Sunoikisis Digital Cultural Heritage, Spring 2021

Session 1.
3D Imaging and Scanning

Gabriel Bodard (University of London)
Kelly McClinton (Indiana University)
Alicia Walsh (Recollection Heritage)
(and thanks to Valeria Vitale [British Library] for slides)

1. 3D methods and formats
2. Case study 1: 3D scanning for museum display
3. Case study 2: Photogrammetry for Roman Houses
4. Photogrammetry tutorial

3D methods

1. 3D imaging (scanning)
2. 3D modelling (visualisaton)
3. Virtual Reality
4. Augmented Reality
5. 3D printing

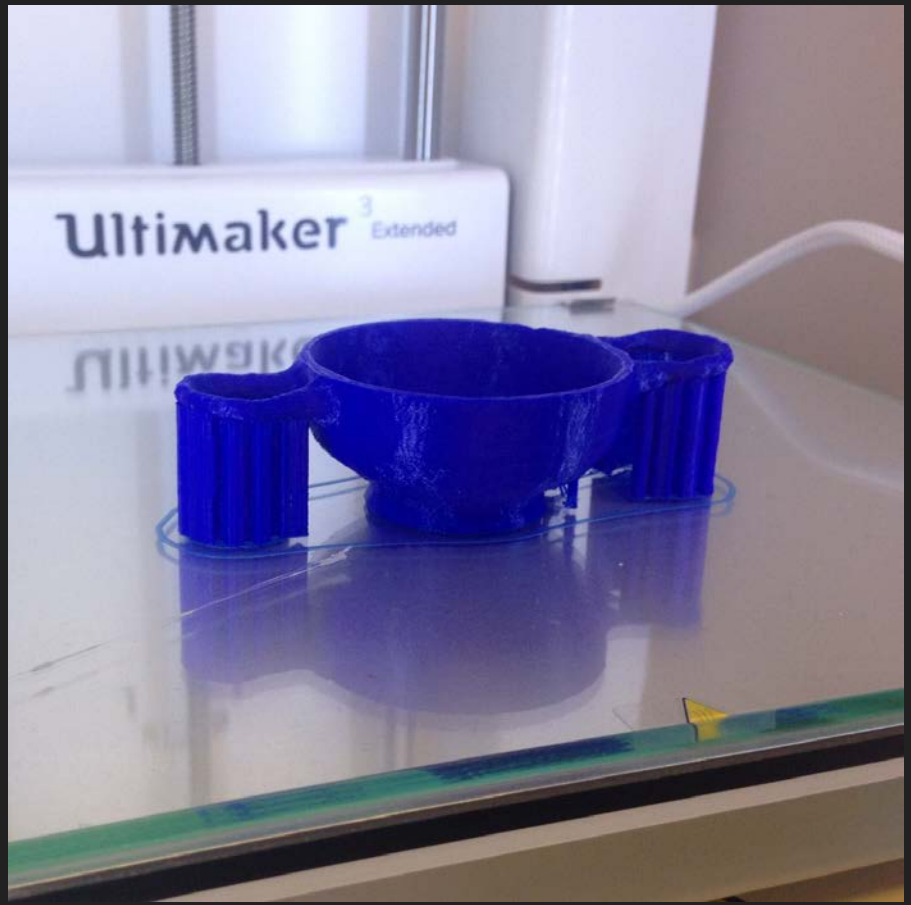
1. 3D imaging or scanning

2. 3D modelling or visualization

3. Virtual Reality (VR)

4. Augmented Reality (AR)

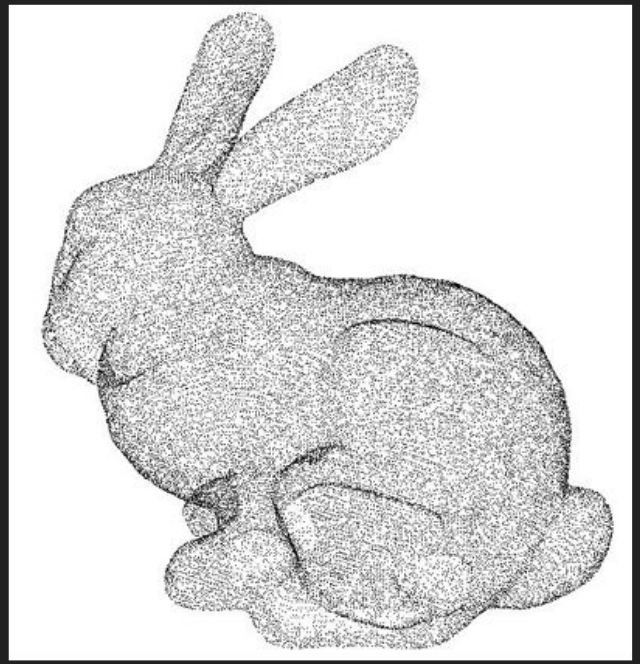
5. 3D printing



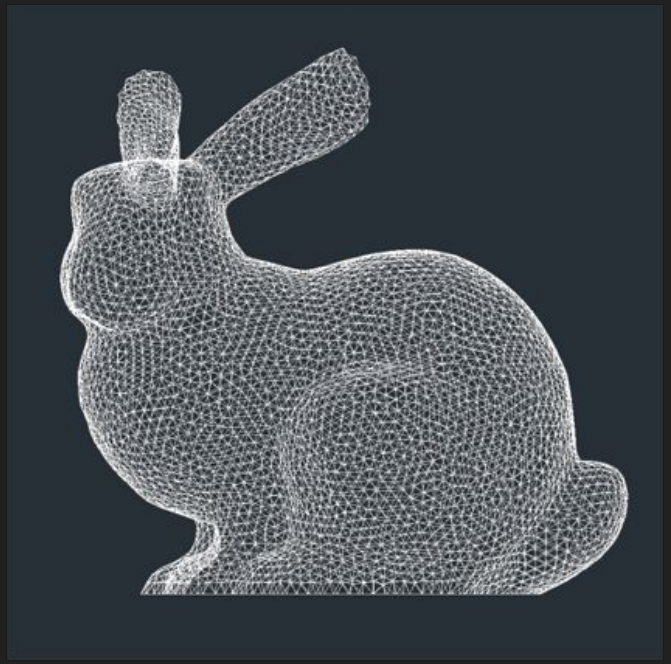
3D technologies and formats

1. Point cloud vs mesh
2. Laser scanning:
    a. time of flight / triangulation / structured light
