine or transparency can be reproduced in the best possible way”, says Urban. “This is exactly what we would like to do at the new competence center. In a first step, we will address the following question: Which printing result can be expected when different materials are arranged in a certain way?” This is where Urban brings in the experience he gathered in the past 14 years when it comes to 2D printing, among others at the Technical University of Darmstadt, where he headed an Emmy-Noether research group with five doctoral students.

Another goal that Urban set for himself: He would like to shift the errors bound to happen due to the physical limitations of digitization and virtual reproduction of objects from the real world in superior quality. CultLab3D not only captures geometry and texture of artifacts but also their optical material properties such as reflection and absorption characteristics for a later photo-realistic representation of their impression under any lighting conditions.

So far, 3D digitization has been very expensive and time-consuming. CultLab3D now relies on the industrialization and automation of the entire 3D digitization process of artifacts by means of state-of-the-art scan and lighting technologies. This is how it works: The artifacts are passing through special scanning arcs on a conveyor belt. In the process, they are scanned from all sides in a fully automated fashion. In a second step, scanners mounted to lightweight robot arms are dissolving any residual undercuts and gaps of the so far reconstructed virtual 3D model. The finished 3D model can then be linked with cultural-historic information such as the period of origin, the artist or related artifacts. The entire process only takes a few minutes, compared to several hours/days before. The mobile digitization lab CultLab3D makes it possible to scan and archive the millions of existing artifacts industrially, cost-effectively and within a flexible time frame.

**Awarded exhibit**

CultLab3D is funded by the Federal Ministry for Economics and Technology (BMWi) and was presented for the first time at the Digital Heritage 2013 Conference in Marseille under the patronage of UNESCO. The biggest event yet on the subject of Digital Cultural Heritage gathered around 700 representatives from research and teaching, industry and politics to discuss and present digital technologies for the preservation, documentation and understanding of cultural heritage.

There, CultLab3D won the “2013 DigitalHeritage International Congress and V-MUST.NET” award for the best technology exhibit.
THE VIRTUAL FACTORY
YOU CAN TOUCH

Today, industrial processes are mechanized, electrified and digitized. In the next step, they will become intelligent. The boundaries between virtual and real world, however, are only slowly blurring. At the Euromold 2013 from 3 - 6 December 2013 in Frankfurt am Main, researchers showed initial applications for Industry 4.0 by means of a miniature factory.

There are big changes in store for industrial operations: Customers are demanding more and more individual products and a greater variety of them. Manufacturers are experiencing a fourth industrial revolution: After water and steam power, electrical energy as well as electronics and information technology, sensor networks and simulation are now entering the factory halls: The products of the future know at any time where they are, know their history, their current state and the production stages they still need to complete to become a finished product. To succeed, real and virtual world need to be linked even more closely.

Miniature model connects digital and real world

At the Euromold, researchers of Fraunhofer IGD demonstrated how to bridge this gap. For this purpose, the scientists have constructed a miniature factory – including a small robot moving tons. The researchers observe the model’s processes with a camera. It takes ten pictures per second and continuously captures the status of the real world, conveying it to the virtual realm.

Industrial enterprises are thus able to plan the routes of a fork-lift truck: While it virtually moves through the digitalized factory hall, the system analyzes where and when it will collide with a real robot. Inside the miniature factory, objects may be rearranged.

When somebody holds his hand in the way of the virtual fork-lift truck, the system recognizes the new obstacle. “This is the first step in the direction of cyber-physical equivalence. A state in which you can randomly switch between real and virtual world. So far, this term has referred to the geometrical characteristics of real and virtual world. Other features, including function and behavior, are to follow”, says Professor André Stork, a competence center head at Fraunhofer IGD.

Cyber-physical equivalence, industry 4.0 – what exactly do these designations mean? “While today’s manufacturing processes are centrally aligned, each object is soon to be equipped with artificial intelligence – be it a machine, plant, part and tool”, adds Professor Uwe Freiherr von Lukas from the Rostock site of the institute. In daily routines, this would mean: machines and robots exchanging information, making their own decisions and controlling themselves – all in collaboration with the people involved.

Profitably manufacturing small series and individual products

This “new” industry is to secure Germany’s and Europe’s role as an industrial location. While Asia takes the lead in mass production, Europe’s future is in the production of single parts and small series. This is exactly what the flexible Industry 4.0 is to facilitate: production lines are quickly redesigned and adapted so that even small series and individual products can be manufactured at a profit. So far, factories are only using the opposite approach: They are planning and optimizing the production lines on computers and transferring them to the real world. The way back is not or only rarely followed. If anything changes in the production process, it is transferred to the virtual plant in isolated cases only. “Our miniature factory shows that there would already be another way today”, says Freiherr von Lukas.
SOFTWARE HELPS TREAT TUMORS

Tumors of the head and neck are life-threatening. Radiation therapy is an established form of cancer treatment. For doctors to be able to effectively radiate carcinoma, researchers are developing procedures for the automatic detection of a great number of anatomical structures such as bone marrow and larynx so that treatments can be planned precisely and quickly. The way to the tumor is sketched out in this way.

Radiation therapy is a proven treatment option for tumors in cancer patients. In case of a cancer disease of the head or neck, doctors are especially challenged as there are many sensitive organs very close together in a confined space. Radiation must therefore be planned exactly in order to damage as little healthy tissue as possible.

The prerequisite for this is knowing the exact position and shape of the various anatomical structures. These include bone marrow, blood vessels and larynx. “Up to now, a radiologist had to view these anatomical details layer by layer in 3D image files, as we receive them from a CT scan, and mark the relevant organs as well as the tumor with the mouse”, explains Dr. Stefan Wesarg of Fraunhofer IGD. “This takes several hours.”

The Sana Clinic of Offenbach and the University Clinic of Gießen and Marburg are working on a solution together with Medcom GmbH from Darmstadt and Fraunhofer IGD. The goal of the joint research project KOHALA (head-neck atlas for radiation therapy) is the automation of this processing step which was previously so elaborate. The Fraunhofer researchers are developing the software for the automated detection and marking of the anatomical structures in the image data. For this purpose, they are using the radiologists’ knowledge on the shape and relative position of the organs and bone structures. Via a statistical learning process, the anatomical differences and different head postures are imported in a computer model from a great number of real anonymized patient data. The training data originate from the clinics which are also starting the first tests with the new system in the coming months.

Owing to the new procedure by Fraunhofer IGD, the more than twenty relevant structures defined by the clinical partners can be automatically segmented. However, contrary to the previously required number of hours, the result is available within less than five minutes. “In times of our doctors’ increasing workload, such technological solutions are practical to provide us with more time to care for our patients”, says Prof. Dr. med. Hilke Vorwerk of the University Clinic of Gießen and Marburg.

At the Hesse Transfer Forum at Schloss Biebrich, Wiesbaden on October 30, Fraunhofer IGD will present the solution, developed within the scope of the Hesse LOEWE promotion line 3, to the public for the first time. The “State Offensive for the Development of Scientific-Economic Excellence”, LOEWE in brief, is the title of the research promotion program in the German state of Hesse which has been in existence since 2008.