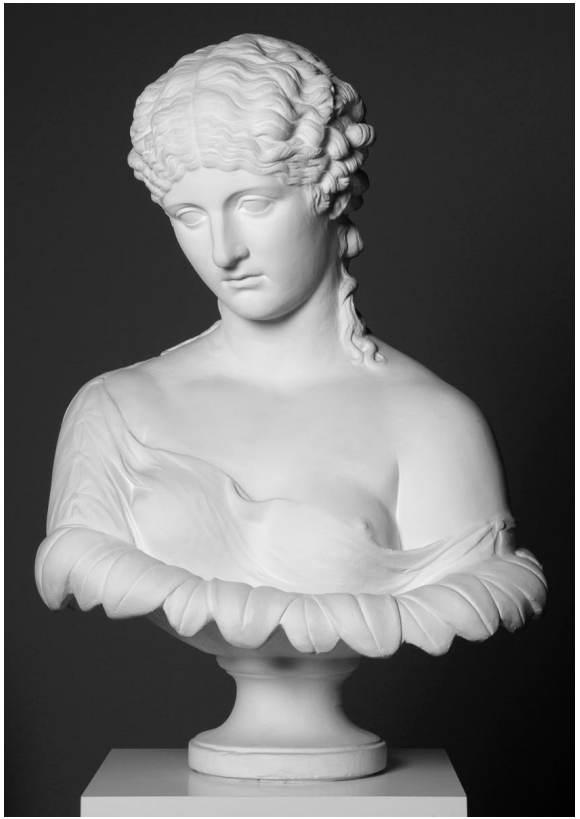
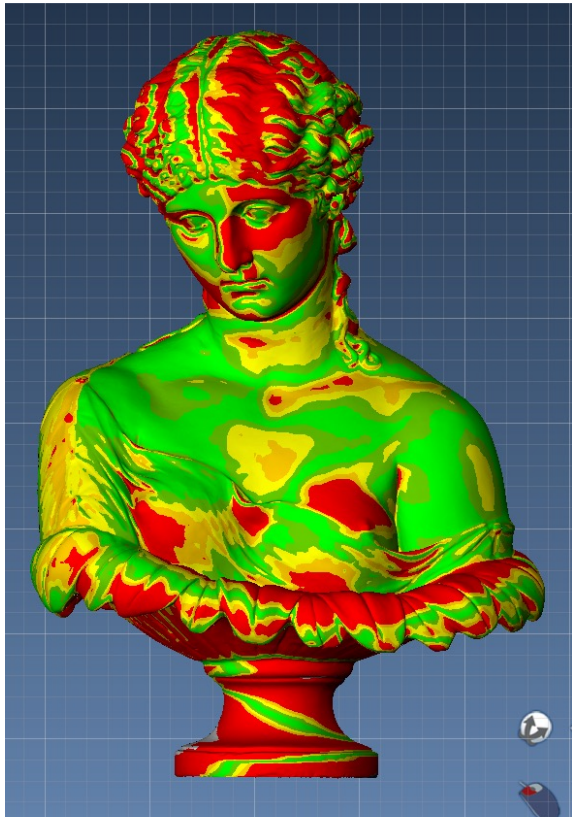
III. Analysis

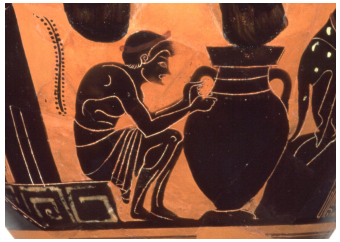
7. Analysis of Three-dimensional Objects

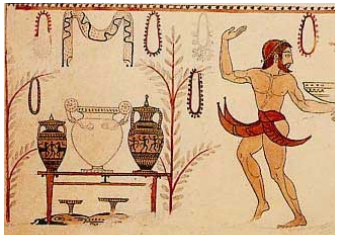
Prof. Dr. Martin Langner

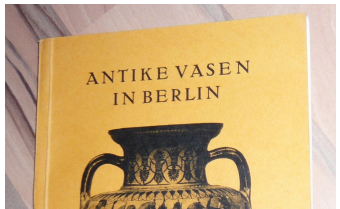
Bernard Frischer, Three-dimensional Scanning and Modelling, in: Elise A. Friedland, Melanie Grunow Sobocinski (Hrsg.), The Oxford Handbook of Roman Sculpture, Oxford 2015, 74–89







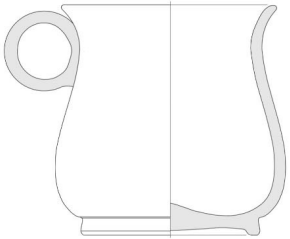



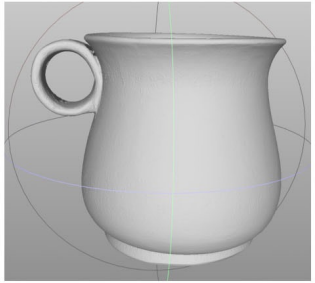
MATERIALITÄT

Design	Shape Analysis
Production	
Trade	Statistics & Network Analysis
Use	
Deposition	Function- & Context Analysis
Excavation	
Collecting events	Simulation
Restoration	
Presentation	Databases & Visualisation
Publication	

- Orthofoto
- 360° Photo series
- Profile drawing
- Photogrammetry
- 3D Scanning
- RTI

et al.





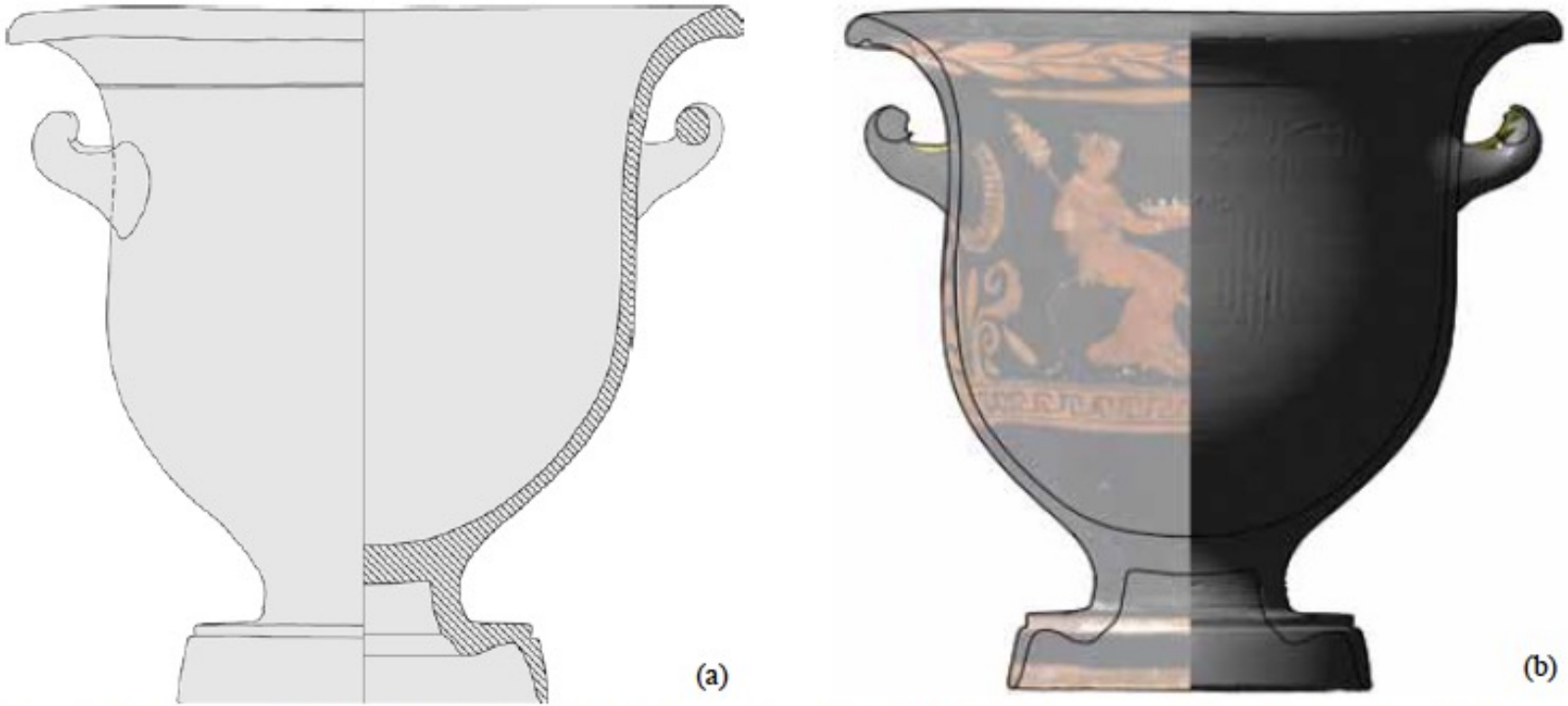


Figure 6: Front view of UMJ Inv. Nr. 4611: (a) Manual drawing by Stephan Karl. (b) Silhouette, profile and 3D-model with/without texture map and illumination.

H. Mara – J. Portl, Acquisition and Documentation of Vessels using High-Resolution 3D-Scanners, in: CVA Österreich Beih. 1 (Wien 2013) 25–40

Figure 5: Universalmuseum Joanneum Graz, Department Archaeology & Coin Cabinet, inv. 4611; a.) 3D scan with contour line (© University Heidelberg, IWR); b.) comparison between profile lines from conventional drawing (black) and extracted from 3D scan (red) (graphic Karl)

B. Breuckmann – St. Karl – E. Trinkl, Digitising Ancient Pottery. Precision in 3D, Forum Archaeologiae 66/III/2013 (http://farch.net)

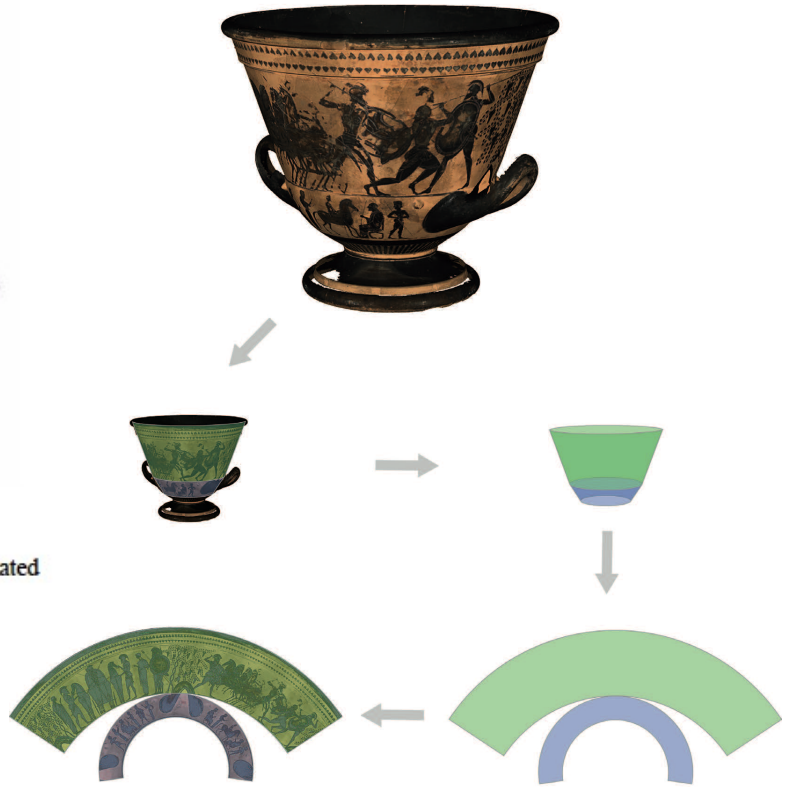
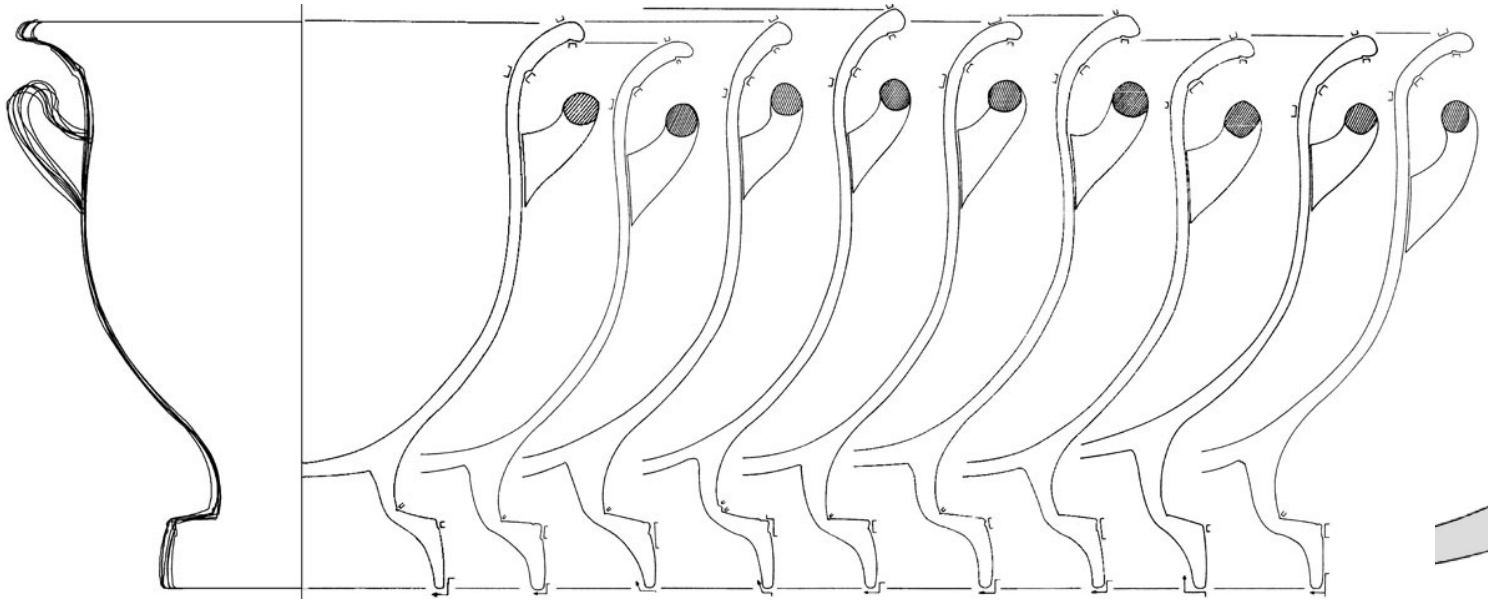
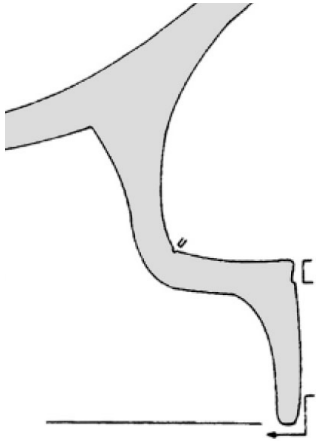


Figure 10: Schematic illustration of creating the rollout of a vessel (KHM ANSA IV 3618) that can be approximated by conical frustums and its distortion-free rollout.

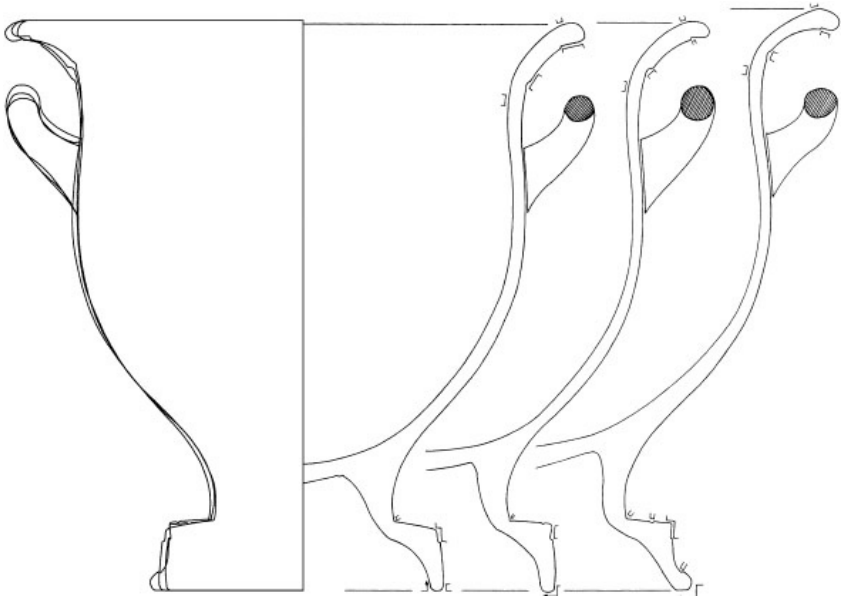
H. Mara – J. Portl, Acquisition and Documentation of Vessels using High-Resolution 3D-Scanners, in: CVA Österreich Beih. 1 (Wien 2013) 25–40



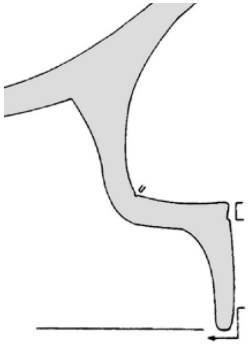
Profile comparison of bell craters from the workshop of the Meleager painter



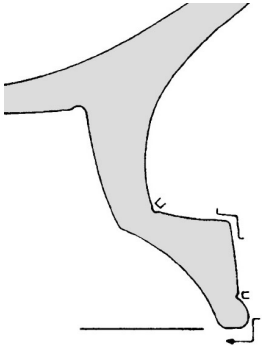
Grundlagen der Chronologie spätrotfiguriger Vasen aus Athen,
BABESCH 88, 2013, 127–170



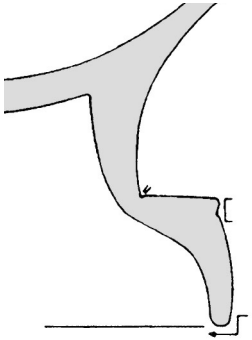
Profile comparison of bell craters from the workshop of the Meleager painter



Meleager-P.



Plainer Gr. A

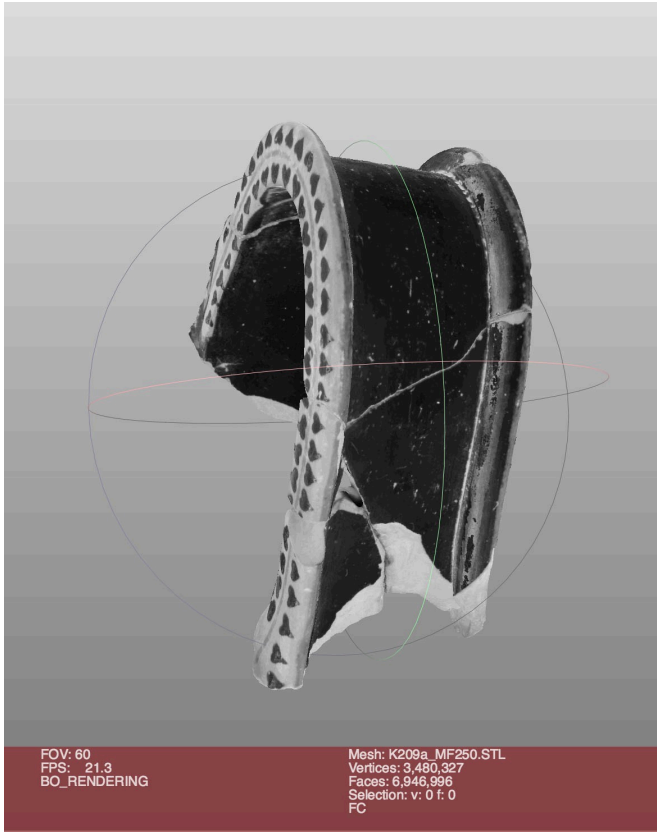


Plainer Gr. B

Figure 7: University Graz, Institute of Archaeology, inv. G 741 and University Göttingen, Institute of Archaeology inv. Hu 533 s
a.) original fragments; b.) Graz fragment together with a 3D print of Göttingen fragment (© University Graz, Institute for Archaeology;
3D print with permission by University Göttingen, Institute for Archaeology; executed by Christian Fuchs / Organic Form Productions)

B. Breuckmann – St. Karl – E. Trinkl, Digitising Ancient Pottery. Precision in 3D, Forum Archaeologiae 66/III/2013 (http://farch.net).

HANDLE EXEKIAS AMPHORA



Göttingen K 209a

<- Philadelphia MS3497

ANALYSIS OPTIONS

Which research questions can be pursued with digitisation?

How and to what extent are form-analytical approaches more stringently comprehensible through digitisation?

Can artefacts be acquired non-verbally with digital methods of pattern recognition and to what degree of accuracy?

What new cognitive possibilities arise from digitisation?

SHAPE DESCRIPTION

a) Raw data

b) Curves and areas

c) Volumes

d) Graphs and feature-based descriptors

SHAPE ANALYSIS

a) Shape identity (Shape Correspondence)

b) Shape similarity (Shape Classification)

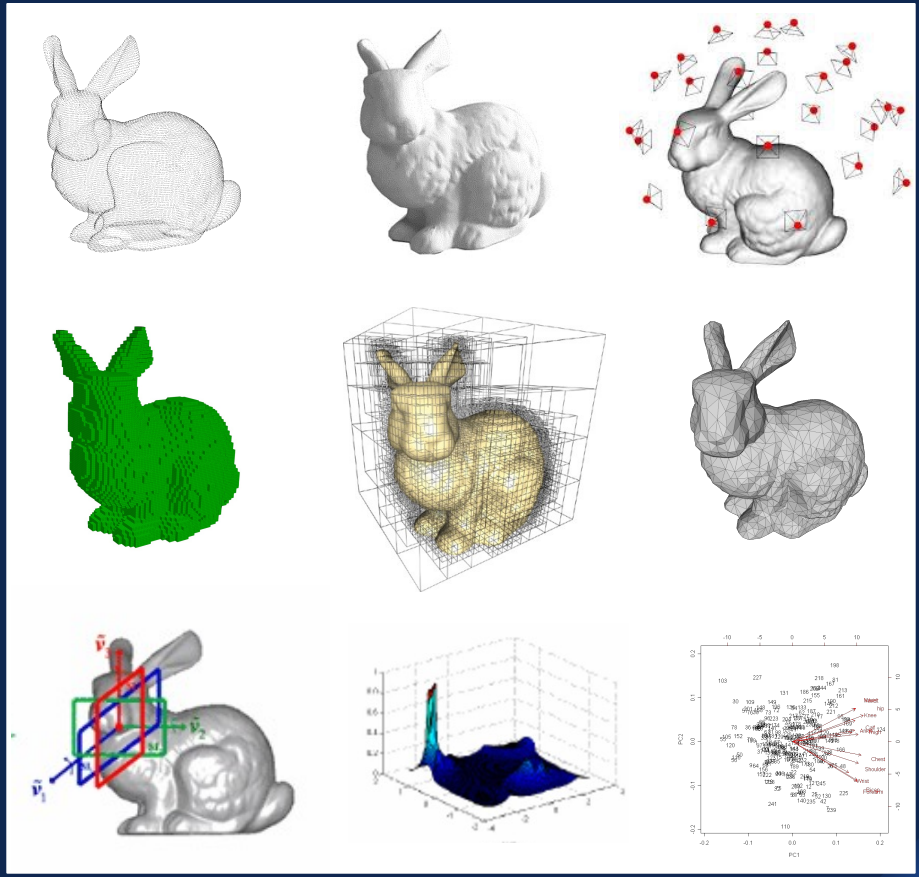
c) Shape retrieval systems (Shape Retrieval)

MODEL BUILDING

a) 3D reconstruction and completion

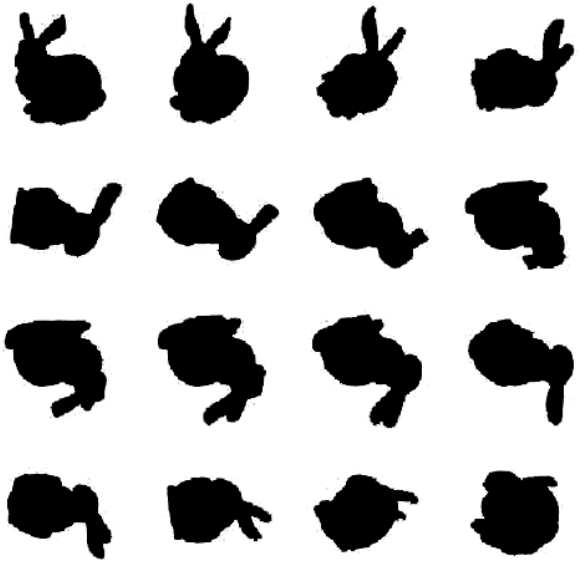
b) Simulation of style development and cultural practice

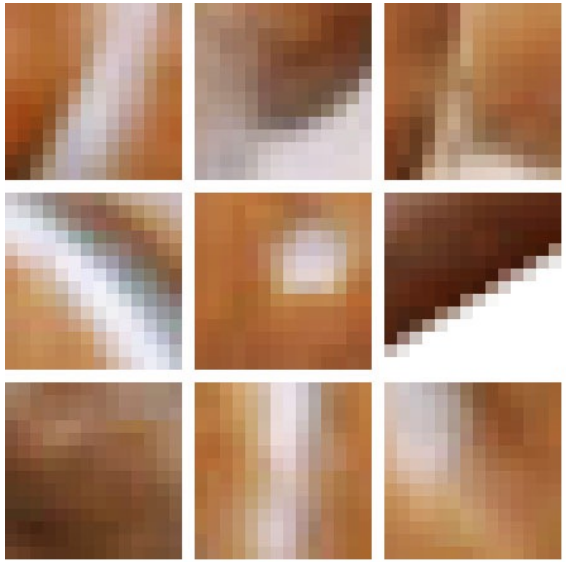
SHAPE DESCRIPTION



2D object recognition

through image processing

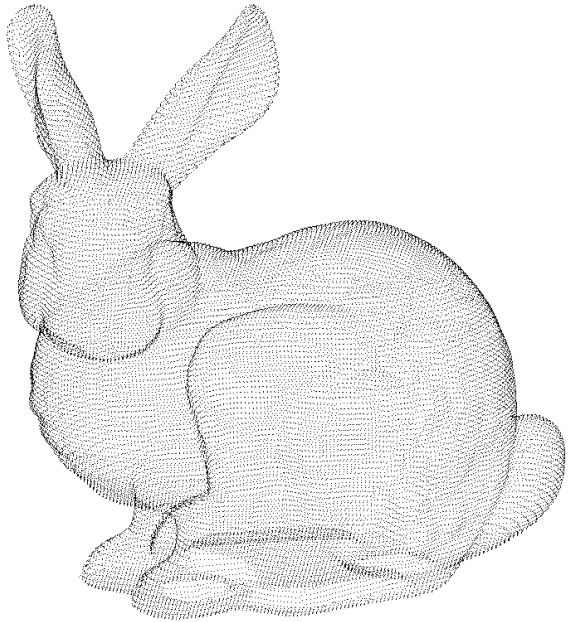




Point Cloud

- disorganised spatial structure ('cloud') of points in space
- object = list of points = 3D vectors of 3 coordinates (x,y,z).
- information about edges, volume and surface of the object is not included in the data.
- memory-intensive
- leaves some room for interpretation in the description of the object

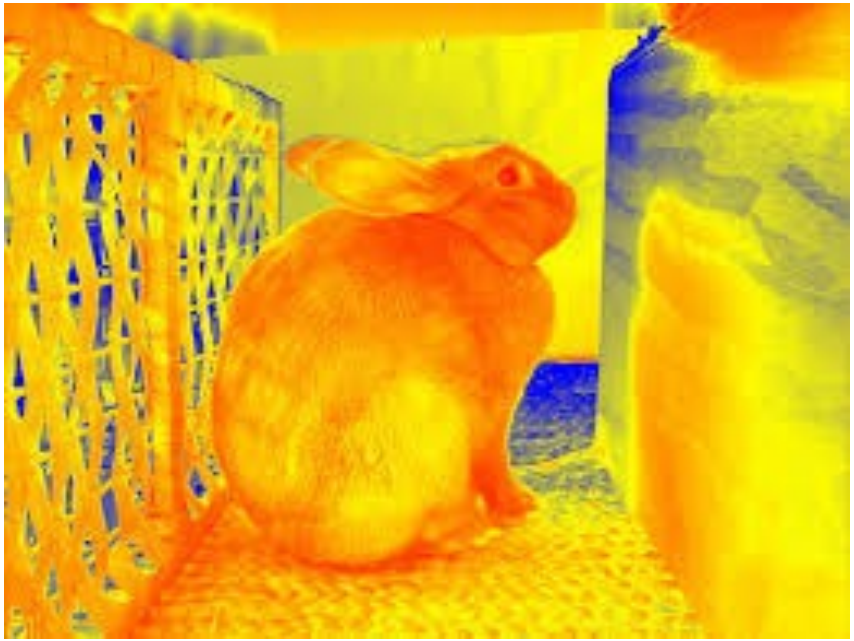
Raw data | Point Cloud



RGB-Depth

Raw Data	Point Cloud
	RGB-D

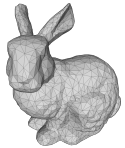
Depth images generated in combination of RGB colour camera and infrared measurement

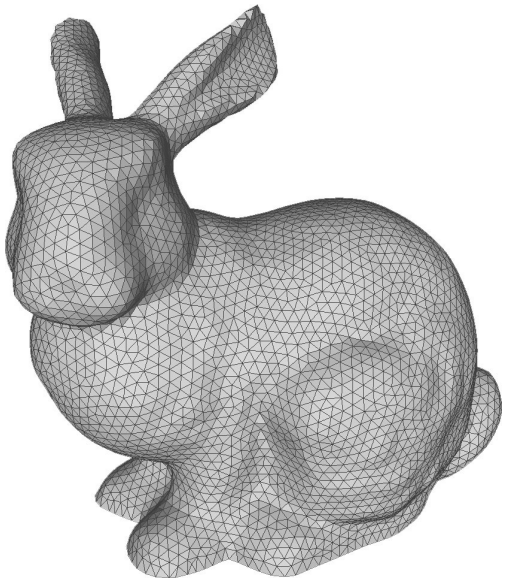


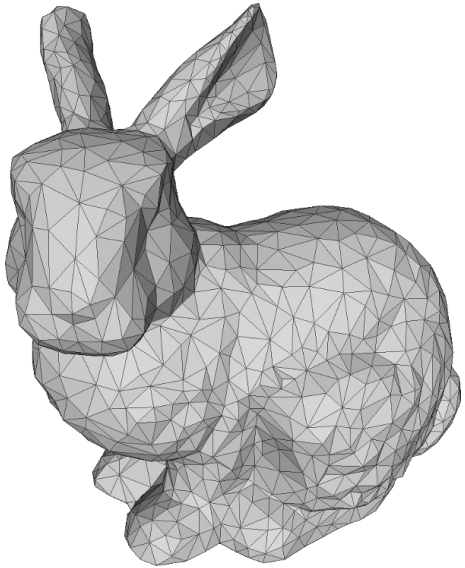
Mesh

List of 3D polygons representing a set of linked 3D points (vertices).

