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CultLab3D - On the verge of 3D mass digitization

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Abstract

Acquisition of 3D geometry, texture and optical material properties of real objects still consumes a considerable amount of time, and forces humans to dedicate their full attention to this process. We propose CultLab3D, an automatic modular 3D digitization pipeline, aiming for efficient mass digitization of 3D geometry, texture, and optical material properties. CultLab3D requires minimal human intervention and reduces processing time to a fraction of today's efforts for manual digitization. The final step in our digitization workflow involves the integration of the digital object into enduring 3D Cultural Heritage Collections together with the available semantic information related to the object. In addition, a software tool facilitates virtual, location-independent analysis and publication of the virtual surrogates of the objects, and encourages collaboration between scientists all around the world. The pipeline is designed in a modular fashion and allows for further extensions to incorporate newer technologies. For instance, by switching scanning heads, it is possible to acquire coarser or more refined 3D geometry.

Categories and Subject Descriptors (according to ACM CCS): I.4.1 [IMAGE PROCESSING AND COMPUTER VISION]: Digitization and Image Capture—Imaging geometry I.4.1 [IMAGE PROCESSING AND COMPUTER VISION]: Digitization and Image Capture—Reflectance

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1. Introduction

In 2001 the buddhas of Bamiyan were dynamited and totally destroyed by the Taliban in Afghanistan. In 2003 a major earthquake struck Bam and the surrounding Kerman province of southeastern Iran resulting in the destruction of some of the largest mud brick buildings in the world. In 2009 the historical archives of Cologne, Germany collapsed burying around 90% of its archival records. In 2012 part of the UNESCO World Heritage Site in Timbuktu, Mali was destroyed by war.

Unfortunately, disasters such as the ones mentioned above have happened, happen and will continue to happen anytime and anywhere. In general, when these eventualities occur, the only thing left to do is to minimize the losses, recover what can be recovered and was recorded and painfully reconstruct what can be reconstructed. Yet, sadly enough, many cultural heritage artifacts remain irrecoverably lost. On such occasions, many are the people who demand better preservation and documentation strategies for cultural heritage. Ten years ago, several initiatives at national, European and international level (e.g.: the German Digital Library, Europeana, Google Library Project, Microsoft Book Digitization Project) led to new technologies for the mass digitization of 2D documents such as books, photographs and paintings and they established a market for device manufacturers and service providers of around 100 million Euros worldwide.

CultLab3D takes mass digitization to the third dimension, as it represents one of the first approaches enabling fast and economic, high quality 3D digitization for cultural heritage artifacts, capturing their geometry, texture and optical material properties ensuring an overall, average throughput of a few minutes per artifact. Millions of cultural heritage artifacts await digitization, classification, and in many cases (re)discovery in museum archives. The collection of the National Museums in Berlin for example, consists of more than six million objects with about 120,000 new additions per year. Precise digital 3D models will allow for high and concurrent availability of artifacts and their use in hybrid exhibitions, replacing expensive and time-consuming loans, avoiding damage to the originals, avoiding insurance costs and legal procedures. Finally, the ability to create physical replicas using high quality 3D models helps preservation and restoration of the originals in case of deterioration, natural or man-made disasters.

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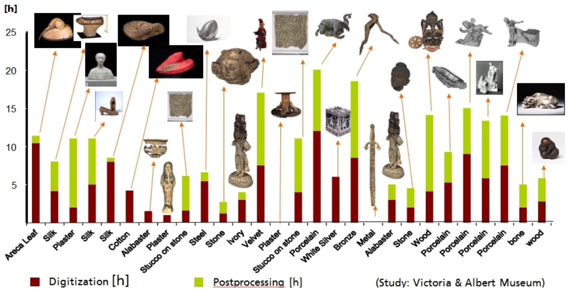

Figure 1: *Results from the digitization campaign conducted by the V&A Museum. Time varies between 5 and 20 hours for geometry and texture acquisition and does not consider complex materials. Scanner used: Breuckmann optoTOP-HE. The red bars indicate the acquisition time and the green bar the post-processing time.*

3D mass digitization of cultural heritage artifacts unlocks a big usage and market potential. According to statistics gathered for Europeana by ENUMERATE (http://www.enumerate.eu/), we may safely assume that less than 1% of all 3D cultural heritage artifacts have already been digitized.