3. Computer Tomography / XRay
4. Photogrammetry / Structure from Motion
5. Reflectance Transformation Imaging

3D Imaging outputs



Point Cloud



3D Mesh

Laser Scanning Time of Flight

PROS

* Good geometric fidelity
* Suitable for large areas

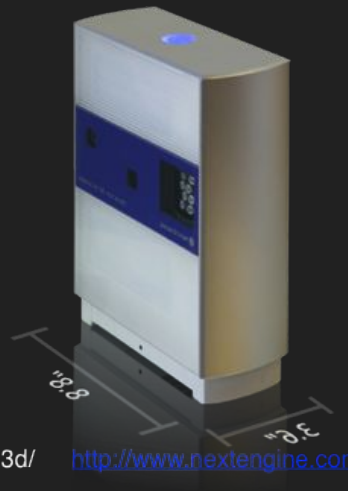
The Pompeii Quadriporticus Project

CONS

* Cost
* Massive data set
* Slow process
* Not accurate on smaller artefacts

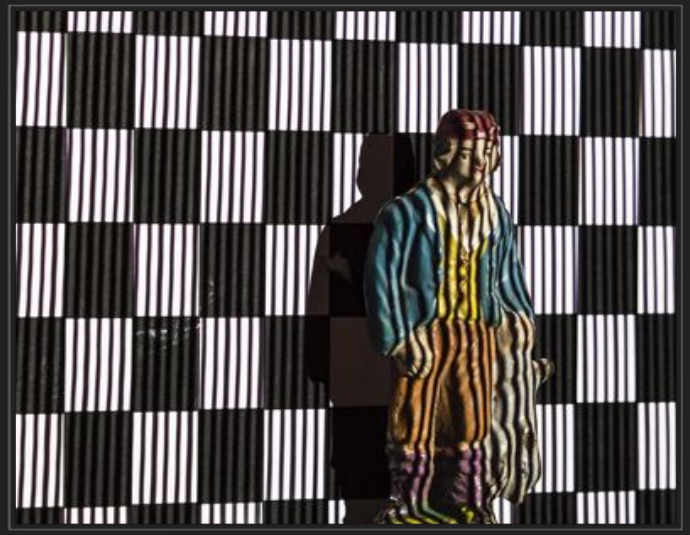
Laser Scanning Triangulation

* Cheaper
* Better on smaller surfaces (not adequate for larger ones)
* Portable
* Ready to use



http://surveyequipment.com/faro-scanner-freestyle-3d/ http://www.nextengine.com/

Structured Light

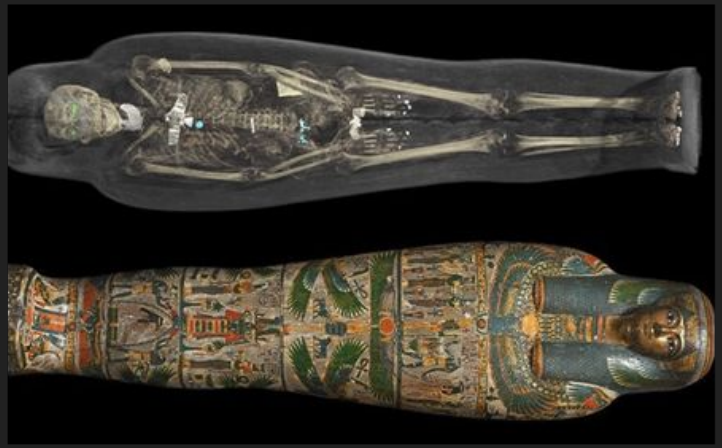


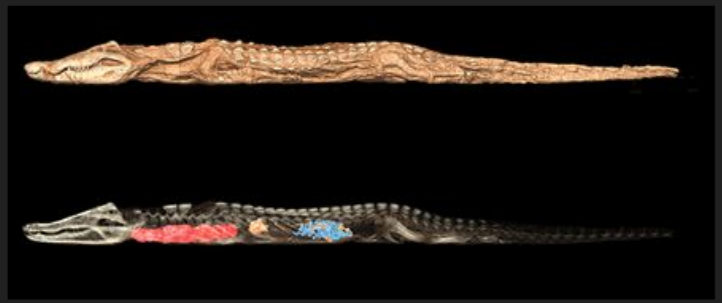
3D scanning by Structured Light using a mini (pico) projector coupled with the "3D scanning software" developed by D. Moreno and G. Taubin at Brown University School of Engineering.