Raw Data	Point Cloud
	RGB-D
Planes	Mesh



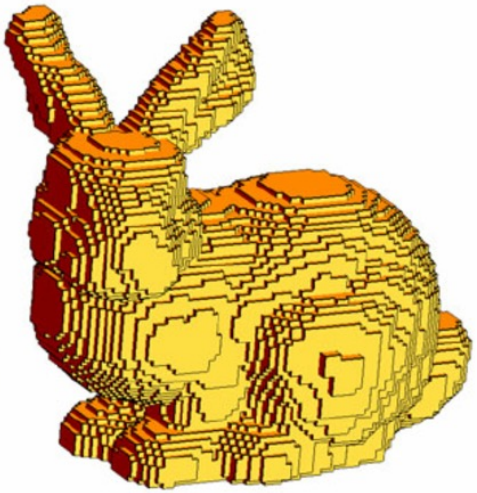


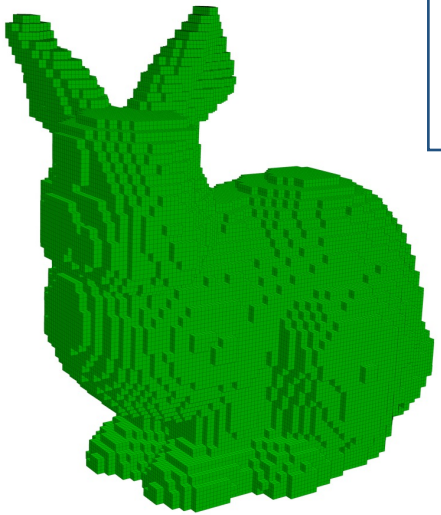


Voxels

the volume of an object in geometric information units of the same size (voxels)

Raw Data	Point Cloud
	RGB-D
Planes	Mesh
Volumina	Voxels

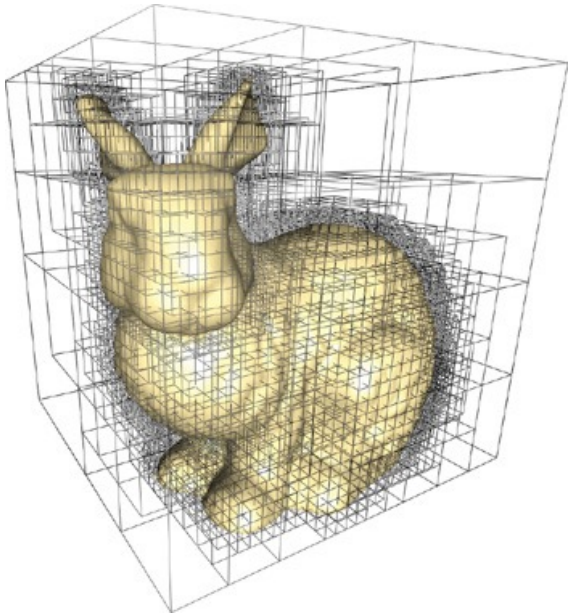


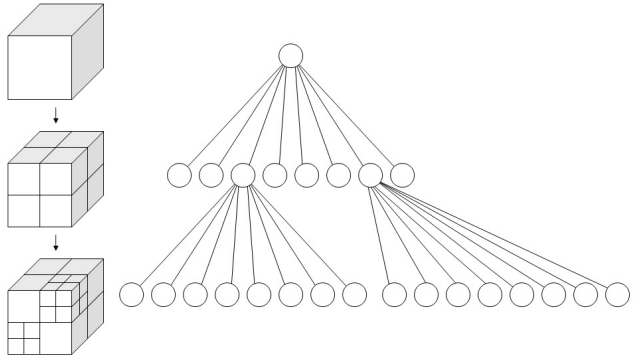


Octree

hierarchical 3D data structure representing volumes as a rooted tree

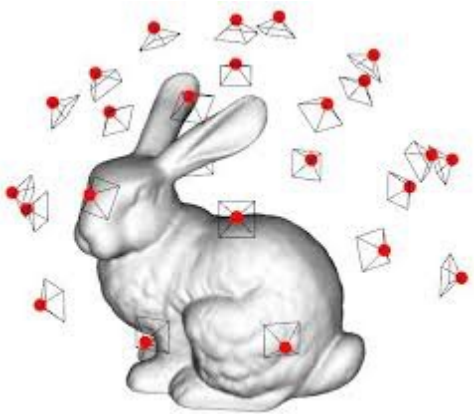
Raw Data	Point Cloud
	RGB-D
Planes	Mesh
Volumina	Voxels
	Octree

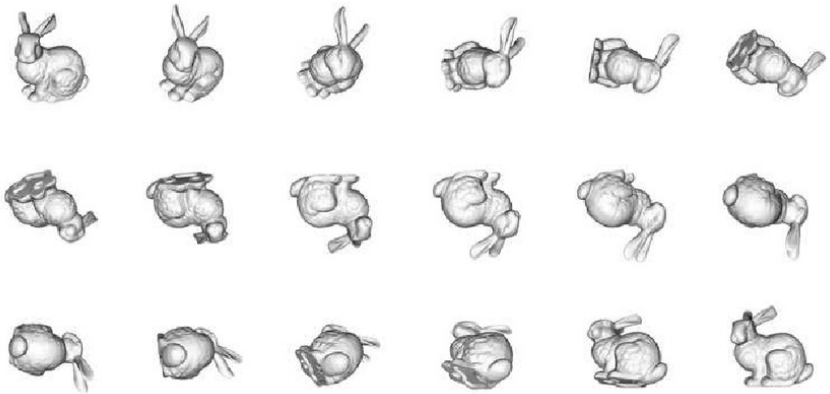




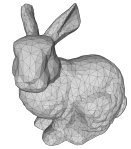
Multi-View

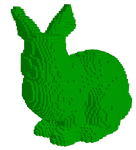
Series of 2D shots from different camera positions

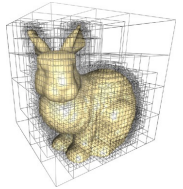


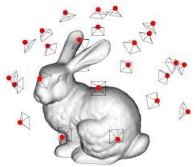


Raw Data	Point Cloud
	RGB-D
Planes	Mesh
Volumina	Voxels
	Octree
2D Repres.	Multi-View



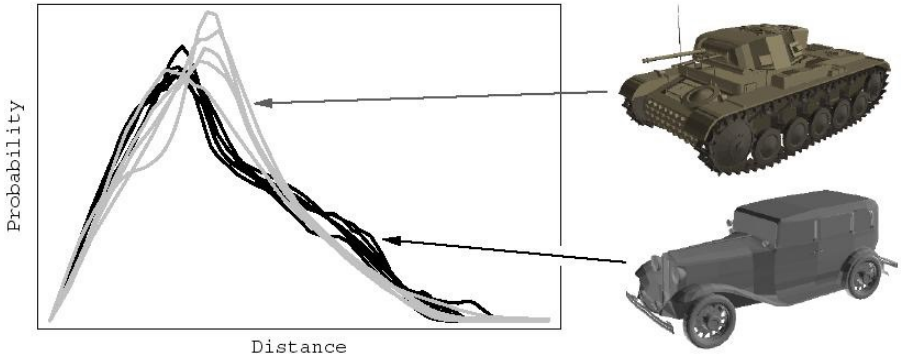




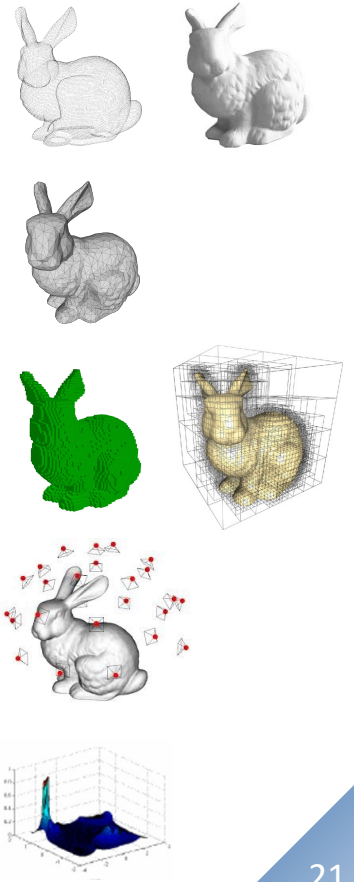


Graph

e.g. probability distribution of Euclidean distances between randomly selected points

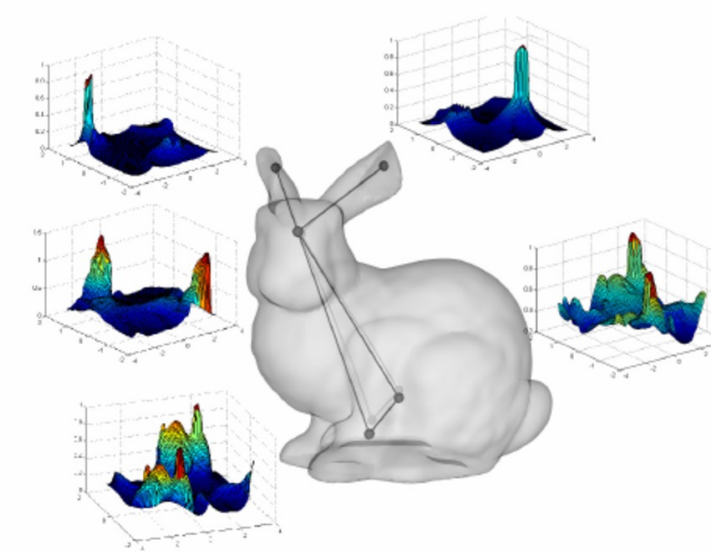


Raw Data	Point Cloud
	RGB-D
Planes	Mesh
Volumina	Voxels
	Octree
2D Repres.	Multi-View
mathemat. Structure	Graph



Graph

e.g. distance calculations between randomly selected points and their surrounding surfaces



Raw Data	Point Cloud
	RGB-D
Planes	Mesh
Volumina	Voxels
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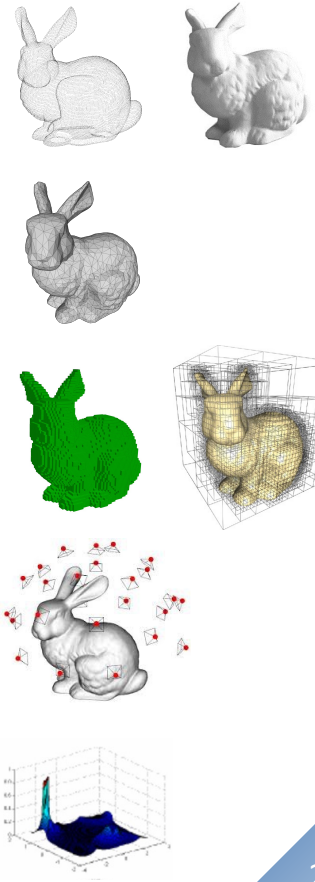
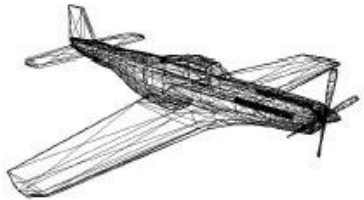
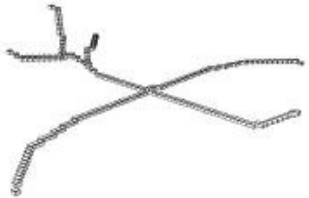
2D Repres.	Multi-View
mathemat. Structure	Graph

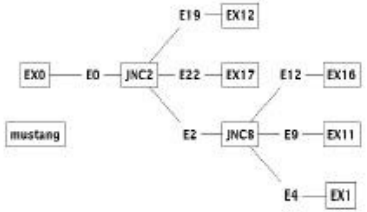


Graph

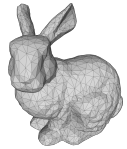
e.g. skeleton diagrams

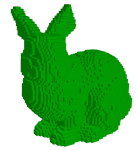


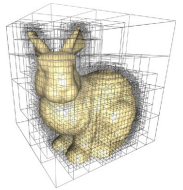


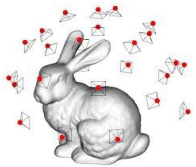


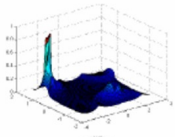
Raw Data	Point Cloud
	RGB-D
Planes	Mesh
Volumina	Voxels
	Octree
2D Repres.	Multi-View
mathemat. Structure	Graph





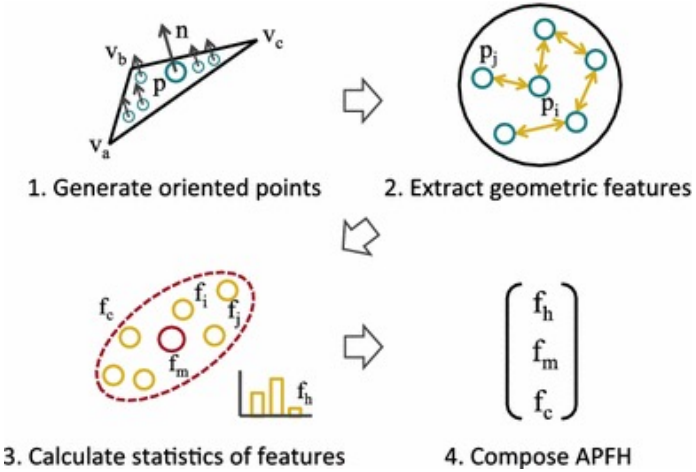






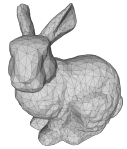
Feature-based descriptors

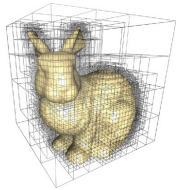
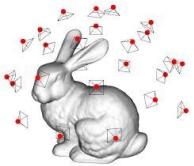
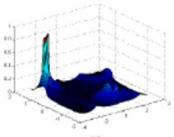
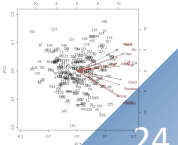
- represent the shape with a single descriptor consisting of a d-dimensional vector-valued function.
- represent a 3D shape as a point in high-dimensional space.



Raw Data	Point Cloud
	RGB-D
Planes	Mesh
Volumina	Voxels
	Octree
2D Repres.	Multi-View
mathemat. Structure	Graph
	3D-Descriptor



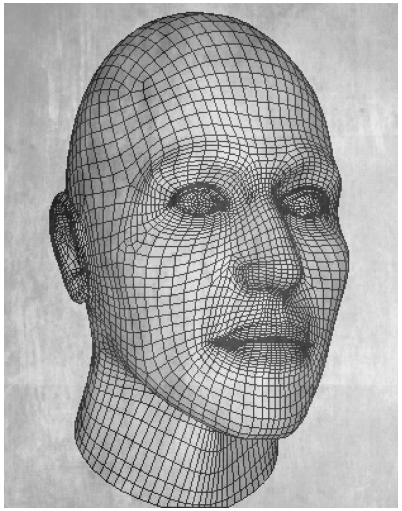


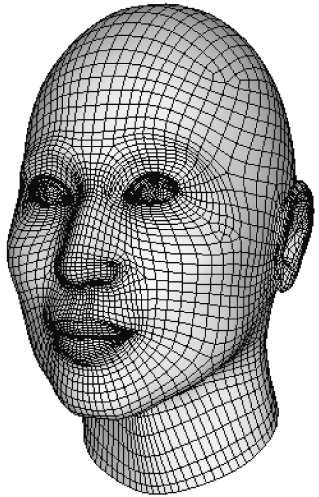





SHAPE ANALYSIS

Basic Problems of Object Analysis

- Determine extensive correspondence between two or more objects (Shape Correspondence).

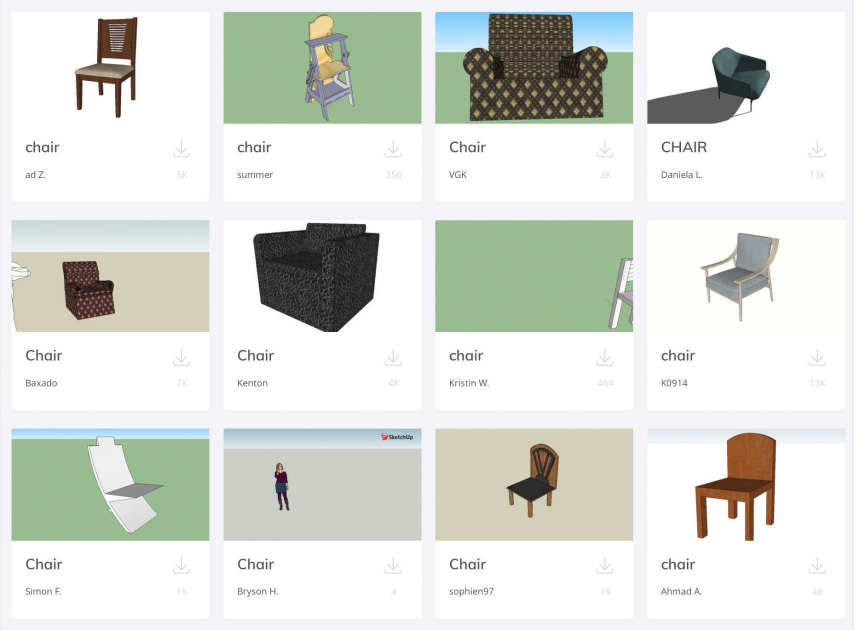




Basic Problems of Object Analysis

- Determine extensive correspondence between two or more objects (Shape Correspondence).

- Determine extensive shape similarity on a geometric and semantic level (Shape Classification)



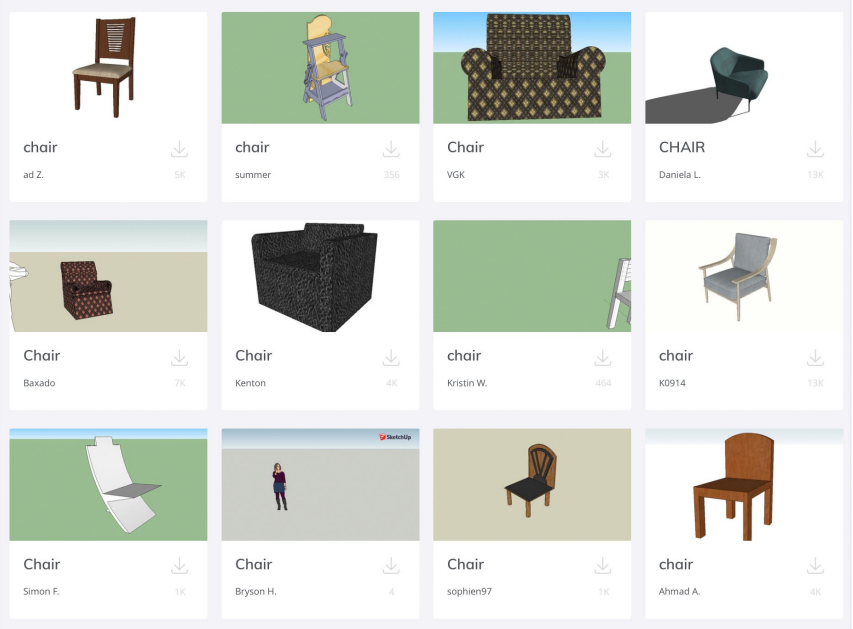
https://3dwarehouse.sketchup.com/search/?q=chair

Basic Problems of Object Analysis

- Determine extensive correspondence between two or more objects (Shape Correspondence).

- Determine extensive shape similarity on a geometric and semantic level (Shape Classification)

- Automated generation and modification of shapes (Shape Modelling)

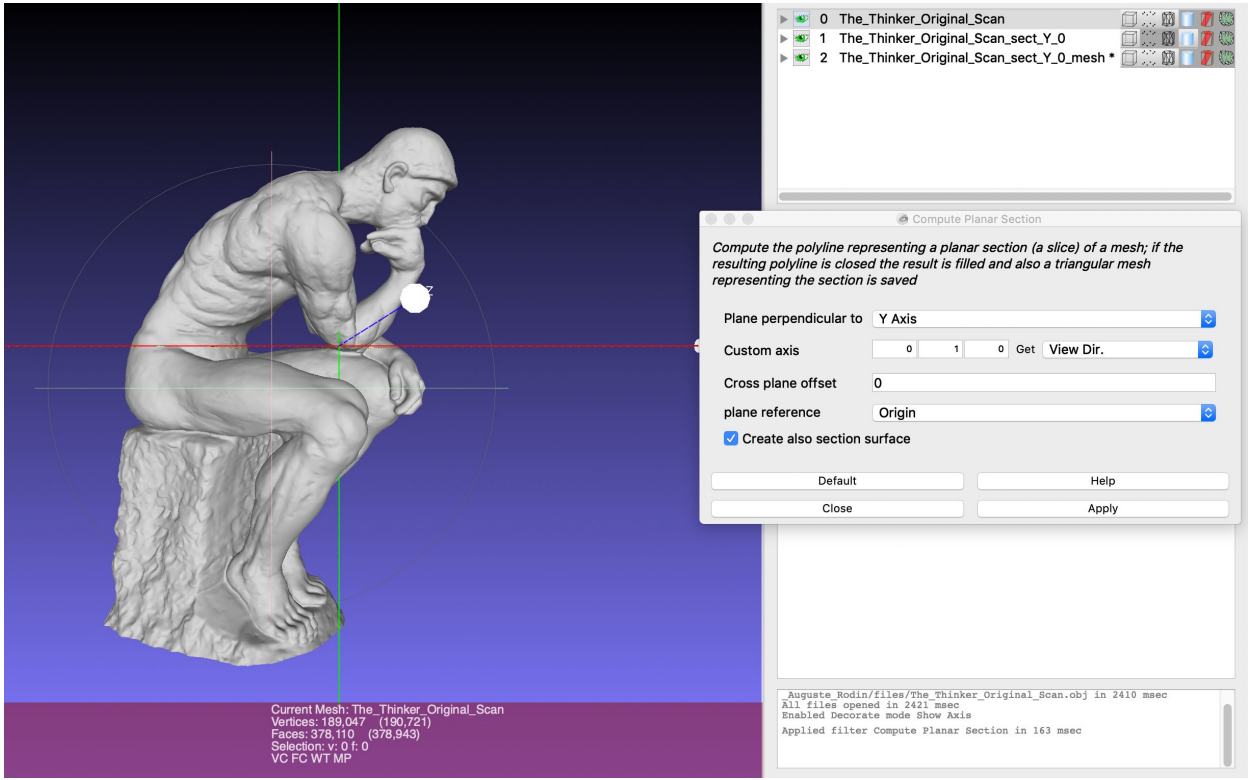


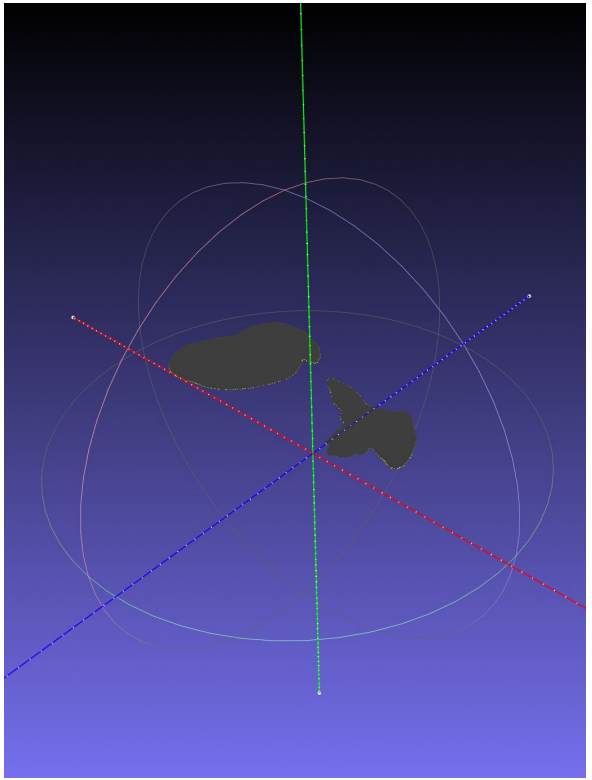
https://3dwarehouse.sketchup.com/search/?q=chair


```
V: 189047 E: 567165 F:378110
Unreferenced Vertices 0
Boundary Edges 0
Mesh is composed by 1 connected component(s)
Mesh is two-manifold
Mesh has 0 holes
Genus is 5
Applied filter Compute Topological Measures in 356
msec
```

```
Mesh Bounding Box Size 448.566376 624.657593
406.973328
Mesh Bounding Box Diag 870.078247
Mesh Bounding Box min -305.865784 -363.592133
-261.866974
Mesh Bounding Box max 142.700592 261.065460
145.106354
Mesh Surface Area is 825161.812500
Mesh Total Len of 566651 Edges is 1329494.000000 Avg
Len 2.346231
Mesh Total Len of 567165 Edges is 1330521.750000 Avg
Len 2.345917 (including faux edges))
Thin shell (faces) barycenter: -93.263107 -88.203911
-59.412140
Vertices barycenter -94.054710 -84.516594 -60.849876
Mesh Volume is 23469776.000000
Center of Mass is -118.618332 -94.269814 -70.091270
Inertia Tensor is :
| 789023686656.000000 -160434307072.000000
-51939098624.000000 |
| -160434307072.000000 286947377152.000000
-92133416960.000000 |
| -51939098624.000000 -92133416960.000000
850707546112.000000 |
Principal axes are :
| -0.282895 -0.945337 -0.162196 |
| -0.823562 0.326086 -0.464127 |
| -0.491646 -0.002279 0.870792 |
axis momenta are :
| 223129157632.000000 823276142592.000000
880273326080.000000 |
Applied filter Compute Geometric Measures in 659 msec
```

Laying sections through the object

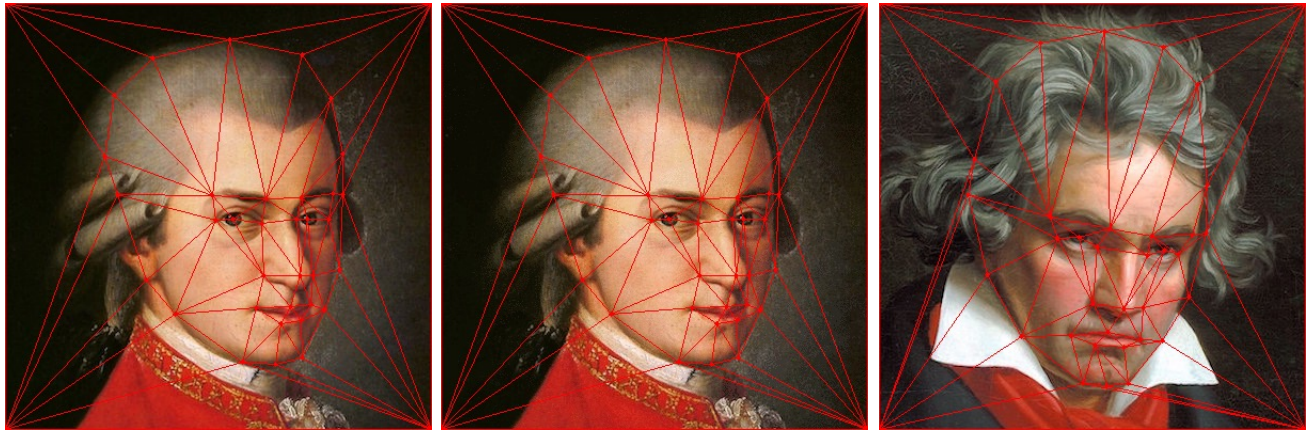




Morphing

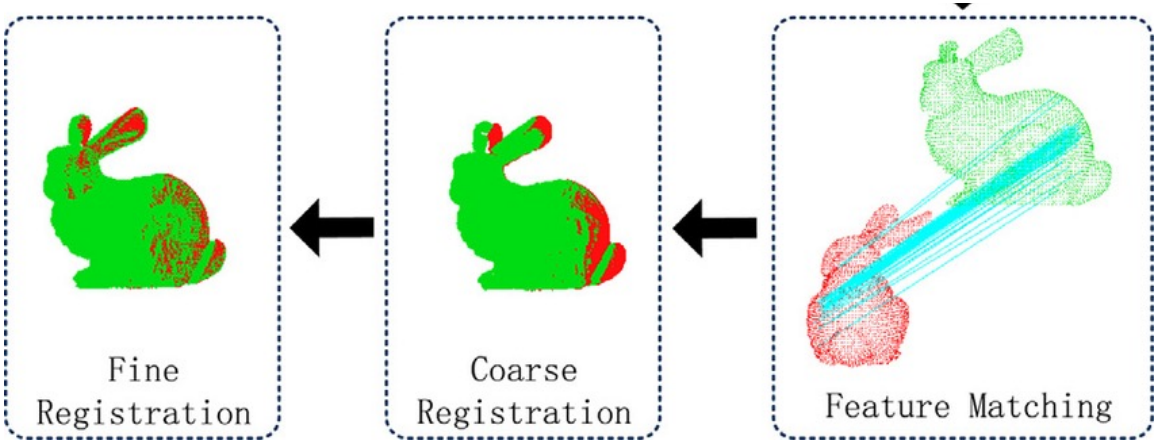
Transformation of one image or object into another using intentional distortions.

https://steven.codes/blog/face-morphing/



Registration

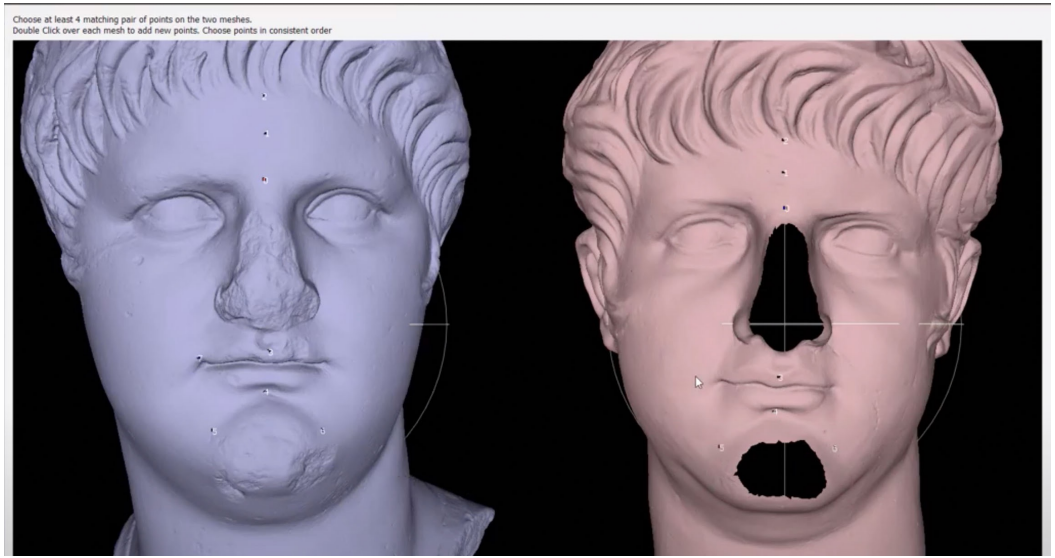
Process of finding a spatial transformation (e.g. scaling, rotation and translation) that aligns two sets of points (3D point clouds or 2D pixel coordinates) with each other.