Currently 3D digitization is prohibitively expensive and slow. According to studies undertaken by the Victoria and Albert Museum in London (Fig.1) during the 3D-COFORM (http://www.3d-coform.eu) project, digitization of 3D artifacts takes from half a day to two days on average. The process requires a considerable amount of manual work (up to 85% of the overall time), mainly to re-position the sensor device depending on the artifact's size, complexity and the presence of geometric occlusions.
CultLab3D advances the state-of-the-art by heavily focusing on industrialization and automation of the entire 3D digitization process using conveyor belt systems combined with modern autonomous robots as carriers and manipulators of appropriate optical scanning technologies to ensure high throughput and cost reduction at controlled lighting conditions for reproducible, high quality results.
Technologies for 3D-centered annotation, search and storage of cultural heritage artifacts developed in previous EU projects such as 3D-COFORM and now taken up and continued in CultLab3D complement our efforts turning 3D digitization into an easy and affordable common practice for museums.

2. CultLab3D

CultLab3D represents lessons learned from our own previous work and from a variety of other fellow researchers to achieve one single goal: enabling high quality and affordable 3D mass digitization for the millions of cultural heritage artifacts in museums. Gorthi et al. [GR10] and Salvi et al. [SFPL10] have made surveys on 3D geometry and texture acquisition using structured light. Weyrich et al. [WLL*08] wrote a report on the acquisition of optical material properties. The combined acquisition process of 3D geometry, texture and optical material properties range from simple to very extreme setups. Holroyd et al. [HLZ10] move a co-axial setup of a camera and a light-source around an artifact during acquisition with an identical setup looking down on the artifact from above. Schwartz et al. [SWRK11] do highly parallel acquisition of geometry, texture and optical material properties with a multiview/multilight setup of 151 consumer cameras and LED lights, called the DOME. Its improved version [SK12] replaces the extreme number of cameras by 11 industrial video cameras mounted on a vertical arc revolving inside a hemisphere covered by LED lights, thus increasing acquisition time slightly, but improving on the quality of results. Koehler et al. [KNRS13] have built the ORCAM, a fully spherical setup similar to the DOME [SK12], which is also able to resolve the bottom of artifacts by placing them on a transparent, rotational, anti-reflective glass carrier, pivo-mounted on a steel ring. Seven high resolution photo cameras and a projector revolve around the sphere for data capture.

Compared to previous work, one of the issues not yet solved in the current first version of CultLab3D (Fig. 2) is digitizing the bottom-side of artifacts. Yet it can be solved similar to the ORCAM approach. CultLab3D offers significant advantages over the current state-of-the-art. Artifacts move along a fully automated digitization pipeline on tablets transported by conveyor belts - they don't have to manually be placed in and out of a capturing setup. At the first scan station, CultArc3D, CultLab3D captures geometry, texture and optical material properties using a motorized camera and light arc, featuring industrial, high resolution video cameras. By using the information from the first scan station, an iterative scan plan is calculated for the second station where a structured light scanner mounted on a lightweight and compliant robotic arm resolves the remaining occlusions which could not be resolved at the first scan station. If no optical material capture is needed, the first scan station can be enabled to operate on objects moving through the pipeline on-the-fly so they would not even need to stop for a geometry and texture scan. The pipeline can be attached to other automation components so artifacts can be picked up and returned to a high rack warehouse in a museum archive (see the Albertina in Vienna for example). Although many museum curators might be critical of automation technologies to handle cultural heritage artifacts, it is our conviction that it is the only way to lower cost and increase throughput in order to handle the millions of artifacts in need of digitization.

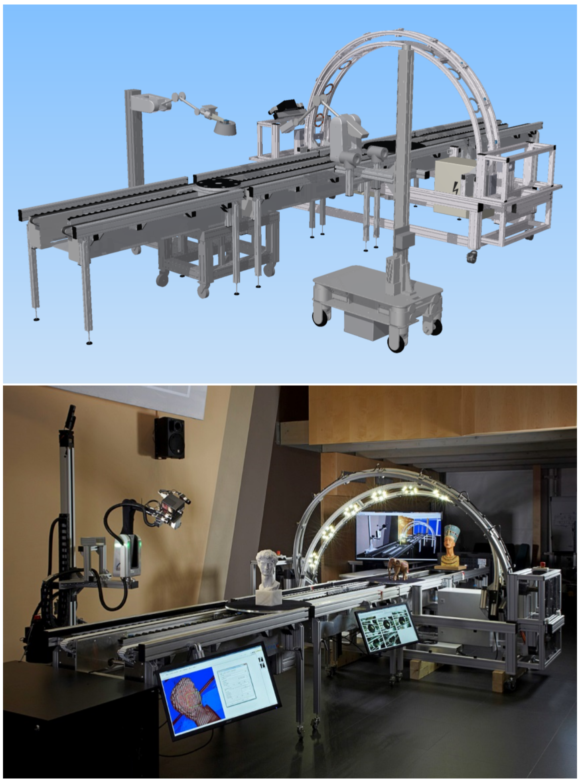

Figure 2: *Digitization CultLab3D pipeline system with two scan stations acquiring 3D geometry, texture and material properties as well as resolving occlusions as CAD design (above) and real laboratory setup (below).*

2.1. Automatic Modular 3D Digitization Pipeline

Acquisition of the 3D-geometry, texture or optical material properties of an artifact may take a lot of time and currently requires one ore more persons to dedicate their full attention to the process. The reason is that acquisition has to be performed in several single steps leading to a consolidated final result. Each step consists at least of:

- Precise positioning of the acquisition sensor head relative to the artifact which is very time consuming and might involve human error, deteriorating overall quality.
- Potential recalibration of the sensor head.

