Universität Bamberg

Einführung Digitale Denkmaltechnologien Vorlesung

Prof. Dr. Mona Hess
Kontakt: mona.hess@uni-bamberg.de
Twitter: @Mona3Dimaging

Institut für Archäologische Wissenschaften, Denkmalwissenschaften und Kunstgeschichte

KDWT

Inhalt der Vorlesung

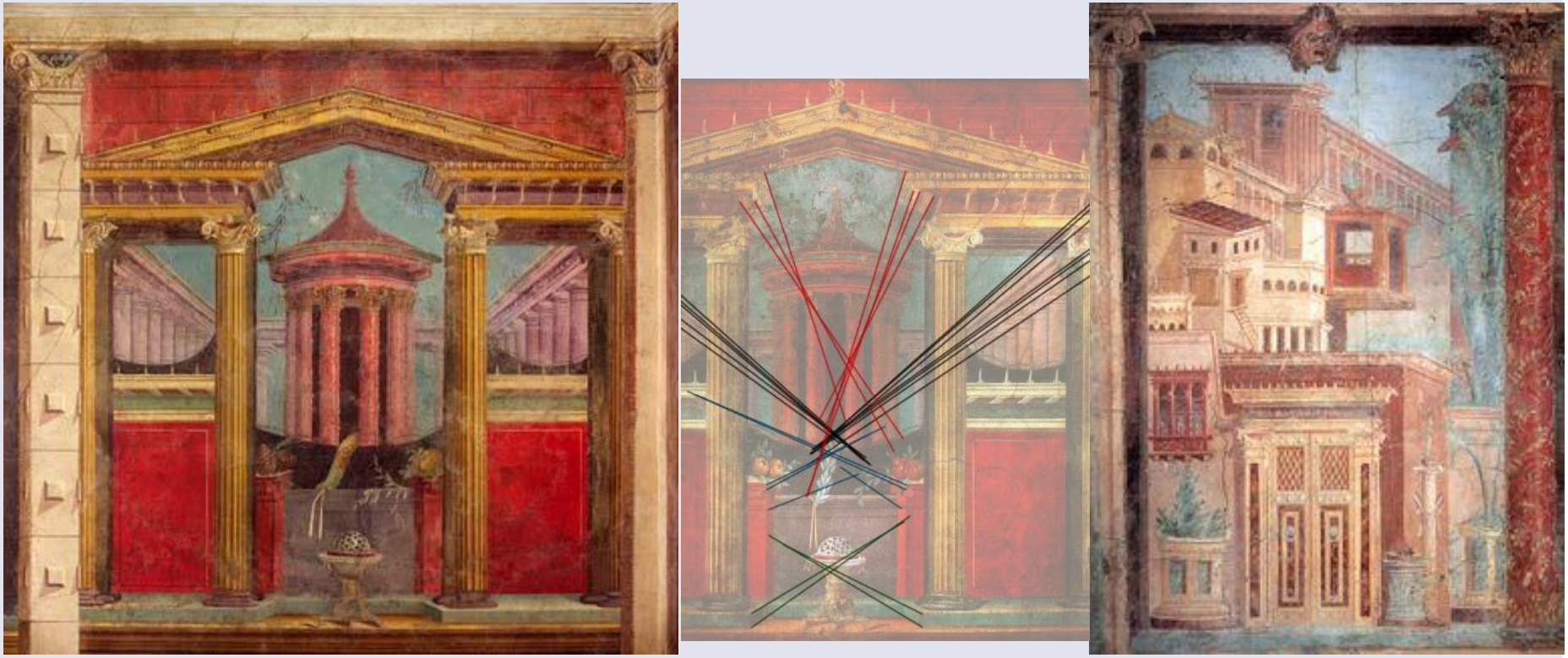
- Darstellung III: Kurzer Exkurs in die Perspektive
- Aktuelle Diskussion : Nefertitihack II
- Computer Graphics and Cultural Heritage
  - David Arnold
  - Meilensteine der Digitalen Denkmaltechnologien

DARSTELLUNG DER PROJEKTIONSARTEN IN DER DARSTELLENDEN GEOMETRIE / PERSPEKTIVE

PARALLELPROJEKTION							ZENTRALPROJEKTION		
		AXONOMETRIE					BEI SENKRECHTER BILDEBENE		
		DIMETRIE				TRIMETRIE			
SENKRECHTE EINTAFELPROJEKTION (KOTIERTE PROJEKTION)	SENKRECHTE ZWEI- U. DREITAFELPROJEKTION	MILITÄRPROJEKTION	KAVALIERPROJEKTION	DIN 5 INGENIEURPROJEKTION	ISOMETRIE	SENKRECHTE AXONOMETRIE	OBJEKT SENKRECHT ZUR BILDEBENE (FRONTALPERSPEKTIVE)	OBJEKT ZUR BILDEBENE ABGEDREHT (ÜBER ECK-PERSPEKTIVE)	BEI GENEIGTER BILDEBENE
MASSTÄBLICHKEIT → ANSCHAULICHKEIT									
		X : Y : Z 1 : 1 :0,5 α = BELIEBIG	X : Y : Z 1:0,5:1 α = 45° 1 :2/3: 1 α = 30°	X : Y : Z 1 :0,5: 1 α = 7° β = 42°	X : Y : Z 1 : 1 : 1 α =β = 30°	X : Y : Z AUS KONSTR. α, β=BELIEBIG			

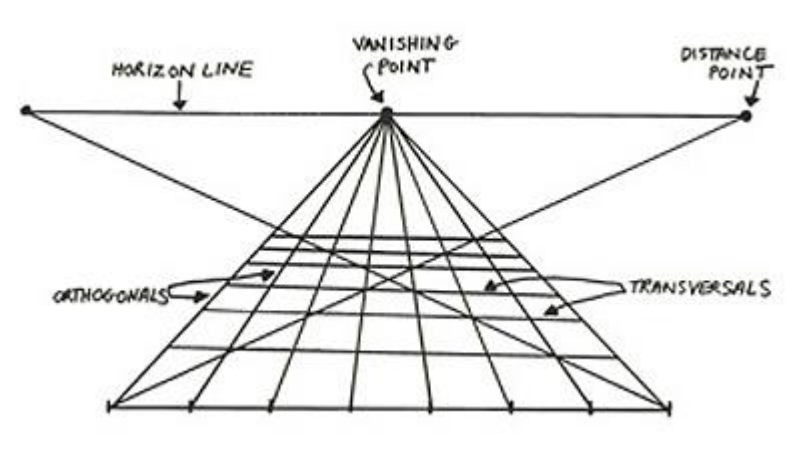
Darstellung - Perspektive

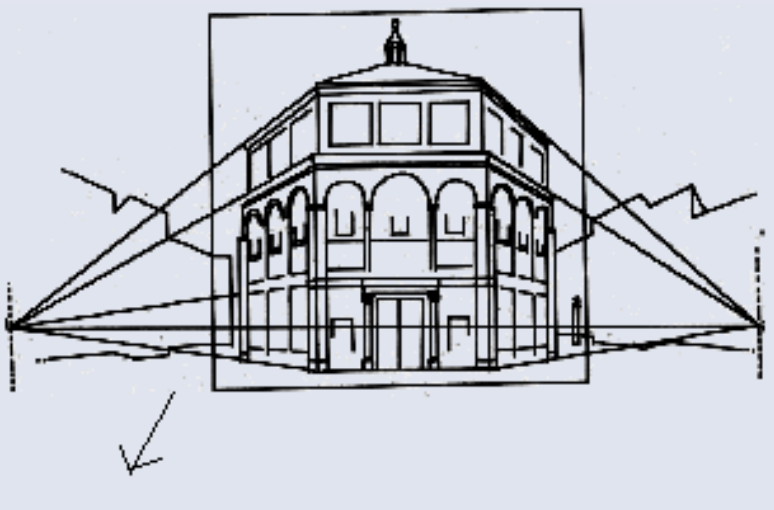
Historical Context



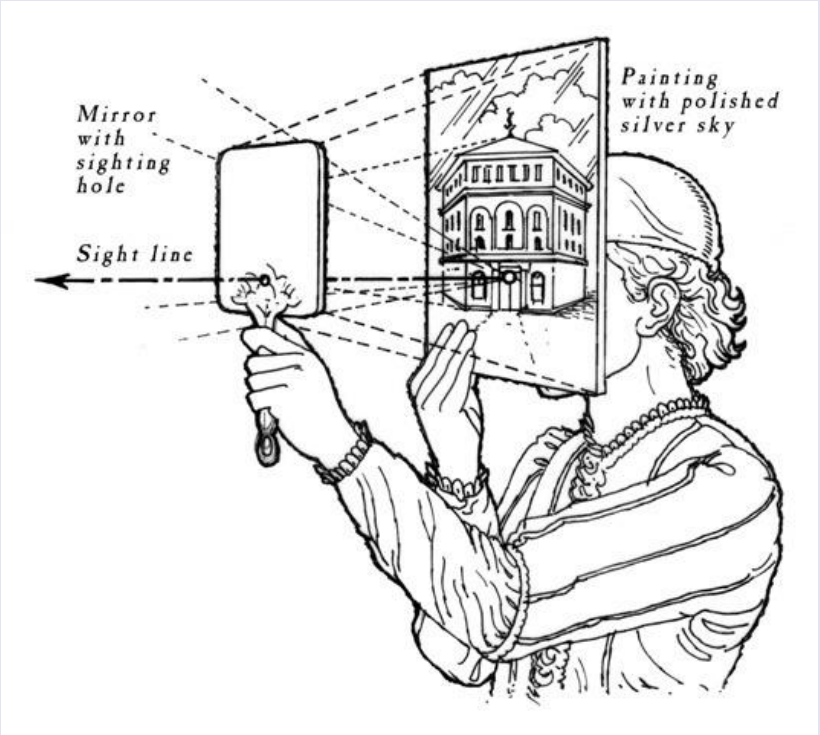
Right : Fresco from the Villa of Publius Fannius Synistor, second-style wall painting, preserved by ash in 79 AD