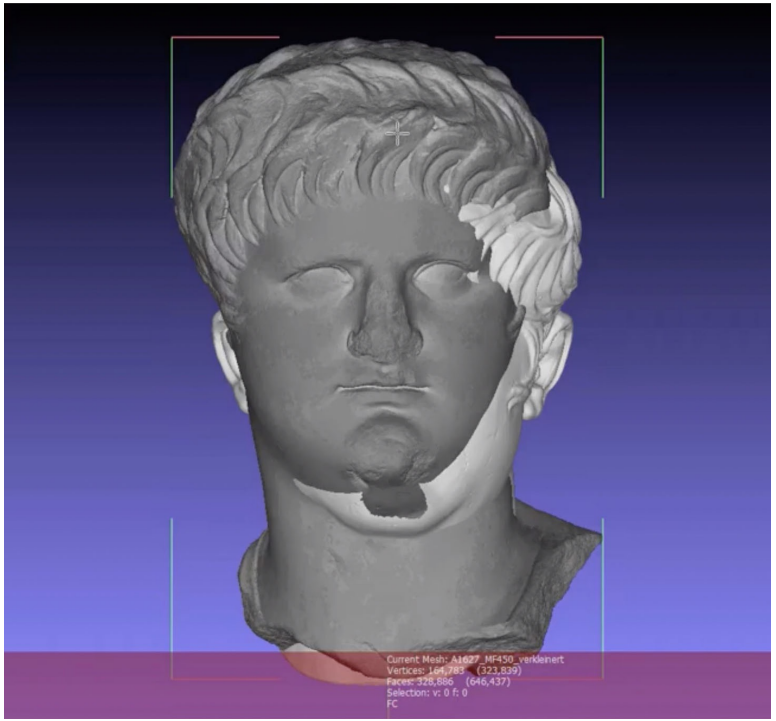


Jiaqi Yang et al., "A fast and robust local descriptor for 3D point cloud registration," Information Sciences 346 (2016), 163-179

Alignment

moves different meshes into a common reference system

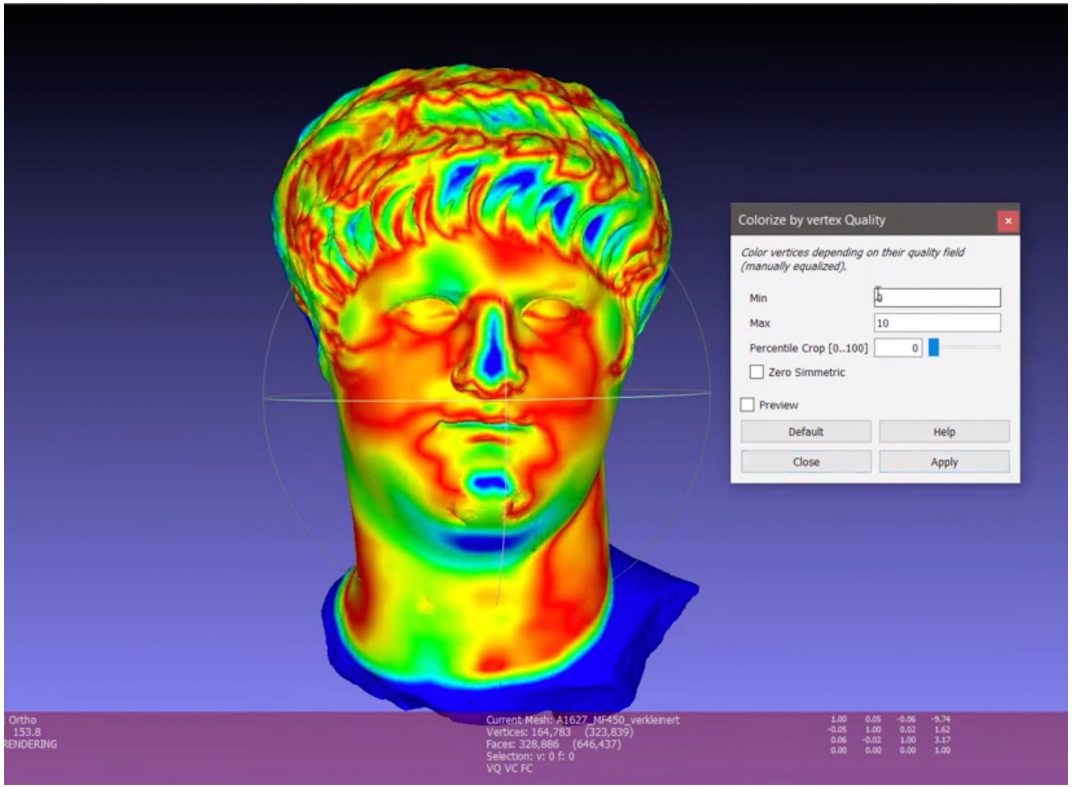




www.youtube.com/watch?v=SlWow13gd8Y

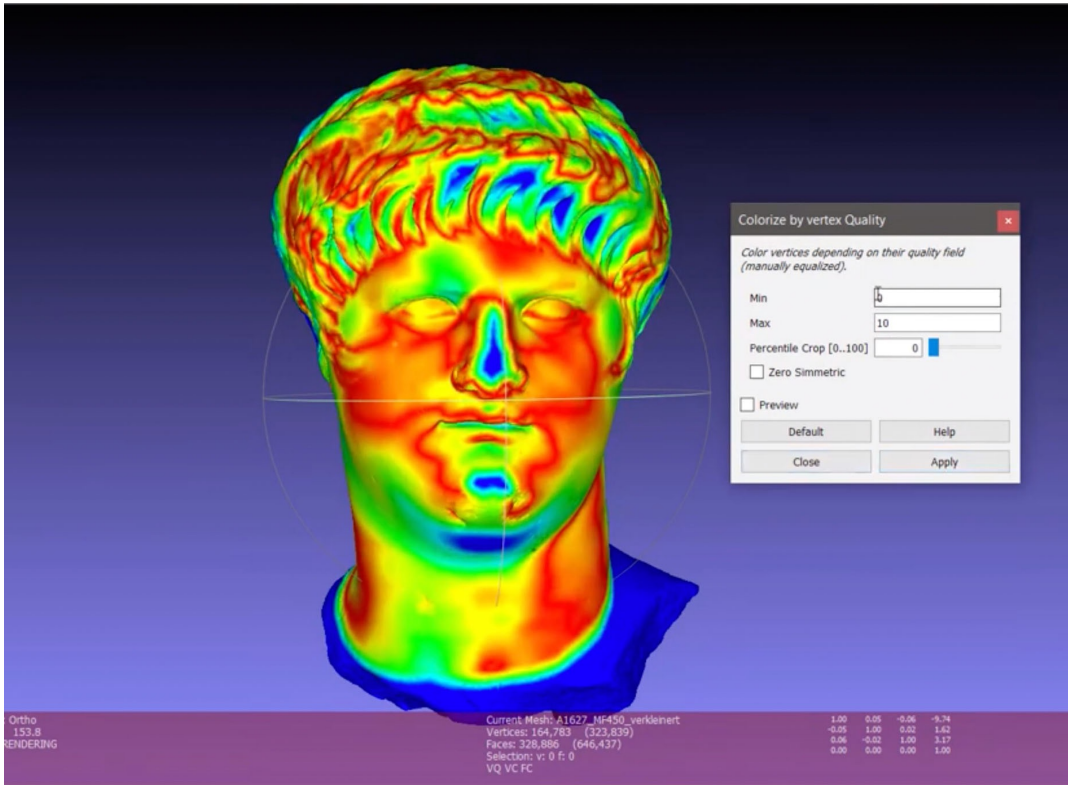
Hausdorff-Distance

determines how far apart two subsets of a metric space are from each other



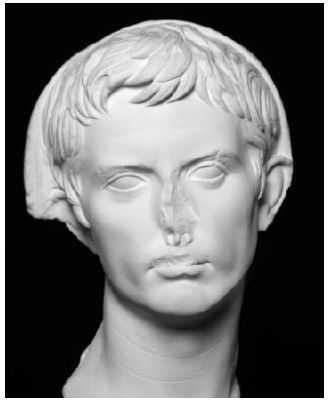
TOLERANCE BASED SHAPE COMPARISON

- normalises the target polygon so that it fits into a bounding box of predefined size.
- triangulates the zone between the outer and inner polygon (best fit).
- measures the distances between the polygons (average if necessary)
- The result can be output as a false colour table.

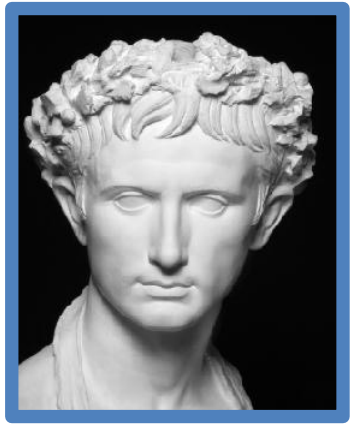


https://twinsornot.net

100%



Augustus, La Alcudia Type

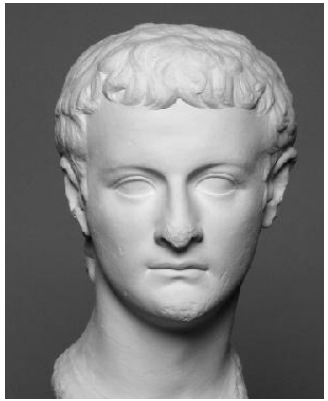


Augustus, Prima Porta Type

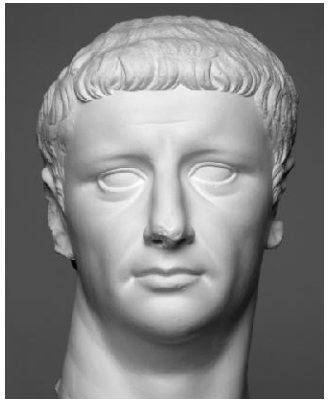
86%

Tiberius, Type Copenhagen 624

90%

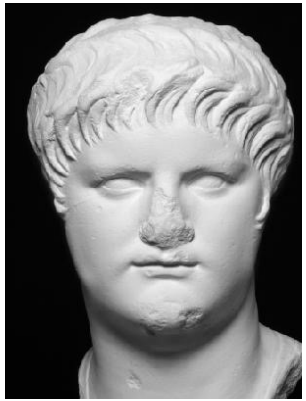


Caligula, Main Type



100%

Claudius, Main Type

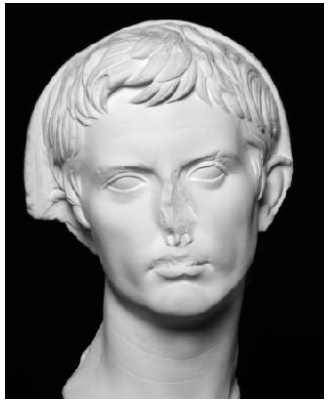


87%

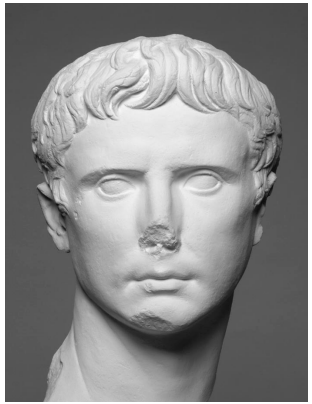
Nero, 4th Type

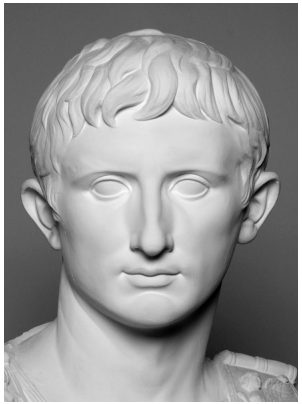
Faceplusplus (http://www.faceplusplus.com/demo-detect)

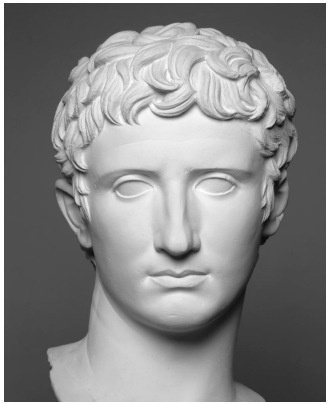
https://www.instagram.com/gesichtermix/



Augustus, La Alcudia Type

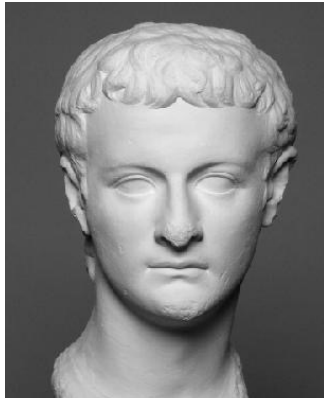




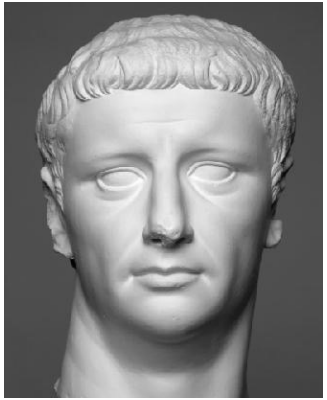


Augustus, Prima Porta Type

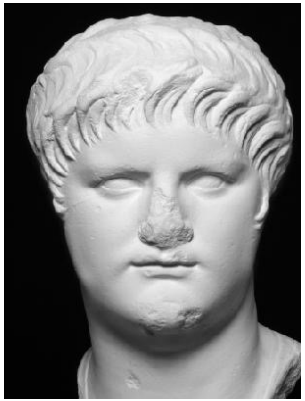
Tiberius, Type Copenhagen 624



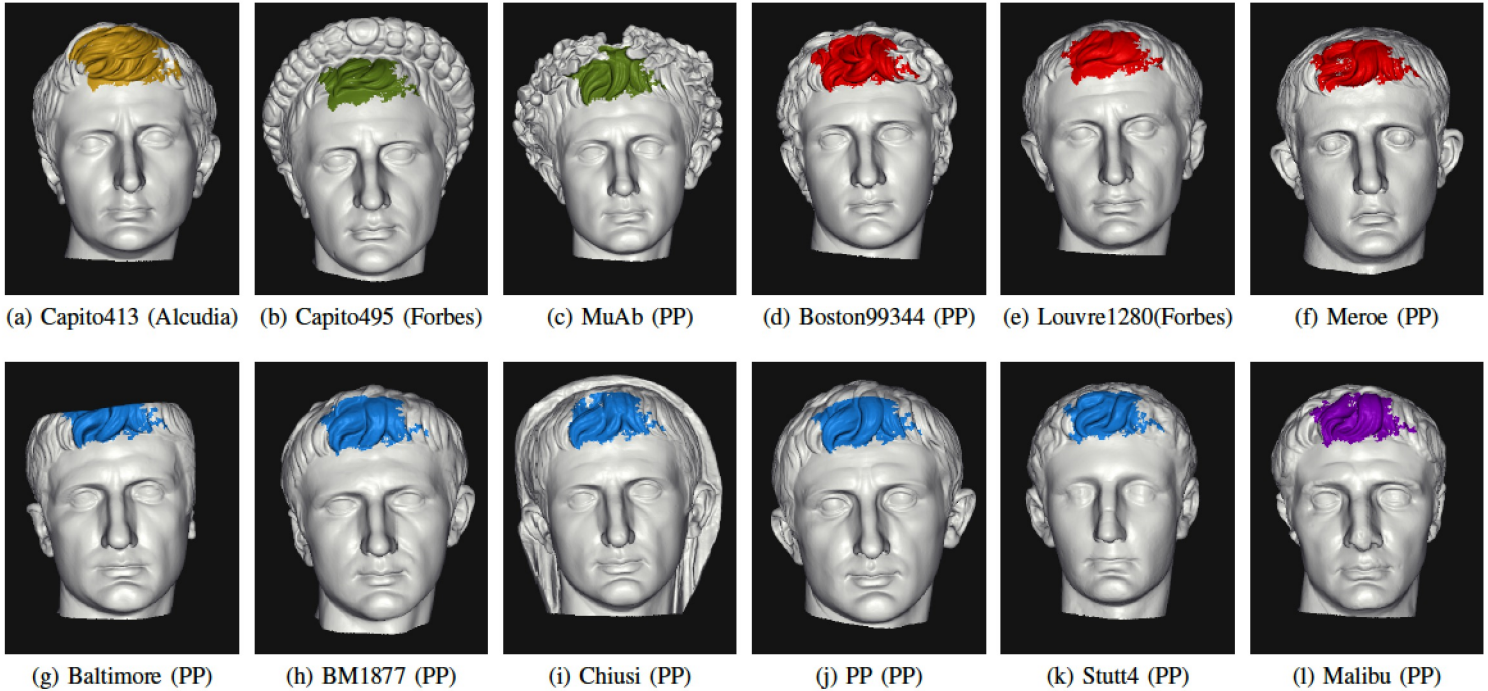
Caligula, Main Type



Claudius, Main Type



Nero, 4th Type



(a) Capito413 (Alcudia) (b) Capito495 (Forbes) (c) MuAb (PP) (d) Boston99344 (PP) (e) Louvre1280(Forbes) (f) Meroe (PP)

(g) Baltimore (PP) (h) BM1877 (PP) (i) Chiusi (PP) (j) PP (PP) (k) Stutt4 (PP) (l) Malibu (PP)

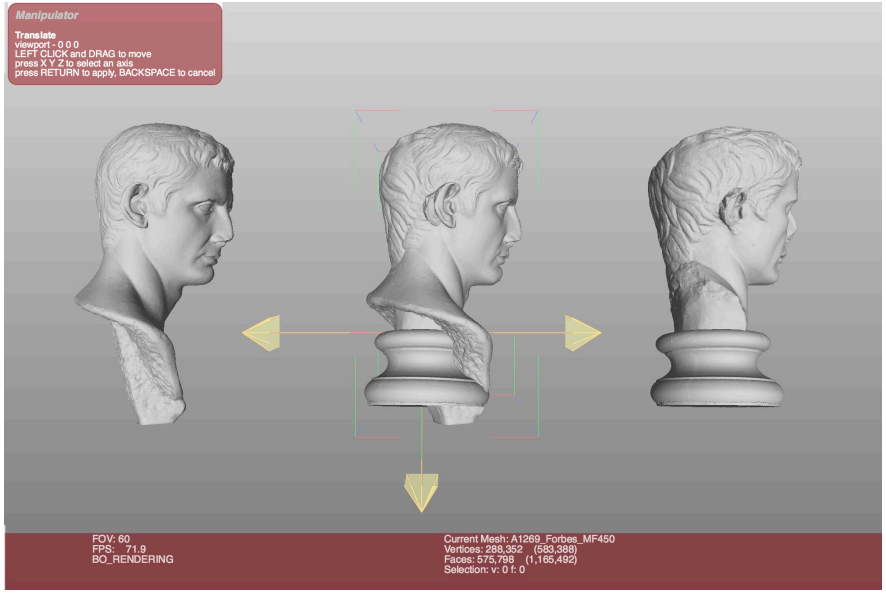
Fig. 8. Visualization of the categorization result in the forehead hair patch. Reference category labels given by archaeologists are also indicated in parentheses. Here "PP" is the abbreviation of "Prima Porta".

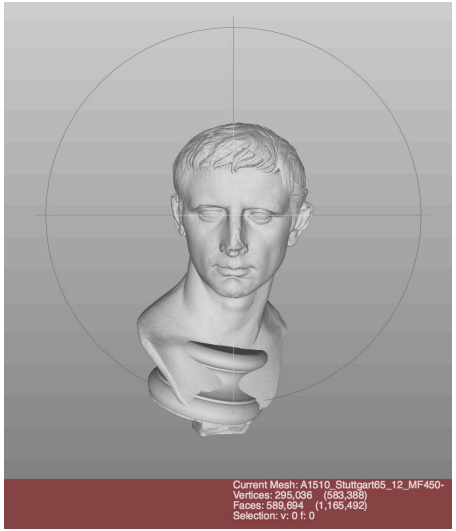
Min Lu et al., "Portrait sculptures of Augustus. Categorization via local shape comparison," in *Digital Heritage. International Congress 2013* (DOI: 10.1109/DigitalHeritage.2013.6743812)

Abb. 30. Typus Forbes des Augustus: Entwicklungsstränge. An jede der beiden Profillinien lassen sich weitere Vertreter anschließen. Capitol und Louvre 1280 (gestrichelt). M. 1 : 4

Michael Pfanner, Über das Herstellen von Porträts. Ein Beitrag zu Rationalisierungsmaßnahmen und Produktionsmechanismen von Massenware im späten Hellenismus und in der römischen Kaiserzeit, Jahrbuch des Deutschen Archäologischen Instituts 104, 1989, 157–257

ALIGNMENT WITH THE PROFILE LINE





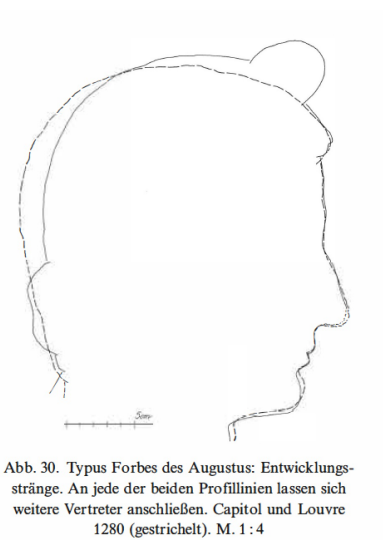
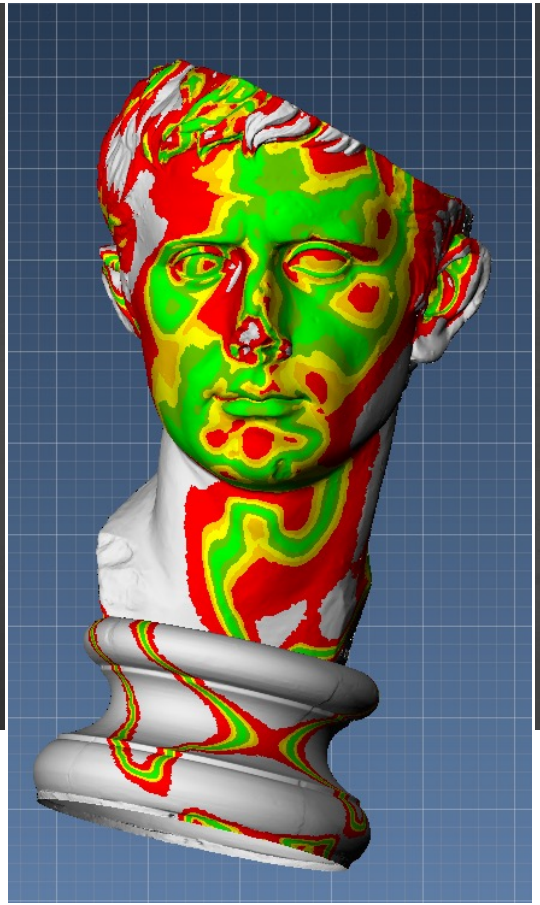
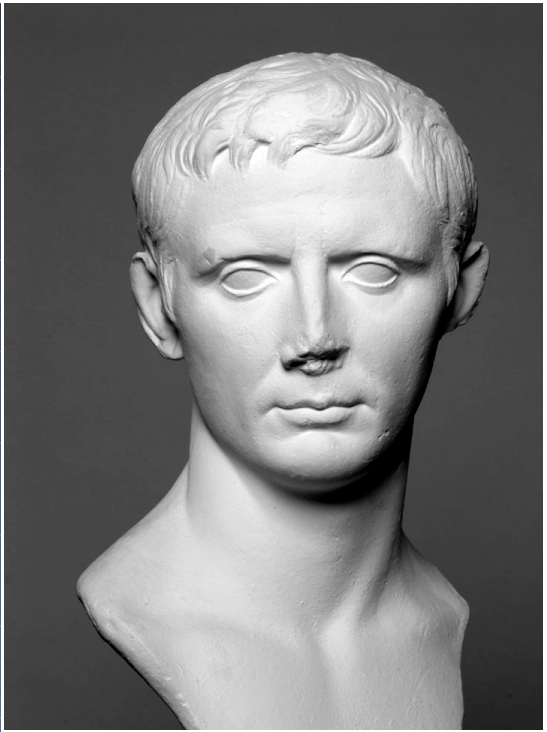


Abb. 30. Typus Forbes des Augustus: Entwicklungsstränge. An jede der beiden Profillinien lassen sich weitere Vertreter anschließen. Capitol und Louvre 1280 (gestrichelt). M. 1 : 4

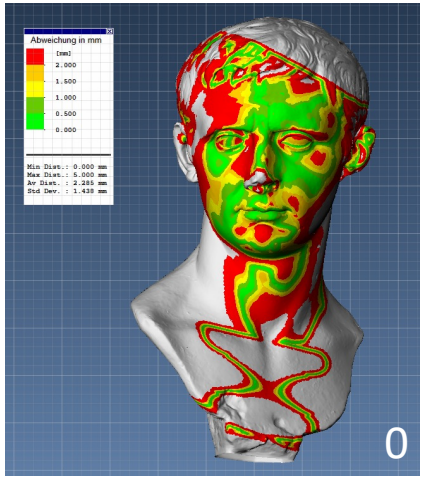
Augustus Type
Louvre MA 1280 in
Boston (A 1269)

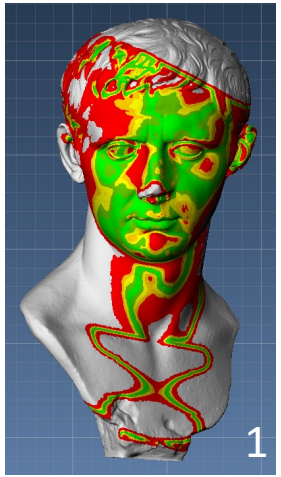


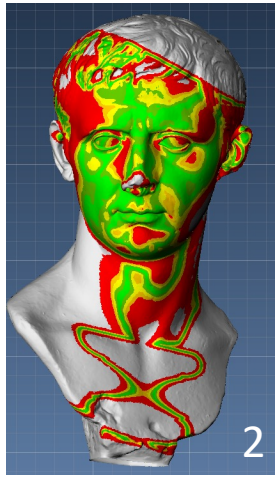


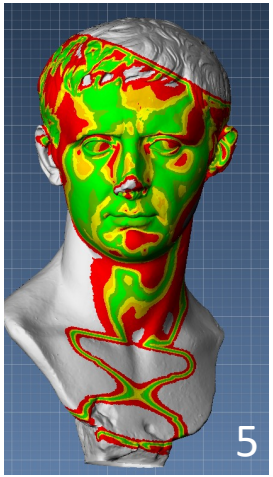
Augustus Typue
Louvre MA 1280 in
Stuttgart 65.12 (A 1510)

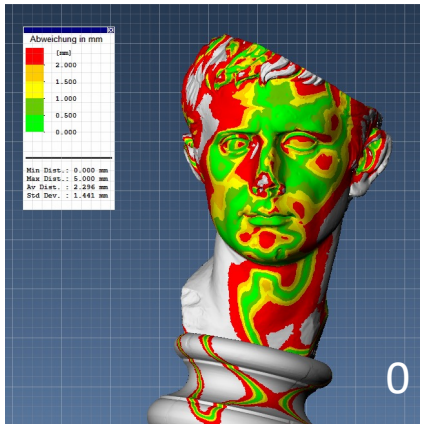
ALIGNMENT ACCORDING TO BEST FIT WITHIN A SEARCH RANGE

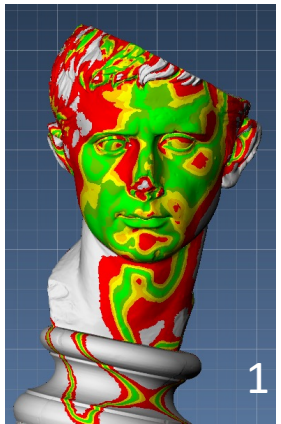


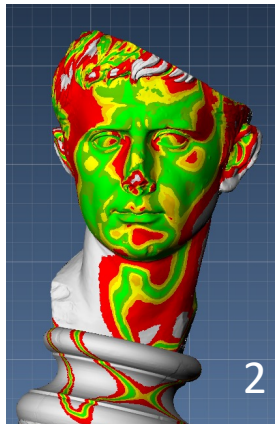


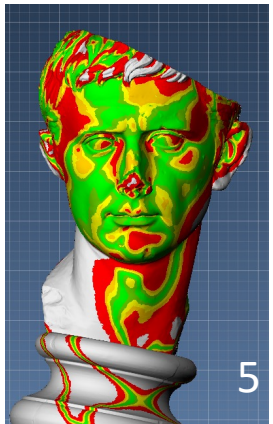




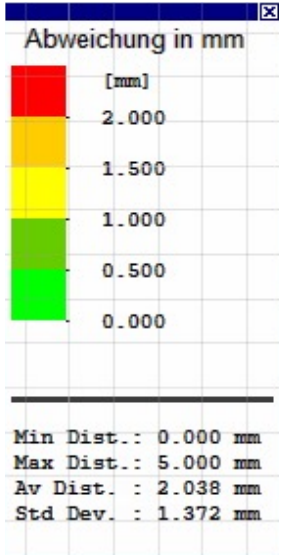


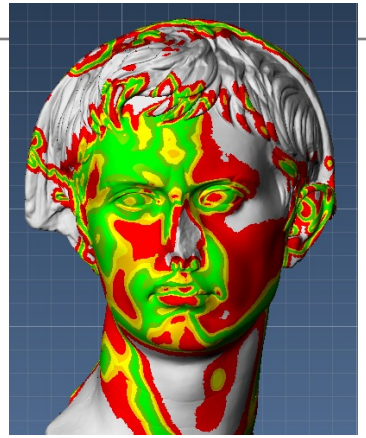




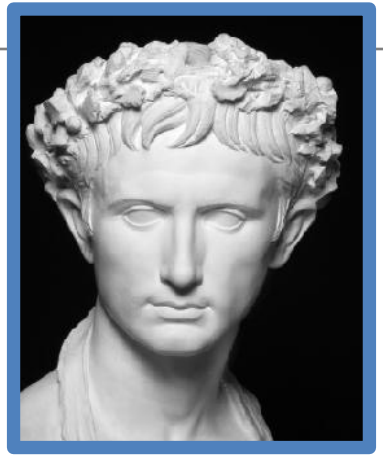


Search area where adjustments could be made, in mm

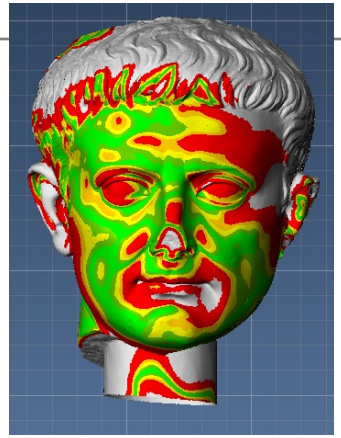




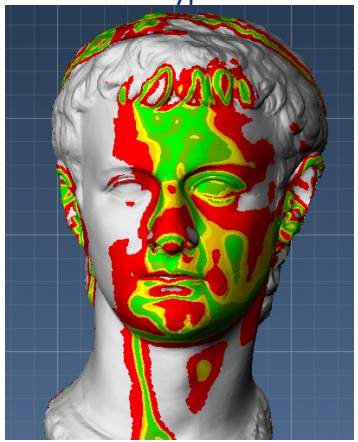
Augustus, La Alcudia Type



Augustus, Prima Porta Type

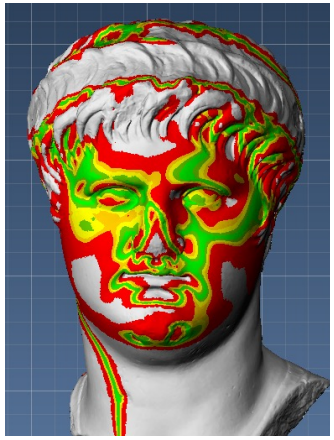


Tiberius, Type Copenhagen 624

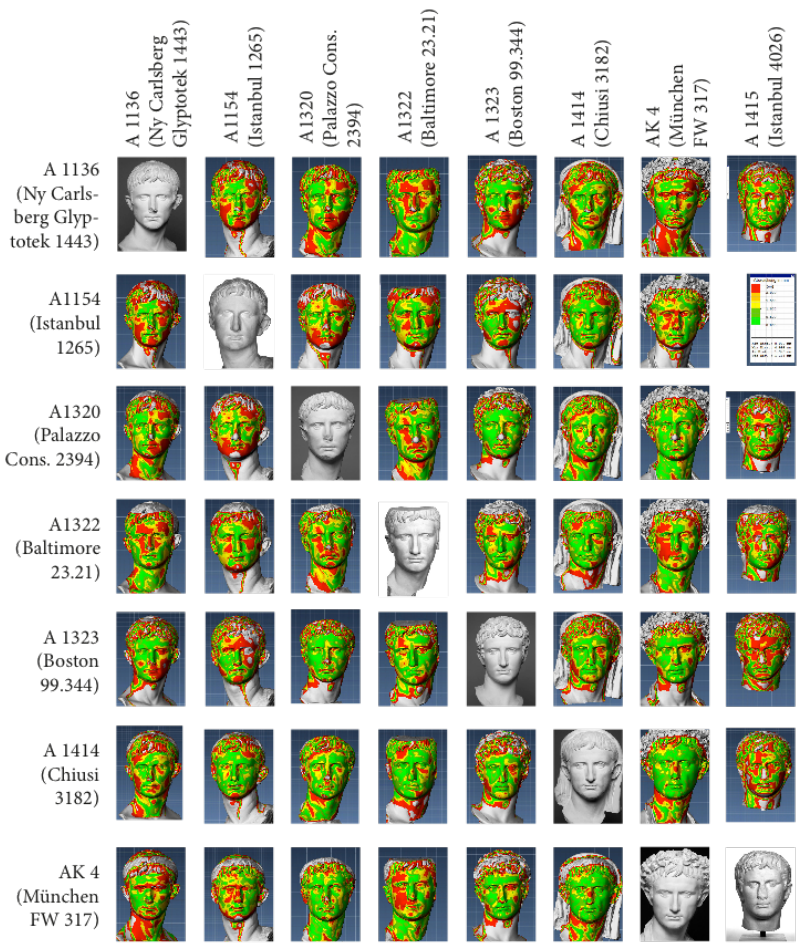


Caligula, Main Type

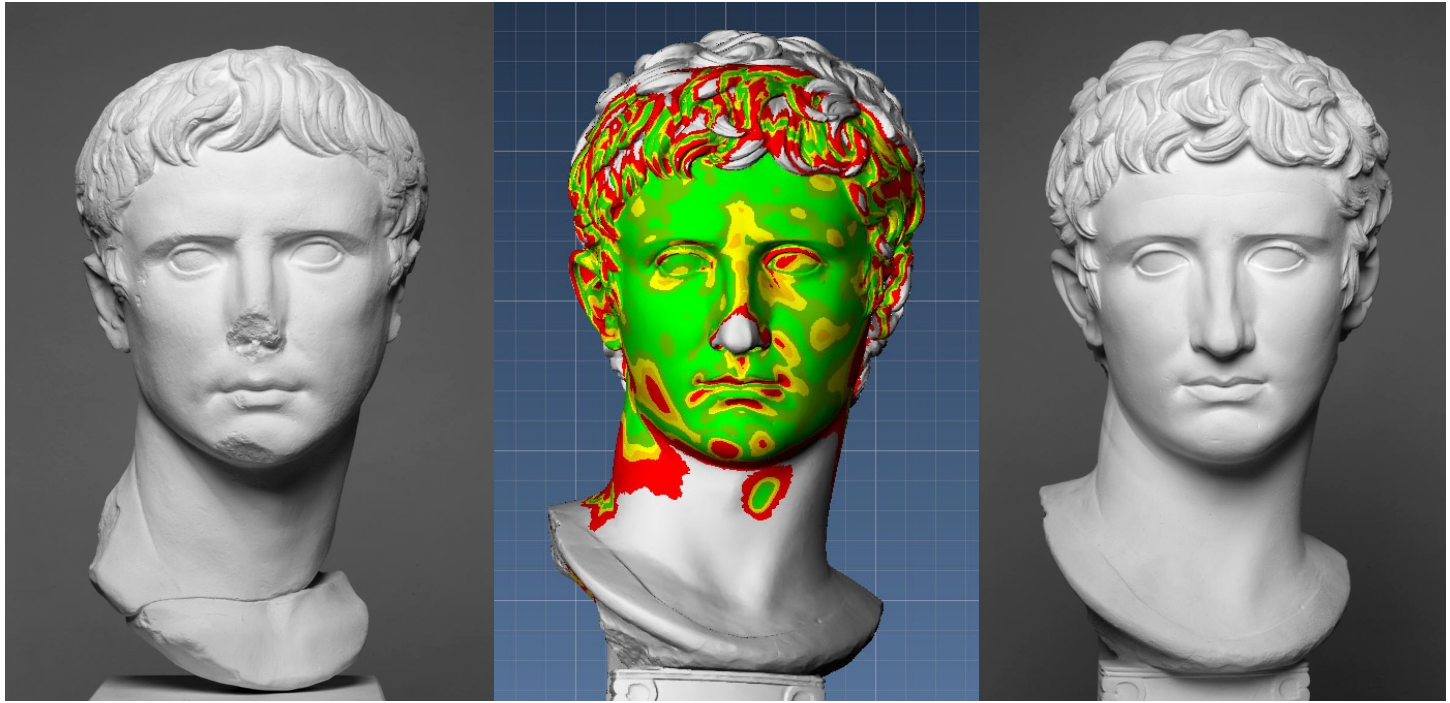
Claudius, Main Type



Nero, 4th Type



Deviation analysis target to actual (false colour representations) on Augustus portraits in the Prima Porta type (left) and type Louvre MA 1280 (right)