For each object, an initial step has to be performed, consisting of:

- Positioning the target artifact on a turn table or at a predefined position, required by the respective scanning system. Manual artifact manipulation represents a large overhead in the process, conflicting with the requirement of cultural heritage artifact preservation to minimize physical contact.
- Setting up the acquisition system and adjusting it to the target artifact (dimensions).
- Removing the target artifact again to prepare for acquisition of the next object (once more requiring manual handling of the cultural heritage artifact).

The above tasks largely require human interaction which is responsible for most of the time overhead both during the acquisition phase and in between acquisition processes of several consecutive artifacts. The acquisition process is neither optimal nor efficient, and physical contact with cultural heritage artifacts is frequent. The best tradeoff between minimizing the number of acquisition steps (partial acquisitions from a certain position and orientation) and maximizing the overlap between the partial coverage achieved by each single acquisition step is difficult to meet, and requires high attention and time. Yet, it is necessary to provide complete artifact coverage, and at the same time, sufficient overlap for faithful reconstruction.

2.2. Vision

Our vision is clear: the overall process of acquiring the model of an artifact, whether 3D geometry with texture or optical material properties or both, or even derived from future techniques of metrology yet to be integrated in our pipeline, has to be drastically sped up, and rather than involving users to take care about every detail of the process, human interaction must be removed and limited to the role of defining what is to be acquired and which parameters of acquisition are to be used, in analogy to the evolution of digitization in the 2D domain: When capturing artifact images, parameters are set by the photographer, such as the region of the scene to be acquired and the field of view is set, but besides triggering the process, the user then is no longer involved in details until the end of the process. Also, the whole process of acquiring 2D data of artifacts has been both sped up and significantly automated during the last decades. Now is the time to proceed accordingly in the field of 3D acquisition. With CultLab3D, user interaction is limited to setting up target objects on carrier tablets, and picking them up again after acquisition or automatically storing them in a high rack warehouse respectively.

2.3. Construction

CultLab3D is modular, so an acquisition pipeline appropriate for any requirement can be set up, simply by combining conveyor primitives. Each conveyor primitive, depicted in Fig. 3, can seamlessly be integrated into the pipeline and its control flow, and equipped with an individual scanning system. Fig. 3 also shows a carrier tablet (disk) for cultural heritage artifacts. Physical handling of the artifacts is limited to their setup on the disk as part of the preparation, and their removal at the end of the process. In addition, artifact preparation is decoupled from the acquisition process in time and space, so while artifacts are being prepared, others are being fed into the pipeline. All subsequent steps of moving the target artifacts, i.e., transport, turning, raising and lowering etc., are done implicitly by moving the carrier tablets, so the artifacts are not touched during the whole acquisition process. Currently the maximum dimensions of artifacts for which CultLab3D is built, are 60cm in height and diameter and 50Kg of weight.

2.4. CultArc3D

The CultArc3D[†] module is a self-sufficient mechanism, consisting of two coaxial, semi-circular arcs that rotate around a common axis, coplanar with the surface of the carrier tablets which pass through it on a conveyor belt module. CultArc3D's two arcs cover a hemisphere around the center of an artifact's tablet (cf. Fig. 3 and Fig. 4). Each arc is driven by its own actuator, allowing for a discrete number of stop positions. The radii of the arcs differ to allow for independent movement. The outer arc, subsequently referred to as the camera arc, holds nine equiangular cameras, mounted at the same distance to the center of the hemisphere. Any image sensor can be used. Currently we use nine industrial 10 MP video cameras capturing the visible spectrum of light. However, we plan to add multi-spectral sensors, lasers and even volumetric data capturing sensors using X-ray or MRT could be added, either on the camera arc or as additional data capturing arcs. In analogy to the outer camera arc, the inner arc (subsequently referred to as light arc) holds nine equiangular light sources. Currently our light sources emit light in the visual spectrum, but we plan to also include multi-spectral lighting for example ultra-violet illumination which can for example be used to visualize traces of chisels used to carve wooden sculptures. Let there be N camera positions on the camera arc and N light positions on the light arc. N positions divide the virtual hemisphere into N+1 longitudinal divisions in one dimension. The discrete stopping positions of each arc divide the virtual hemisphere into N+1 latitudinal divisions. The result is an equiangular spacing in two dimensions of possible (reachable) camera and light positions on the virtual hemisphere. There are N cases where the position of the two arcs around their common rotation axis is identical due to equal angle (motor position). In order to prevent the light sources or parts of the light arc (inner arc) from blocking the cameras' views, light sources are designed as ring lights with inner diameters large enough to avoid intersection of any of their parts with camera viewing cones. Light arc and camera arc are driven such that the center points of the ring light sources are positioned on the optical axis of the respective camera (potential or real) whenever both arcs are in the same stop position. The result of this design concept is the capability to achieve any combination of an arbitrary light direction, limited to a discrete homogeneous spacing over the virtual hemisphere at NxN light positions, with an arbitrary camera angle, limited to a discrete homogeneous spacing over the virtual hemisphere at NxN camera positions. This leads to a combination space of N^4 possible combinations of a camera view with a light direction in a homogeneously distributed discrete space of NxN positions on a virtual hemisphere.