Historical Context



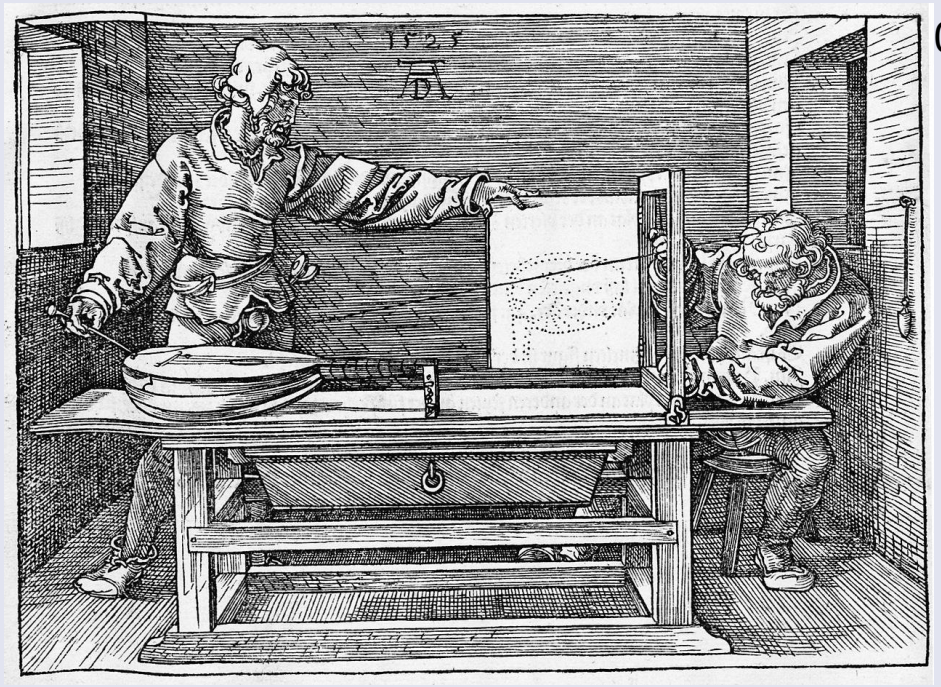


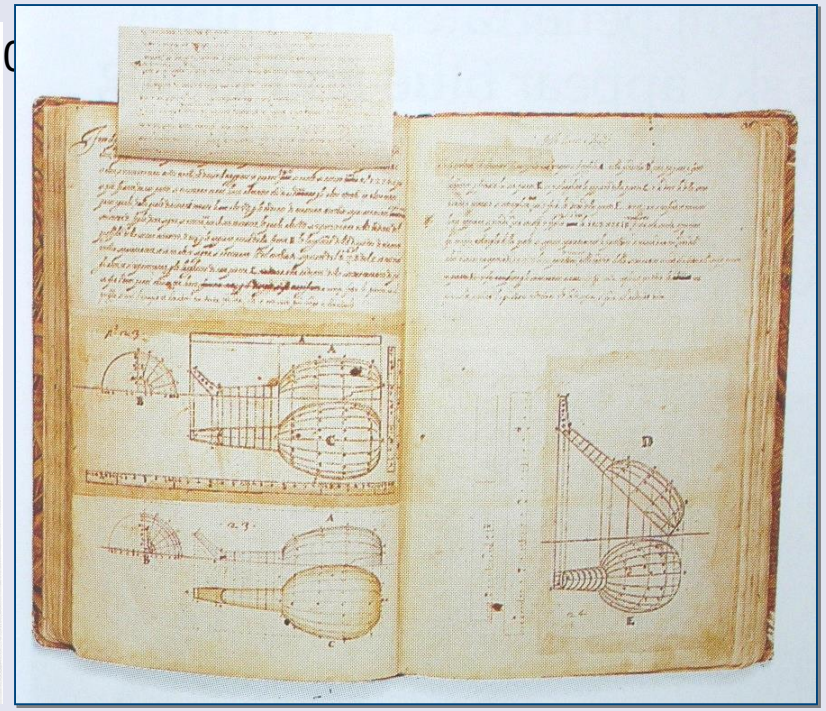
Linear Perspective



Dürer's devices (early 1500s)

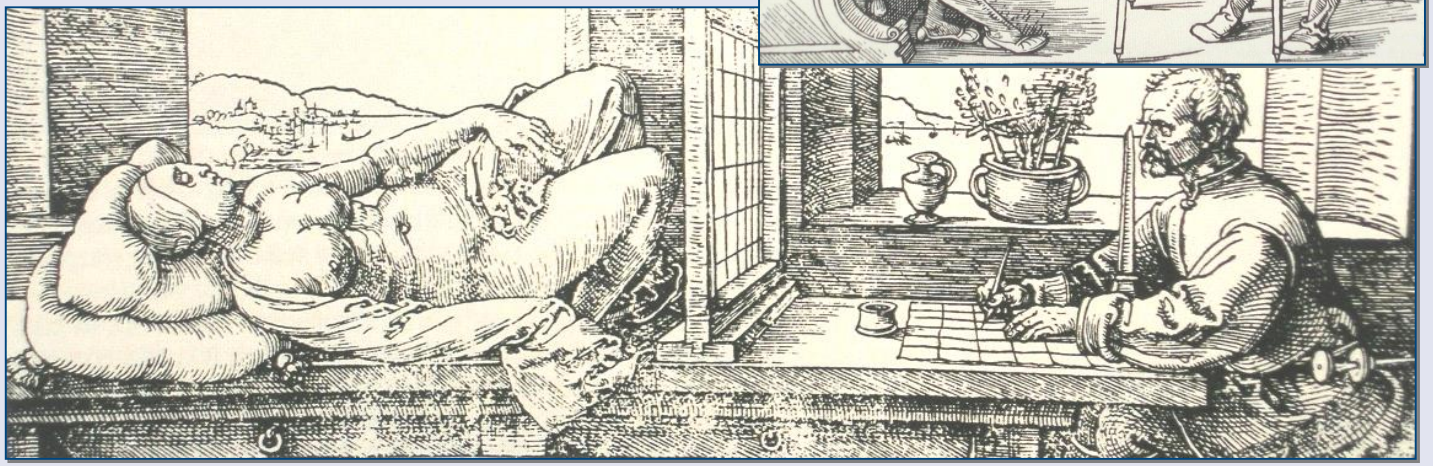
- Point plotting device





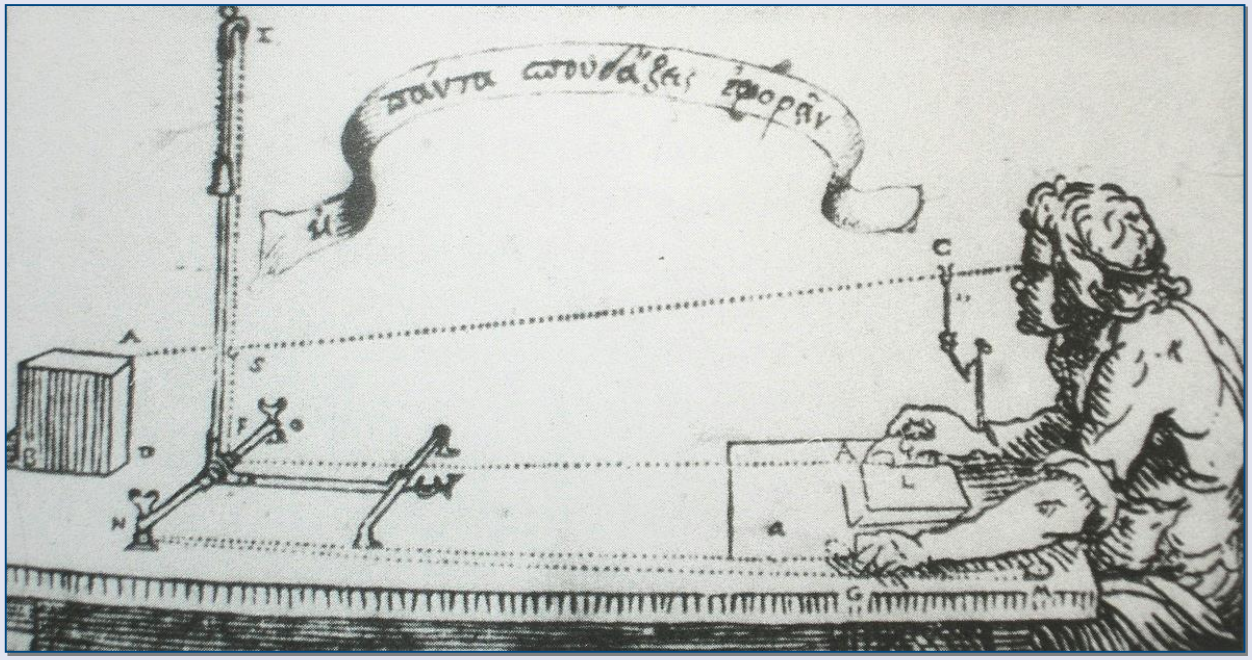
Dürer's devices (early 1500s)

- Draftsman's net
- Artist's glass



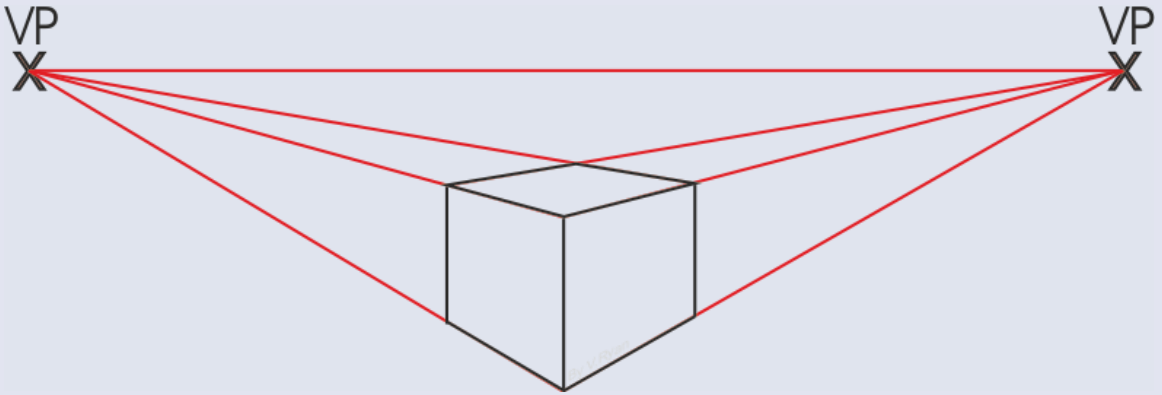
Cigoli's Perspective Machine (1610)

- Moving pen moves bead in viewing frame
- Two-handed interface (first etch-a-sketch?)