Augustus Prima Porta Type: Rom, Pal. Cons. 2394 (A 1320)

Augustus Prima Porta Type: Boston 99.344 (A 1323)

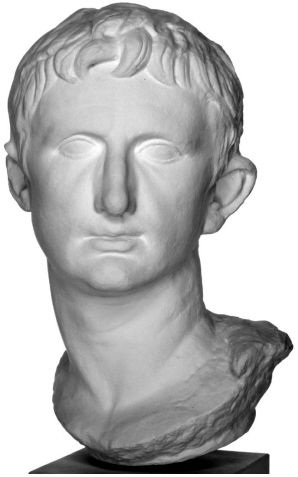
Augustus Prima Porta
Type:

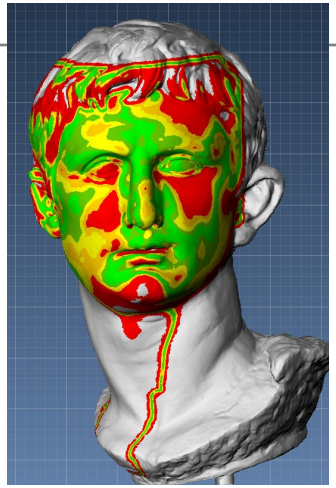
A. Istanbul 2165
(A 1154)

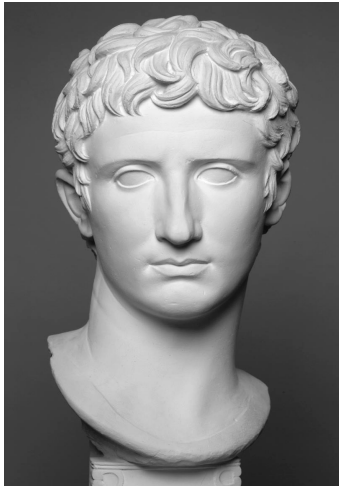
B. Baltimore 23.21 (A
1322)

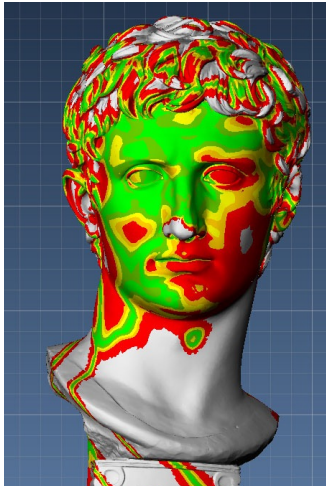
C. Boston 99.344
(A 1323)

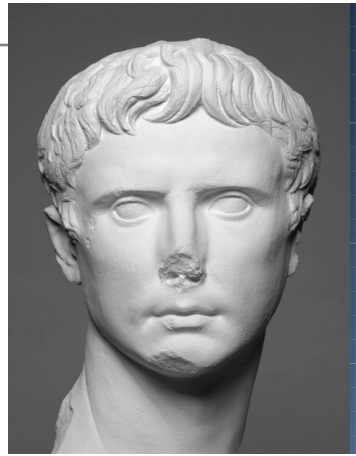
D. Ny Carlsberg
Glyptotek 1443
(A 1136)



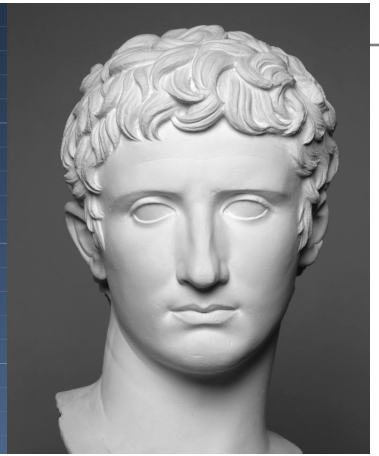








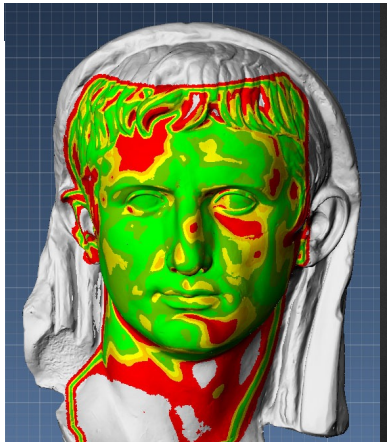
Rom, Pal. Cons. 2394 (A 1320)

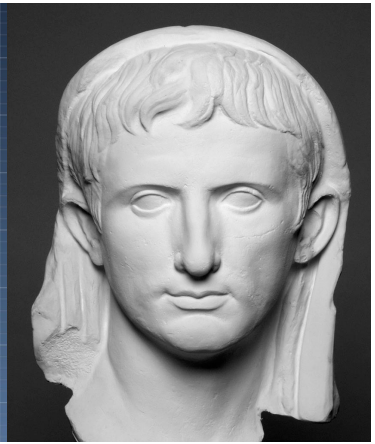


Boston 99.344 (A 1323)

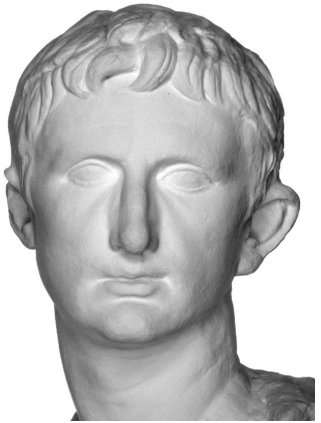
Munich FW 317 (AK 4)

Baltimore 23.21 (A 1322)



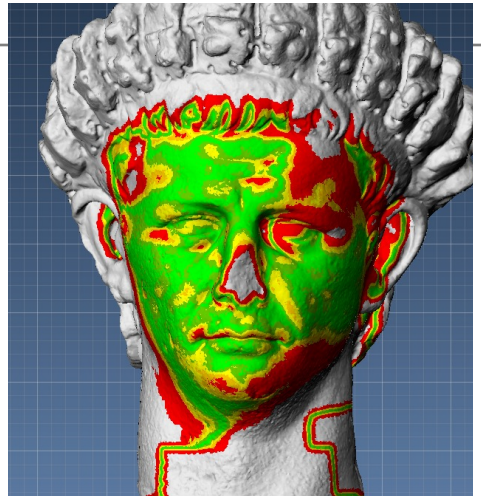


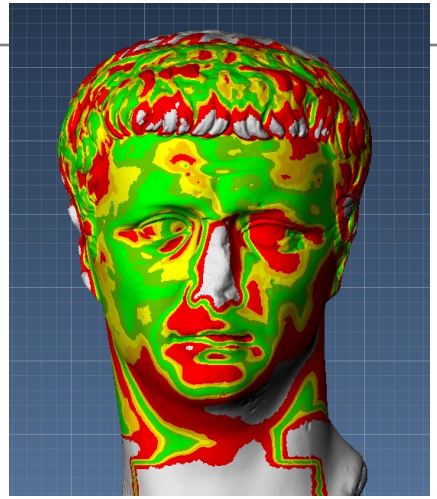
Chiusi 3182 (A 1414)



Istanbul 2165 (A 1154)

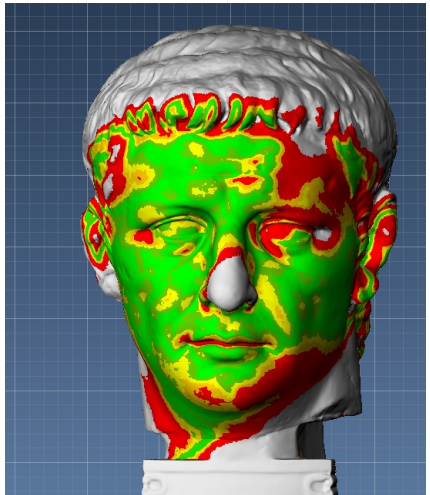
A. Ny Carlsberg Glyptotek 1423 (comp. with D)



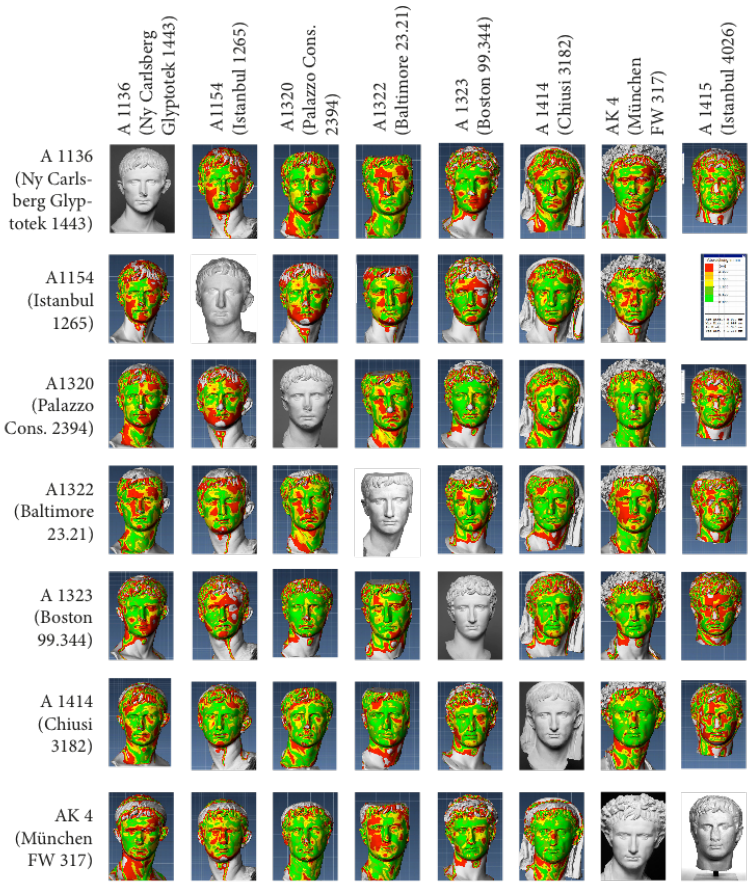


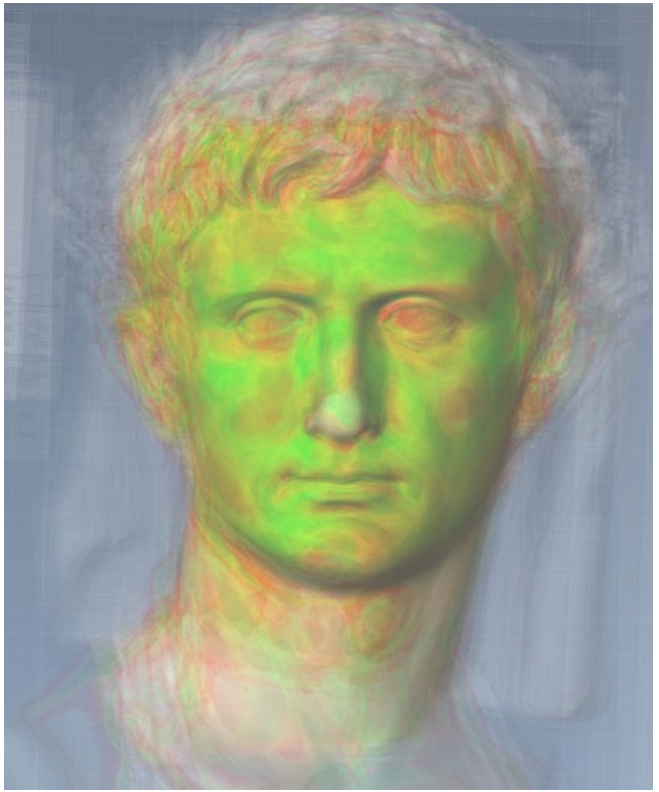
B. Ny Carlsberg Glyptotek 1277 (comp. with D)

C. Ny Carlsberg Glyptotek 1948 (comp. with A)

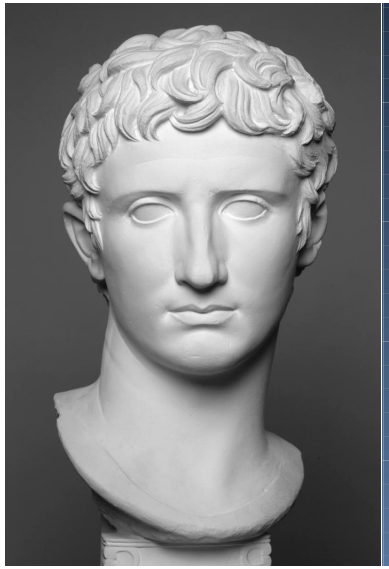


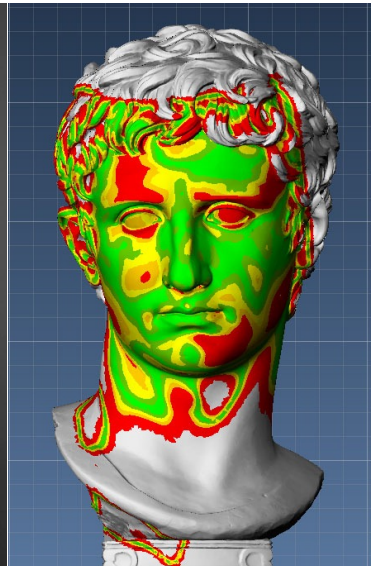
D. Braunschweig AS 7 (comp. with A)





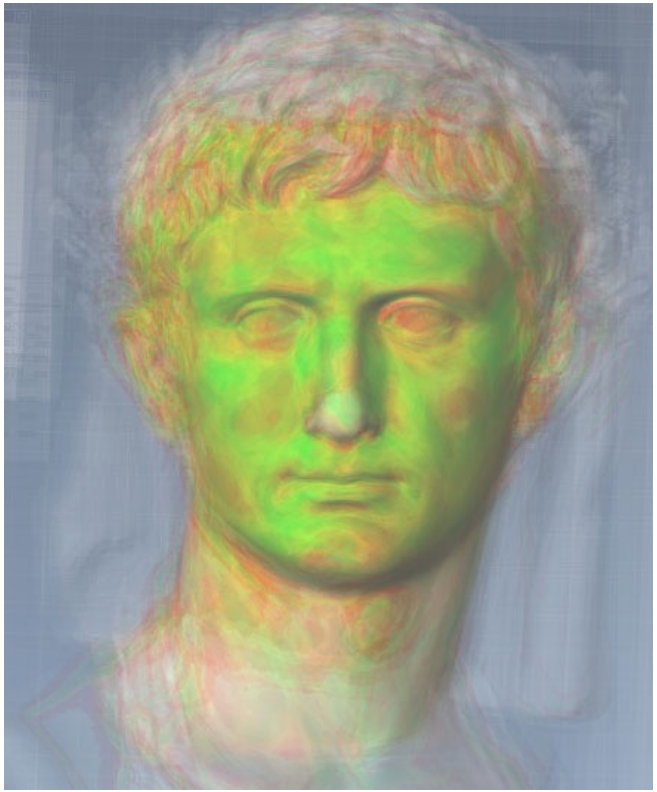
Deviation analysis target-actual (false colour representations) on eight Augustus portraits in Primaporta type





Augustus Prima Porta Type:
Boston 99.344 (A 1323)

Augustus Prima Porta Type:
Baltimore 23.21 (A 1322)

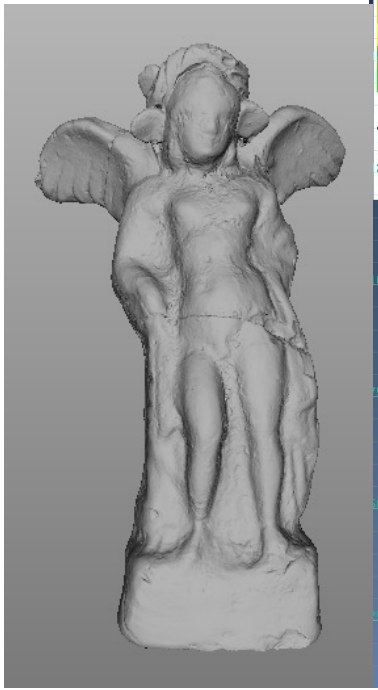


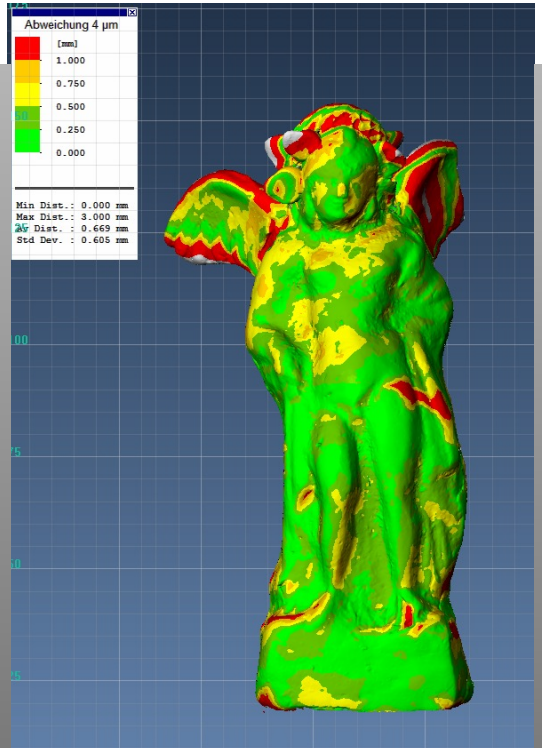
Deviation analysis target-actual (false colour representations) on eight Augustus portraits in Primaporta type

Martin Langner, Das Gesicht hinter dem Marmor. Computergestützte Maßvergleiche an römischen Kaiserporträts, in C. Marcks and J. Lang (eds.), Arbeit am Bildnis (2020) 377–384. 411–415

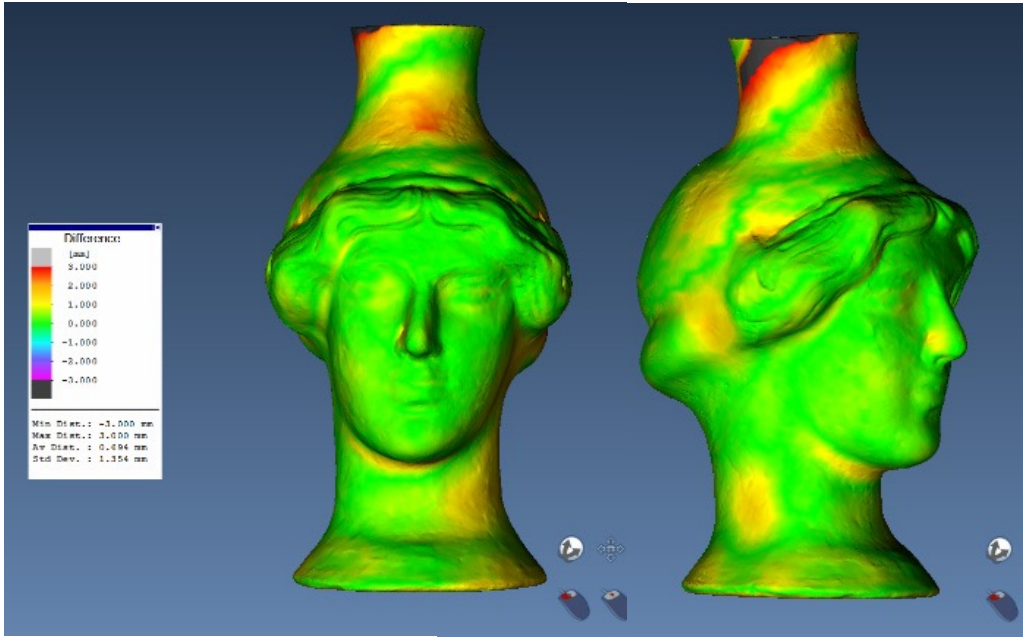
Comparison of two terracotta statuettes from the archaeological collection in Göttingen

Göttingen Tk 22

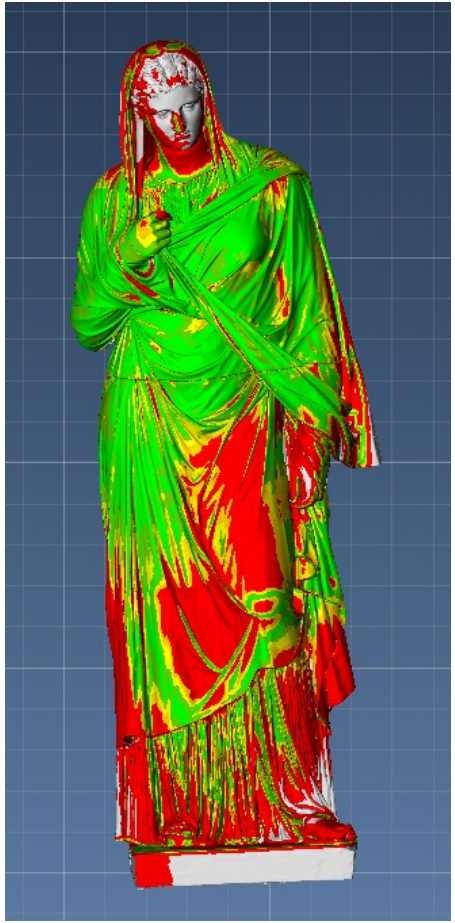


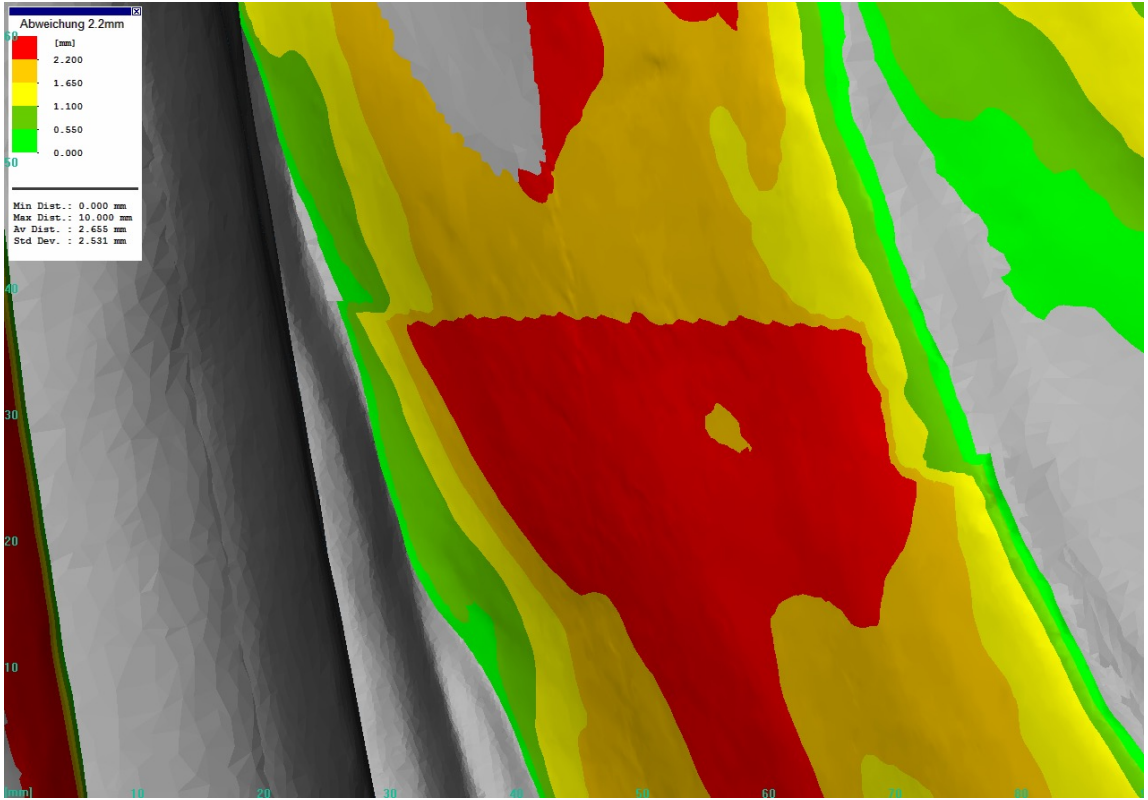


Göttingen Tk 23

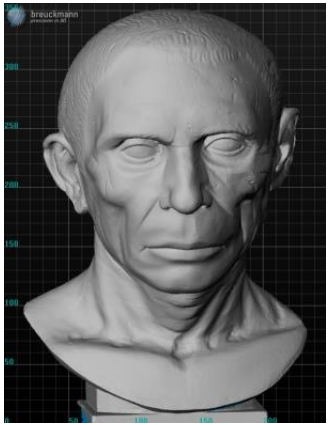


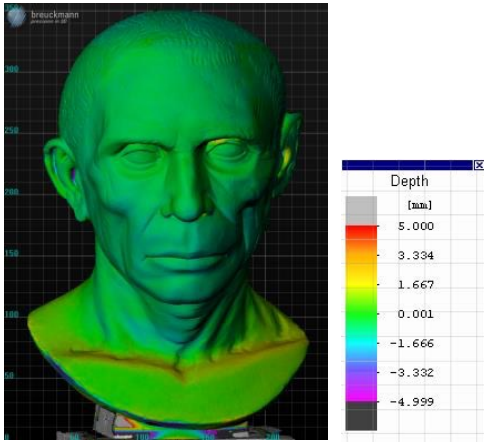
D.H. Rieke-Zapp – E. Trinkl, Face to face - close range inspection of head vases, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2/W5, 2017, 601-604



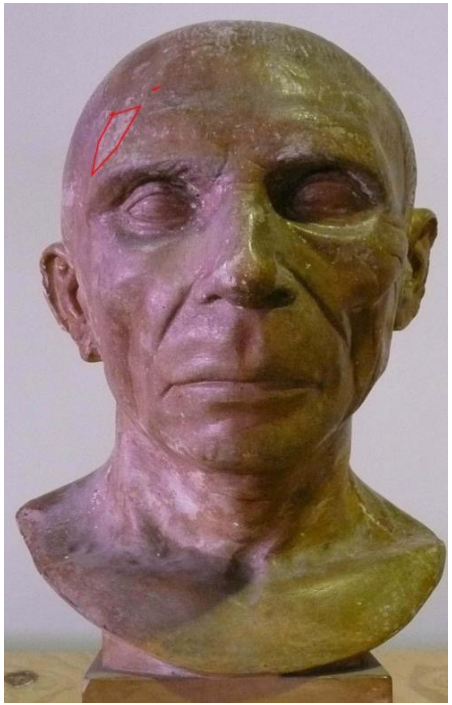


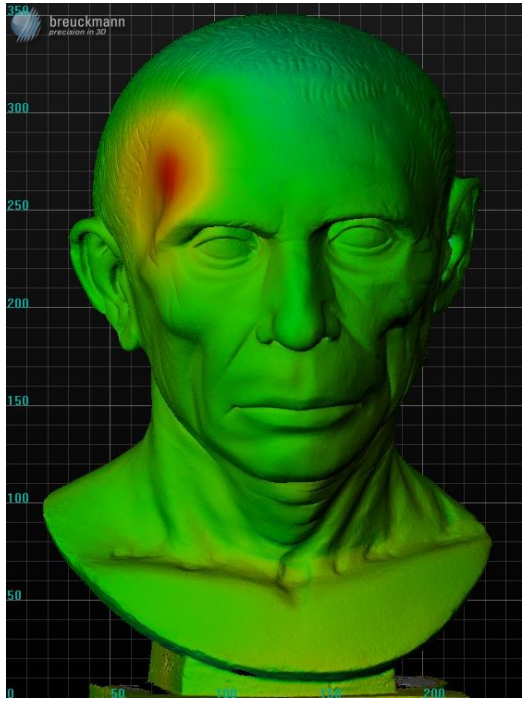
The so-called Large Herculaneum Woman: Comparison of the two casts in Göttingen and Weimar

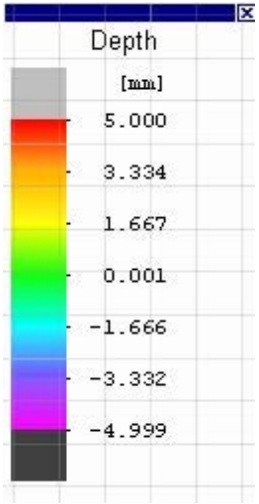




Shape Comparison of a Roman bronze bust with two casts right: copy from the 1950s, left: more recent copy (Dresden State Art Collections in cooperation with the University of Virginia)



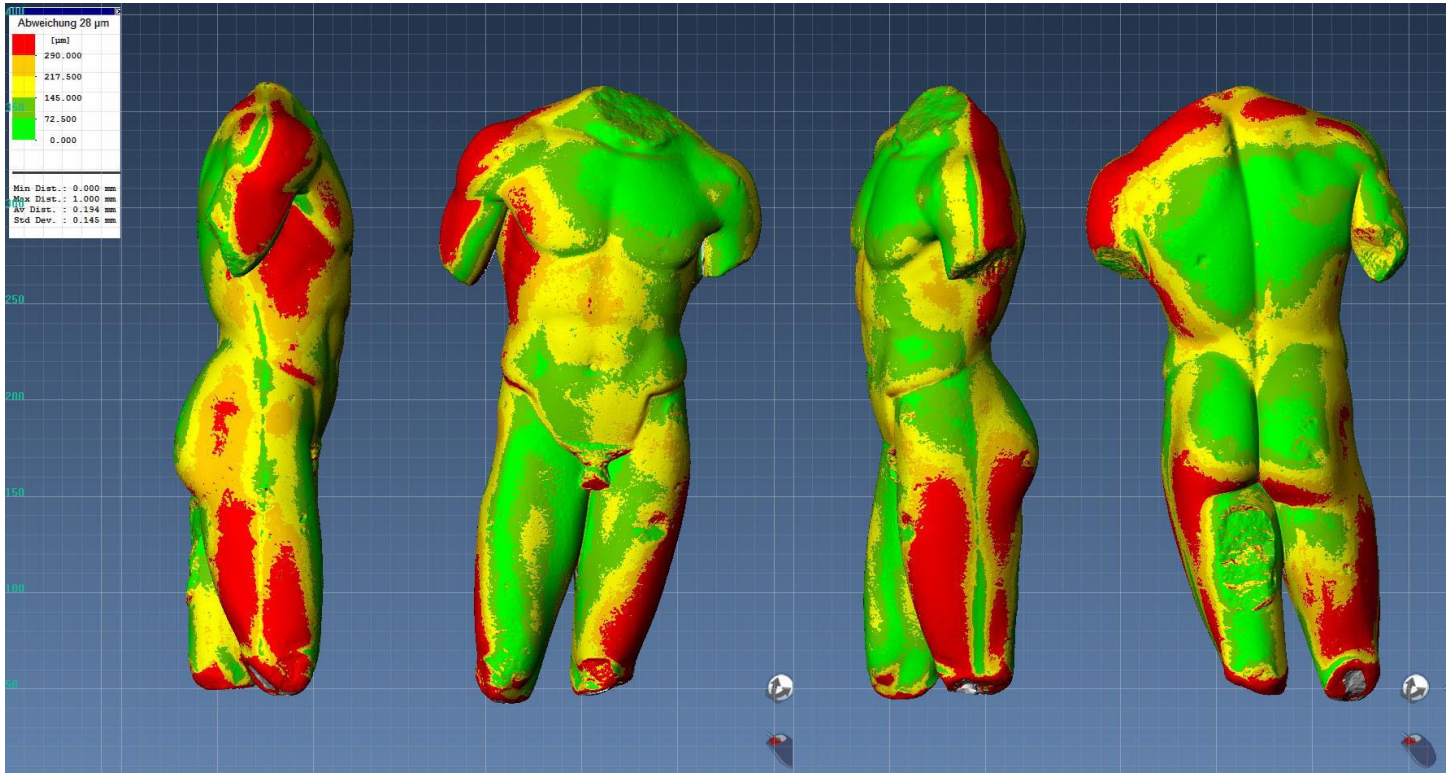




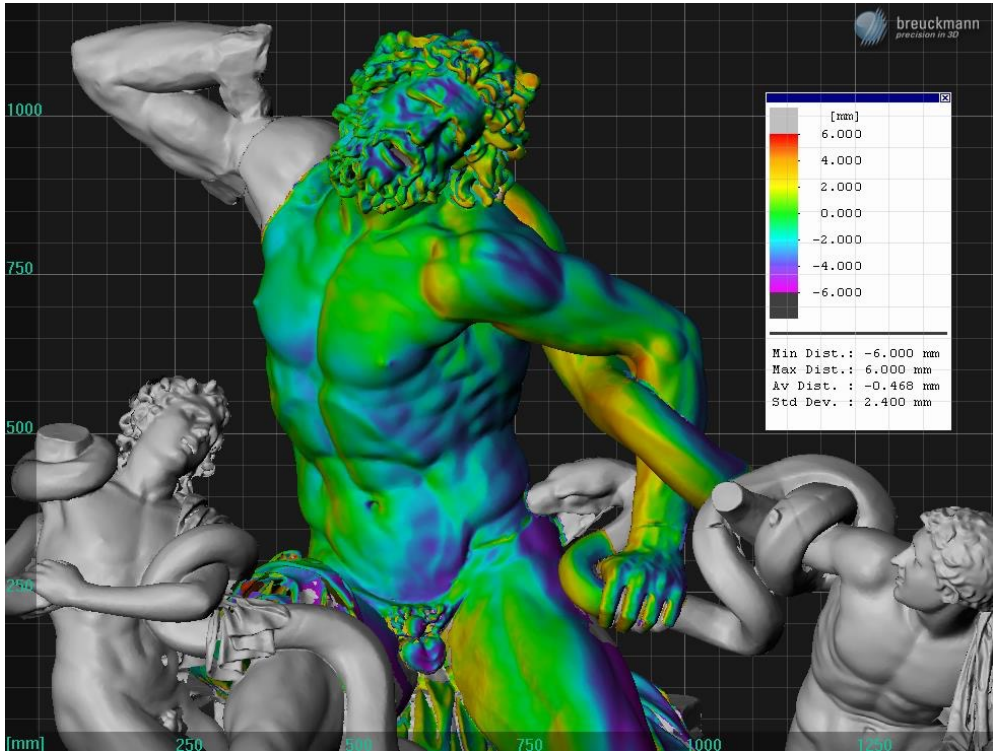
The 3D data evaluation revealed an indentation on the right side of the head, which even experts had not noticed before.