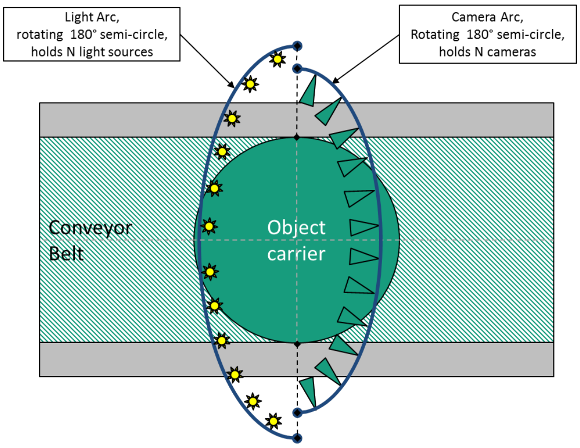

Figure 3: *Constellation of camera and light arcs over conveyor belt module.*

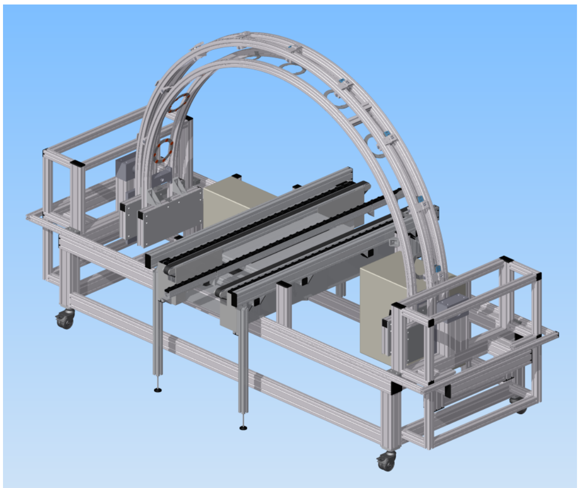

Figure 4: *Conveyor belt module equipped with CultArc3D.*

2.4.1. Versatility of Acquisition Modes

Currently, CultArc3D allows two distinct acquisition modes when a tablet stops in the center of the capturing hemisphere on the conveyor belt. When doing 3D geometry and texture acquisition only, both arcs move in synchrony and stop at nine equiangular positions on the upper hemisphere around their joint rotating axis, resulting in 9^2=81 images being

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[†] Patent pending.

taken, which can be used for 3D photogrammetric reconstruction of the artifact. When doing 3D geometry, texture and optical material acquisition, both arcs move in a way, so all discrete combinations of evenly displaced camera and light positions on the upper hemisphere around an artifact occur, resulting in 9^4=6561 images being taken, which can be used for both, 3D photogrammetric reconstruction of an artifact and to compute its optical material properties. After completion of each mode, the arcs move into the upright position and the artifact is moved out of the CultArc3D module. Yet, we can implement further acquisition modes, for example a synchronous, continuous movement of both arcs while an artifact passes the CultArc3D module for a geometry and texture scan. For long artifacts one could think of the same synchronous and continuous movement of both arcs temporarily halting them in a vertical position while the center part of the artifact passes underneath.