http://chsopensource.org/2015/02/02/structured-light-3d-pico-projectors/

- Fast
- Accurate
- Has to be performed in a studio
- Requires calibration
- Is slightly out of date, but still used and researched

CT Scan (Computed Tomography)





Images of CT scans used by the British Museum for the exhibitions "Ancient Lives, New Discoveries" and "Scanning Sobekh".

- Expensive
- Non portable
- Requires training
- Non invasive
- Virtual autopsy

Photogrammetry

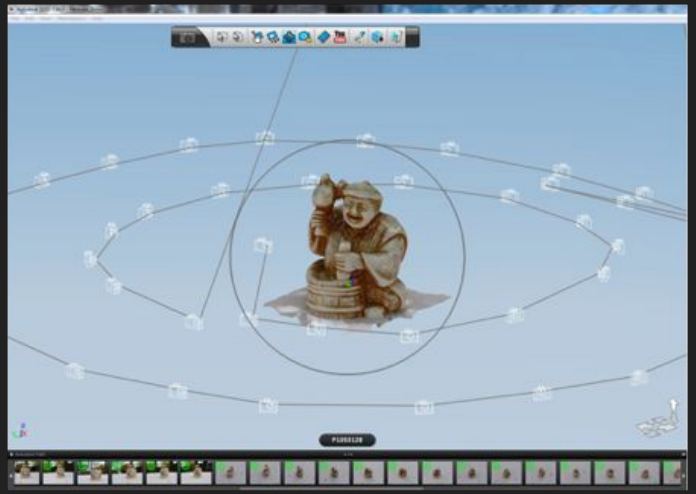
- Based on triangulation
- Cheap
- Easy to learn
- Portable equipment
- 3D mesh as an output

Agisoft Photoscan

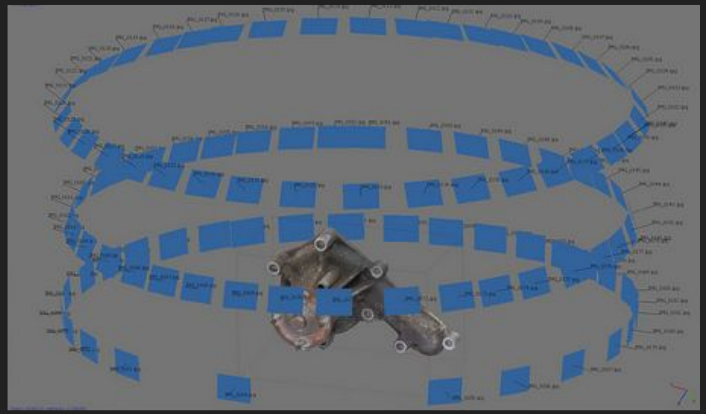
http://www.agisoft.com/

3DF Zephir

https://www.3dflow.net/3df-zephyr-free/



Capture with 123D catch http://www.tcproject.net



Capture with Photoscan https://www.flickr.com/photos/erik-nl/sets/72157628813159493/

Structure from Motion

* Similar to Photogrammetry
* Cheap
* Relatively simple to use (but requires more IT skills)
* Accurate colour information
* Long processing time
* Output in point cloud

Visual SFM

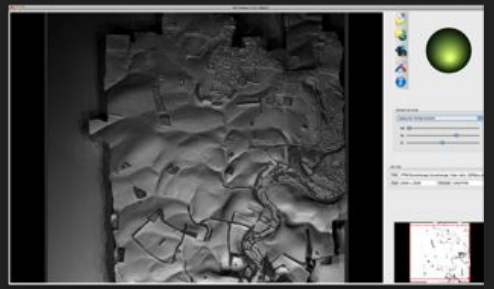
http://ccwu.me/vsfm/

http://www.praehistorische-archaeologie.de

Reflectance Transformation Imaging (RTI)