Vanishing Points

- Groups of parallel lines in the world intersect at a point in the image
  - Does this always happen? If not, when?
- Different vanishing points for each *direction* of parallel lines



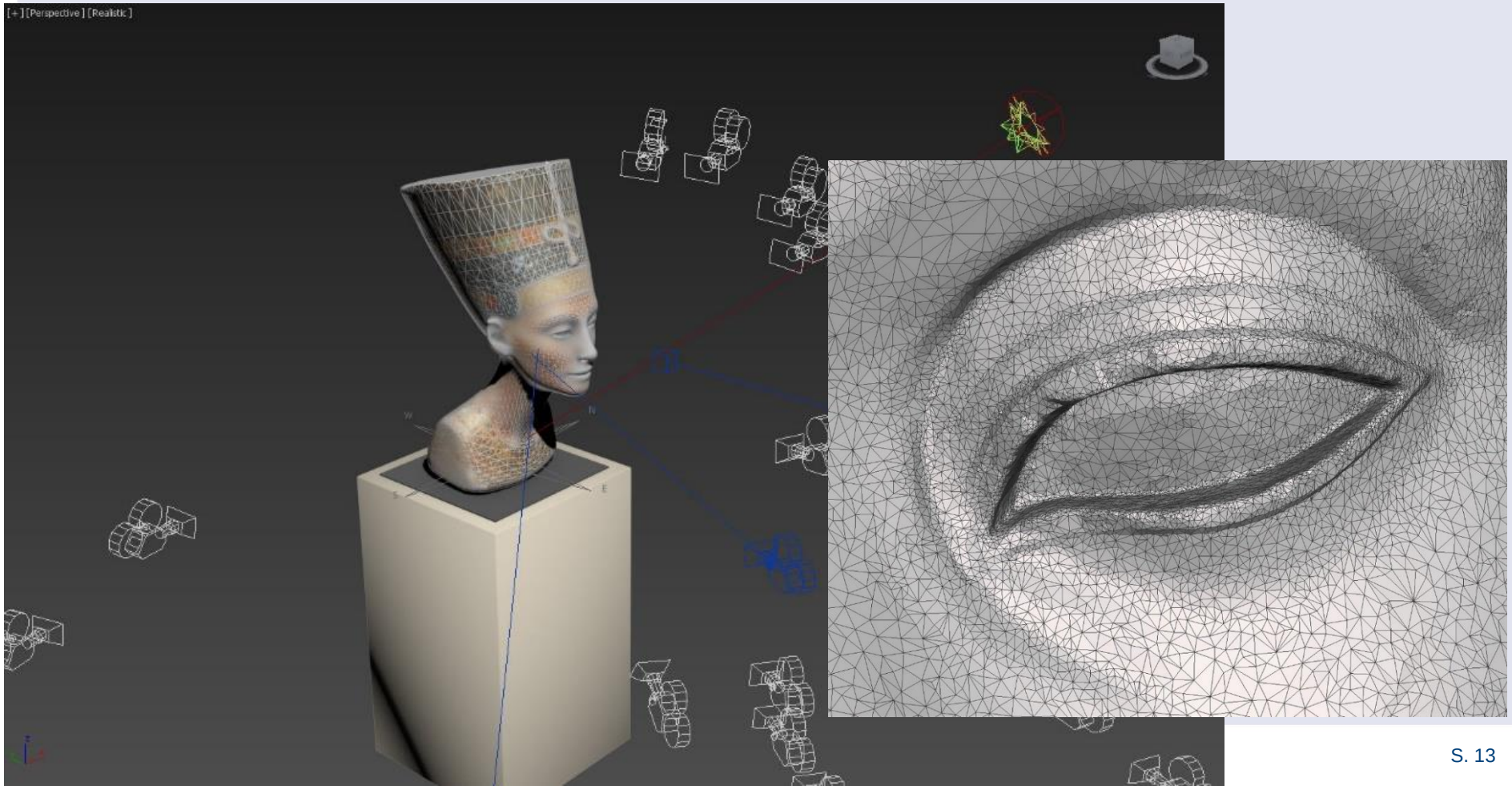
Nefertitihack … part 1

The bust (the original one that is) was "found" by an expedition of the Deutsche Orient-Gesellschaft (DOG) in 1912 at Amarna, Egypt. The DOG was founded, and funded, by Kaiser Wilhelm II to "acquire" knowledge and artefacts of the Biblical lands for Prussia. (Dezeen)

Nefertiti -Hack

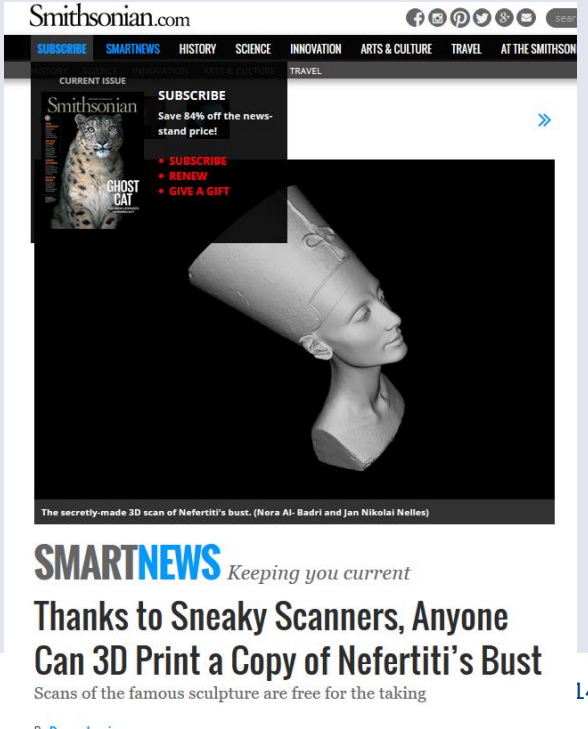
- **Nefertiti Hack**
- ***nefertiti****hack.alloversky.com/*
- The Other *Nefertiti*" is an artistic intervention by Jan Nikolai Nelles and Nora ... a public domain without any charge, this *torrent* provides you a STL-file (100 MB): ... Al-Badri and Nelles *scanned* the head of *Nefertiti clandestinely* in the Neues ...

February 22, 2016
The 3D Nefertiti Hack https://www.fabbaloo.com/blog/2016/2/21/the-3d-nefertiti-hack



The copy in contemporary culture is both despised and feared

- http://www.dezeen.com/2016/02/25/sam-jacob-opinion-column-copying-conservation-contemporary-culture-queen-other-nefertiti/



Nefertitihack – part 2

https://reason.com/2019/11/13/a-german-museum-tried-t 70%

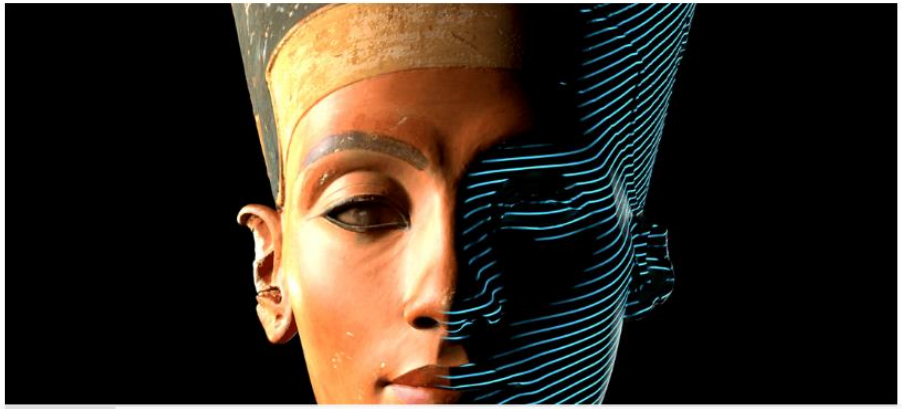
LATEST MAGAZINE VIDEO PODCASTS STOSSEL VOLOKH NEWSLETTERS

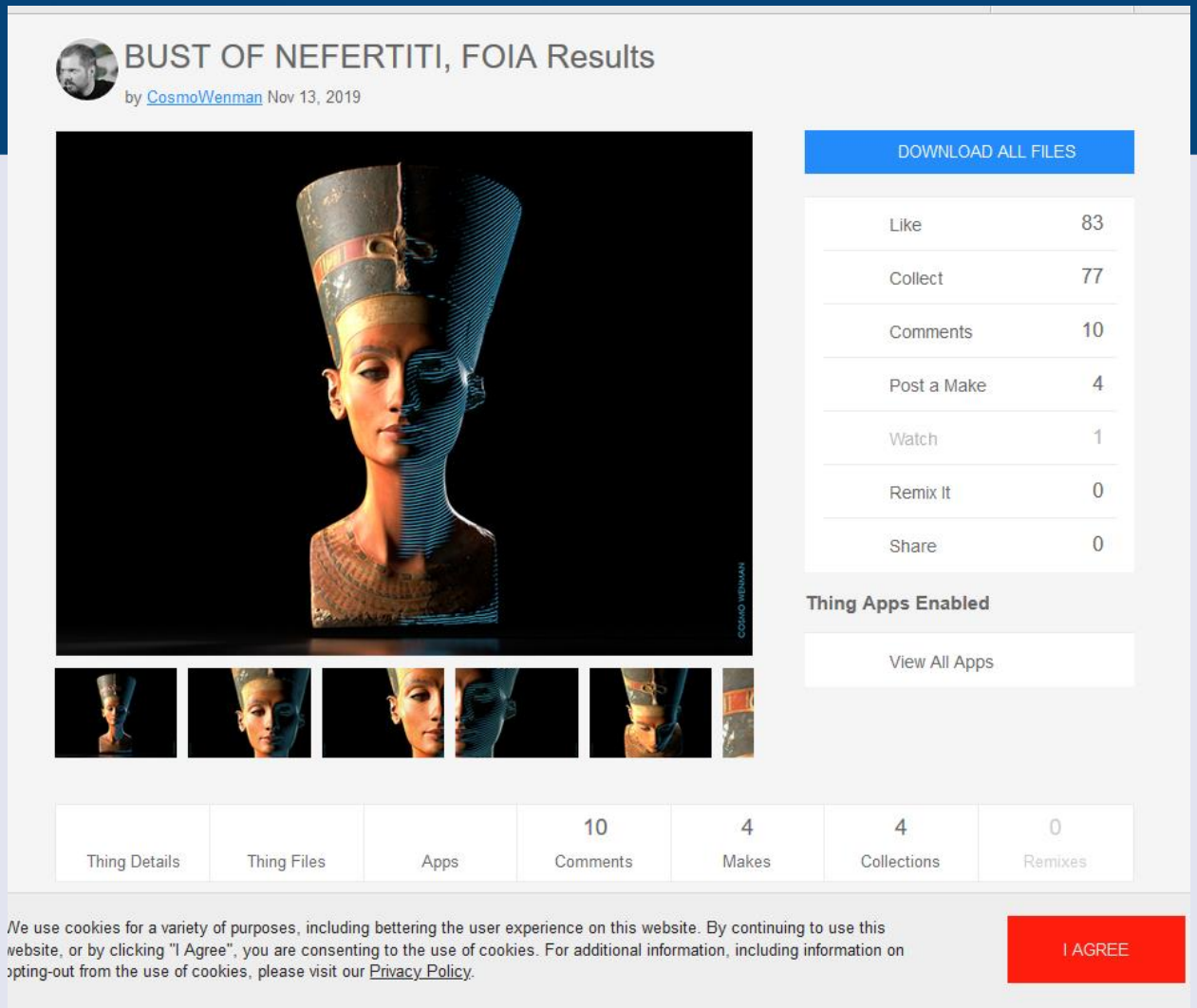
COPYRIGHT

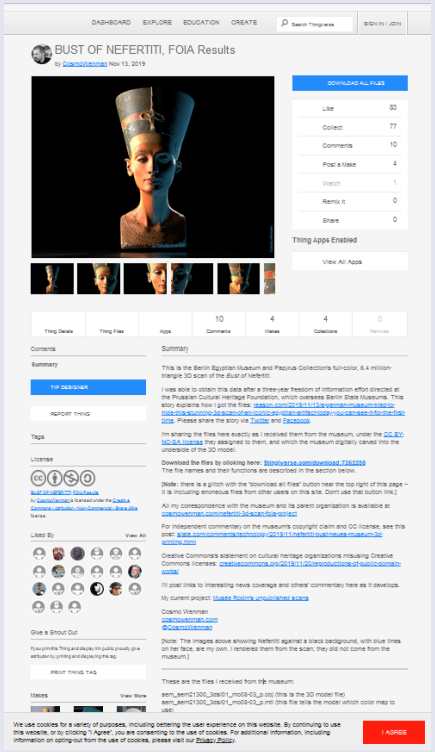
A German Museum Tried To Hide This Stunning 3D Scan of an Iconic Egyptian Artifact. Today You Can See It for the First Time