2.4.2. 3D Geometry and Texture acquisition

The CultArc3D setup provides an ideal basis for controlling incident light angles of one or many simultaneous light sources, and capturing from one or many different angles using an equidistant distribution of viewing directions over a hemisphere. Many approaches to surface reconstruction can easily be realized, some examples are:

- MVS:
  The well known method of Multi-view Stereo (MVS) [GAF*10], drawing from a set of multiple images, shot from several different directions with sufficient overlap, centered on the target artifact under a corresponding lighting situation, is used to generate a 3D reconstruction of the artifact's surface points, based on a previous registration of all camera coordinate systems in one world coordinate system and sparse reconstruction of 3D points using features. A surface is then generated based on the reconstruction results and the information on the image point topology.
- PS:
  The method of Photometric Stereo (PS) [HS05], somewhat complementary to MVS due to its exploitation of visual depth cues from a set of multiple images shot from a single perspective, centered on the target artifact under different incident light angles, is used to generate a normal map of the artifact's surface. This is then repeated for different camera views and the results merged. A depth map is generated by interpolating the normal map, and analogously as for MVS reconstructions, a surface will be generated.
- Laser-based Line Scanning:
  For yet higher accuracies, one ore more light sources on the light arc can be complemented or replaced by laser lines in order to be able to code the surface of the target artifact and derive 3D positions of the surface by plane-ray-intersection.

2.4.3. Optical Material Properties

The term 'Optical Material Properties' describes a class of manifold characters of materials, leading to different visible effects. The goal of material acquisition is to record these effects as well as possible and reproduce them as close to reality as possible. There are different models to capture these effects that can be acquired with the acquisition modes currently available for CultArc3D:

- BTF:
  'Material' acquisition is a term used for the acquisition of material behavior in response to incident light from a certain direction reflected in a certain outgoing angle. Its explanation is straight forward: Every possible combination of incoming light directions and outgoing observer (camera) directions within the discrete set of combinations defined by the hemispherical spacing is simulated. This is achieved by lighting the respective light, while the resulting light-surface interaction is captured by the respective camera, implicitly including texture due to the color array (camera) sensor. Rendering using Bi-directional Texture Function (BTF) exploits the data acquired in the material behavior simulation, in that for each surface point to be rendered, the corresponding simulation data defined by the angle towards the camera and the light source(s) is used for surface point shading, according to the material response recorded in the acquisition phase. In addition, the position to be used within the measured arrays, is determined by a texture-like mapping of the measured material representation on the target geometry.
- SVBRDF:
  The representation of BTFs as Spatially Varying Bi-directional Reflectance Distribution Functions (SVBRDF) can be derived using the approach of Massively parallel SVBRDF fitting BTF data [SM09]. Using this technique, the vast amount of data needed by the BTF representation is parametrized by fitting a parametric model to the data such that it represents the optical material behavior sufficiently well, with the advantages over BTF that the model then is controllable, and requires a fraction of the space needed by a BTF (several Terabytes), making real-time rendering possible with standard hardware.
- BRDF:
  This method is a special case of BTFs, where instead of a matrix of measurements of the material, only one intensity measure is taken, e.g., by averaging over the sensor matrix for each camera position, and abstracting to obtain two different measures using filters: First, the reflected light intensity, which is proportional to the specularity of the material for the given light and observer direction, and second, the hue of the material which basically is the color averaged over the sensor matrix or over sub-regions of the sensor matrix. The result is a material measurement that expresses both reflectivity of the material and hue for a hemispherical, discrete set of combinations of incident

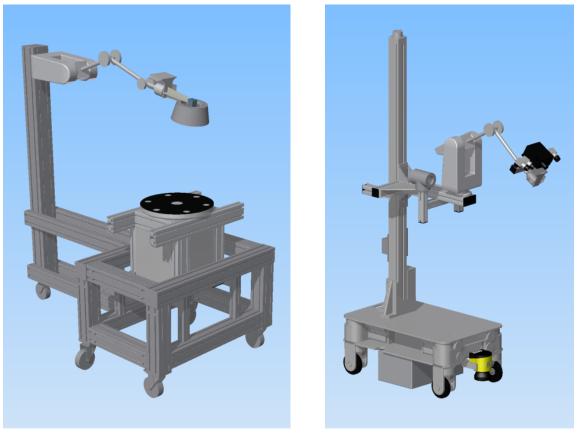


Figure 5: *CultArm3D: robot arm with scanner stationary at the turntable or mounted on the mobile platform.*

light and outgoing view directions. Rendering is done by omitting the step of deciding for a specific position within the measured arrays, as this is already accounted for by averaging as described above, since a BRDF is not spatially varying, but stays the same for the whole surface applied to, as a function of incoming and outgoing light directions.

The sets of camera- and light positions required by the methods for 3D geometry and texture acquisition and for optical material properties acquisition have a non-empty set of intersection, which means that in subsequent runs of the methods mentioned above, there would be a high number of redundant positions. As a consequence, optical material properties acquisition of BTFs, using the super-set of any of the other methods can be run, resulting in a BTF of the material. Subsets of the acquired data then lead to BRDF and SVBRDF, as well as 3D geometry and texture. If not all representations are required, the set of positions recorded by the device can of course be restricted.