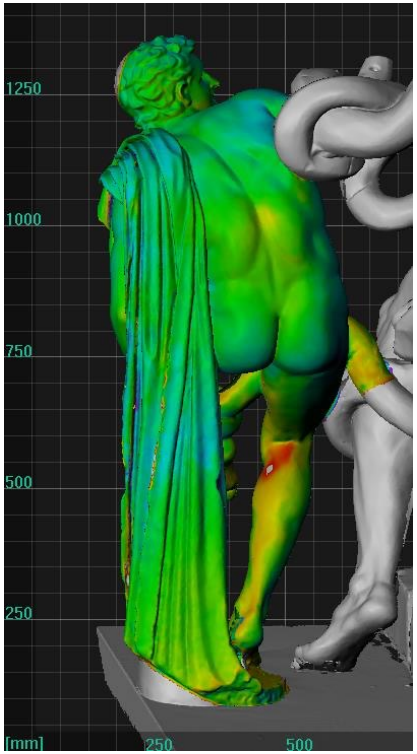
http://www.digitalsculpture.org/roman-portrait.html

Tolerance based pass/fail shape comparison



Herakles torso Göttingen: Comparison of original und cast



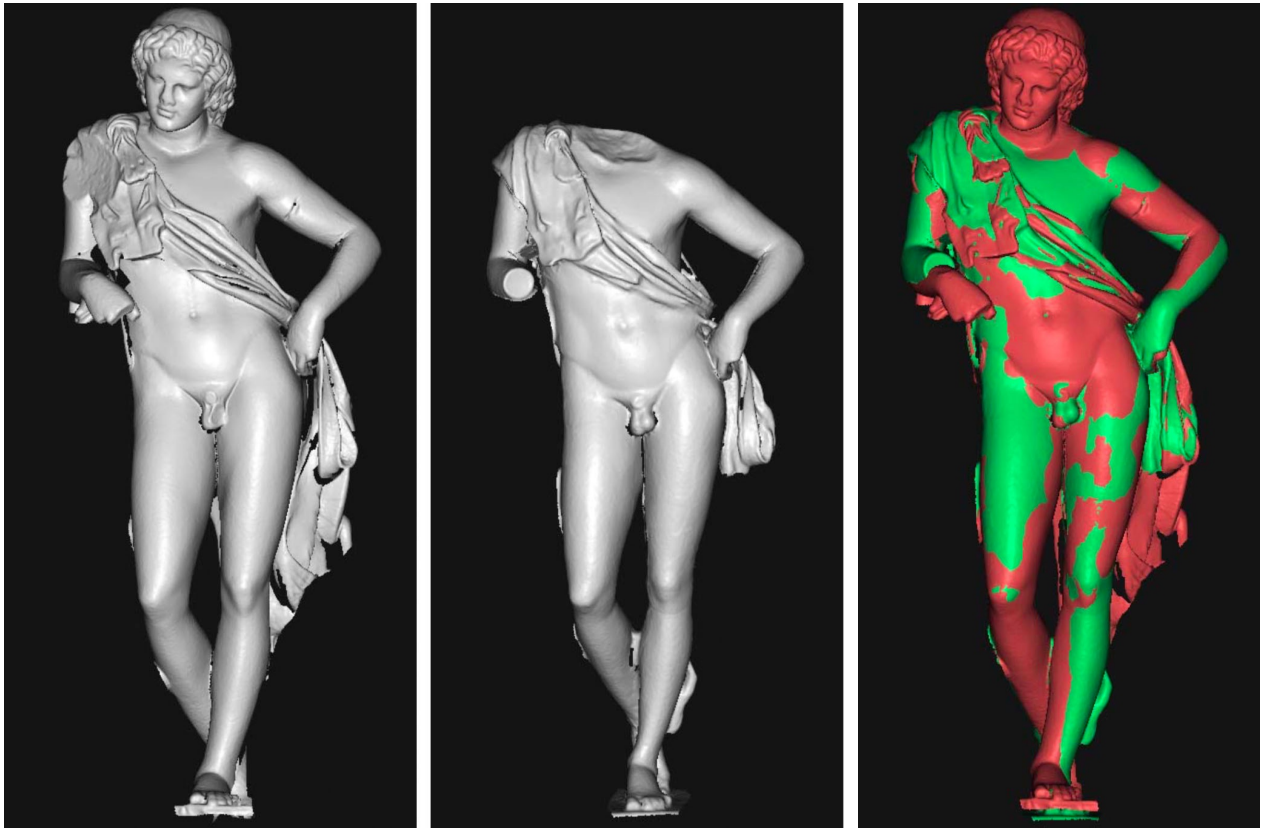


Laocoon: Comparison of the original statue with plaster casts with deviations of up to 4 mm. Musei Vaticani and Kress Foundation in cooperation with the University of Virginia)

B. Frischer, Digital Sculpture Projekt: Laocoön (2009-13): http://www.digitalsculpture.org/laocoon/; ders., 3D Data Capture, Restoration and Online Publication of Sculpture, Appendix I: A Comparison of casts vs. Originals, in: F. Remondino and S. Campana (eds.), 3D Recording and Modelling in Archaeology and Cultural Heritage. Theory and best practices (Oxford 2014), 141–143

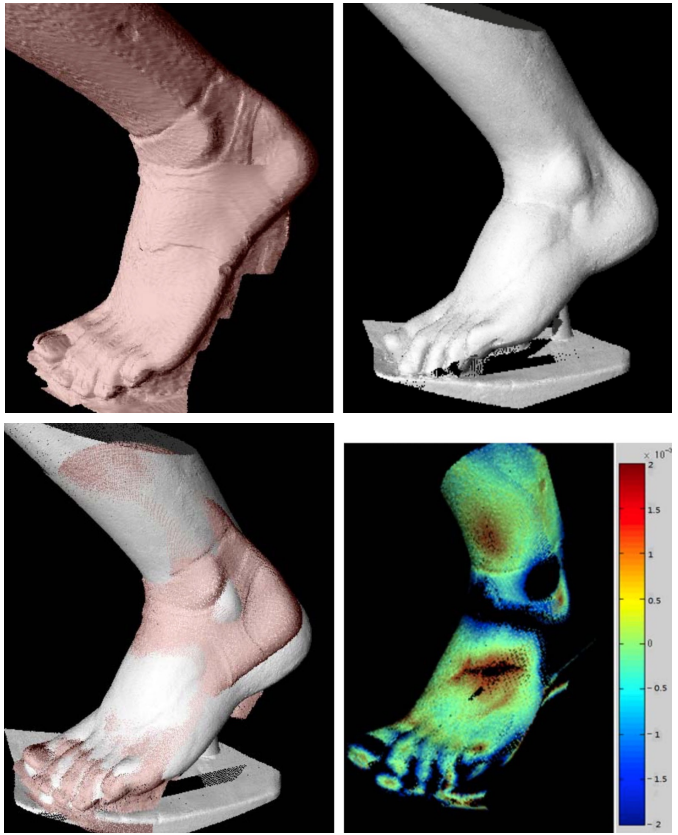
SHAPE COMPARISON

Yujin Zhang et al., „Classical Sculpture Analysis via Shape Comparison," in *International Conference on Culture and Computing,* Kyoto, 2013 (2013) 57–61: https://ieeexplore.ieee.org/document/6680331



SHAPE COMPARISION

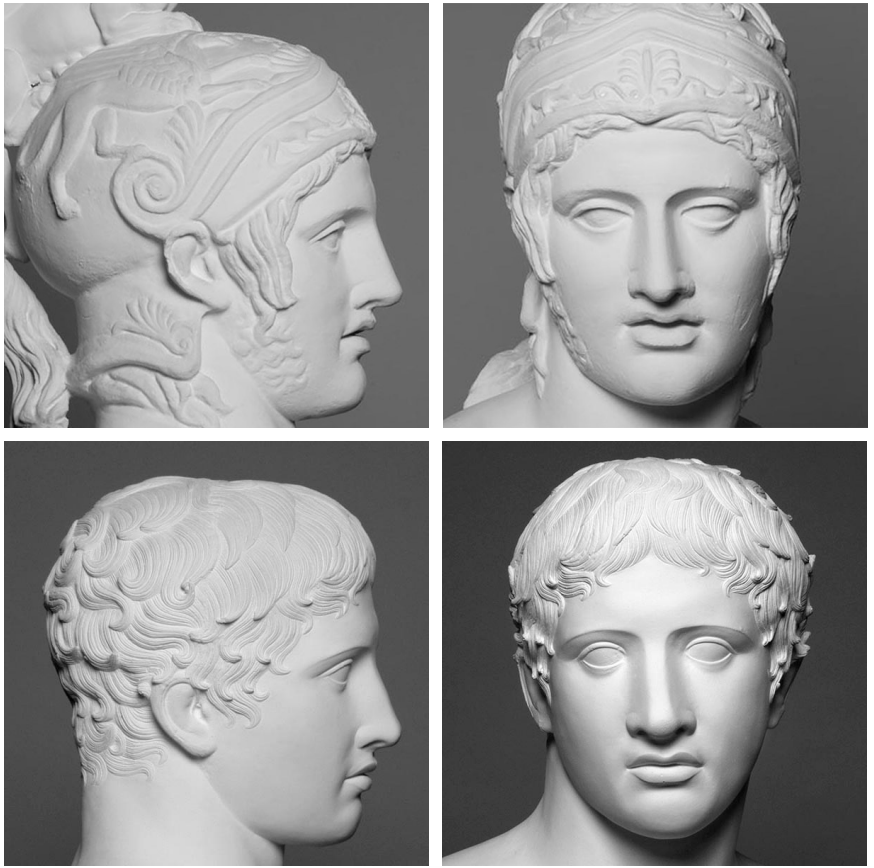
Yujin Zhang et al., „Classical Sculpture Analysis via Shape Comparison," in *International Conference on Culture and Computing,* Kyoto, 2013 (2013) 57–61: https://ieeexplore.ieee.org/document/6680331



Amazon in the type Sciarra in Copenhagen and replica of Diadumenos in Athens

PROFILE LINE

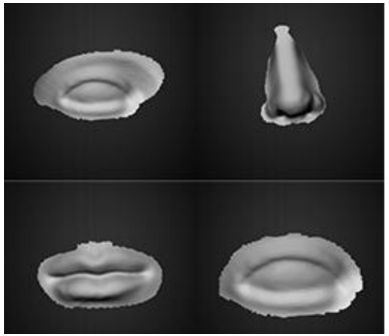
András Patay-Horváth, Master-hand Attributions of Classical Greek Sculptors by 3D-Analysis at Olympia - Some Preliminary Remarks, in Eurographics Workshop on Graphics and Cultural Heritage (2014): http://diglib.eg.org/handle/10.2312/gch.20141327.041-042



CONTOUR LINE

Matteo Dellepiane et al., Using 3D Scanning to Analyze a Proposal for the Attribution of a Bronze Horse to Leonardo da Vinci, in The 8th International Symposium on Virtual Reality, Archaeology and Intelligent Cultural Heritage, Brighton, UK, 2007 ed. D. Arnold, F. Niccolucci, A. Chalmers (2007), 117–124: http://dx.doi.org/10.2312/VAST/VAST07/117-124

DETAIL COMPARISON



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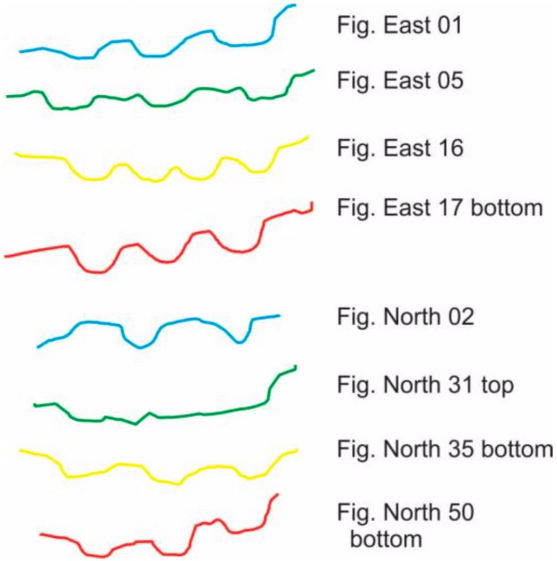
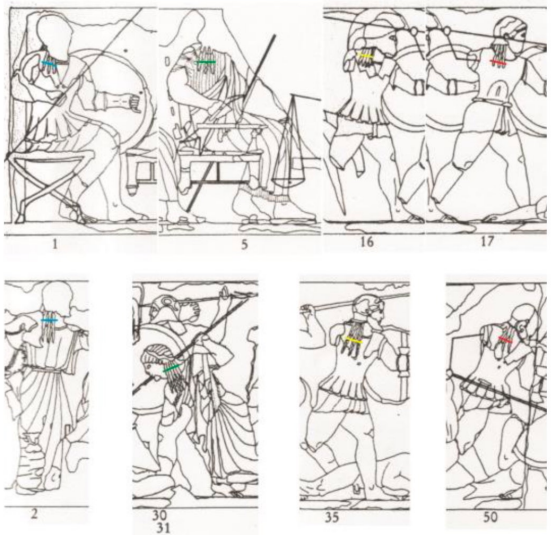
1	E_N_eyeL.OBJ	0.6	0.4	0.0917	0.6102
2	E_N_eyeR.OBJ	0.2	0.8	0.9937	0.0196
3	E_O_eyeL.OBJ	0.6	0.4	0.5640	0.0728
4	E_O_eyeR.OBJ	0.4	0.6	0.3127	0.0302
5	E_P_eyeL.OBJ	0.6	0.4	0.3312	0.1168
6	E_P_eyeR.OBJ	0.4	0.6	0.4196	0.0385
7	W_A_eyeL.OBJ	0.8	0.2	0.2200	0.1016
8	W_A_eyeR.OBJ	0.8	0.2	0.3149	0.1634
9	W_B_eyeL.OBJ	0.8	0.2	0.1838	0.3205
10	W_B_eyeR.OBJ	0.8	0.2	0.0712	0.5014
11	W_D_eyeL.OBJ	0.8	0.2	0.0730	0.6274
12	W_D_eyeR.OBJ	0.6	0.4	0.0127	0.2382
13	W_E_eyeL.OBJ	0.4	0.6	0.0081	0.4567
14	W_E_eyeR.OBJ	0.6	0.4	0.6777	0.9316
15	W_I_eyeL.OBJ	0.6	0.4	0.0012	0.1373
16	W_I_eyeR.OBJ	0.8	0.2	0.0155	0.6554
17	W_U_eyeL.OBJ	0.8	0.2	0.0633	0.6175
18	W_U_eyeR.OBJ	0.6	0.4	0.0206	0.2428

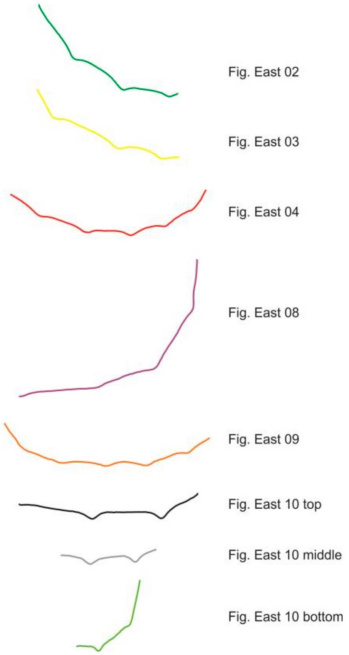
Measurements on the eyes of some statues of the east and west pediment from the Temple of Zeus in Olympia with the values of the f-test for the variance quotient and the two-sample t-test.

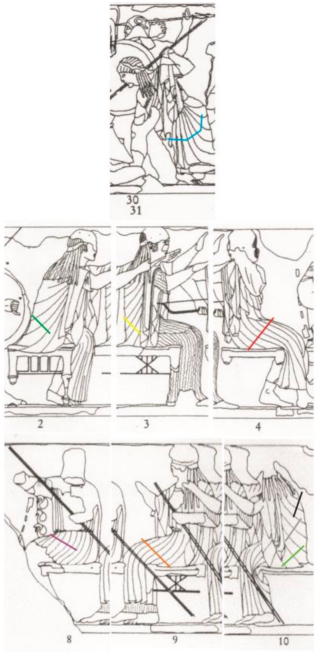
András Patay-Horváth and Leif Christiansen, „From Reconstruction to Analysis. Re-use and Re-purposing of 3D Scan Datasets Obtained from Ancient Greek Marble Sculpture“, Studies in Digital Heritage 1, no. 2 (2017), 491-500: https://doi.org/10.14434/sdh.v1i2.23236;
András Patay-Horváth, „Final report for the project Identification of Classical Greek Sculptors – Master-hand Attributions by 3D-analysis” (2018): http://nyilvanos.otka-palyazat.hu/index.php?menuid=930&lang=EN&num=101755

DETAILED COMPARISON





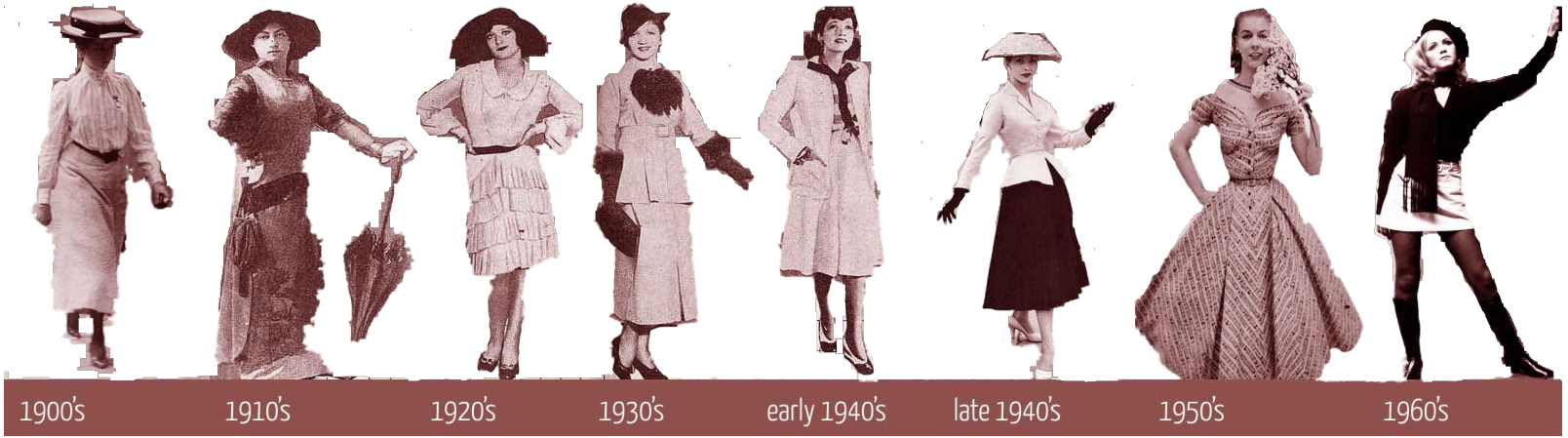




East- und North frieze of the Siphnian reasury in Delphi (Cast in Göttingen)

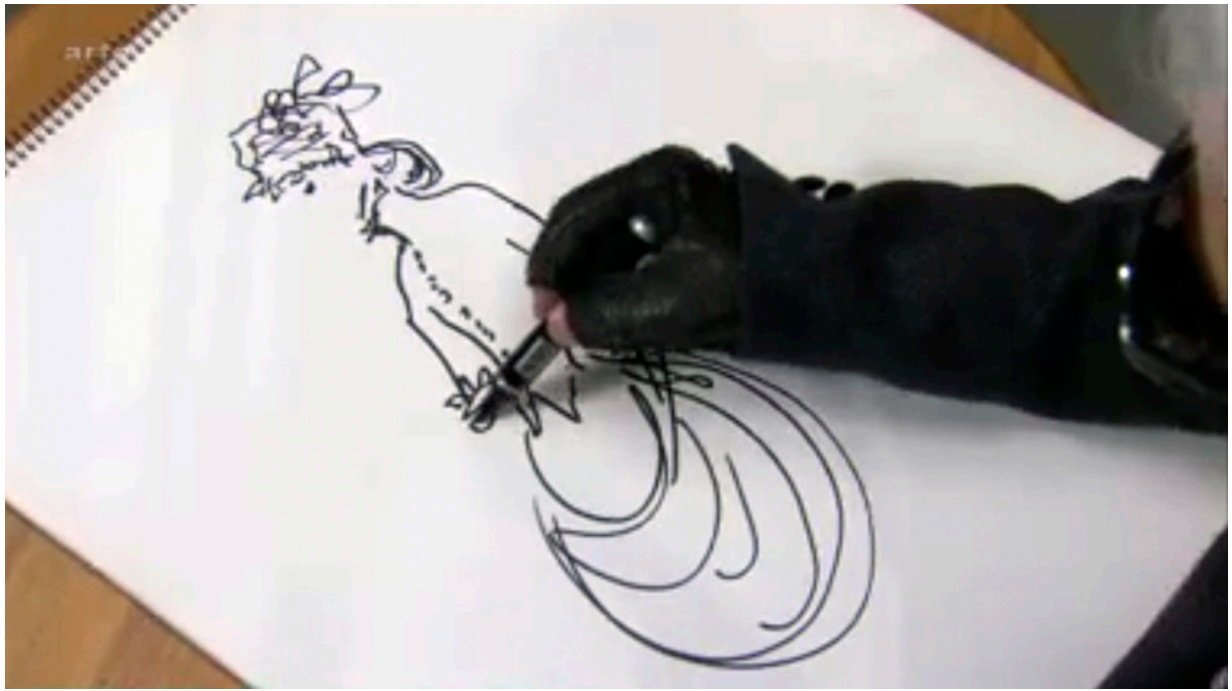
FASHION AND FASHIONS

'Fashions' (or 'tastes of the time') are snapshots of a process of continuous change.
They can be used for dating, because the way we use and consume things is subject to time-related patterns that are not only reflected in behaviour and thinking, but also in the design of objects.



RELATIONSHIP BETWEEN CONTEMPORARY TASTE AND DESIGN

Design is an active and reflective shaping process, but design and contemporary taste influence each other, as producers also participate in contemporary taste.



Karl Lagerfeld designs a dress

STYLE

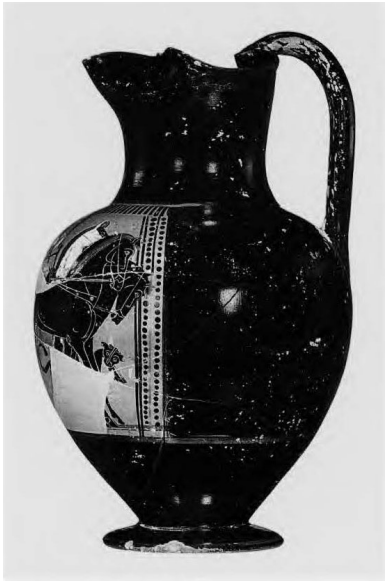
- The formal design of things as a function of time and thus indirectly of social or cultural changes.

Stylistic features (= individual characteristics) can express themselves on several levels:

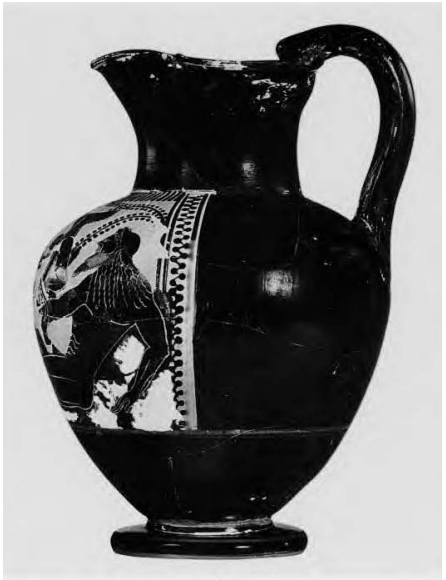
- Style of an epoch (period style)
- Style of a region (regional style)
- Style of a genre (genre style)
- Style of a workshop (workshop style)
- Style of a work or an artist (individual style)

DEVELOPMENT

- Distinction between earlier and later stylistic elements



Munich 1762
(ca. 520 BC)



Munich 1784
(ca. 510 BC)

Munich 1806
(ca. 500 BC)

Corpus Vasorum Antiquorum Deutschland 65, München 12 (München: Beck 1993)

TYPE

- firmly marked shape of relatively long temporal duration
- is determined by abstraction of individual forms under determination of the characteristic commonalities

Va Vb III I II VI VII X VIII

Olpe Chous Oinochoe

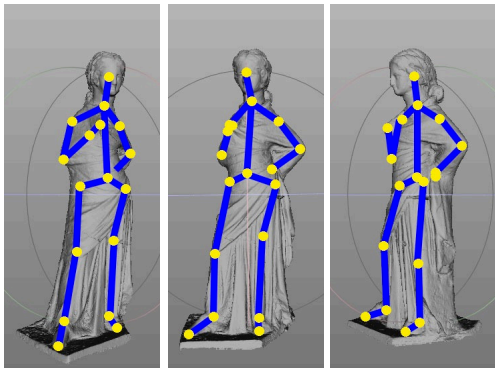
TYPOLOGY AS PATTERN RECOGNITION

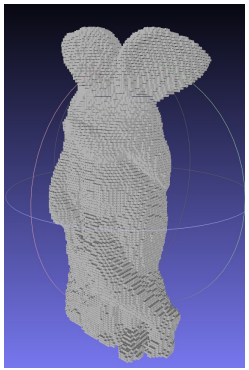
By determining types and styles, the image and artefact sciences attempt to extract patterns from the sum of the remains of past societies, from which conclusions can be drawn about the conditions of the time.

1. Development of a classification system for the so-called Tanagraeans

2. Combination and further development of procedures for automated corpus formation through 3D pattern recognition

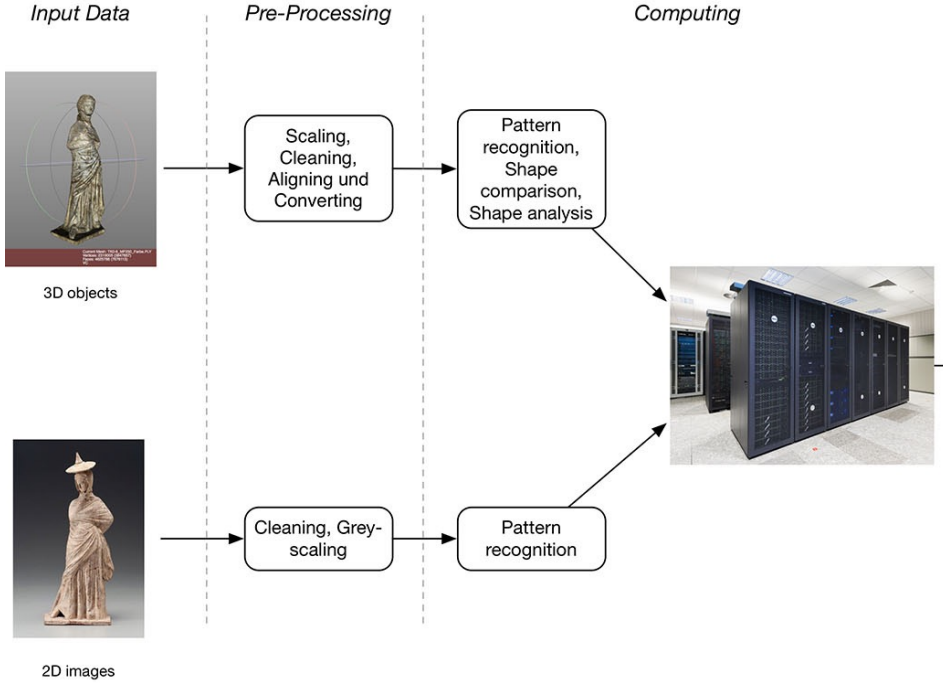
3. Reflection on the associated schematisation and its scientific usefulness

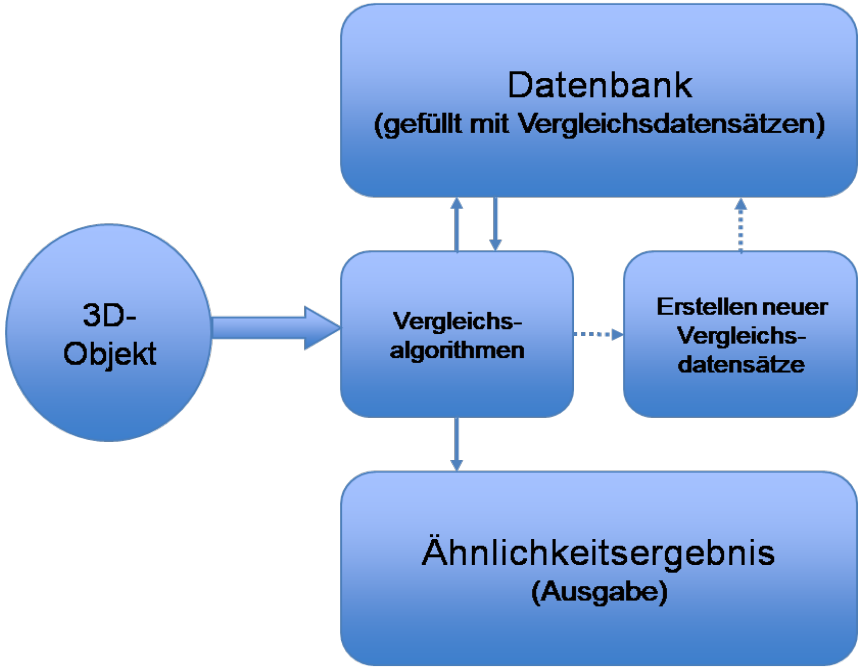




Lucie Böttger, "Classifications and Categorisations with Digital Methods. Shape constancy and shape variance of female terracottas of the Hellenism".