- Virtual relighting
- Cheap (when not performed with the dome)
- Free software
- Can only be seen (easily) in the viewer

www.topoi.org



http://www.wessexarch.co.uk

3D Imaging and Scanning : Techniques and uses

Alicia Walsh
Recollection Heritage

January 21, 2021
SuniokisisDC Session 1

Disclaimer: Images and 3D models of human skeletal remains shown

Introduction

3D Imaging techniques

* Laser Scanning
* Structured Light Scanning
* Photogrammetry

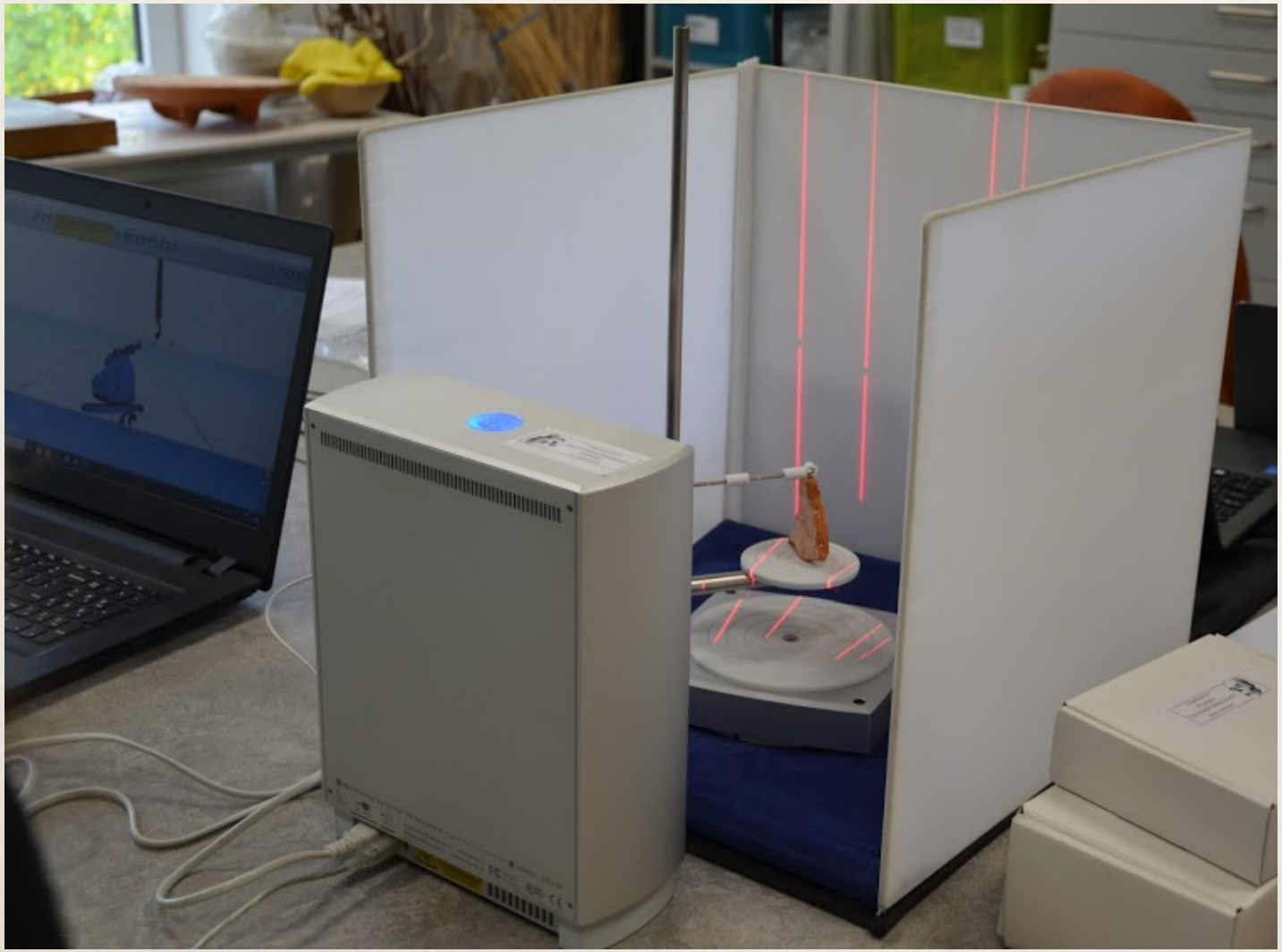
Case Study:

"Future of Experiencing the Past": Pilot Project through Leiden University's departments of Material Culture Studies, Human Osteology, and Human Origins.

* Create a digital reference collection to assist instructors and students
  * Methodology/Techniques Used
  * Visualization Methods and Formatting
  * Results
  * Practical Challenges