After a three-year freedom of information campaign, everyone can finally see the Egyptian Museum of Berlin's official scan of the Bust of Nefertiti.

COSMO WENMAN | 11.13.2019 1:30 PM







https://reason.com/2019/11/13/a-german-museum-tried-to-hide-this-stunning-3d-scan-of-an-iconic-egyptian-artifact-today-you-can-see-it-for-the-first-time/

Nefertitihack 2

Detail of copyright claim and Creative Commons license digitally carved into the scan of the bust of Nefertiti.
Cosmo Wenman

https://slate.com/technology/2019/11/nefertiti-bust-neues-museum-3d-printing.html

creative commons | Share your work | Use & remi

Help us build a vibrant, collaborative global commons | Don

Creative Commons > Blog > Legal tools / licenses > Reproductions of Public Domain Works Should Remain in the Public Domain

Reproductions of Public Domain Works Should Remain in the Public Domain

Claudio Ruiz and Scann
November 20, 2019

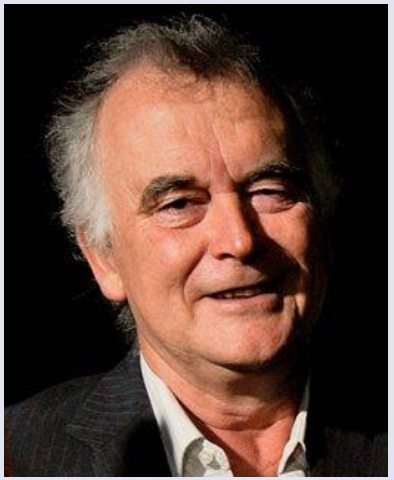
It has come to the attention of Creative Commons that there is an increased use of CC licenses by cultural heritage institutions on photographic reproductions and 3D scans of objects such as sculptures, busts, engravings, and inscriptions, among others, that are indisputably in the public domain worldwide. A recent example is the 3000-year-old Nefertiti bust on display at the Neues Museum in Berlin that the museum licensed under BY-NC-SA. The practices vary widely, from using a CC BY license, to using our most restrictive license—CC BY-NC-ND.

Most of these objects have been in the public domain for a long time now, indeed many that have never been subject to copyright. The copyright holder is the only person that can apply a CC license to a work. If the work is in the public domain, no copyright licenses should be applied, and in the case of CC licenses, which are designed to only operate where copyright exists, the application of a CC license is ineffective. In these cases, if anything, the Public Domain Mark or the CC0 public domain dedication tool should be applied to confirm worldwide public domain status.

> **If the work is in the public domain, no copyright licenses should be applied,**

Computer Graphics and Cultural Heritage

- Computer Graphics and Cultural Heritage, David Arnold
  - Inhalt Teil 1 mit Beispielen
    - Digital Michelangelo
    - Cultlab3D
    - Parthenon Debevec
    - Fragment Assembly
  - Inhalt Teil 2 Future Tools mit Beispielen
    - Rekonstruktion, Shape Grammar and Procedural Modelling



https://jocch.acm.org/memoriam.cfm

Literatur

- Siehe VC.
  - Arnold, D. “Computer Graphics and Cultural Heritage: From One-Way Inspiration to Symbiosis, Part 1.” *IEEE Computer Graphics and Applications* 34, no. 3 (May 2014): 76–86. https://doi.org/10.1109/MCG.2014.47 .
  - Arnold, D. “Computer Graphics and Cultural Heritage, Part 2: Continuing Inspiration for Future Tools.” *IEEE Computer Graphics and Applications* 34, no. 4 (July 2014): 70–79. https://doi.org/10.1109/MCG.2014.65.
  - Weiterführende Literatur auf den Folien

Bedeutung und Verkörperung, Significance

- This definition as *significance in the present* has also led some to point out that cultural heritage can be manufactured—with the significance embodied and created primarily through the narratives surrounding the tangible evidence.
- This significance could draw on a combination of the physical evidence, the intermediate events, and the narratives presented by thought leaders, whether inspired by religious belief, media reporting, politics, or entertainment. For computer graphicists, the message is clear. Every time we create a visualization or interpretation of a cultural object or site, we're potentially adding to its cultural significance. We should seek to do that in an informed way.

Was hat Lara Croft zu tun mit Denkmalpflege?

- D.Arnold “The Cambodian temple Ta Prohm, also called the “Angelina Jolie Temple.” You could argue that the temple’s use as a location for the movie *Lara Croft: Tomb Raider* fundamentally changed its significance.”

Was hat Lara Croft zu tun mit Denkmalpflege?

- Tomb Raider , 2001
- So the impact of Tomb Raider could be significant. If the film incarnation of Lara Croft is anything like as successful as her virtual counterpart, Cambodia can expect to enjoy something of a renaissance. Judging by the impact on tourism of the modestly successful Leonardo DiCaprio vehicle The Beach, which triggered a mini-invasion of Thailand's Phi Phi Leh island, Angkor could be swamped with tourists within a couple of years.
- The film is also good news for the temples. The conservation authority responsible for preserving and protecting the complex is charging Paramount $10,000 per day for seven days. Much of the money will go back into caring for the temples themselves.
- https://www.theguardian.com/film/2000/dec/08/culture.features2 , **Raiders of the lost temple , 8 Dec 2000,** James East

New Renaissance Report und andere Texte, die wir teilweise schon gesehen haben

- ICOM. (**2006**, revised). *Statues and Code of Professional Ethics International Council for Museums, first published 1996*. Zugriff am 9.7.2008. Verfügbar unter: http://icom.museum/ethics.html#intro
- European Commission. (**2010**, Mai 19). A Digital Agenda for Europe . EUR-Lex - 52010DC0245 - EN - EUR-Lex. (No longer in force.). Zugriff am 16.8.2017. Verfügbar unter: http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1502889462112&uri=CELEX:52010DC0245
- **10 Januar 2011; Niggemann, E., De Decker, J. and Levy, M. (2011) *The New Renaissance. Report of the 'Comites des Sages' . Reflection group on bringing Europe's Cultural Heritage Online.* Available at: https://ec.europa.eu/digital-agenda/sites/digital-agenda/files/final_report_cds_0.pdf**
- October 2011: European Commission. (**2011**). Commission Recommendation of 27 October 2011 on the digitisation and online accessibility of cultural material and digital preservation. *Official Journal of the European Union*, *L 283*, 39–45.
- UNESCO/PERSIST Content Task Force & UNESCO. (**2016**, März). The UNESCO/PERSIST Guidelines for the selection of digital heritage for long-term preservation. *International Federation of Library Associations and Institutions (IFLA)*. Zugriff am 3.1.2017. Verfügbar unter: http://www.ifla.org/files/assets/hq/topics/cultural-heritage/documents/persist-content-guidelines.pdf

What is the New Renaissance Report?

- *The New Renaissance*,2011
- report commissioned by the European Commission
- justified the estimated 100-billion-euro cost of digitization to bring “our complete heritage online” as follows: “Digitisation breathes new life into material from the past, and turns it into a formidable asset for the individual user and an important building block of the digital economy.”
- E. Niggemann, J. De Decker, and M. Lévy, *The New*
- *Renaissance*, Comité des Sages, 2011; http://ec.europa.eu/information_society/activities/digital_libraries/doc/refgroup/final_report_cds.pdf

The New Renaissance Report, EU, 2011

- We make our recommendations with these potential benefits in mind and with the aim to promote
- an environment that will help to:
- - share our rich and diverse common heritage
- - link the past with the present
- - preserve this heritage for future generations
- - protect the interests of European creators
- - nurture creativity, including creative efforts by non-professionals
- - contribute to education, and
- - spur innovation and entrepreneurship.

Computer Graphics and Cultural Heritage

From One-Way Inspiration to Symbiosis, Part 1, David Arnold

- ICT (information and communication technology) tools and techniques
- Computer Graphics, computational geometry and interactive techniques
  - -> tools and applications for documenting and preserving tangible cultural heritage

Computer Graphics and Cultural Heritage

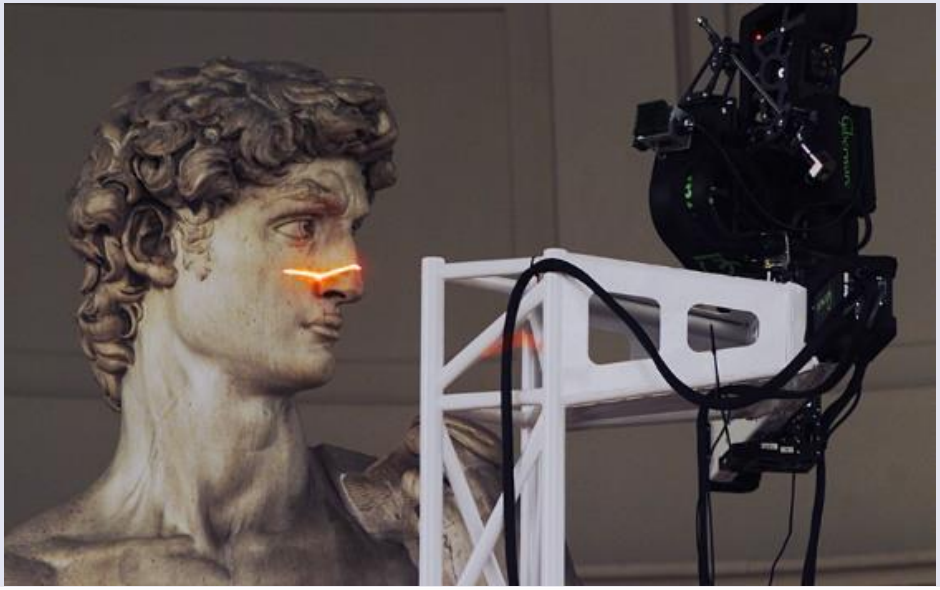
From One-Way Inspiration to Symbiosis, Part 1, David Arnold

- What makes Cultural Heritage Different and Challenging?
- Recording Tangible Evidence
  - Michelangelo Project
  - CultLab3D

"When all the museums of the world have their collections online …" is a typical precursor of a vision of the future.