Alexander Zeckey, "3D Pattern Recognition of Ancient Terracottas. Contributions to automated object mining"


Input Data
Pre-Processing
Computing
3D objects
Scaling, Cleaning, Aligning und Converting
Pattern recognition, Shape comparison, Shape analysis
2D images
Cleaning, Grey-scaling
Pattern recognition

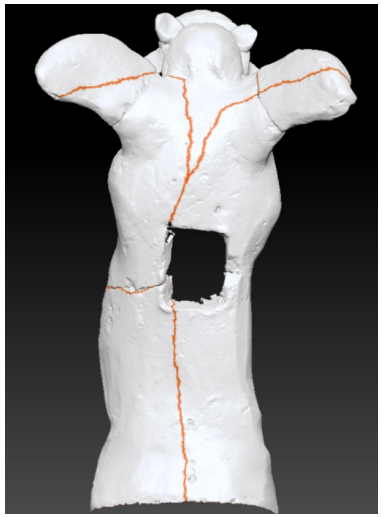

Datenbank
(gefüllt mit Vergleichsdatensätzen)
3D-Objekt
Vergleichs-algorithmen
Erstellen neuer Vergleichs-datensätze
Ähnlichkeitsergebnis
(Ausgabe)

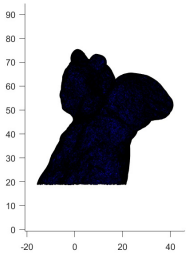
6 Berlin, Antiquarium 6311. Die Zeichnung ist etwas zu unruhig. — h. 0,30 m. — Aus Tanagra.
b. Ebenda 6312. Mit Kopftuch. — h. 0,23 m. — Aus Tanagra.
c. Ebenda 6314. Griech. Terrak. aus Tanagra u. Ephesos Taf. 16. Ausgebessert. Kopf verhüllt und mit Hut, nach links gewendet. — h. 0,27 m. — Aus Tanagra.
d. Ebenda 8409. Arch. Anz. 1895 S. 131 n. 50. Kopf (aufgesetzt, zugehörig) einem Vögelchen auf der linken Schulter zugewendet. — h. 0,195 m. — Tanagraeisch.
e. Athen (Centralmuseum 789). Kopf mit Hut, nach links geneigt. — h. 0,23 m. — Aus Tanagra.
f. British Museum $10\frac{7.5}{9}12$. Kopf verhüllt und mit Hut, nach links gewendet. — h. 0,24 m. — Aus Tanagra.
g. Louvre. Gazette des Beaux Arts 1875 I S. 557. Kopf verhüllt und nach links. — h. 0,30 m. — Aus Tanagra.
h. Rayet, Monuments de l'art II Taf. 34 (Coll. Gambetta). Mit Kopftuch. — Aus Tanagra.

Berlin TC 6311

Berlin TC 6312

Berlin TC 6314




90
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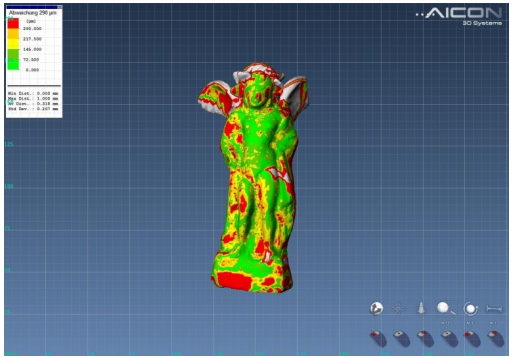
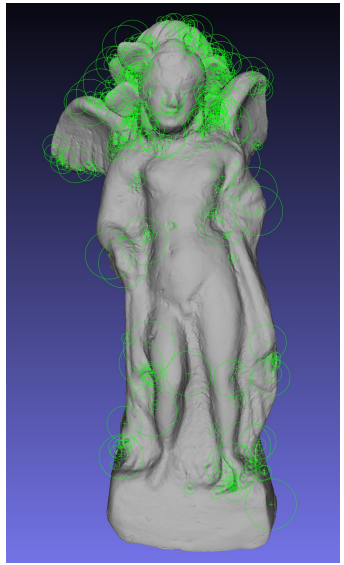
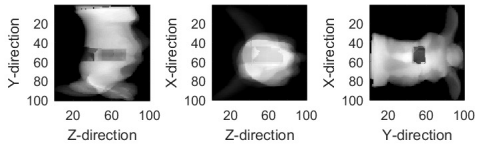
-20
0
20
40


AICON
3D Systems




Y-direction
20
40
60
80
100
20
60
100
Z-direction
X-direction
20
40
60
80
100
20
60
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Z-direction
X-direction
20
40
60
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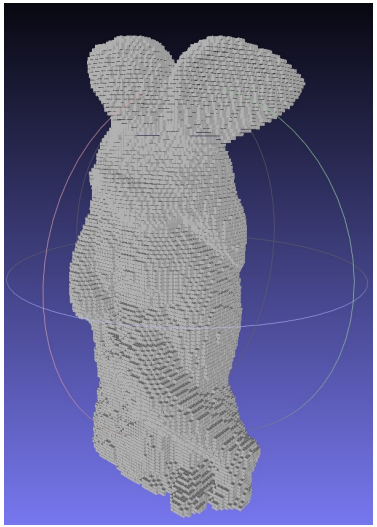
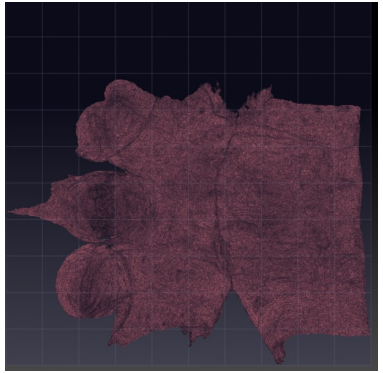
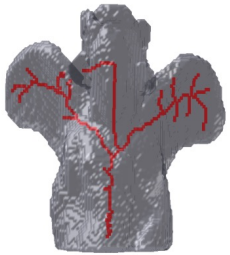
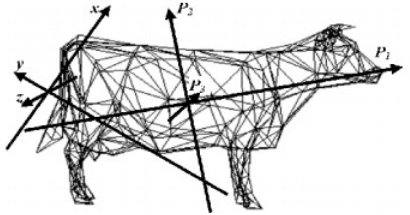
60
100
Y-direction

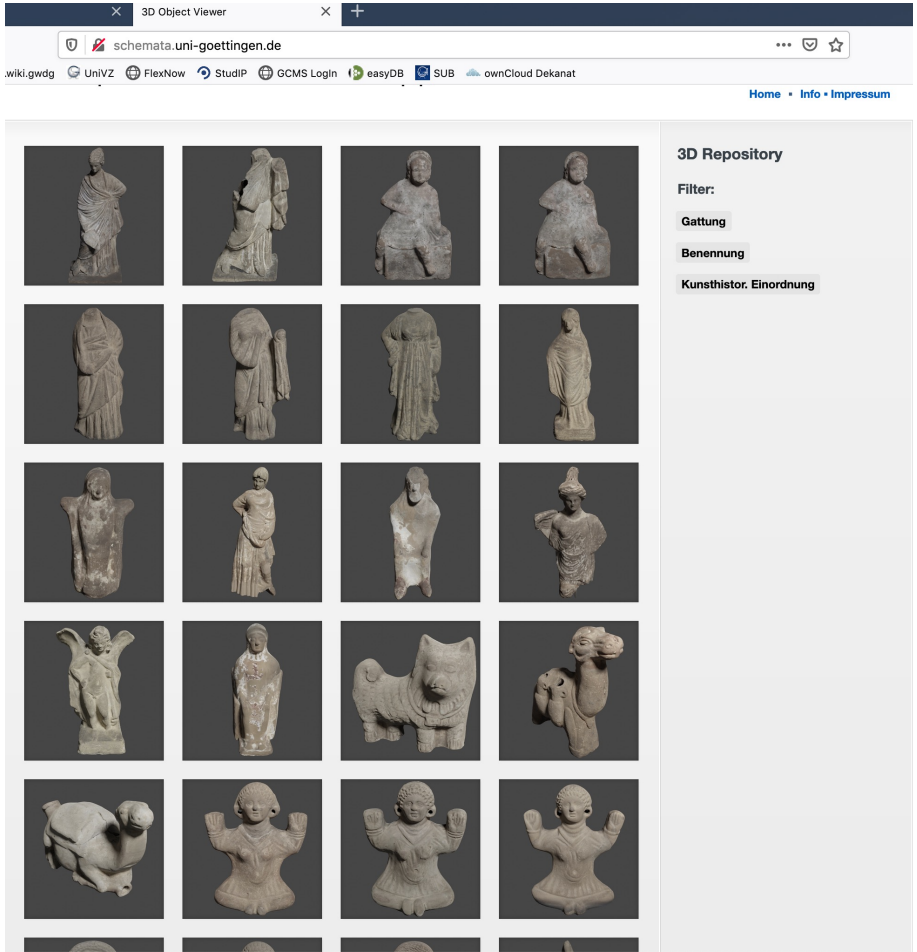


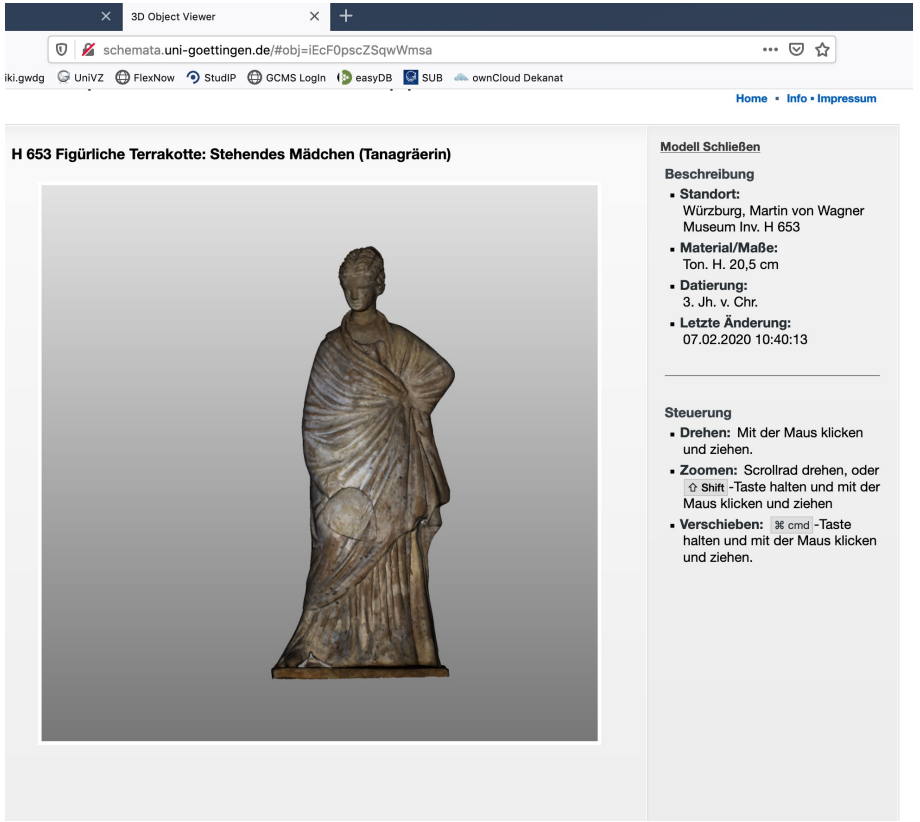





x
y
z
P_2
P_1
P_i

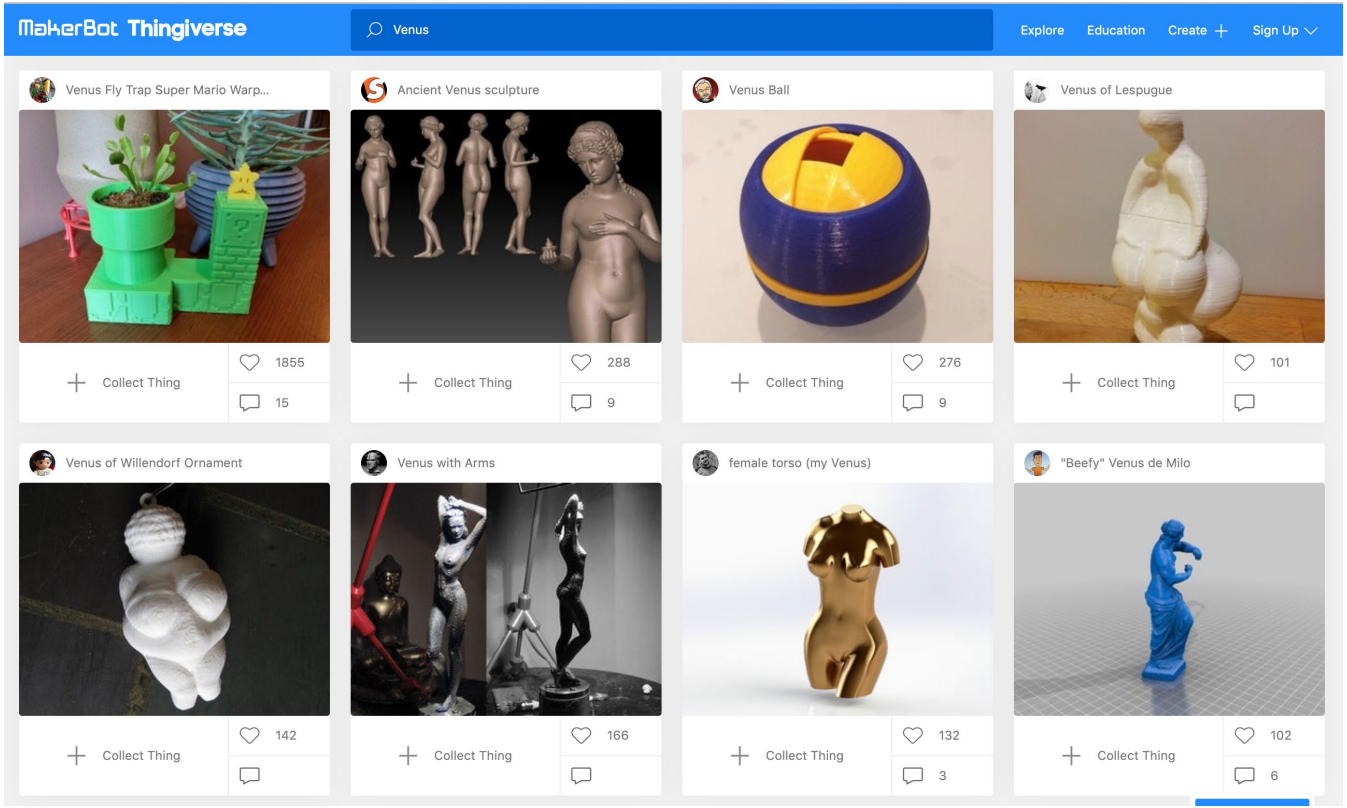
SCHEMATA: 3D REPOSITORY





http://schemata.uni-goettingen.de

Retrieval of models from large 3D repositories

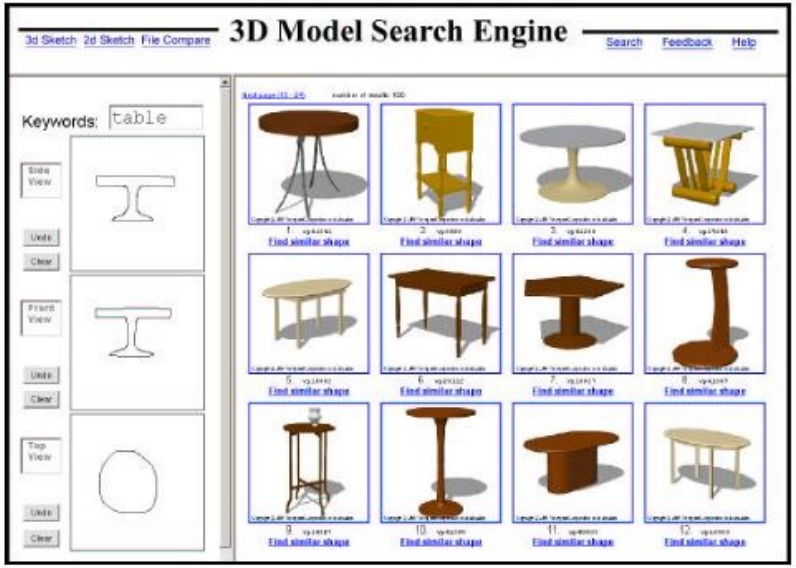


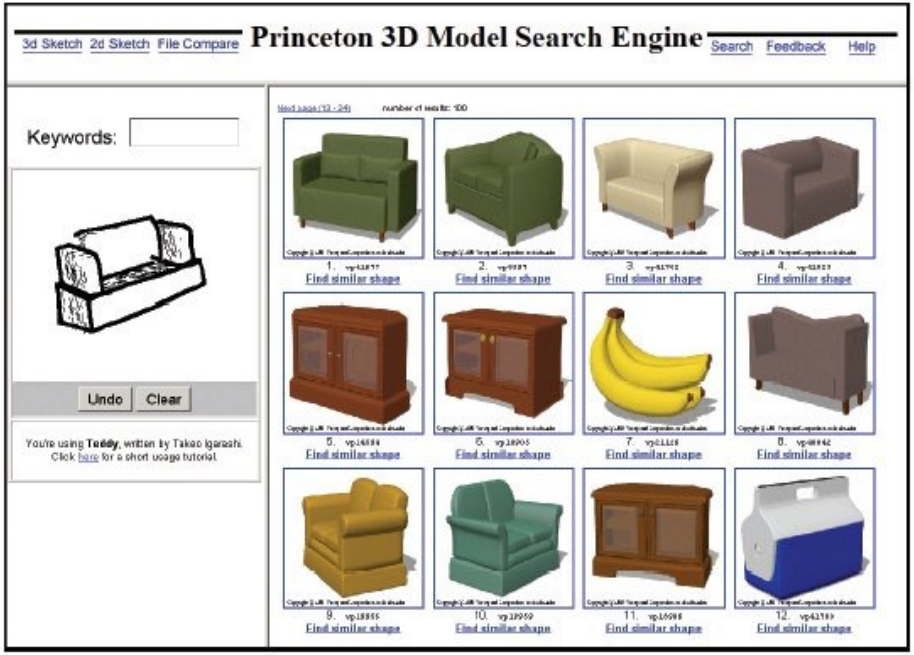
- Keyword-based
- Sketch-based
- Shape Content Collection Exploration

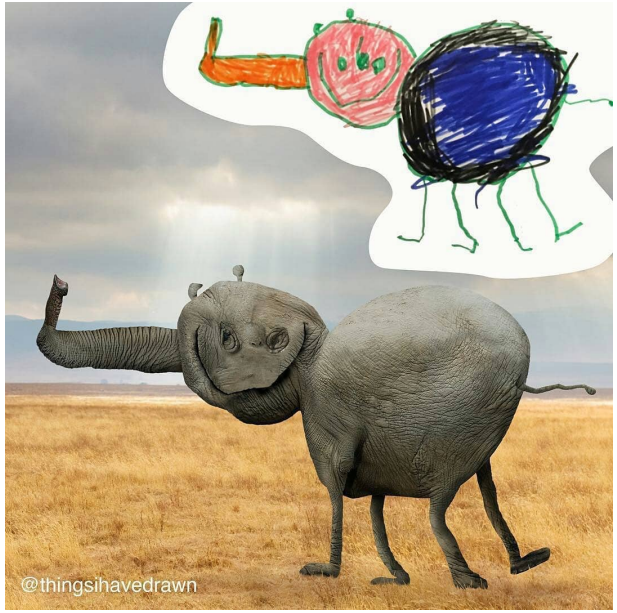
Sketch-Based Shape Retrieval
(http://cybertron.cg.tu-berlin.de/eitz/projects/sbsr)

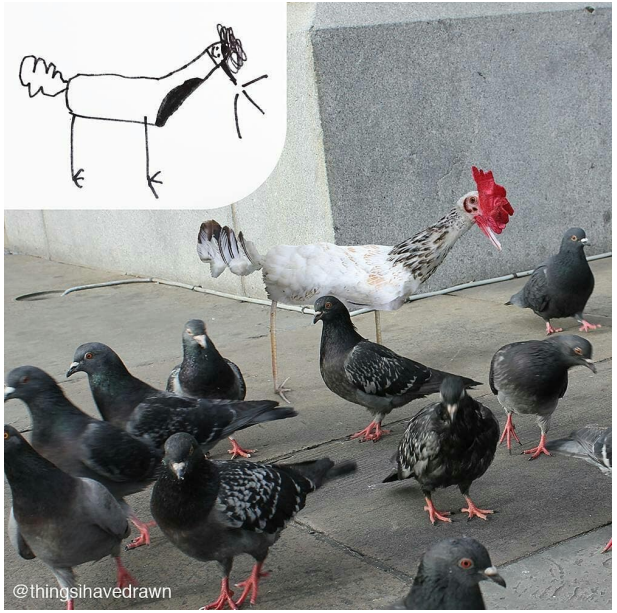
Sketch-Based Shape Retrieval
(http://gfx.cs.princeton.edu/proj/shape/)

s.a. http://cacm.acm.org/magazines/2005/6/6204-shape-based-retrieval-and-analysis-of-3d-models/abstract



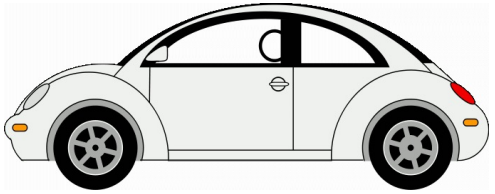


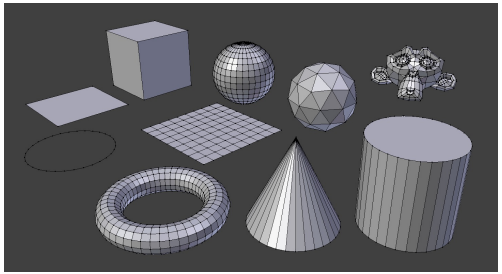


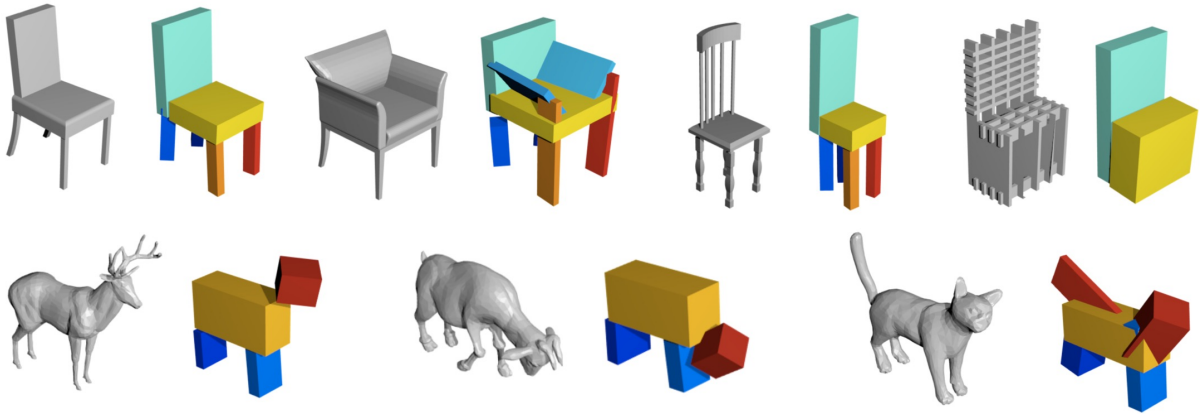


https://www.instagram.com/thingsihavedrawn/

Determination of shape similarity through abstraction

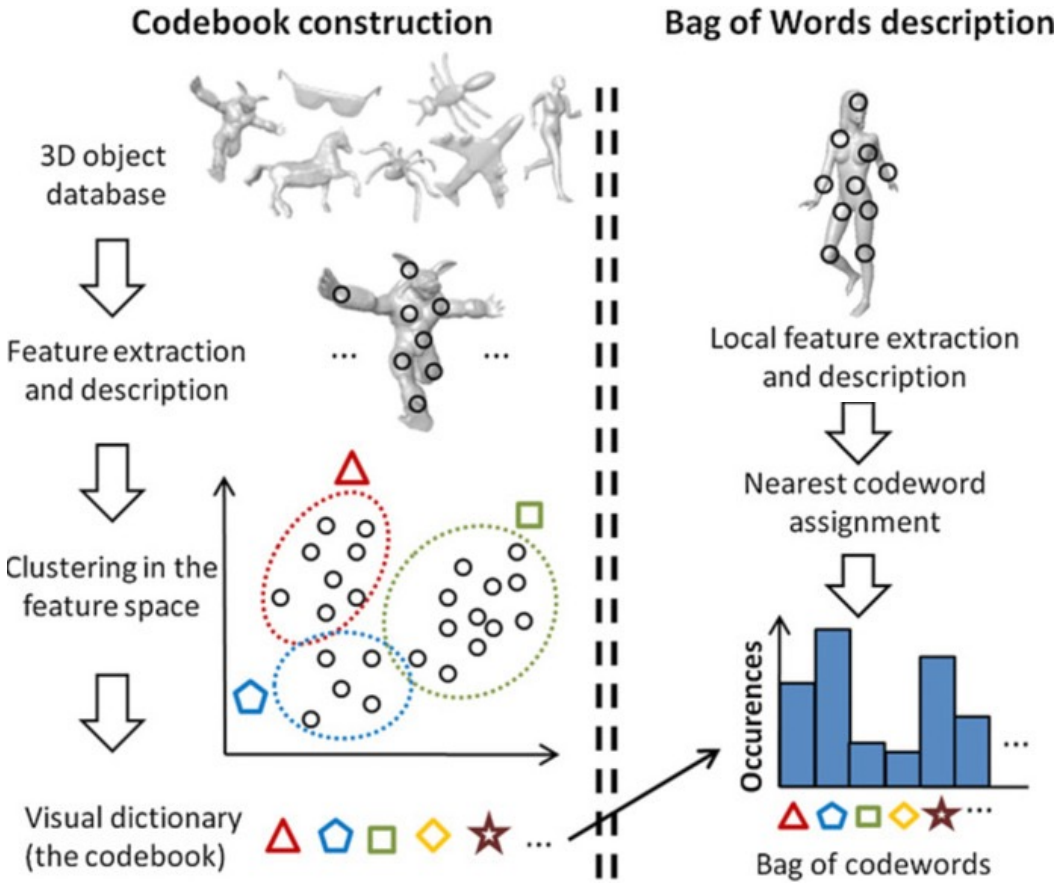






https://upload.wikimedia.org/wikipedia/commons/b/b7/Beetle.gif

Shubham Tulsiani et al., Learning Shape Abstractions by Assembling Volumetric Primitives, in 2017 IEEE Conference on Computer Vision and Pattern Recognition (2017), 2635–2643: https://shubhtuls.github.io/volumetricPrimitives/; Salman Hameed Khan et al., Unsupervised Primitive Discovery for Improved 3D Generative Modeling, in 2019 IEEE Conference on Computer Vision and Pattern Recognition (2019): https://salman-h-khan.github.io/papers/CVPR19_2.pdf

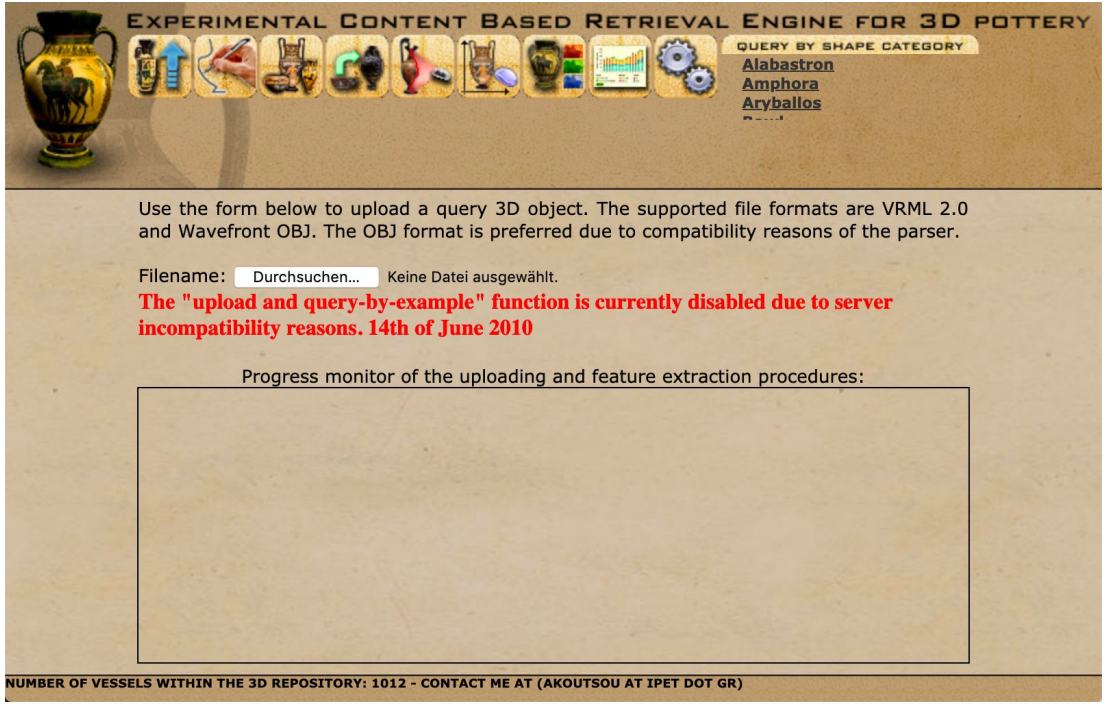


Bag of features

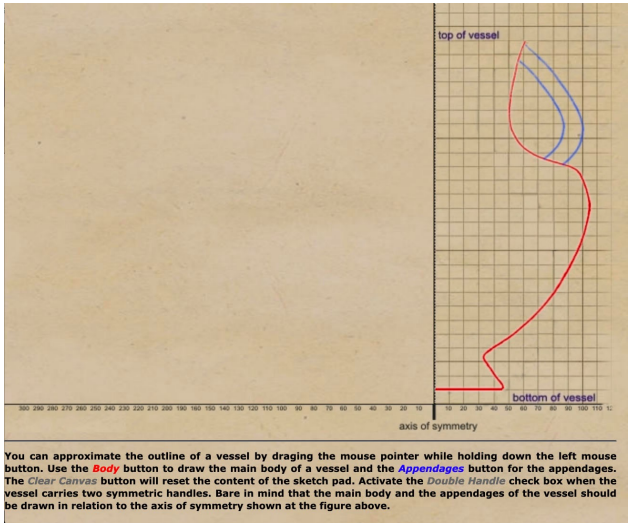
Collection of local feature descriptors that are matched with a codebook (geometric vocabulary)

Suhail Ahmed Memon et al., "3D shape retrieval using bag of word approaches," in 3D Shape Retrieval using Bag of Word Approaches, 2019 2nd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET), Sukkur, Pakistan (2019), 1-7, doi: 10.1109/ICOMET.2019.8673397.