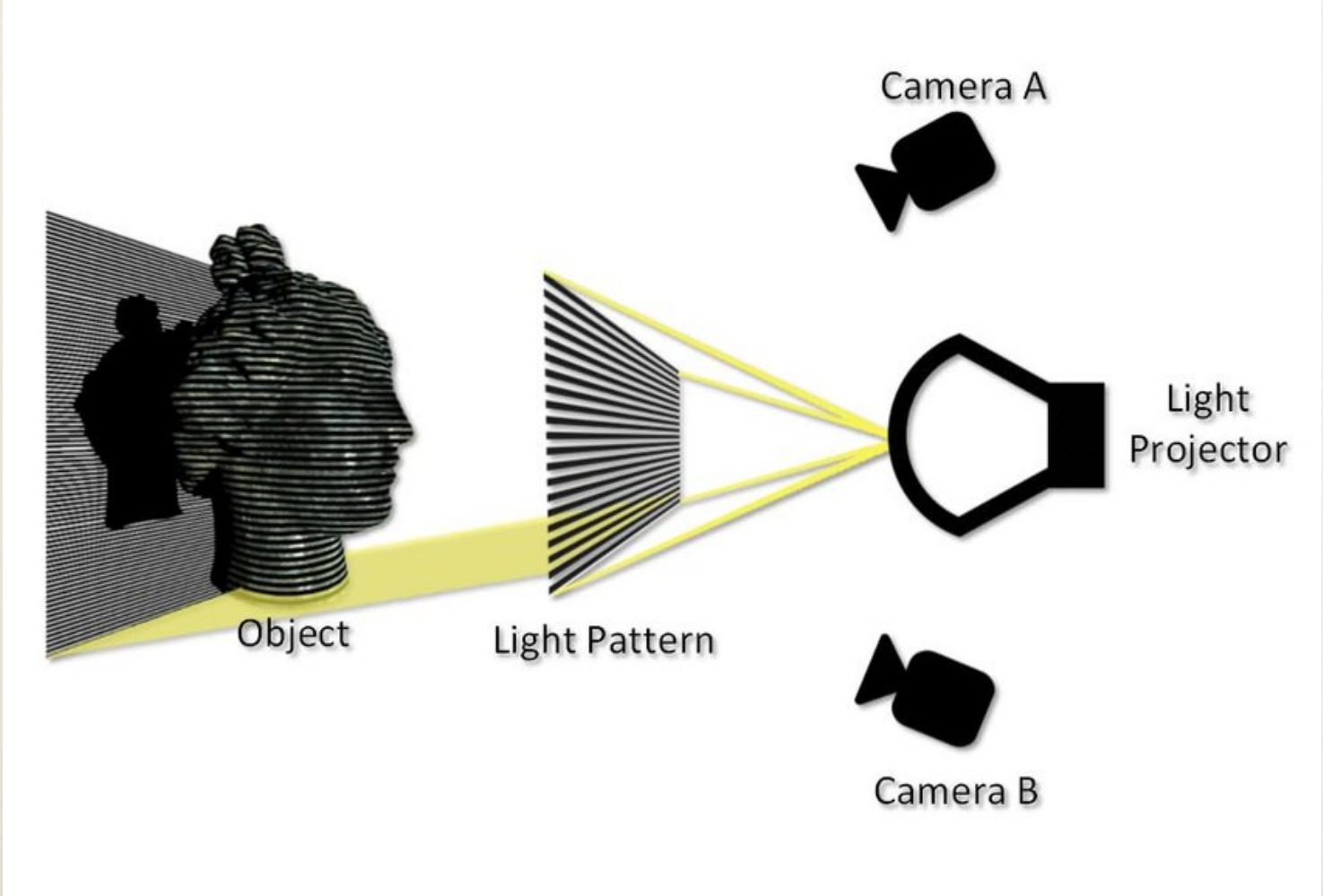
Laser Scanning

* Either time-of-flight or triangulation
* Triangulation: Laser is projected onto the object and the sensor measures the distance that the laser stretches to the object. Sensor determines the position of the object by using reference points.



Structured Light Scanning

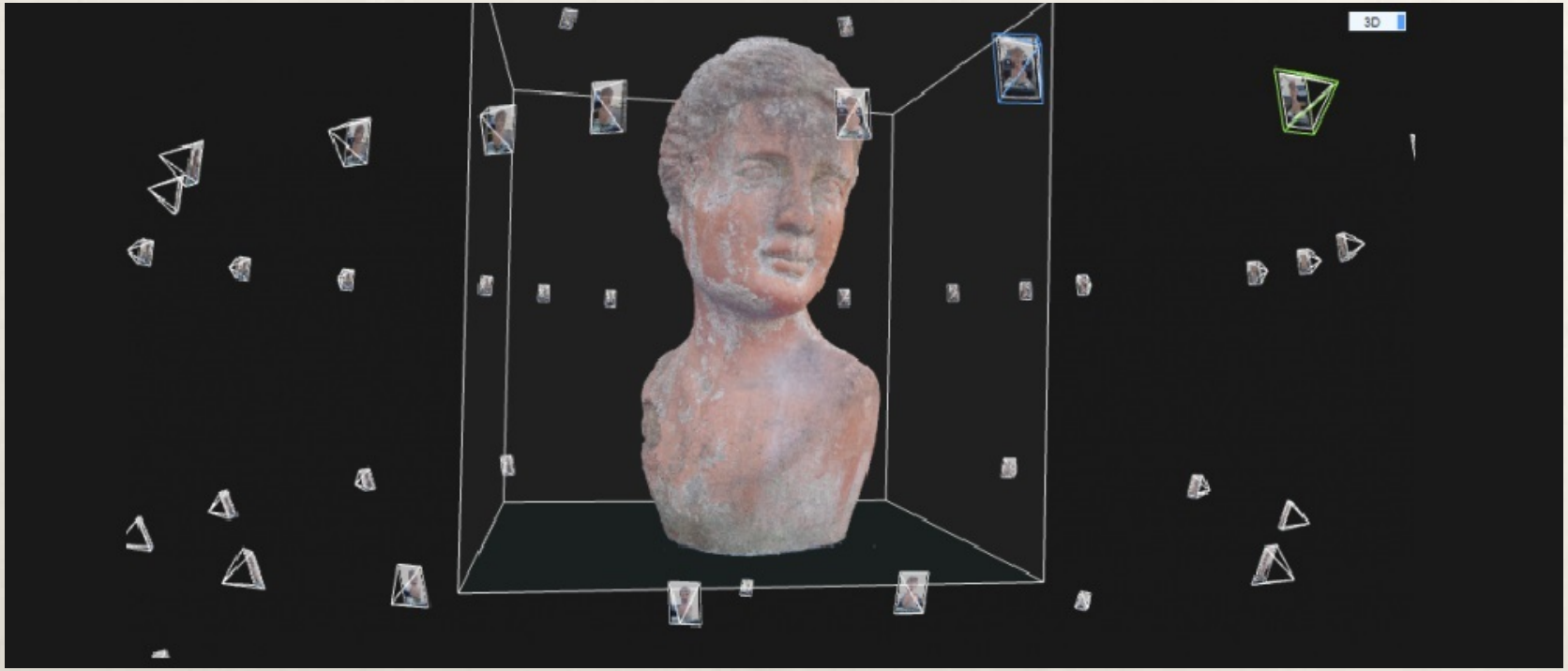
* Triangulation based scanning
* Cameras + projections = capture light patterns
* Expensive