2.5. CultArm3D - 3D Refinement and handling of Concavities and Occlusions

CultArm3D, the second acquisition module of the pipeline, is equipped with a turn table and a 3D structured light scanner attached to a light-weight robotic arm mounted on a vertical axis. CultArc3D (2.4) cannot resolve occlusions, because its image-based acquisition sensors have fixed mounting points on the camera arc. Therefore reconstructed 3D models of artifacts might still contain holes or undefined areas respectively, which still have to be resolved. CultArm3D does this, by computing an iterative next best view planning (NBV) based on CultArc3D's result, filling possibly existing holes and resolving remaining occlusions.

Works on iterative NBV for 3D modeling date back to Klein [KS00]. During the process of iterative view planning, the next best position and orientation of the measurement head (i.e. the scanner installed at the robot arm end effector) is calculated based on the scanner's calibration parameters which define the optimal measurement volume and the initially unknown or partly known geometry of the model. The fully automated acquisition cycle can roughly be described in four steps:

1. Scanning: acquisition of the scan, e.g. range and color image.
2. Integration: registration and integration of the partial scan with the final model.
3. Planning: determination of the next best acquisition parameters of scanner and robot.
4. Positioning: applying parameters and moving the scanner to the next scan position.

Step 3. is solving an optimization problem with various parameters, such as the scanner's position and dynamic camera and projector settings. Constraints are the measurement volume, as well as the movement and safety constraints of robot and turntable. The goal is maximizing the quality and completeness of the 3D model by competitively minimizing the time. Hence, for each new scan view the system maximizes the visible volume by resolving occluded volumes. This process of hole-filling results in a "waterproof" triangulated 3D model. Additionally, the measured surface is required to fulfill a quality threshold in terms of sampling density and texture. With respect to the iteratively growing 3D surface, holes and borders are identified, where obvious and major discontinuities are discovered and filled first, thus minimizing the overall number of scans, redundant data and consumed time.

As described in [KSB12] we require the artifact of interest to fit and be placed inside an initially defined safety zone, for example a cylinder covering the turntable (represented by the blue voxels in figure 6). That zone is labeled as unknown and is not breached by the robotic arm and measurement head but successively resolved during the scanning process. While the object's true surface is discovered (represented by the red voxels in figure 6) a local quality ratio is optimized until the coverage is considered adequate (green voxels). In further research we will introduce new parameters to the view planning problem to find and apply optimal dynamic settings for the projection pattern and camera exposure time and the local and time-consuming process of material property acquisition. We will also tackle the safe trajectory planning to be able to approach and observe objects from close-up views and carefully enter cavities with the measurement head.

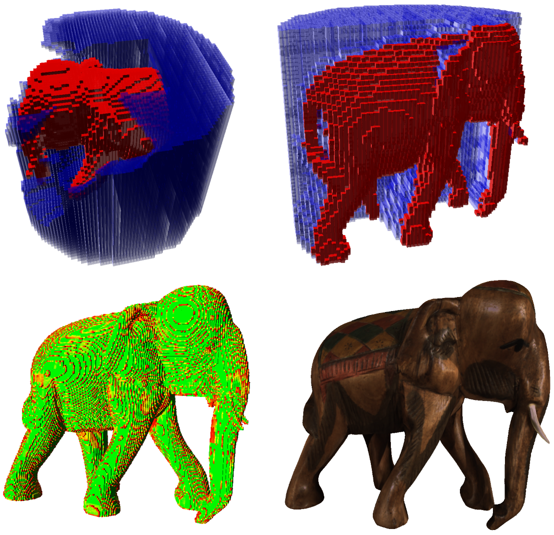


Figure 6: *Volumetric view planning using a voxel representation of the artifact and the surrounding cylindrical safety zone.*

2.6. Results

In user tests this year with the Berlin Museums (Stiftung Preussischer Kulturbesitz) and Liebieghaus in Frankfurt, we will test series of artifacts, captured with traditional methods and through CultLab3D to thoroughly analyze corresponding results in terms of throughput time and quality of the reconstructions. As a current example, one of the many artifacts we already used to test CultLab3D is an acrylic resin reproduction of the bust of Nefertiti currently on display in Berlin's Neues Museum. In Figure 7 it is possible to see the results when using the CultArc3D system (300μm-400μm accuracy) and then the structured-light scanner on CultArm3D (down to 25μm accuracy). The initial photogrammetric 3D reconstruction yields around 70 thousand points while the structured light reconstruction can add up to 2.2 million points.