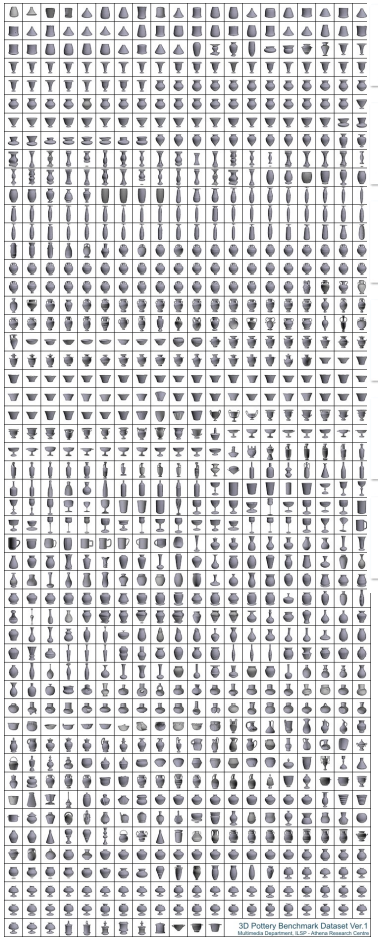
Content Based Shape Retrieval

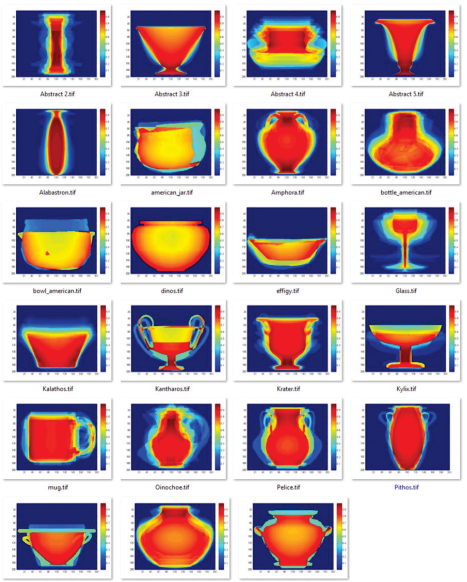


http://www.ceti.gr/~akoutsou/akoutsou_phd/



A. Koutsoudis et al., 3D Pottery Content Based Retrieval based on Pose Normalisation and Segmentation, Journal of Cultural Heritage 11 (2010), 329-338: http://dsp.ee.duth.gr/~chamzas/chamzas_pdfs/publications/201008_3D_Pottery_content_based_retrieval.pdf.pdf

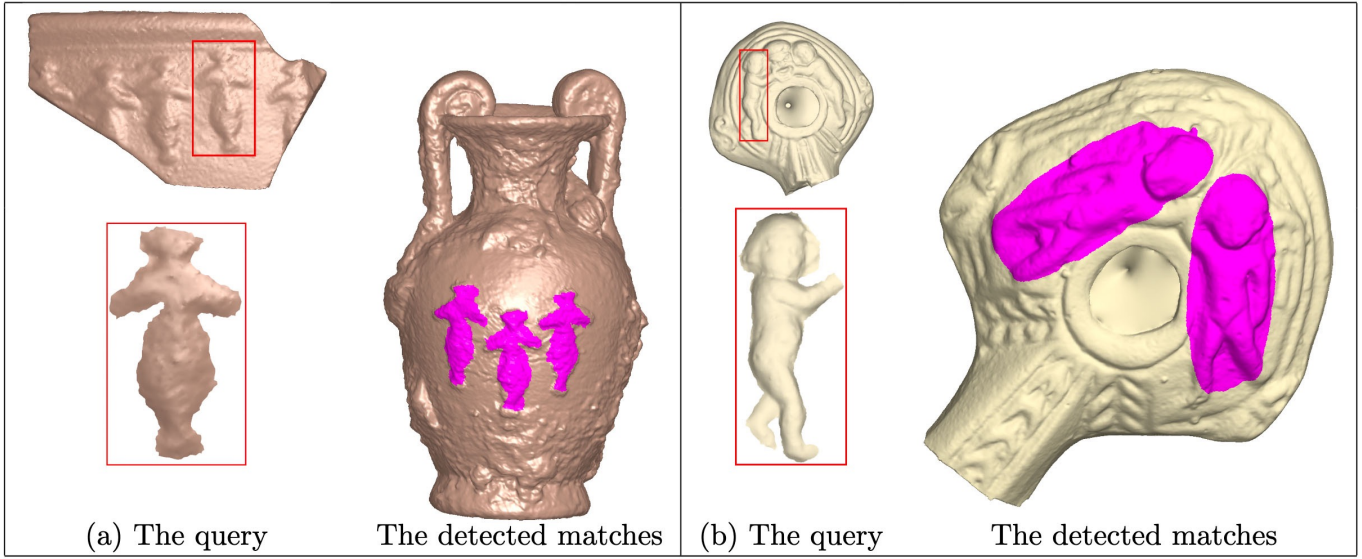




http://www.youtube.com/watch?v=K5t5FgzME5c

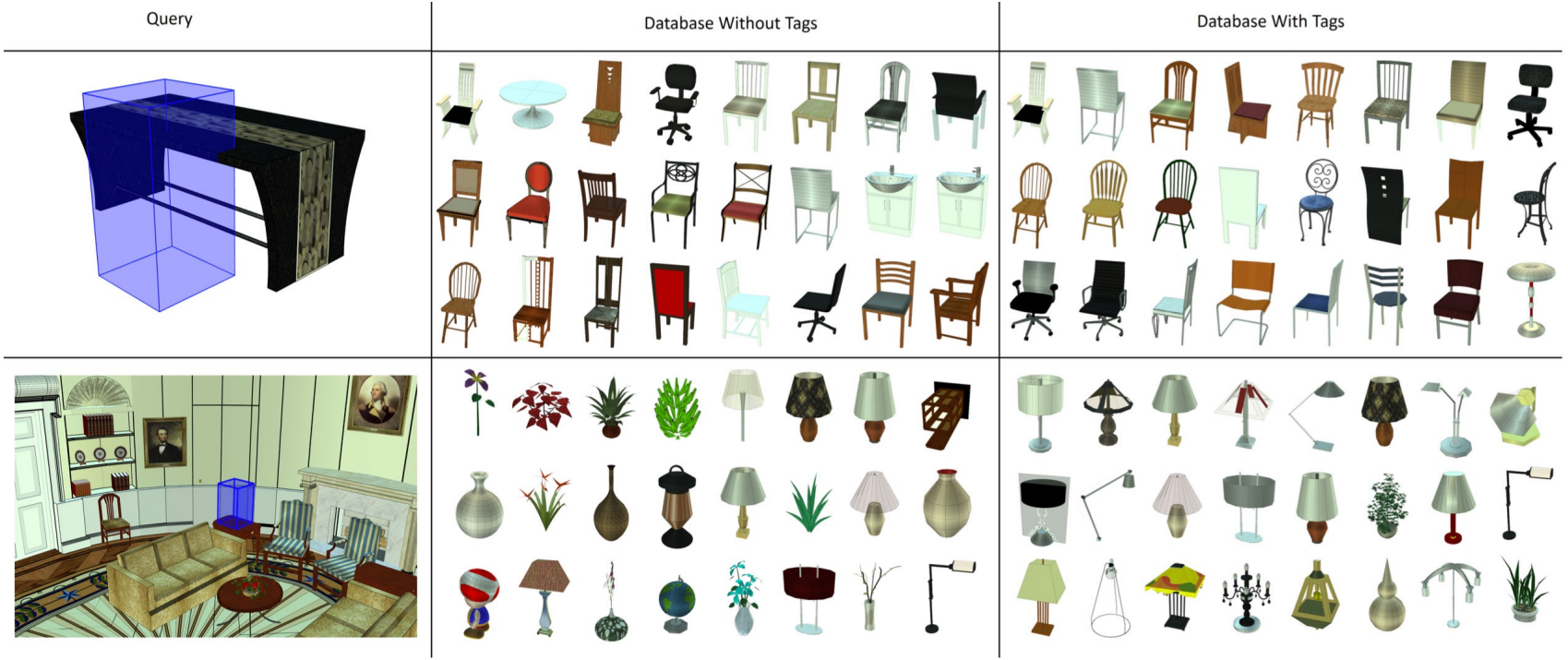
http://www.ipet.gr/~akoutsou/qp/

http://www.ipet.gr/~akoutsou/benchmark/



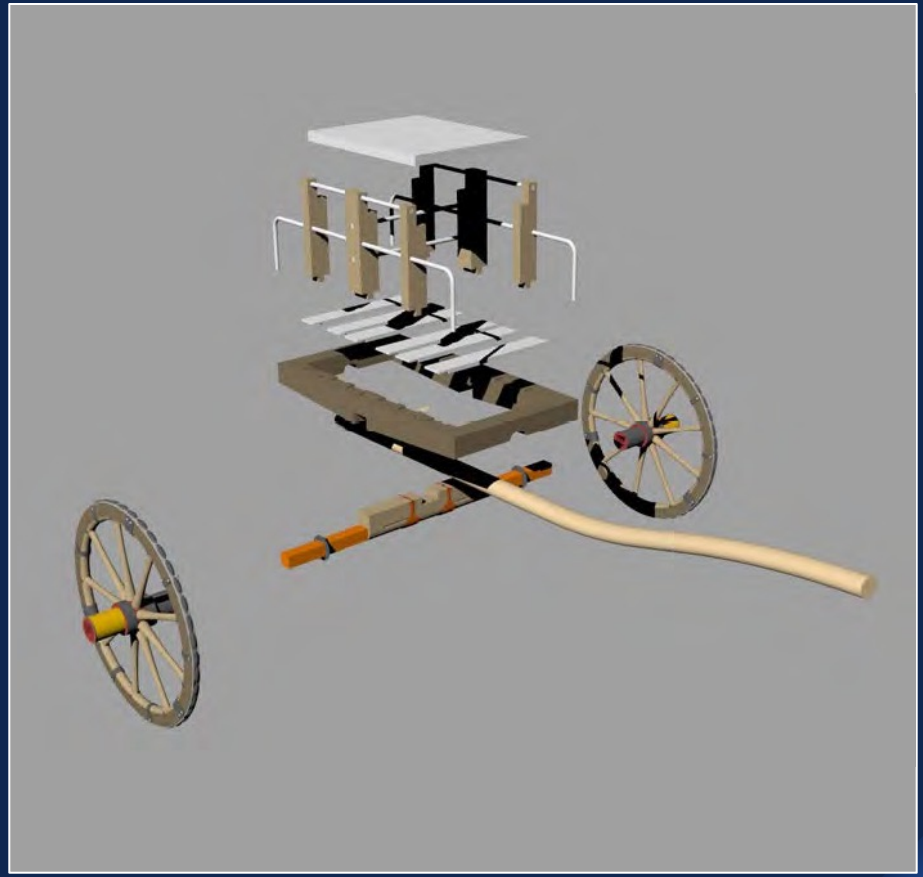
Arik Itskovich and Ayellet Tal, „Surface partial matching and application to archaeology,“ *Computers & Graphics* 35, no. 2 (2011), 334–341: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.220.9336&rep=rep1&type=pdf

Context-dependent retrieval of models from large 3D repositories

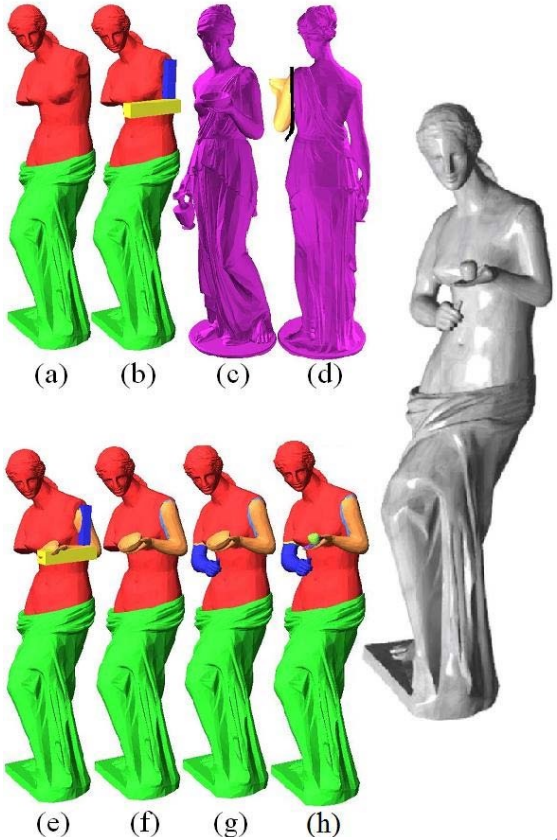


Matthew Fisher and Pat Hanrahan, Context-Based Search for 3D Models, ACM Transactions on Graphics 29 no. 6 (2010), 182:1-10: https://doi.org/10.1145/1882261.1866204

MODEL BUILDING

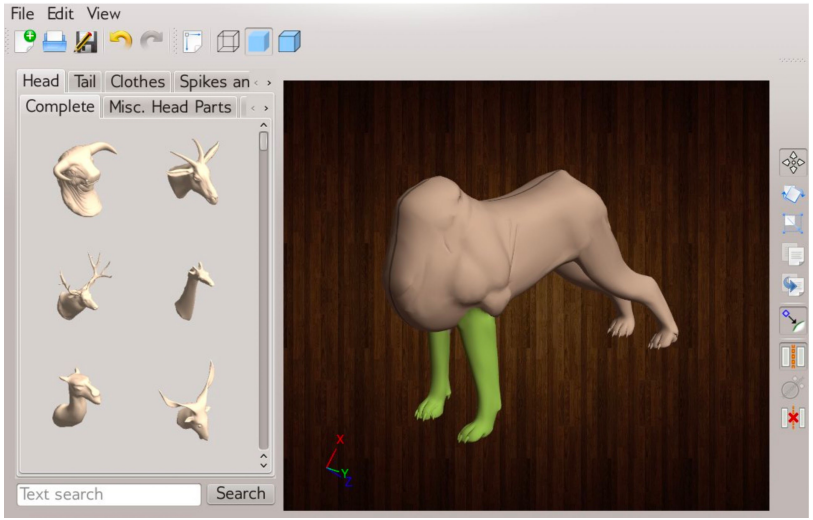


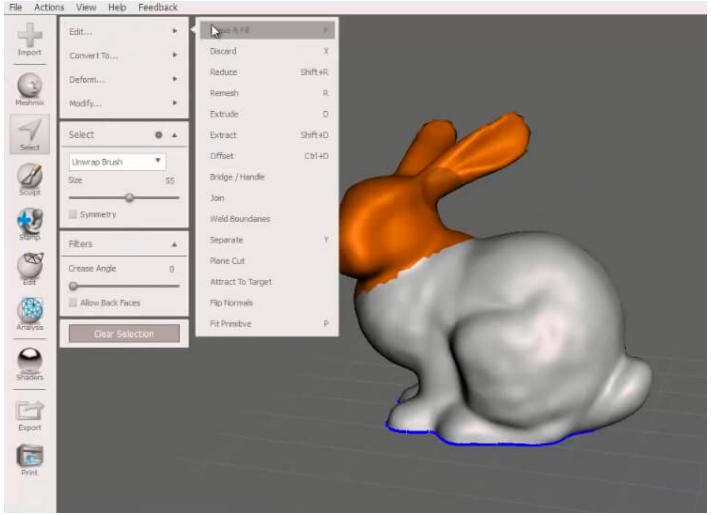
Interactive Shape Modelling



Thomas Funkhouser et al., Modeling by Example, ACM Transactions on Graphics 23 no.3 (2004), 652–663: https://dl.acm.org/doi/pdf/10.1145/1015706.1015775; Diego Gonzalez and Oliver van Kaick, 3D synthesis of man-made objects based on fine-grained parts, Computers & Graphics 74 (2018), 150–160: http://gigl.scs.carleton.ca/sites/default/files/diego_gonzalez/papersmi2018-final.pdf

CONTEXTUAL SHAPE MODELLING

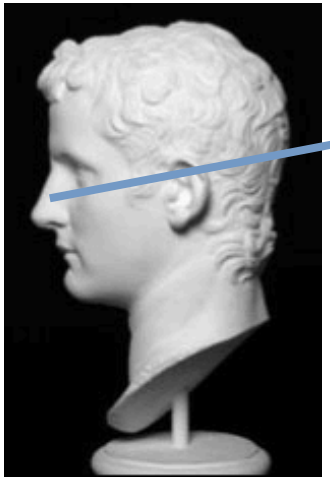




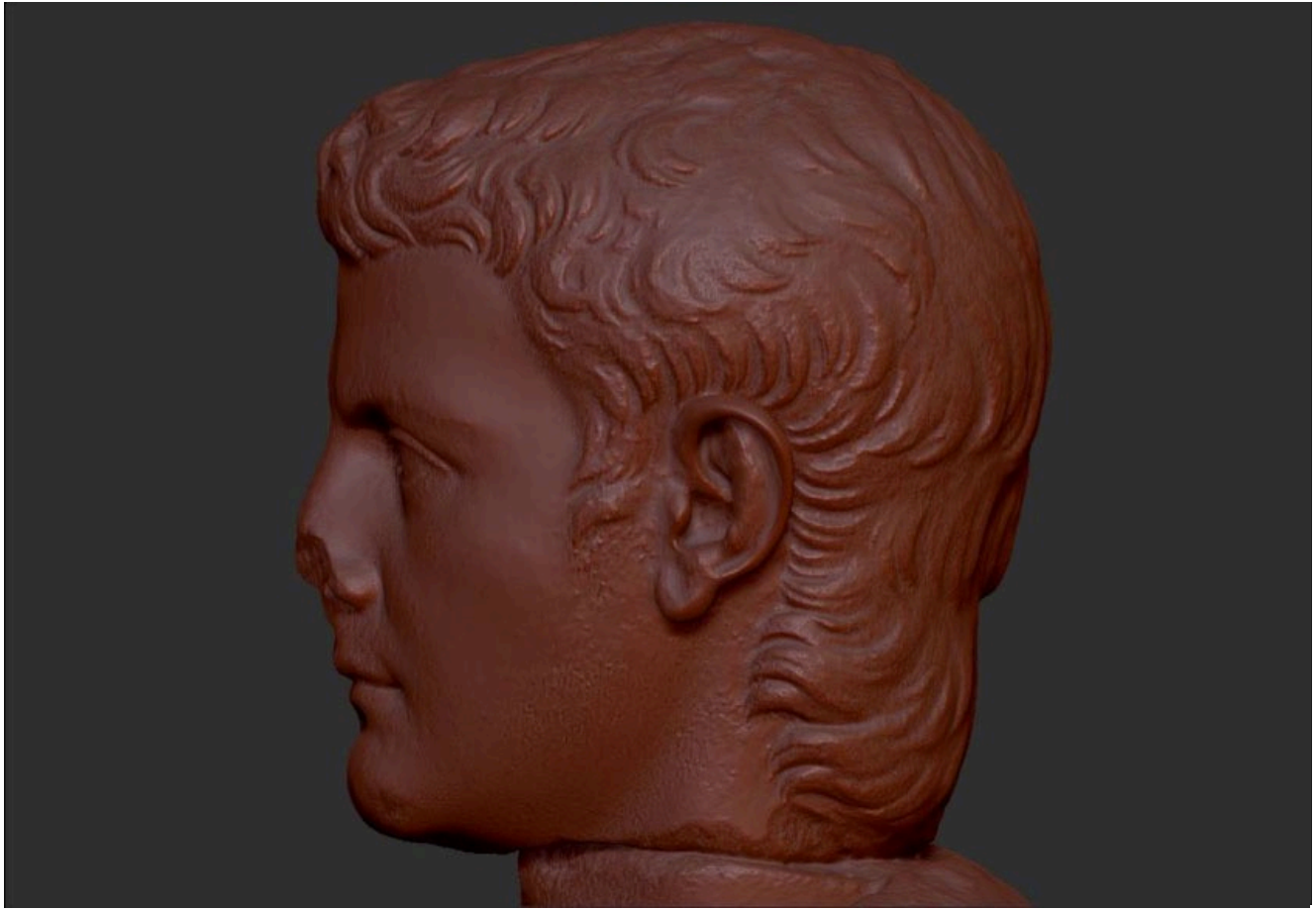
http://www.meshmixer.com

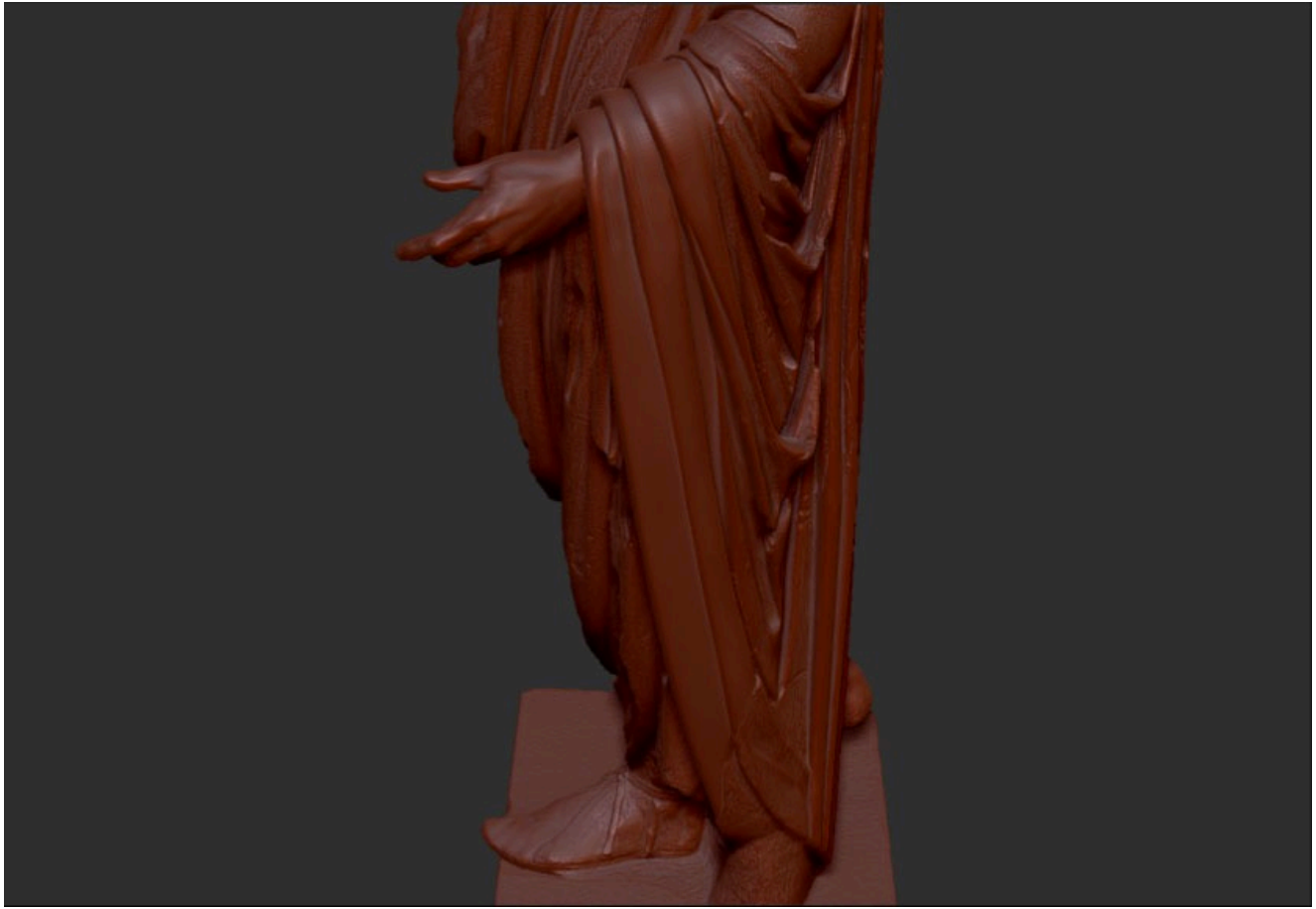
Siddhartha Chaudhuri et al., Probabilistic Reasoning for Assembly-Based 3D Modeling, ACM Transactions on Graphics 30 no. 4 (2011), 35:1–9: https://dl.acm.org/doi/pdf/10.1145/2010324.1964930; Siddhartha Chaudhuri et al., AttribIt: Content Creation with Semantic Attributes, Proceedings of the 26th annual ACM symposium on User interface software and technology (2013), 193–202: https://doi.org/10.1145/2501988.2502008

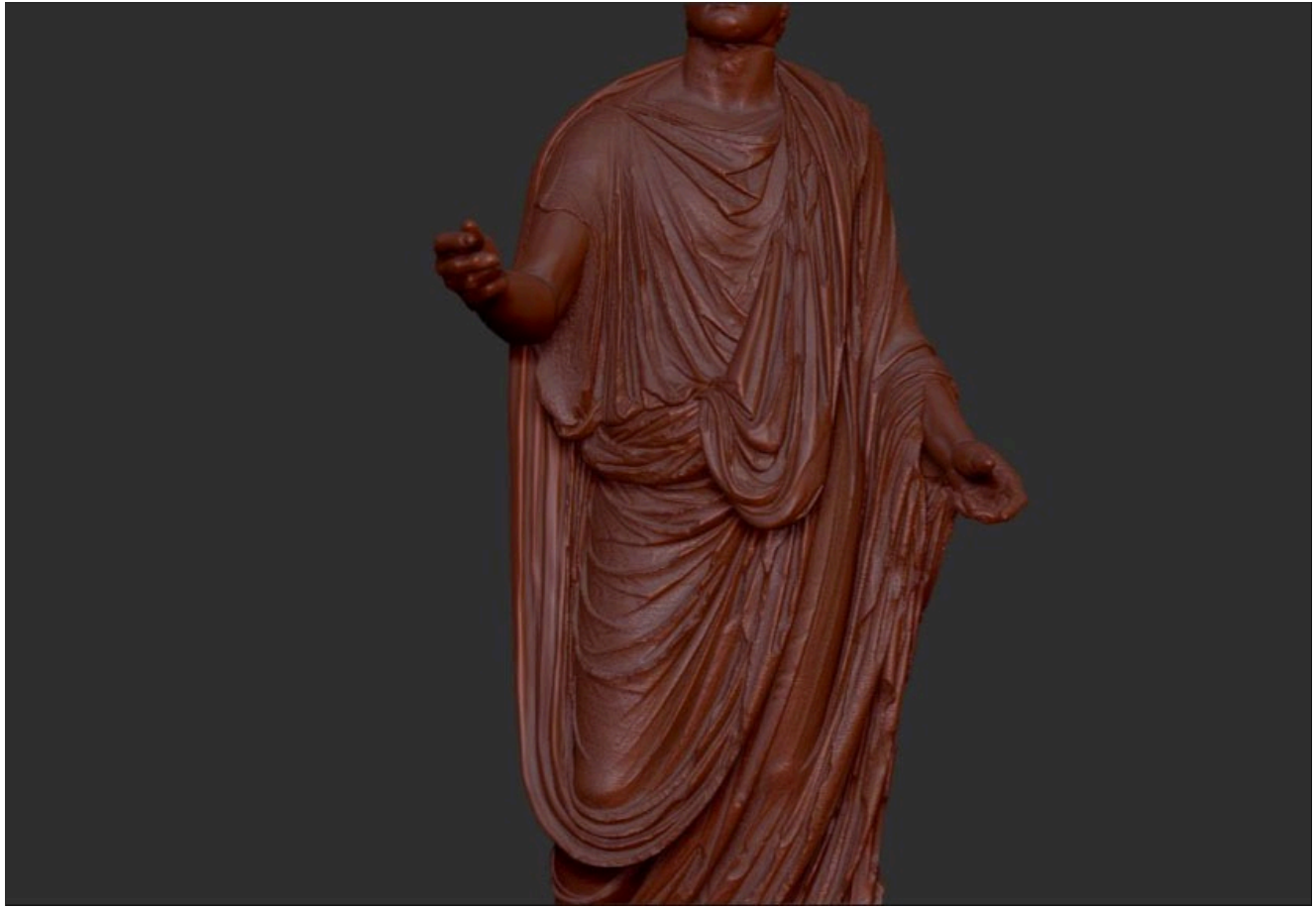
High-resolution laser scan by DirectDimensions with a Faro laser scanner on the Faro Platinum scanning arm (1 working day, Sept. 2010)
http://www.dirdim.com/port_featuredprojects.php?fileName=fp_caligula



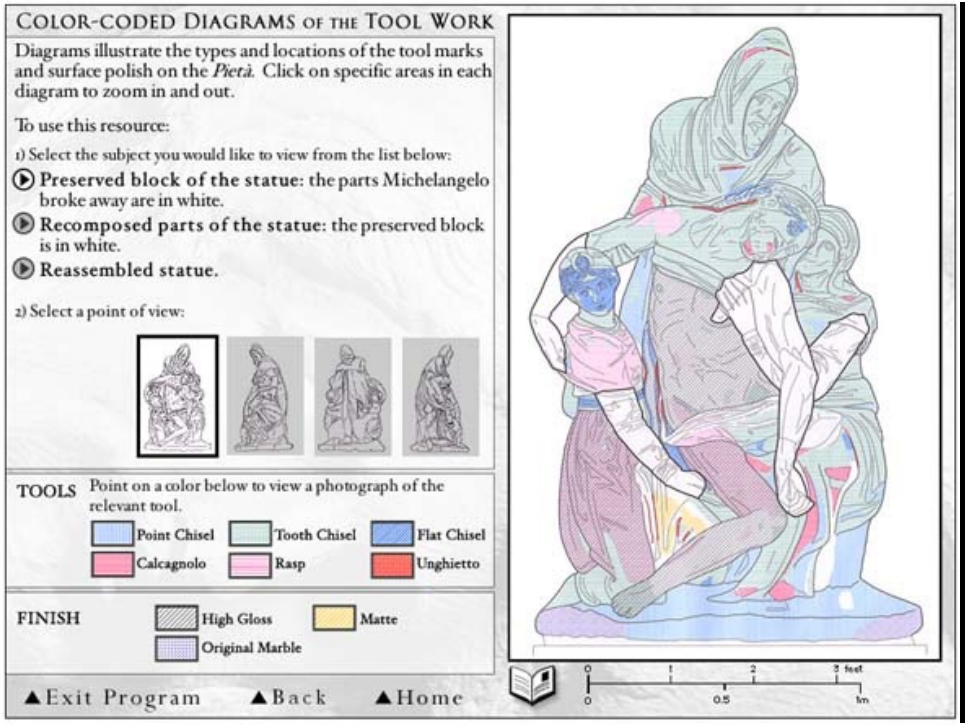







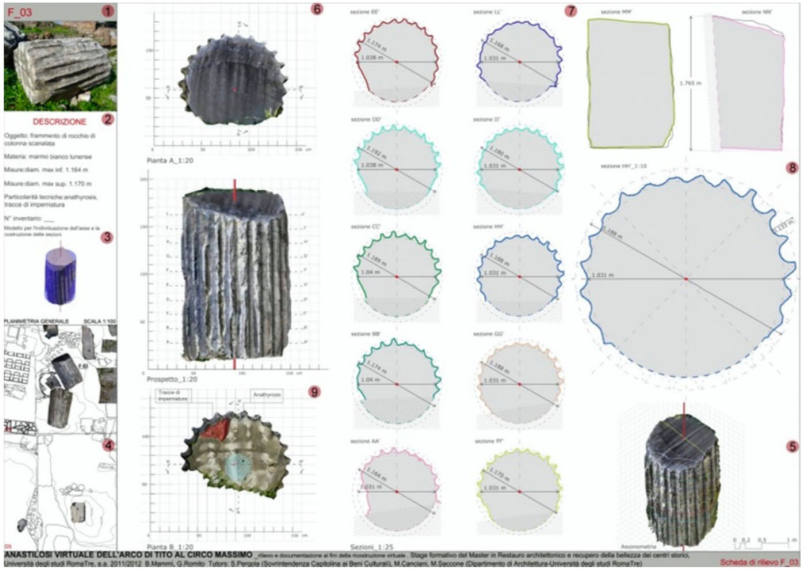
PALMYRA, DESTROYED BY THE IS

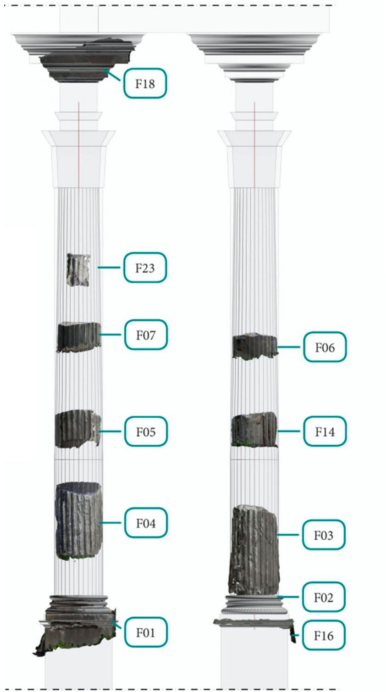
https://www.dailymail.co.uk/news/article-4231386/Italian-teams-restore-damaged-busts-ancient-Syrian-city.html

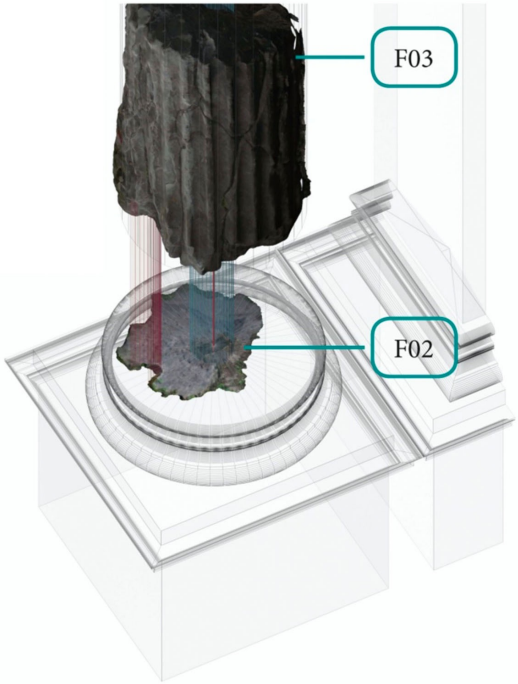


F. Bernardini et al., Building a digital model of Michelangelo's Florentine Pietà. Computer Graphics and Applications, IEEE 22, no. 1 (2002), 59–67; Jack Wasserman et al., Michelangelo's Florence Pietà (Princeton University Press, 2003) mit 3D-Modell auf CD-ROM. http://www.hunter.cuny.edu/cs/Faculty/Stamos/3DP_F03/PAPERS/pieta-cga.pdf

VIRTUAL ANASTYLOSIS

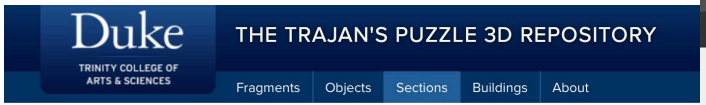




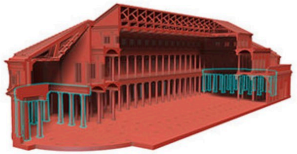


M. Canciani et al., „A method for virtual anastylosis: The case of the Arch of Titus at the Circus Maximus in Rome," *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences* II-5/W1 (2013), 61–66: https://www.academia.edu/4401217/_2013_A_METHOD_FOR_VIRTUAL_ANASTYLOSIS_THE_CASE_OF_THE_ARCH_OF_TITUS_AT_THE_CIRCUS_MAXIMUS_IN_ROME

TRAJAN'S PUZZLE



Sections



Absidi | Apses

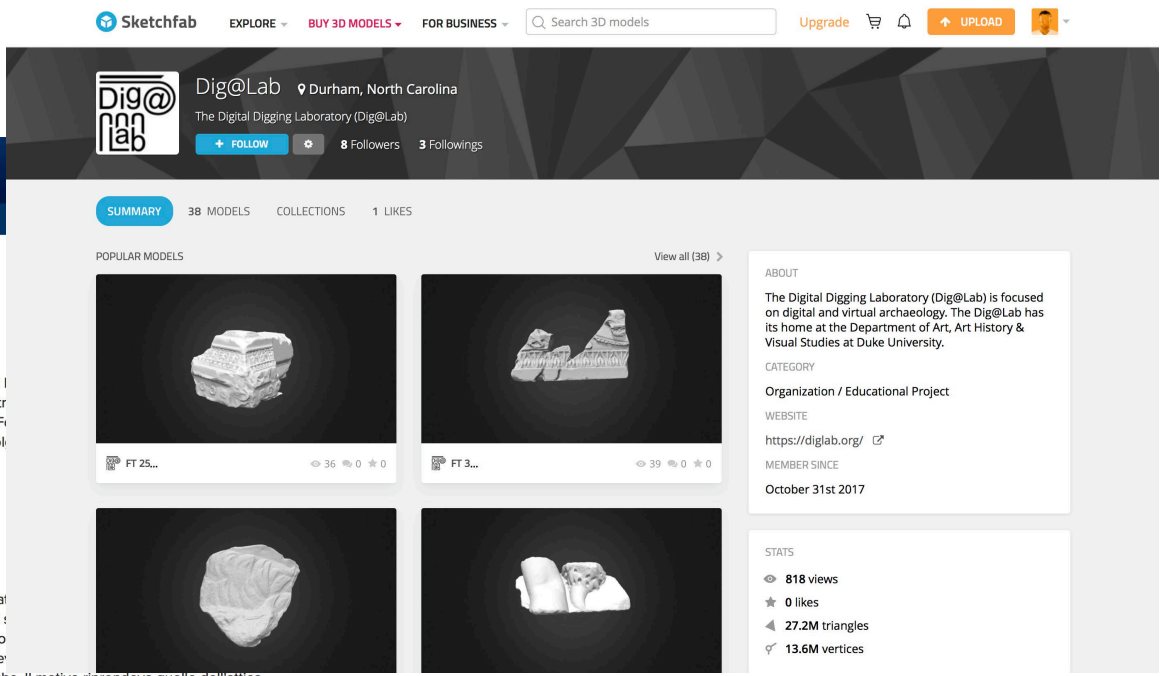
Per la decorazione delle absidi che chiudevano i lati l
colonne inserite alle estremità dei setti murari; al centr
utilizzata probabilmente come tribunale. Secondo la F
era collocato l'Atrium Libertatis in cui si dovevano svol
schiavi.