https://www.researchgate.net/figure/Working-principle-of-structured-light-scanner_fig2_320657865

Photogrammetry

* Point clouds constructed from digital photographs
* Spare cloud – dense point cloud – mesh – texture
* Close range vs. aerial photogrammetry
* Least expensive



https://www.sculpteo.com/en/3d-learning-hub/3d-printing-software/photogrammetry-software/

Case Study

“Future of Experiencing the Past”- 3D imaging for teaching and research

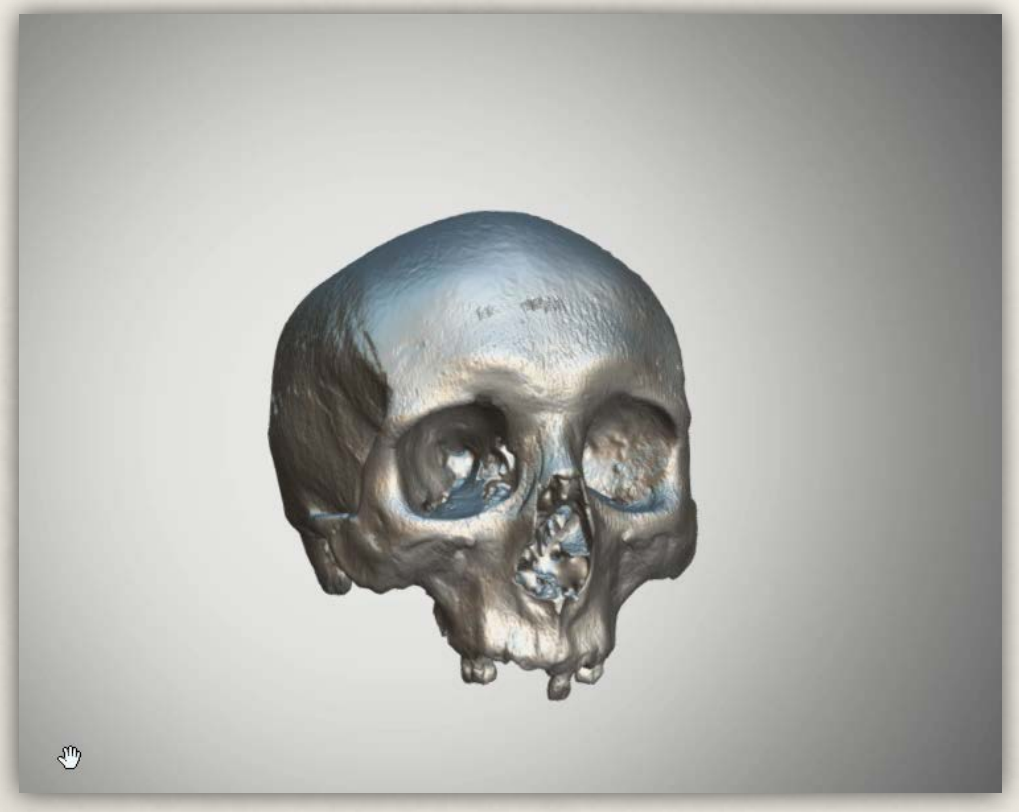
Dr. Martina Revello Lami, Dr. Rachel Schats and Prof. Dr. Marie Soressi – Leiden University

* Photogrammetry
  * Agisoft Metashape Pro
* 3D Laser Scanning
  * Next Engine Ultra HD Scanner
* Structured Light Scanning
  * Artec3D Space Spider
* Ceramics, Bones, Lithics
* One month for each artifact type