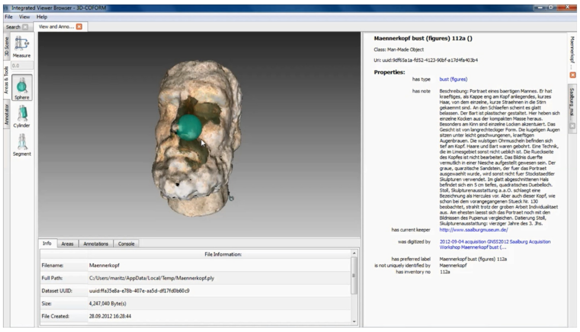
3. 3D Centered Annotation of Cultural Heritage Artifacts

A digital 3D model without context information is useless, because it only comes to life when annotated with meta- and provenance data. Only when the digital replica is semantically enriched and correlated to documents, photographs, video-clips and further artifacts can it be searched for, found and worked on.

To date, most of the collection management systems [mov] require predominantly textual input, many embed photos and multimedia data of artifacts, but only few if any directly work with or on 3D models.

Figure 7: *Comparison of the resulting 3D models from scanning a reproduction of a Nefertiti bust with the CultArc3D system (top row) and with a structured-light scanner (bottom row), textured (left) and gray shaded (right).*

To take advantage of the fact that we target 3D mass digitization and therefore have a 3D model of each artifact we wish to annotate, we have developed a 3D centered annotation tool called the Integrated Viewer Browser (IVB). Initially developed within the European research project 3D-COFORM [pro] as a front-end to a distributed database of meta- and object-data repositories, it fully supports the CIDOC-CRM schema. The graphical user interface (Fig. 8) allows annotation of objects directly on their 3D surface geometry and their correlation to semantically structured in-



Maennerkopf bust (figures) 112a ()

Class: Man-Made Object

Uri: uuid:9df65a1a-fd52-4123-90bf-a17d4fa403b4

Properties:

has type: bust (figures)

has note: Beschreibung: Portraet eines baertigen Mannes. Er hat kraeftiges, als Kappe eng am Kopf anliegendes, kurzes Haar, von dem einzelne, kurze Straehnen in die Stirn gekaemmt sind. An den Schlaefen scheint es glatt belassen. Der Bart ist plastischer gestaltet. Hier heben sich einzelne Kocken aus der kompakten Masse heraus. Besonders am Kinn sind einzelne Locken akzentuiert. Das Gesicht ist von langrechteckiger Form. Die kugeligen Augen sitzen unter leicht geschwungenen, kraeftigen Augenbrauen. Die wulstigen Ohrmuscheln befinden sich tief am Kopf. Haare und Bart waren gebohrt. Eine Technik, die im Limesgebiet sonst nicht ueblich ist. Die Rueckseite des Kopfes ist nicht bearbeitet. Das Bildnis duerfte vermutlich in einer Niesche aufgestellt gewesen sein. Der graue, quarzitische Sandstein, der fuer das Portraet ausgewaehlt wurde, wird sonst nicht fuer Stockstaedtler Skulpturen verwendet. Im glatt abgeschnittenen Hals befindet sich ein 5 cm tiefes, quadratisches Duebelloch. Stoll, Skulpturenausstattung a.a.O. schlaegt eine Bezeichnung als Hercules vor. Aber auch dieser Kopf, wie schon bei dem vorangegangenen Stueck Nr. 130 beobachtet, strahlt trotz der groben Arbeit Individualitaet aus. Am ehesten laesst sich das Portraet noch mit den Bildnissen des Pupienus vergleichen. Datierung Stoll, Skulpturenausstattung: vierziger Jahre des 3. Jhs.

has current keeper: http://www.saalburgmuseum.de/

was digitized by: 2012-09-04 acquisition GNSS2012 Saalburg Acquisition Workshop Maennerkopf bust (...

has preferred label: Maennerkopf bust (figures) 112a

is not uniquely identified by: Maennerkopf

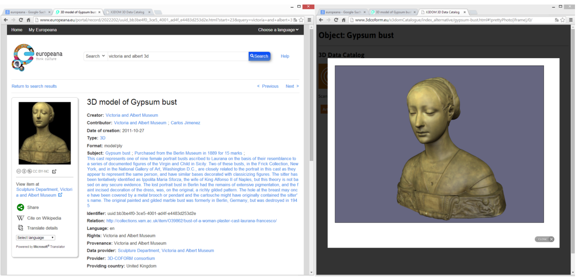
has inventory no: 112a

File Information:	
Filename:	Maennerkopf
Full Path:	C:/Users/maritz/AppData/Local/Temp/Maennerkopf.ply
Dataset UUID:	uuid:ffa35e8a-e78b-407e-aa5d-df17fd0b60c9
Size:	4,247,040 Byte(s)
File Created:	28.09.2012 16:28:44

Figure 8: *Graphical User Interface of our IVB semantic enrichment tool - annotating a relation between Maennerkopf bust and its finding spot at the Saalburg (Hesse, Germany)*

formation and knowledge as well as the creation of links between different data sets, features which have increasingly gained popularity, driven by the Semantic Web technologies [lin]. Current annotation approaches mostly include semantic models for describing the intrinsic structure of 3D shapes ([DFPC08], [PF09], [ARSF07], [AM09]). For example, a model for describing the provenance (lifecycle) of digital 3D shapes in the Cultural Heritage domain ([REMA09], [HSB*08], [SSD*11]) is proposed by Doerr and Theodoridou [DT11].