Beispiel Digital Michelangelo! Landmark Project.1992

- David moved to the Galleria dell'Accademia 1873
- Levoy, M. "The Digital Michelangelo Project - Stanford University," ca 1998 http://graphics.stanford.edu/projects/mich/.
- Lets have a look at the website.
- 2004 David cleaned and restored



2010 Rescan of leg

Since the discovery of this potential endagering condition of the Michelangelo's masterpiece, the hypothesis under discussion included both the bad quality of the marble or the occurrence of external actions .

Figure 1: *The two images show the regions affected by the fractures (the back of the left leg and the so-called "broncone", i.e. the tree stump on the back of the right leg), most of them extremely thin. Images courtesy of A. Borri (BORRI et al, 2004).*

Bathow, C., B. Breuckmann, M. Corsini, M. Dellepiane, U. Dercks, R. Scopigno, and R. Sigismondi. “Documenting and Monitoring Small Fractures on Michelangelo’s David, 2010

Figure 2: *Scanning the David.*

Figure 3: *First results of shape reconstruction from the 3D scanned shape data: the broncone 3D model is presented on the left, a zoom-in view is on the right.*

The final master model has been reconstructed with a sampling resolution of 0.1 mm. Final reconstructed models are very dense: 128 M triangles in the case of the bron cone (back of right leg), 57 M triangles for the left leg. An image of the 3D model obtained in presented in Figure 3.

This paper presents the overall organization of the digital sampling and possible future monitoring of the visible status of the lesions on the lower part of the David statue. We have organized the sampling by performing an accurate digitization of both shape and colour of the selected regions; those high resolution data have been integrated in a single digital model,

Beispiel Digital Michelangelo! Landmark Project. Further reading.

- Levoy, Marc, Kari Pulli, Brian Curless, Szymon Rusinkiewicz, David Koller, Lucas Pereira, Matt Ginzton, et al. “The Digital Michelangelo Project: 3D Scanning of Large Statues.” In *Proceedings of the 27th Annual Conference on Computer Graphics and Interactive Techniques*, 131–144. SIGGRAPH ’00. New York, NY, USA: ACM Press/Addison-Wesley Publishing Co., **2000**. https://doi.org/10.1145/344779.344849.
- Godin, Guy, J.-Angelo Beraldin, Marc Rioux, Marc Levoy, and Luc Cournoyer. “An Assessment of Laser Range Measurement of Marble Surfaces.” In *5th Conference on Optical 3D Measurement Techniques*. Vienna, Austria, **2001**.
- Callieri, M., P. Cignoni, F. Ganovelli, G. Impoco, C. Montani, P. Pingi, F. Ponchio, and R. Scopigno. “Visualization and 3D Data Processing in the David Restoration.” *IEEE Computer Graphics and Applications* 24, no. 2 (March **2004**): 16–21. https://doi.org/10.1109/MCG.2004.1274056 .
- Bathow, C., B. Breuckmann, M. Corsini, M. Dellepiane, U. Dercks, R. Scopigno, and R. Sigismondi. “Documenting and Monitoring Small Fractures on Michelangelo’s David.” In *Computer Applications and Quantitative Methods in Archeology - CAA’2010*, **2010**.

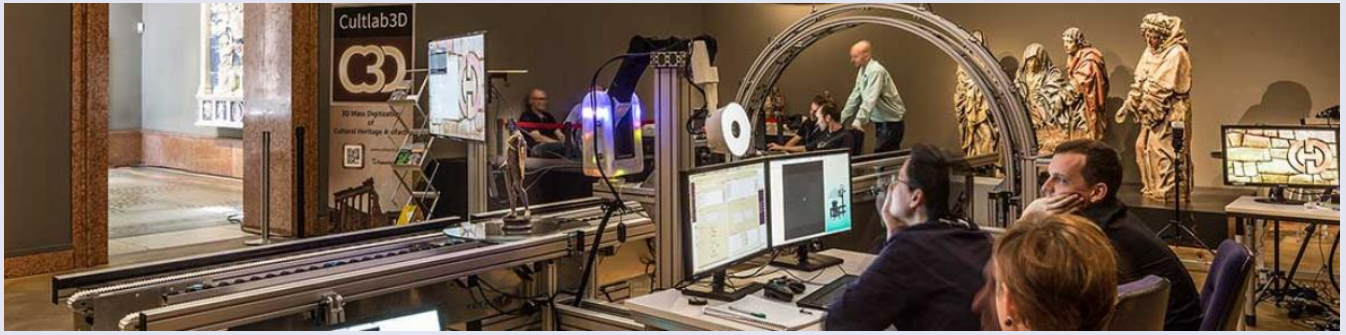
Restaurierung des Davids nach 2010??

- https://sz-magazin.sueddeutsche.de/kunst/der-riss-83043
- https://www.sciencedirect.com/science/article/abs/pii/S1296207414000375 **Modelling the failure mechanisms of Michelangelo's David through small-scale centrifuge experiments**
- **https://www.vam.ac.uk/blog/projects/guest-post-the-restoration-of-michelangelos-david-and-the-interventions-by-clemente-papi**
- G. Corti, et al., Modelling the failure mechanisms of Michelangelo's David through small-scale centrifuge experiments, Journal of Cultural Heritage (**2014**), http://dx.doi.org/10.1016/j.culher.2014.03.001

CultLab3D – Modulare Digitalisierstrasse

3D Vermessung von Objekten und Sammlungen am Fliessband: Cultlab3D

- Santos, P. (2016): 3D mass digitization: a milestone for archeological documentation, Fraunhofer Institute for Computer Graphics Research IGD, Germany, Arqueologica 2.0
- https://www.cultlab3d.de/?lang=de - Schauen wir uns die Webseite an.



CultLab3D – Modulare Digitalisierstrasse

Graphically Speaking

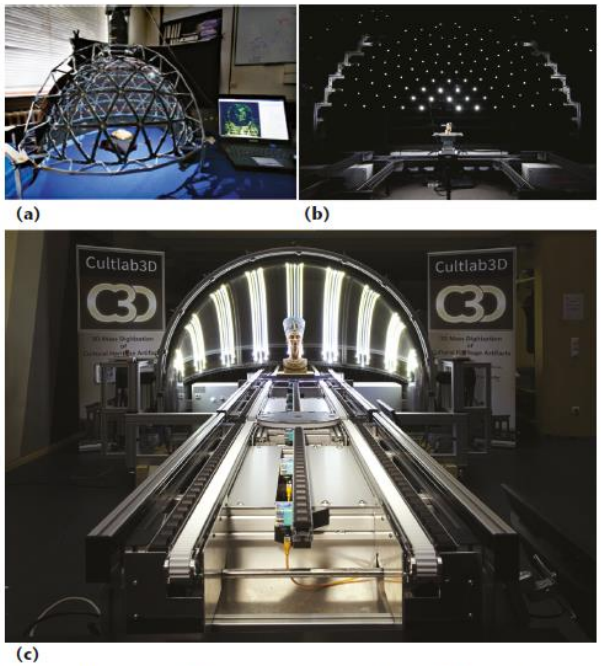
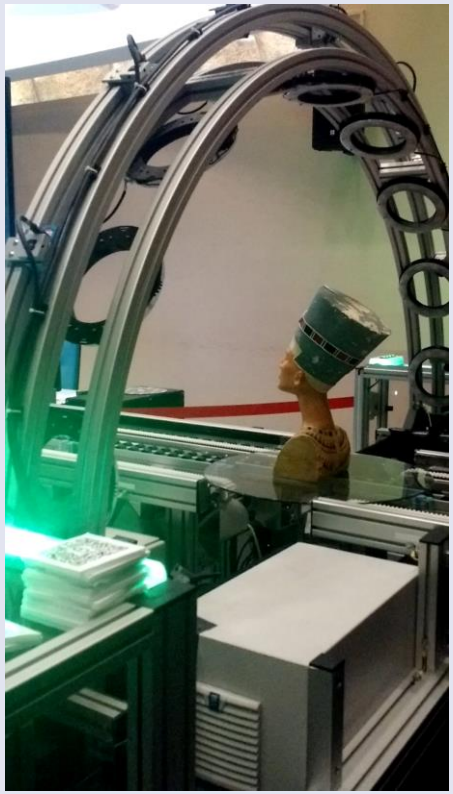
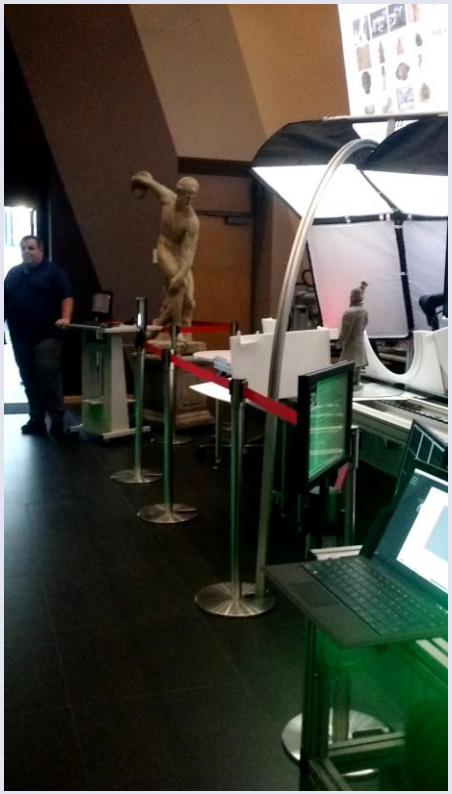


Figure 2. Three devices for documenting optically complicated objects. (a) The Catholic University of Leuven's MiniDome employs controlled lighting in single-camera image-based capture. (b) The University of Bonn's moveable Multiview Dome employs a combination of structured-light and image-based recording technologies. (c) The new CultLab3D Scanner from the Fraunhofer Institute for Computer Graphics Research won the DigitalHeritageExpo's prize for technical proficiency. (Figure 2c courtesy of the Fraunhofer Institute for Computer Graphics Research.)