  = 285 3D models

Aims

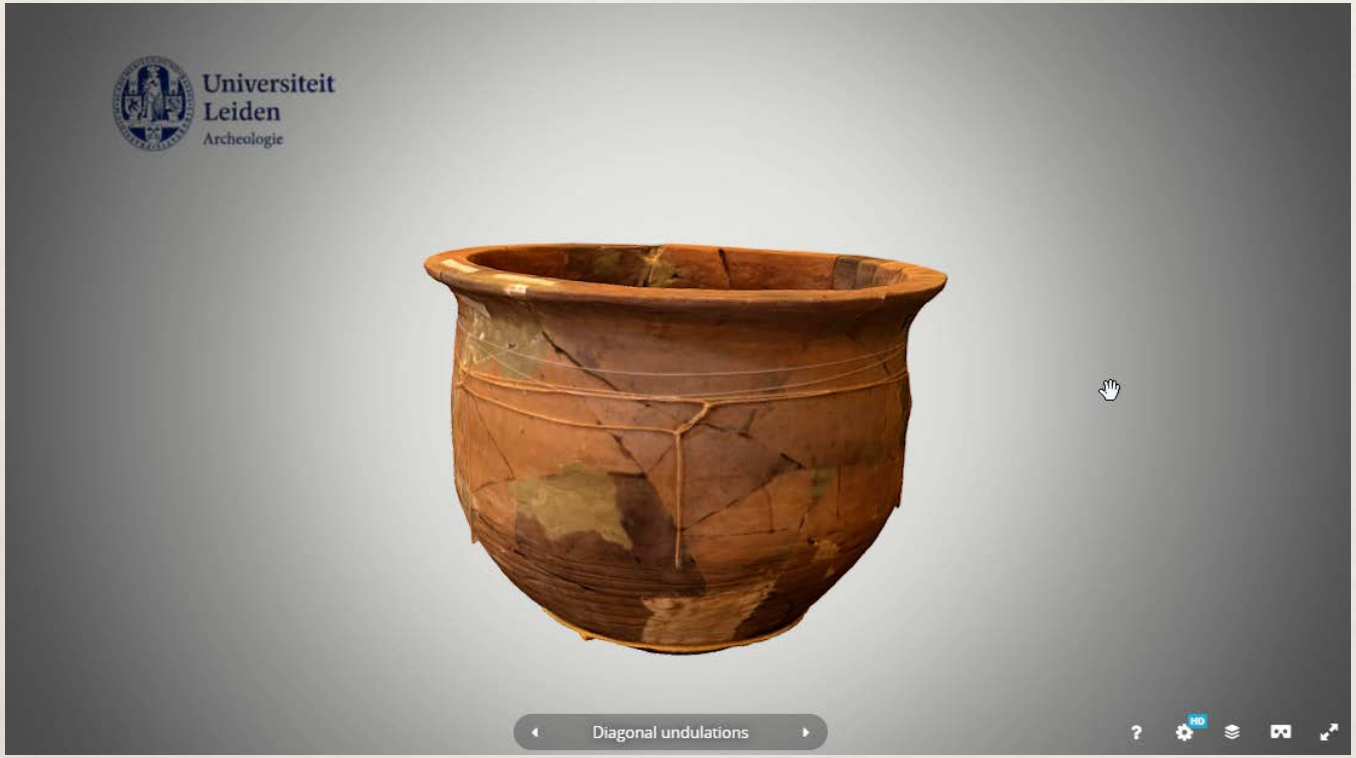
* Use of digital artifacts in classrooms and as study material
* Solution to low accessibility, unsuitable ratios of students to material, and fragility of artifact
* Ceramics
  * Show manufacturing techniques
  * Relate different surface macro traces to potting methods
* Bones
  * Highlight components of bone/ bones that make up a skull
  * Visualize deformation due to disease
* Lithics
  * Create extensive reference collection of various lithic types
  * Increased documentation