Facciata | Façade

La facciata era almeno in parte aperta con un colonnat
marmo giallo antico, ed era articolata in tre avancorpi
un attico decorato con statue di Daci in marmo bianco
a pannelli con rilievi di cataste di armi. I Daci sorregge
legioni che avevano partecipato alle campagne daciche. Il motivo riprendeva quello dell'attico
delle facciate dei portici laterali, con Daci in pavonazzetto alternati a clipei (scudi) con ritratti di...

Navata centrale | Main nave

L'interno della basilica era articolato in uno vasto spazio centrale (25 m di larghezza), circondato sui quattro lati da 96 colonne con fusti in granito grigio di ordine corinzio e un fregio con Vittorie tauroctone (nell'atto di sacrificare tori). Questa navata centrale era circondata da due navate laterali per lato, divise da colonnati sempre in granito grigio. La navata centrale era dotata di un secondo piano, con colonne dai fusti lisci in marmo cipollino, e forse anche un terzo ordine, in parte chiuso da muri e in parte aperto su colonnati sui lati corti. Dal secondo piano si poteva...



https://sketchfab.com/diglab

https://trajanspuzzle.trinity.duke.edu

CONTENT AWARE STUDIES (AI-DRIVEN ADDITIONS)

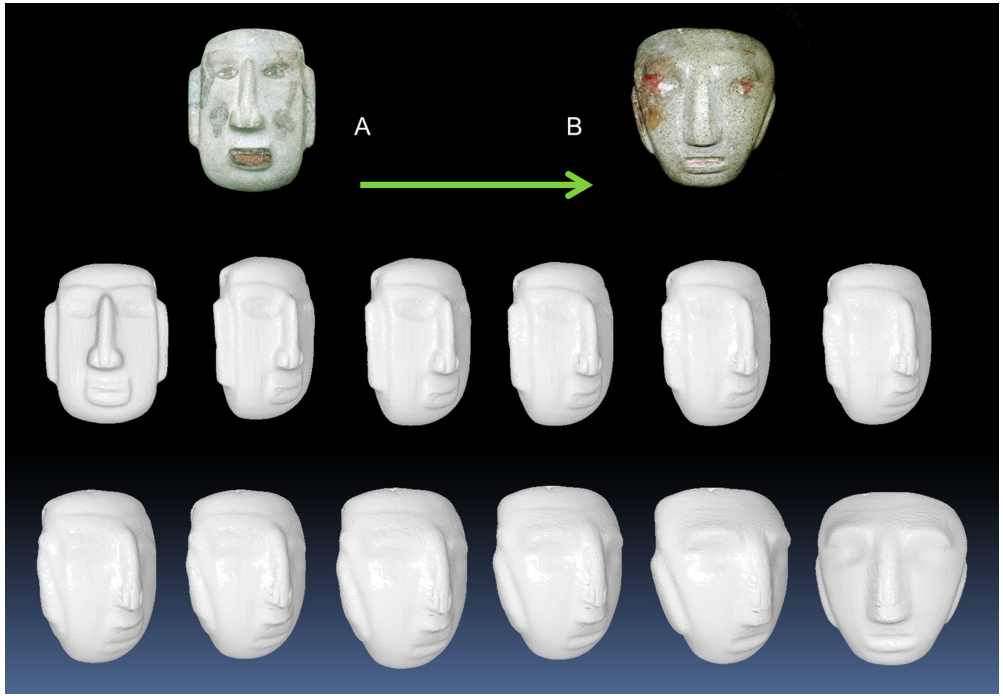
http://egorkraft.com/cas/

CONTENT AWARE STUDIES (AI-DRIVEN ADDITIONS)

Paris, Louvre Ma 1170

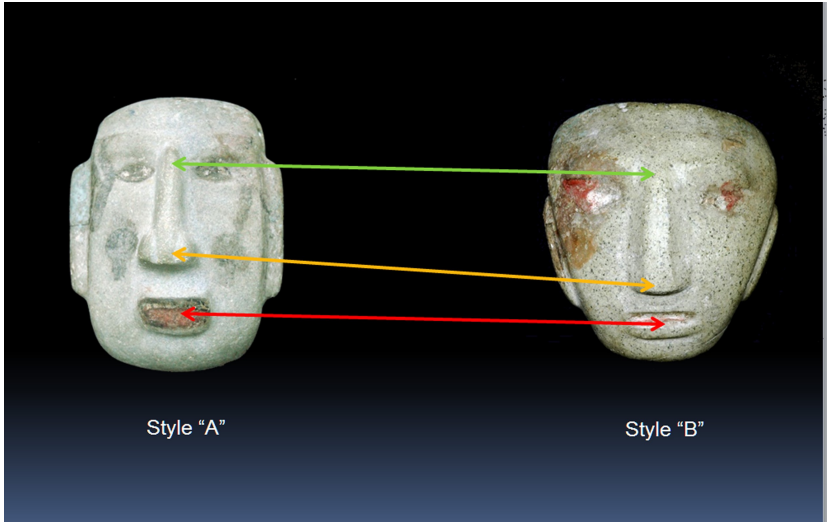
http://egorkraft.com/cas/

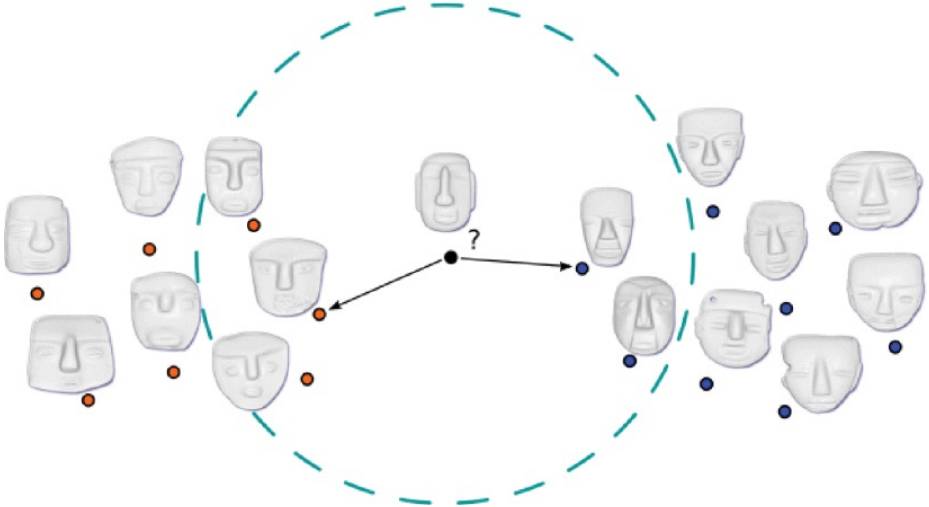
STYLE ANALYSIS THROUGH VIRTUAL SERIES FORMATION



Masken aus dem aztekischen Heiligtum Tenochtitlan in Mexiko-Stadt (1390 – 1469 n. Chr.)

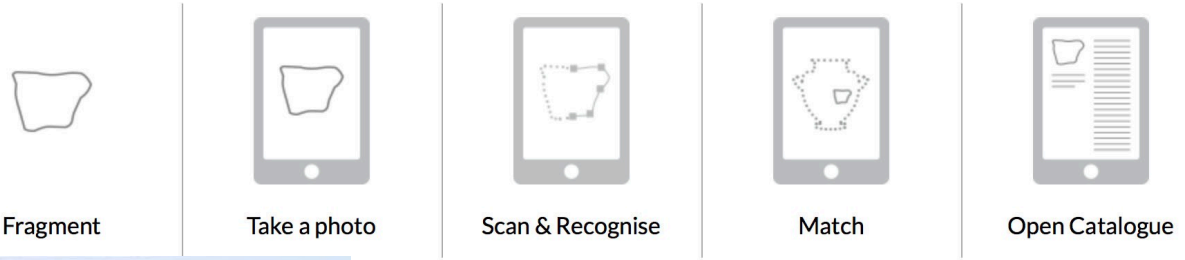
STYLE ANALYSIS THROUGH VIRTUAL SERIES FORMATION

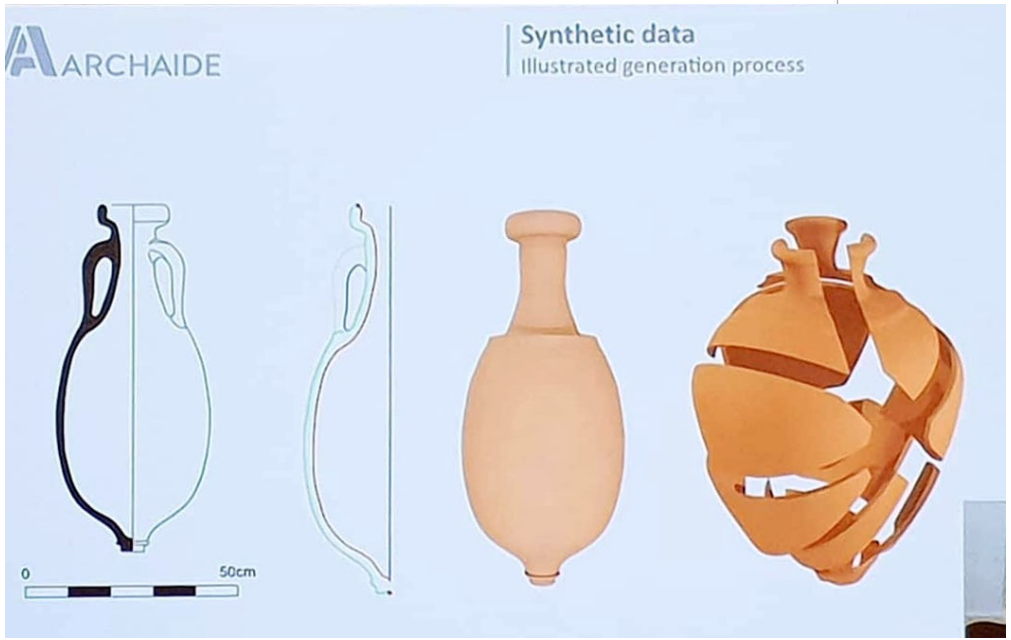




M. Canul-Ku, R. Hasimoto-Beltran, D. Jiménez-Badillo, S. Ruiz-Correa and E. Román-Rangel, „Classification of 3D Archaeological Objects Using Multi-View Curvature Structure Signatures,“ *IEEE Access* 7 (2019), 3298–3313 [https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8576529]; Diego Jiménez-Badillo, Salvador Ruíz-Correa et al., „A machine learning methodology to analyze 3D digital models of cultural heritage objects,“ in *DH 2018* [https://dh2018.adho.org/a-machine-learning-methodology-to-analyze-3d-digital-models-of-cultural-heritage-objects/] s.a. https://www.youtube.com/watch?v=siVo9cyQVCE

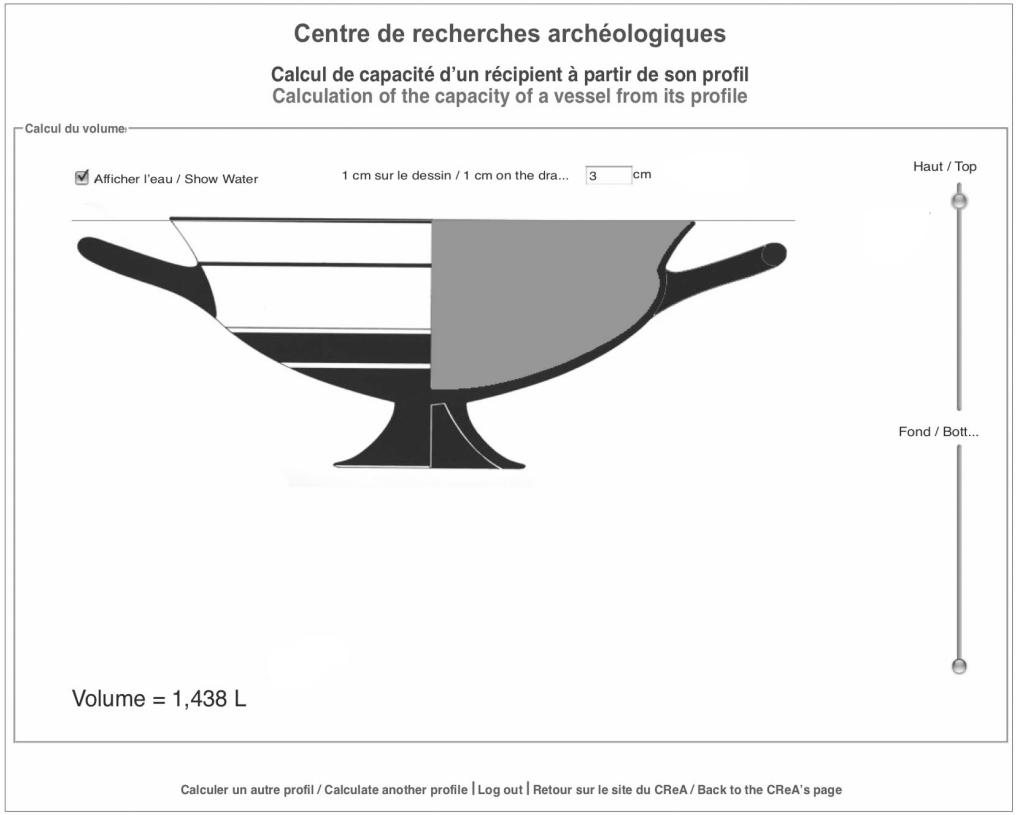
ArchAIDE

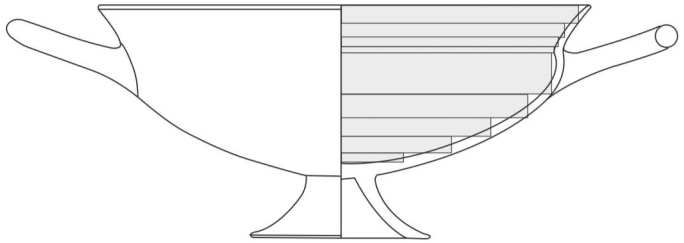




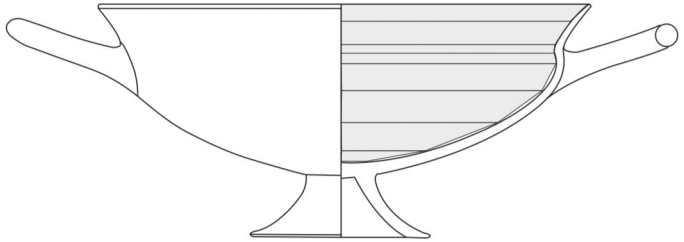
http://www.archaide.eu
https://www.instagram.com/archaide_project/

VOLUME CALCULATION



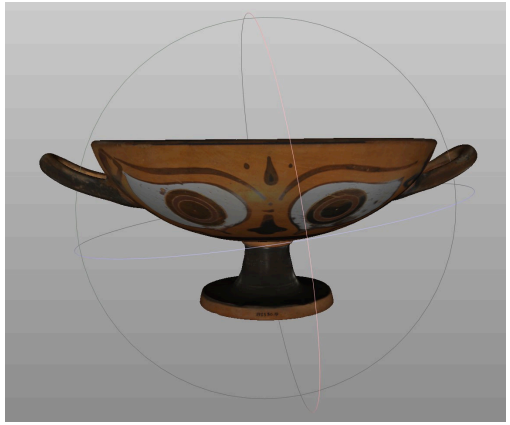


1. Calculating the volume by the stacked cylinders method (the size of the cylinders is exagerated on the figure)



2. Variant of the former method, the bevelled walled technique

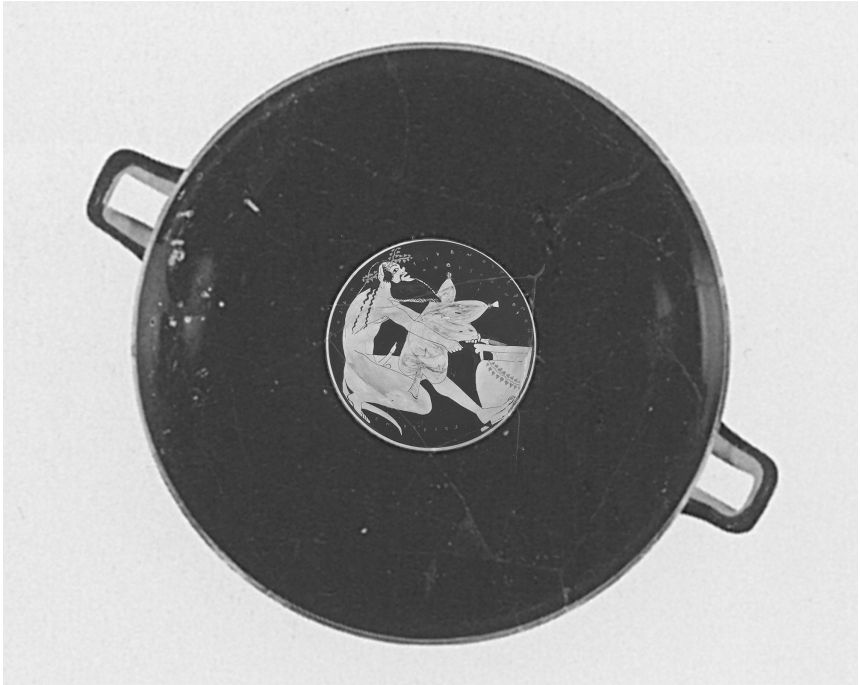
http://capacity.ulb.ac.be/

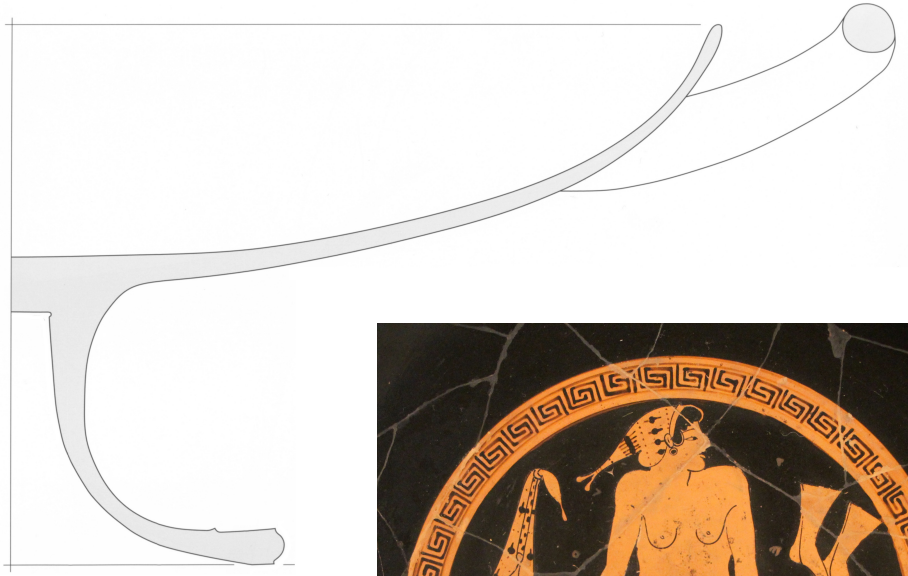


https://www.harvardartmuseums.org/art/292633

München Inv. 2044

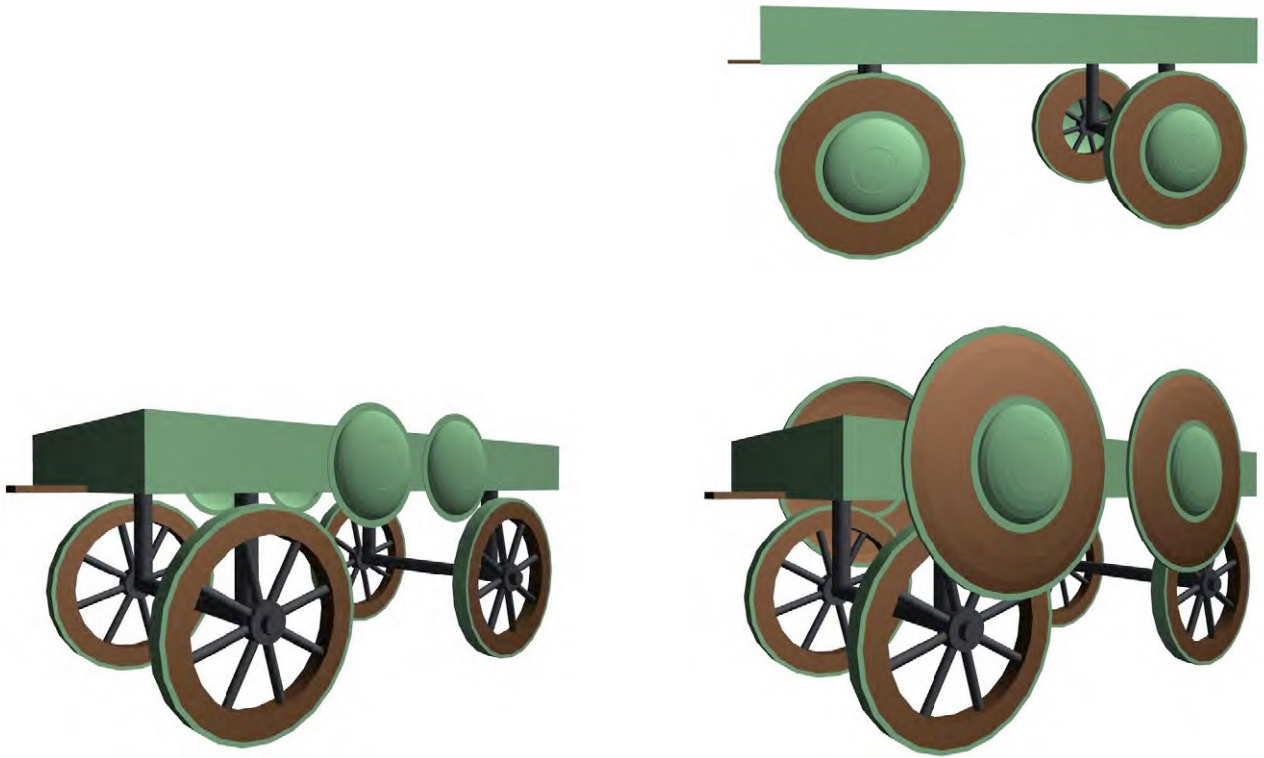
COMPOSITION OF THE CUP INTERIORS



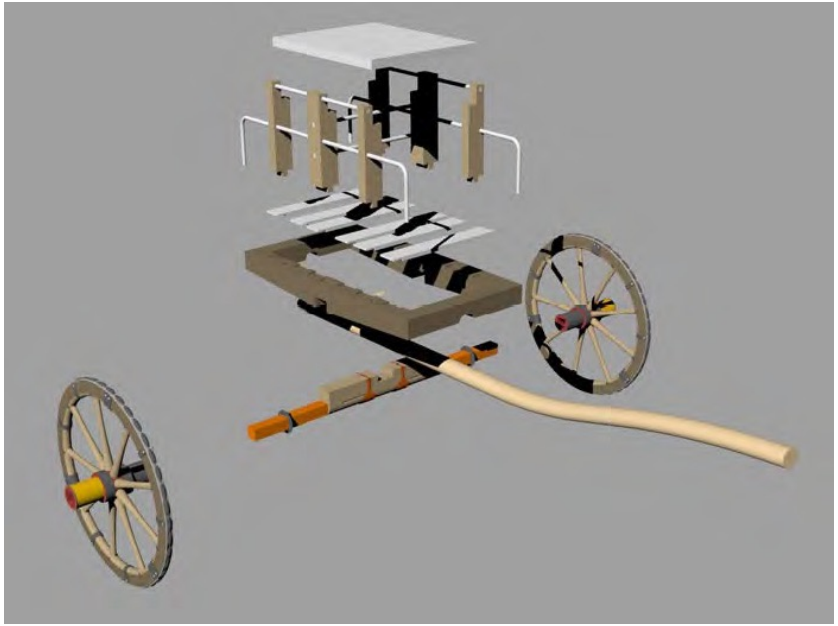


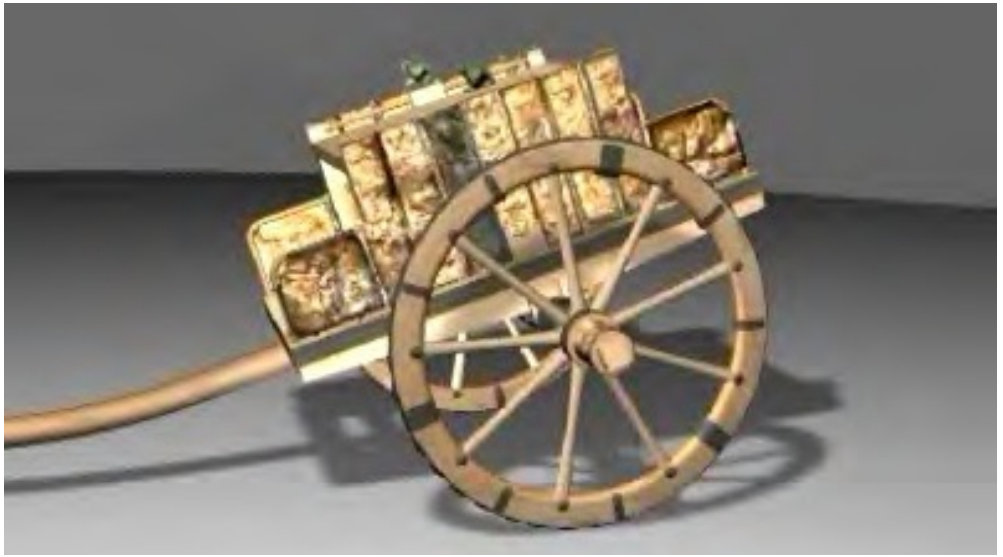
Berlin V.I.3757

Cerveteri, bronze shields of unknown function from an Etruscan tomb (Tomba Regolini-Galassi)



Various hypotheses on the function of the bronze shields





La tomba del principe Sabino
http://www.principisabini.it/

CHALLENGES FOR DIGITAL ARTEFACT ANALYSIS

- Exploring data-driven abstractions of shape
- Solid object mining procedures with regard to image and artefact evidence
- Implications for shape analysis and category formation in the object sciences
- Critical, reflected handling of simulation results

- Data Representations of 3D Shapes
- Basics of Style Research and Shape Analysis
- Good Practice examples of Shape Comparison
- Methods of digital Shape Analysis
- Methods of Shape Retrieval and Object Mining

- Laying and comparing sections through 3D models
- Performing 3D comparisons using the Hausdorff distance (Tolerance Based Shape Comparison)
- Sorting a set of objects and grouping them according to type or style

What are the advantages of digital shape analysis of three-dimensional objects? Give an example!

Give an application example for tolerance based shape comparison!

Folie 36–62

Why do established methods of computer-assisted face recognition have to fail with historical portraits such as the portraits of Roman emperors?

Folie 36–52

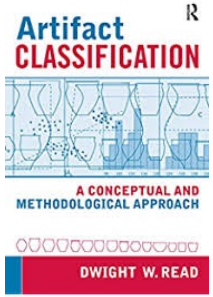
What is meant by style? What are the differences to the concept of type?

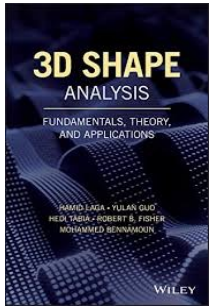
Folie 66–71

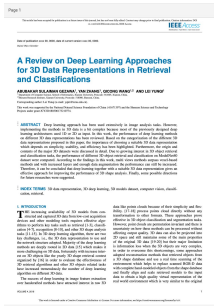
In which way can 3D data of objects be represented?

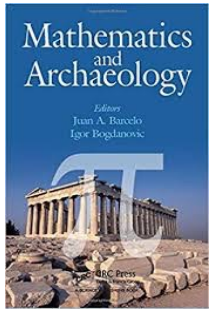
Folie 14–24

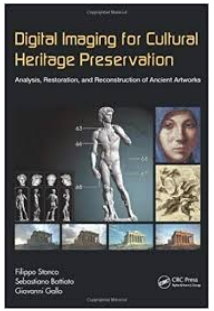
How might working with collection objects change in the future? What consequences does this have for research in artefact sciences?











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i IMPRESSUM

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