CultLab3D – Modulare Digitalisierstrasse

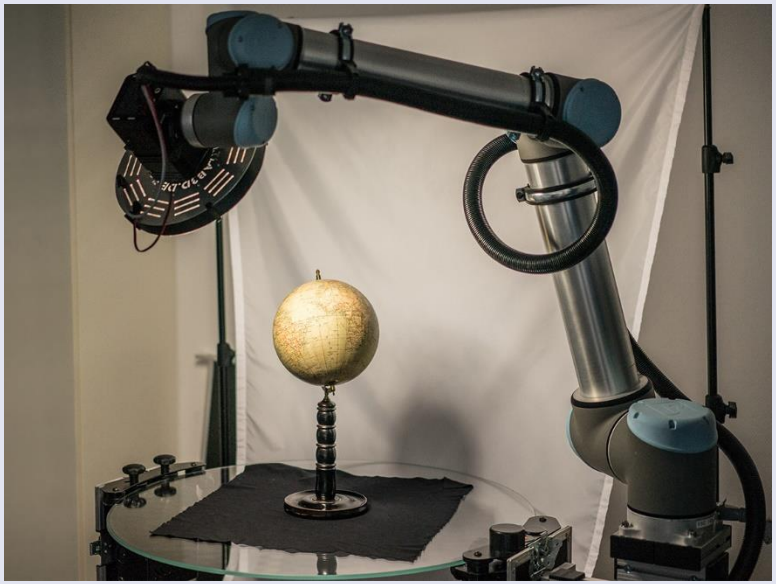


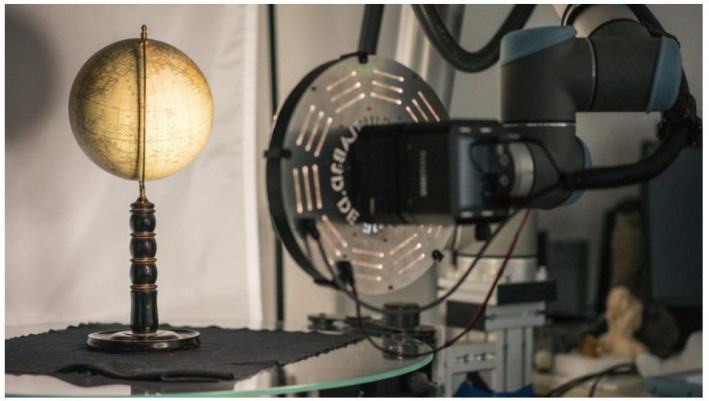
Cultlab3D – Entwicklungen 2018

EUROPEAN HERITAGE
EUROPA NOSTRA
AWARDS

- Europa Nostra Preis 2018
- https://www.fraunhofer.de/de/forschung/aktuelles-aus-der-forschung/kulturerbe-erhalten/3d-digitalisierung.html
- http://www.europeanheritageawards.eu/winner_year/2018/

CultArm3D (Cultlab3D)





Earth Globe "Räth" 1906 Digitization by CultArm3D

https://www.cultlab3d.de/index.php/2019/07/10/cultarm3d-for-cultur3d/

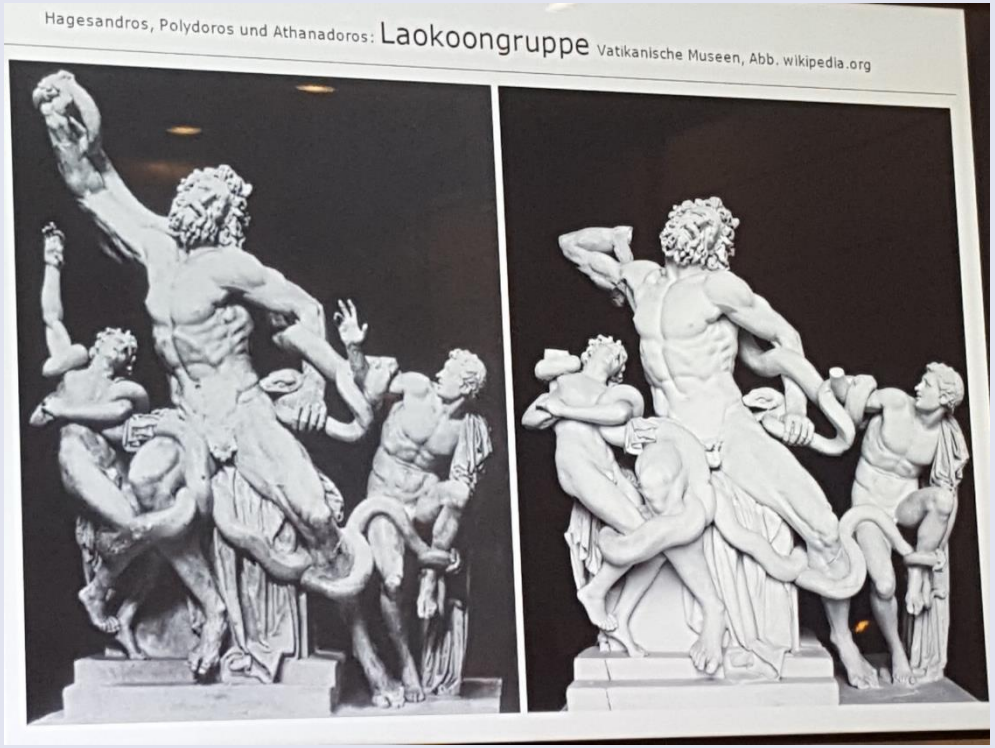
Computer Graphics and Cultural Heritage

From One-Way Inspiration to Symbiosis, Part 1, David Arnold

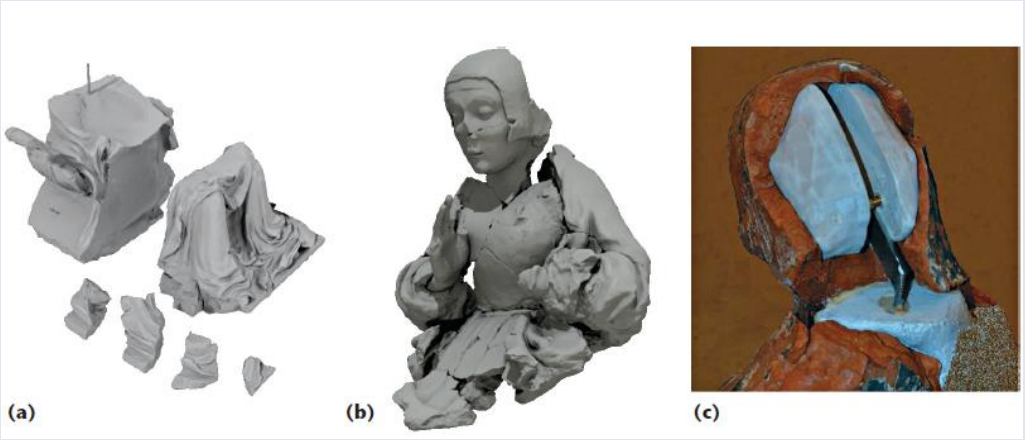
- Interpreting the Evidence to Reconstruct the Past
  - Fragment Reassembly
  - Drawing on Secondary Sources
  - Helping Determine Provenance
  - Challenges of Digitisation

Drawing on secondary sources: Evaluate hypothetical reconstructions

- Laocoon and his sons 1506, further fragments were discovered in the 20th century.
- 3D digitise the fragments: hypothetical reconstruction



Fragment reassembly



Reconstruction of the Madonna di Pietranico.a) 3D scans, b) virtual reconstruction, c) physical reconstruction using 3D prints. Image from (Arnold, 2014a)

Image by (3D-Coform, 2012a)

Akrotiri: Reassembling Theran Wall Paintings

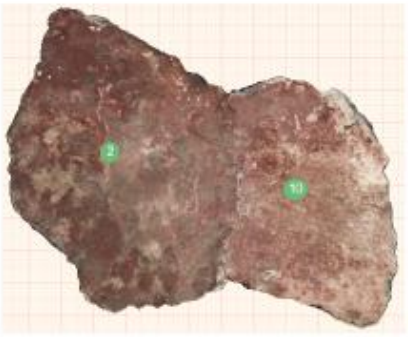


Figure 1: *Our acquisition system, deployed at the Akrotiri Excavation, Thera. We use a flatbed scanner to capture high-resolution images and normals of wall painting fragments (shown at left), and multiple 3-D scanners to acquire geometry. A single user can operate up to four scanners simultaneously, while a second user operates the flatbed scanner and verifies processing results. This yields a throughput of approximately 10 fragments per hour. Our matching algorithm correctly finds the only two matches in this data set using the scanned 3-D geometry.*

Brown, Benedict J., Corey Toler-Franklin, Diego Nehab, Michael Burns, David Dobkin, Andrea Vlachopoulos, Christos Coumas, Szymon Rusinkiewicz, and Tim Weyrich. “A System for High-Volume Acquisition and Matching of Fresco Fragments: Reassembling Theran Wall Paintings.” In *ACM Transactions on Graphics (Proc. SIGGRAPH 2008)*. Los Angeles, 2008. http://web4.cs.ucl.ac.uk/staff/t.weyrich/projects/thera/thera-acquisition.pdf.

Acquisition & Processing

UCL

- Low-cost, bespoke acquisition rig
- Automated processing enabled by
  - highly specialised scanner setup
  - tightly controlled workflow
  - allowed for custom algorithm design
- Workflow developed with conservators

⇒ high usability

Akrotiri: Reassembling Theran Wall Paintings

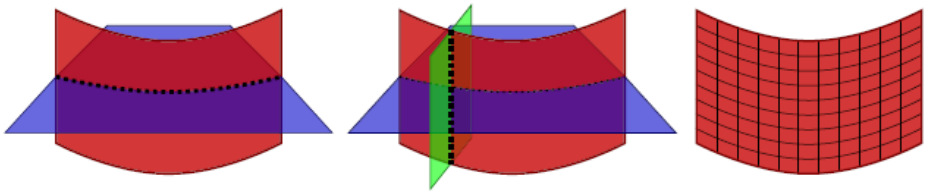


Figure 11: To efficiently compute fragment matches, we regularly resample fragment edges into a "ribbon." A contour is extracted at a fixed offset from the front surface (left), then each sample is extruded vertically in a plane defined by the contour point's smoothed normal (center). Ribbon points are arranged in a grid (right), allowing efficient computation of correspondences.

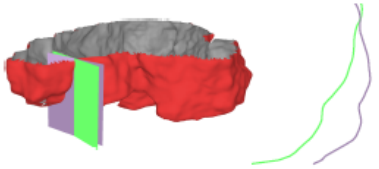


Figure 12: A ribbon, with profiles extracted using smoothed and unsmoothed normals. We use smoothed normals to ensure consistency among fragments.