Since our export functionality supports Europeana's ESE (Europeana Semantic Elements) [ese] metadata format, we can transfer artifact data sets handled by the Integrated Viewer Browser (IVB) to Europeana [eur], the European Digital Library Portal. Through our activities concerning X3D in HTML5 and use of native graphical acceleration capabilities for best possible 3D rendering quality (Fig. 9) we also support interactive visualization of 3D content in regular web-browsers complying with HTML5.



www.europeana.eu/portal/record/2022202/uuid_bb3be4f0_3ce5_4001_ad4f_e4483d253d2e.html?start=23&query=victoria+and+albert+3

Search: victoria and albert 3d

View item at Sculpture Department, Victoria and Albert Museum

3D model of Gypsum bust

Creator: Victoria and Albert Museum

Contributor: Victoria and Albert Museum ; Carlos Jimenez

Date of creation: 2011-10-27

Type: 3D

Format: model/ply

Subject: Gypsum bust ; Purchased from the Berlin Museum in 1889 for 15 marks ; This cast represents one of nine female portrait busts ascribed to Laurana on the basis of their resemblance to a series of documented figures of the Virgin and Child in Sicily. Two of these busts, in the Frick Collection, New York, and in the National Gallery of Art, Washington D.C., are closely related to the portrait in this cast as they appear to represent the same person, and have similar bases decorated with classicizing figures. The sitter has been tentatively identified as Ippolita Maria Sforza, the wife of King Alfonso II of Naples, but this theory is not based on any secure evidence. The lost portrait bust in Berlin had the remains of extensive pigmentation, and the faint incised decoration of the dress, was, on the original, a richly gilded pattern. The hole at the breast may once have been covered by a metal brooch or pendant and the cartouche might have originally contained the sitter's name. The original painted and gilded marble bust was formerly in Berlin, Germany, but was destroyed in 1945

Identifier: uuid:bb3be4f0-3ce5-4001-ad4f-e4483d253d2e

Relation: http://collections.vam.ac.uk/item/O39862/bust-of-a-woman-plaster-cast-laurana-francesco/

Language: en

Rights: Victoria and Albert Museum

Provenance: Victoria and Albert Museum

Data provider: Sculpture Department, Victoria and Albert Museum

Provider: 3D-COFORM consortium

Providing country: United Kingdom

Figure 9: *3D content accessible from Europeana [eur]*

4. Future Work

CultLab3D, our proposed modular 3D acquisition pipeline is just a first step towards economic, 3D mass digitization for cultural heritage artifacts. We see it as a starting point for a multitude of novel approaches to address more and more complex optical material properties, working towards the creation of physically correct replicas of artifacts' appearance. We will extend CultLab3D by adding multispectral illumination and image acquisition capabilities to CultArc3D and by developing additional scanning modules for our pipeline targeting novel forms of optical material property capture. Starting with High Dynamic Range (HDR) textures to account for non-visible effects of complex materials, or to reduce problems of current optical acquisition techniques with specularities, over methods to capture subsurface scattering and translucency effects towards volumetric methods featuring MRT or X-Ray sensors that go beyond the surface of objects into hidden concavities, or even exposing densities of materials an object is composed of, the novel possibilities of digitization modules for CultLab3D are endless.

5. Conclusion

In this paper we presented CultLab3D, to our knowledge, the world-wide first approach at an automated, fast and economic 3D digitization pipeline for cultural heritage artifacts. We described the current base system using a specially designed conveyor belt for safe transport and consisting of a first station acquiring geometry, texture and optical material properties of artifacts and a second station taking care of occlusions using a turntable and 3D scanners attached to robotic arms. We presented the Integrated Viewer Browser, a 3D centered annotation tool combined with a distributed meta- and object repository system developed within the European research project 3D-COFORM and its capability to export data to Europeana as well as its subsequent interactive and native visualization of 3D content in current web browsers.

We see CultLab3D and its innovative level of automation as the dawning of a new age for feasible and affordable large scale 3D digitization of complete archives or new entries to museums at best possible quality, complemented by parallel developments concerning the physical and faithful 3D reproduction of artifacts' appearance. We are aware that in addition to many challenges of 3D digitization itself, for example the support of a variety of materials, mass processing will require much research into many more topics, such as semi-automatic or crowd annotation strategies, long term storage capabilities, formats, digital rights and 3D model certification.

6. Acknowledgements

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