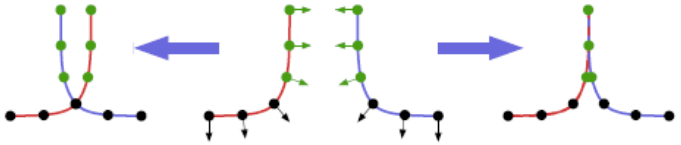


Figure 13: Using all corresponding point pairs on the red and blue curves yields an incorrect alignment (left) because the black points are on eroded portions of the edge. Using only the green points, whose normals' z-components are opposing, yields a correct alignment (right).

point's normal will be affected by the alignment, its z-component is

Wall Painting Matching Results We ran the ribbon matcher on all pairs of fragments within each test set, producing a list of candidate matches ordered by alignment error. The results are summarized in Table 1. For the "real" fragments, we visually examined the top matches, and sent images of the ones we believed could be correct to the conservators for verification against the actual fragments. We used a strip width of 25 mm. For the synthetic fresco, we used strip widths of 6.25 mm, 12.5 mm, 25 mm, 50 mm, as well as the combined results of all four strip widths. We examined the proposed alignment for each matching pair to see if it was correct. Finally, we also tested the ICP matching approach

Akrotiri: Reassembling Theran Wall Paintings

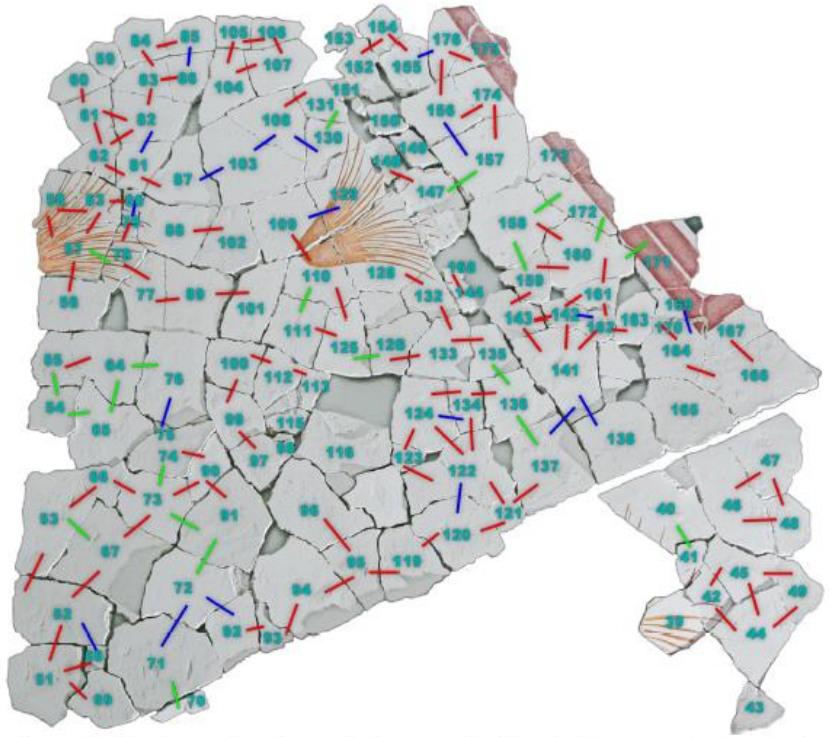


Figure 14: The "ground truth" synthetic fresco. Red lines indicate matches found using the ribbon matcher with a 25 mm strip width. Blue links indicate additional matches found with a 12.5 mm strip width, and green links indicate further matches found with a 50 mm strip width. Only numbered fragments have been scanned.

Figure 15: The six matches from the spiral data set, found with the ribbon matcher. The matcher considers only edge geometry; the decoration's continuity just confirms success. (We did not find the match between fragments 170 and 174.)

Figure 16: The three matches from the white data set.

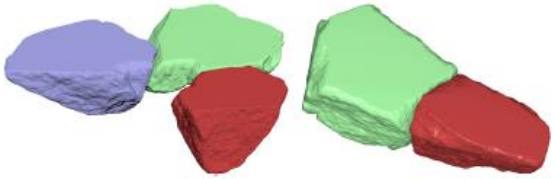


Figure 17: Matches in the Forma Urbis Romae *test set.*

Computer Graphics and Cultural Heritage

Continuing Inspiration for Future Tools, Part 2, David Arnold

- Trust and Techniques developed in Computer Graphics, Computational photography and interactive techniques -> empowering computer scientists and cultural professionals to collaborate on new tools and techniques
- From documenting to reconstruction and visualisation, uncertainties and narratives

Helping determine provenance

- Evidence to help cultural-heritage professional to reach their judgement
- 3D part of a range of evidence
- Computational geometry are providing and additional perspective

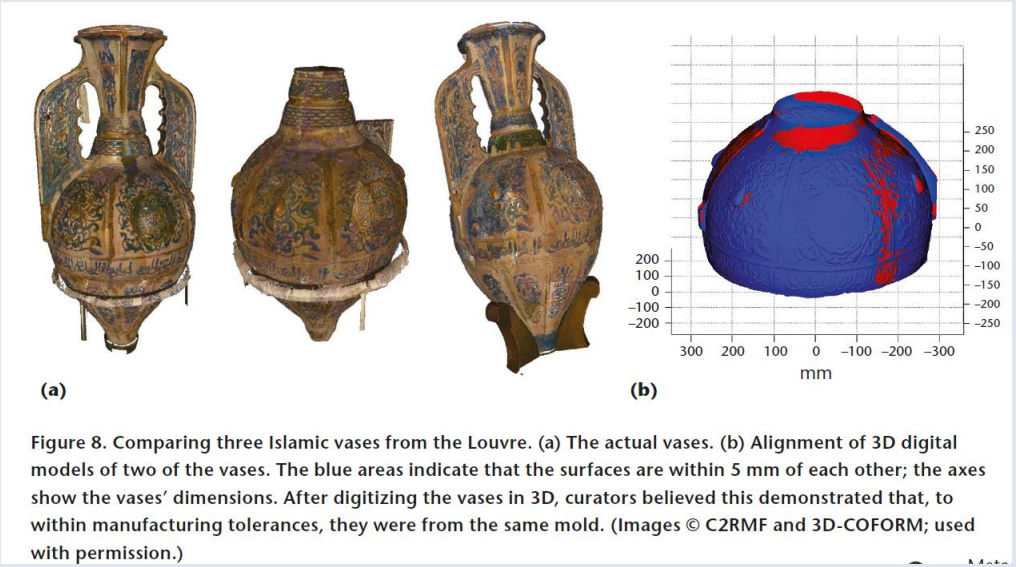


Figure 8. Comparing three Islamic vases from the Louvre. (a) The actual vases. (b) Alignment of 3D digital models of two of the vases. The blue areas indicate that the surfaces are within 5 mm of each other; the axes show the vases' dimensions. After digitizing the vases in 3D, curators believed this demonstrated that, to within manufacturing tolerances, they were from the same mold. (Images © C2RMF and 3D-COFORM; used with permission.)

Helping to determine manufacture – 3DPetrie project - UC29999A shabtis

- Making many https://www.youtube.com/watch?v=C_KWXznxovQ

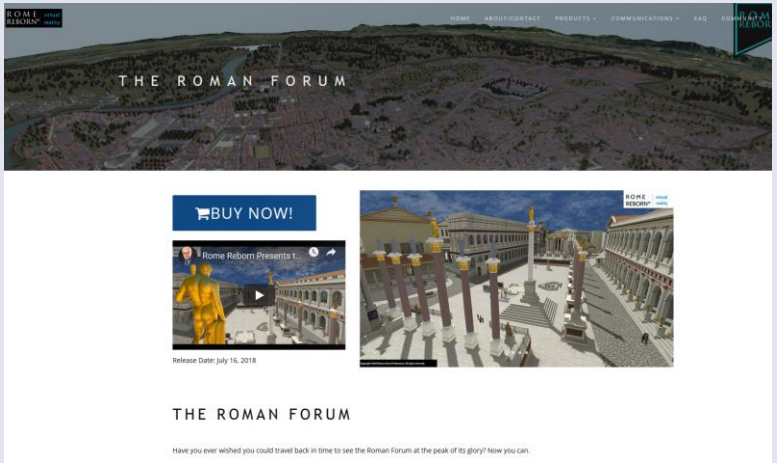
Computer Graphics and Cultural Heritage
Continuing Inspiration for Future Tools, Part 2, David Arnold

- Visualisation - definition
  - *In computer graphics, visualization is the set of tools and techniques that let us visualize a body of data. Time –dimension, animation of processes/ people! Ways to present huge data in understandable forms, demonstrating patterns!*
  - *In archaeology, visualization is mainly the reconstruction of sites, based on the archaeological evidence, whereas the viewing of digital assets is assumed to be inevitable and a somewhat trivial adjunct.*
  - *Visualisation offer chances for communicating these virtual reconstructions with cultural-heritage professionals and the public.*
- Shape grammars and procedural modelling in reconstruction
  - The Science of Light: Multispectral ,
  - Visualising spatially organised datasets
  - 3D Druck as exhibition surrogate

Shape Grammars and Procedural Modelling in Reconstruction

- Shape grammars use a set of production rules to describe the structural composition of a set of shapes in 2D or 3D within a class of objects.
- Procedural modelling also uses a set of rules to generate a parametrized class of object.

- The **Rome Reborn project** (http://romereborn.frischerconsulting.com) sets out to present the city as it might have looked at its height, around AD 320.5



Pompeii : Bewegung von Menschen in Stadträumen – 2007-2014

J. Maïm, S. Haegler, B. Yersin, P. Mueller, D. Thalmann, L. Van Gool / Populating Ancient Pompeii with Crowds of Virtual Romans

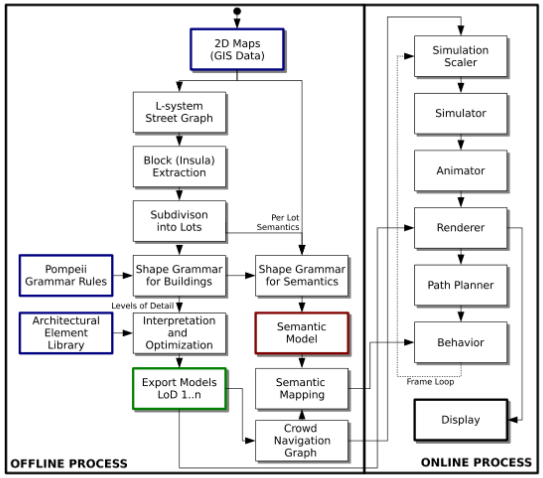


Figure 3: *The overall pipeline consists of an offline and online part. The generation of the city model and semantics is done in an offline preprocess, where also the navigation graph is created and the behavior mapping is achieved. The online part deals with the scene rendering and the execution of the behavior actions based on character location.*

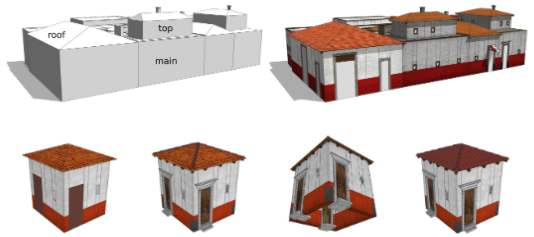


Figure 4: *The Pompeii shape grammar. Top row: On the left an intermediate state in the grammar derivation process after the volume assembly is shown. On the right we show the final subdivided facades. Bottom row: the Pompeii grammar rules contain built-in levels-of-detail which can be controlled with a single variable* `LOD`*. From left to right with increasing complexity:* `LOD=0` *(quads only),* `LOD=1` *(door and window elements),* `LOD=2` *(thick walls) and* `LOD=3` *(individual roof tiles). The results presented in this paper make use of* `LOD=0` *and* `1`*.*

2. Semantic Reconstruction of Pompeii

The ancient site of Pompeii has been extensively studied due to the good preservation of the ruins [Esc79, Ric88, WH94]

- Our Pompeii model was created with an extended version of the CityEngine. The grammar rules were enhanced with levels-of-detail capability (see Figure), semantic information for the crowd engine and more detailed textures and geometry. The Pompeii grammar rules consist of a combination of volumes and a repetitive subdivision scheme. In addition, the rules contain a set of parameters, e.g. , building dimensions, facade proportions, door widths, which are defined as single values or as ranges of values with upper and lower bounds defined by archaeological findings.

Projektbeschreibung Pompeii : Bewegung von Menschen in Stadträumen – 2007-2014

- This Chapter discusses the methods involved in the generation of large crowds of Virtual Humans in environments like cities. We focus on the geometric aspects of these methods in the different steps involved: scaler, simulator, renderer, path planner, and behaviour handler.
- For the crowds, combining the different LOD (level of detail), it is possible to simulate in this environment 4,000 Romans, i.e., about 600,000 triangles and 88 Mb of compressed textures, with real-time performance (30 fps in average).

Bewegung von Menschen in Stadträumen – 2007-2014

- We have revived its glorious past using a 3D model of its former appearance and populated it with crowds[30] (see Fig. 7). In an offline process, the city is first automatically reconstructed and exported into two different representations:
- • A high-resolution model. It is used to generate a Navigation Graph, and is also rendered at runtime.
- • A low-resolution model labeled with semantic data. This model is only composed of annotated building footprints and door / window positions.

Video Pompeii

Youtube Video: Populating Ancient Pompeii with Crowds of Virtual Humans - YouTube

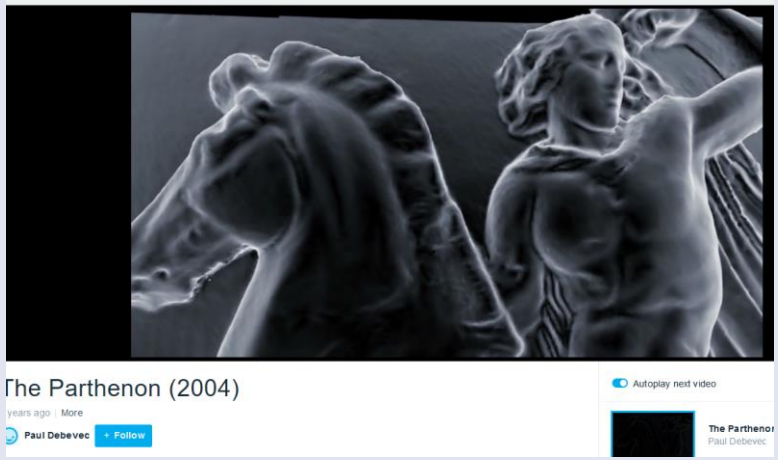
Quellen Pompeii - Bewegung von Menschen in Stadträumen – 2007-2014

- Paper 1: Maïm, Jonathan et al. (Hg.), Populating Ancient Pompeii with Crowds of Virtual Romans, in: *Proceedings of the 8th International Symposium on Virtual Reality, Archeology and Cultural Heritage - VAST*, 2007. https://infoscience.epfl.ch/record/125211
- Paper 2: Thalmann, Daniel et al., Geometric Issues in Reconstruction of Virtual Heritage Involving Large Populations, in: *3D Research Challenges in Cultural Heritage* (Lecture Notes in Computer Science), 2014, 78–92, https://link.springer.com/chapter/10.1007/978-3-662-44630-0_6 (letzter Zugriff am 28.5.2018).
- Anderes Projekt für die Rekonstruktion von Pompei - 2016 https://www.canal-u.tv/video/humanum/digital_pompei_where_computer_vision_meets_archaelogy.34025

Quellen Pompeii - Bewegung von Menschen in Stadträumen – 2007-2014

- Paper 1: Maïm, Jonathan et al. (Hg.), Populating Ancient Pompeii with Crowds of Virtual Romans, in: *Proceedings of the 8th International Symposium on Virtual Reality, Archeology and Cultural Heritage - VAST*, 2007. https://infoscience.epfl.ch/record/125211
- Paper 2: Thalmann, Daniel et al., Geometric Issues in Reconstruction of Virtual Heritage Involving Large Populations, in: *3D Research Challenges in Cultural Heritage* (Lecture Notes in Computer Science), 2014, 78–92, https://link.springer.com/chapter/10.1007/978-3-662-44630-0_6 (letzter Zugriff am 28.5.2018).
- Anderes Projekt für die Rekonstruktion von Pompei - 2016 https://www.canal-u.tv/video/humanum/digital_pompei_where_computer_vision_meets_archaelogy.34025

The Science of Light: Classical Reconstruction Parthenon Paul Debevec



https://vimeo.com/31890599

One of the most iconic combinations of computer graphics and cultural heritage is *The Parthenon*, a film directed by Paul Debevec that built on several years of research. It combines

- documentation of the Parthenon's condition;
- relighting based on onsite observations; and
- reconstructions based on reincorporating statues
- no longer on the site, using plaster casts
- from the Basel Skulpturhalle's Parthenon sculpture
- collection.

Digital Repatriation/ Digitale Repatriation?

- The film combines many computer science innovations with stunning visuals and pioneering research to illustrate technologies' potential to reunite dispersed cultural assets—an objective that has been called *digital repatriation*. The approach provokes a range of reactions; for some individuals and communities this form of repatriation is unwelcome and an inadequate restitution for one culture's looting of another's heritage.

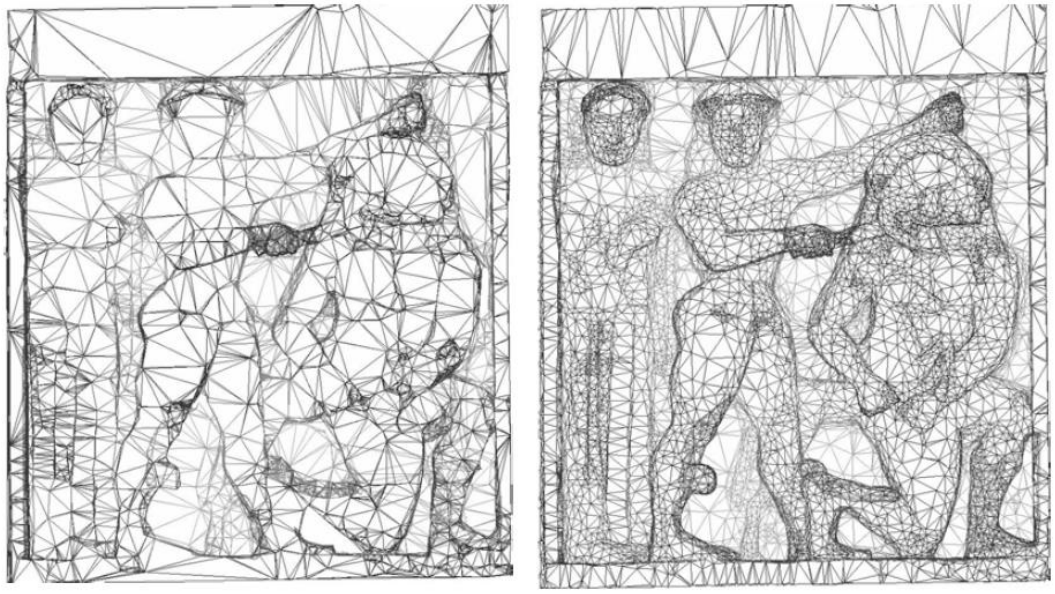
- Siehe: Elgin Marbles (Recherche später, welche Projekte wurden unternommen dies digital zu tun?
- Siehe : Frankreichs versprechen Kulturerbe zurückzuführen (Recherche darüber später)

4. Projektbeschreibung Selinunte und Carpiniana – Angelo Beraldin und Adriana Bandiera

- *Virtual reconstruction of Temple C of Selinunte, Sicily, Italy*
- The goal of this project is to recreate an environment that no longer exits except for some temple remains.
- The project is divided into two broad steps, the first step saw the modeling of the frieze of temple C of Selinunte using 3D laser scanning and the second on-going step will see the reconstruction of temple C of the Acropolis of Selinunte (see Figure 11a) using photogrammetry and CAD tools, and, historical information.
- One of the main concerns was the determination of the required spatial resolution and the technical difficulties the team might encounter in modeling those remains.

Bilder Selinunte und Carpiniana

- FILMS!
- Y:\DDTTeaching_InhaltModule_Planung\Modul8_VirtuelleModellierung\Vorlesung6_VirtuelleRekonstruktionvonArchitektur\Filme



(a) (b)

Figure 4. 3D modeling and compression as a function of operator skills. Same data and modeling software, a) 36 000-polygon model prepared by a skilled operator, b) 20 000-polygon model prepared by an expert operator (the images are not inverted!).

Quellen Selinunte und Carpiniana

- ***Virtual Reconstruction of Heritage Sites: Opportunities and Challenges Created by 3D Technologies *** Beraldin, J.-A., Picard, M., El-Hakim, S., Godin, G., Borgeat, L., Blais, F., Paquet, E., Rioux, M., Valzano, V., and Bandiera, A. May 2005
- *published at The International Workshop on Recording, Modeling and Visualization of Cultural Heritage. May 22-27, 2005. Ascona, Switzerland. NRC 48100.

Physical replicas by 3D printing – siehe oben oder Vorlesung 1

http://www.seaha-cdt.ac.uk/