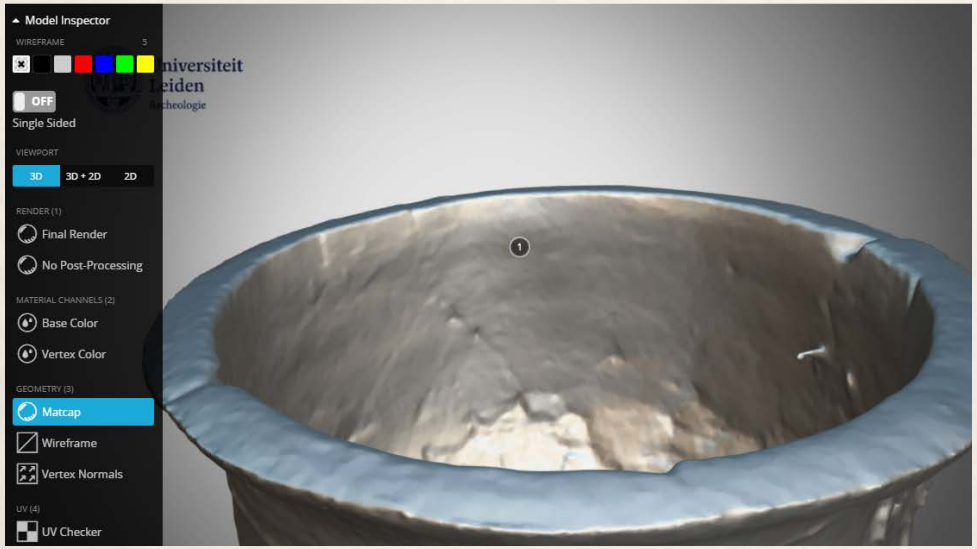
CERAMICS

Ceramics

Photogrammetry: Agisoft Metashape Pro



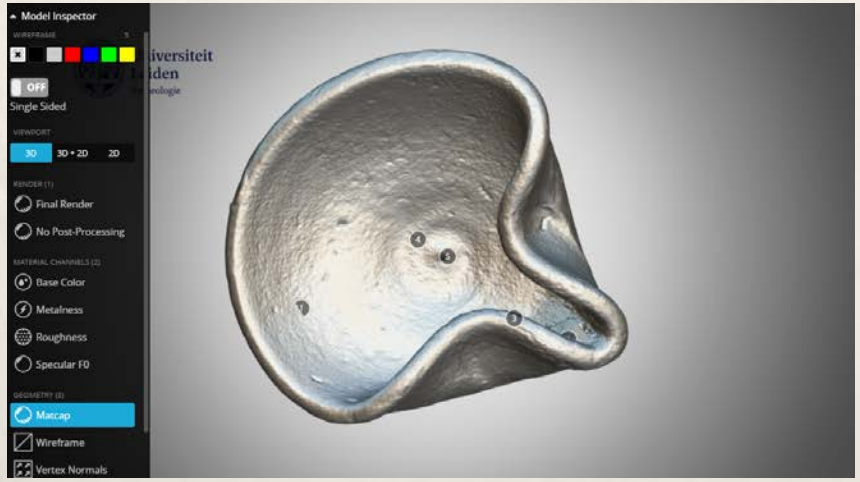
- High resolution texture, low resolution mesh
- Long processing times



Wide basin with outward flat rim (fully restored)
Coiling technology
348.9K triangles, 174.4K vertices.

Ceramics

Laser Scanning: Next Engine Ultra HD Scanner



Byzantine oil lamp- handmade/moulded
8.5M triangles, 5.4M vertices

BONES

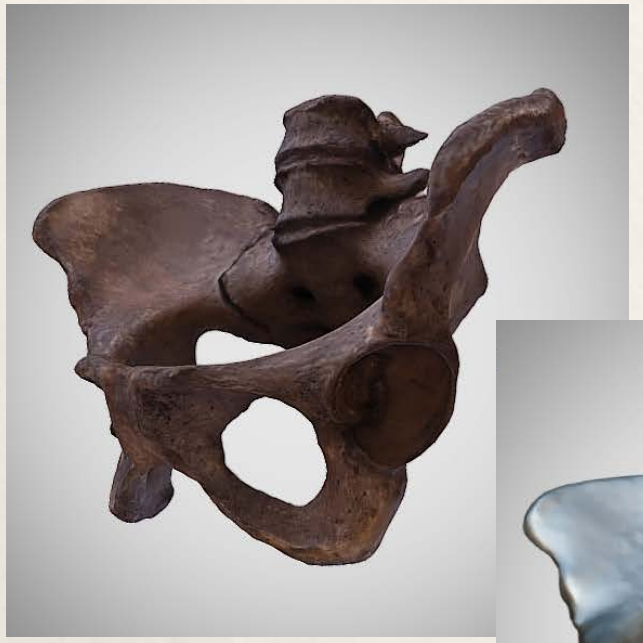


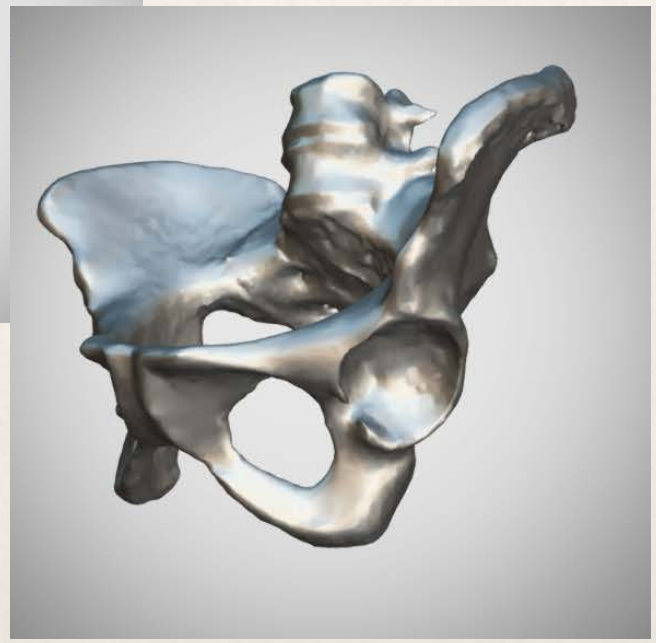

* Skulls
* Mandibles
* Pelvises
* Sacrums

- Benefit of 3D models compared to model casts

Complete Pelvis

Photogrammetry: Agisoft Metashape Pro



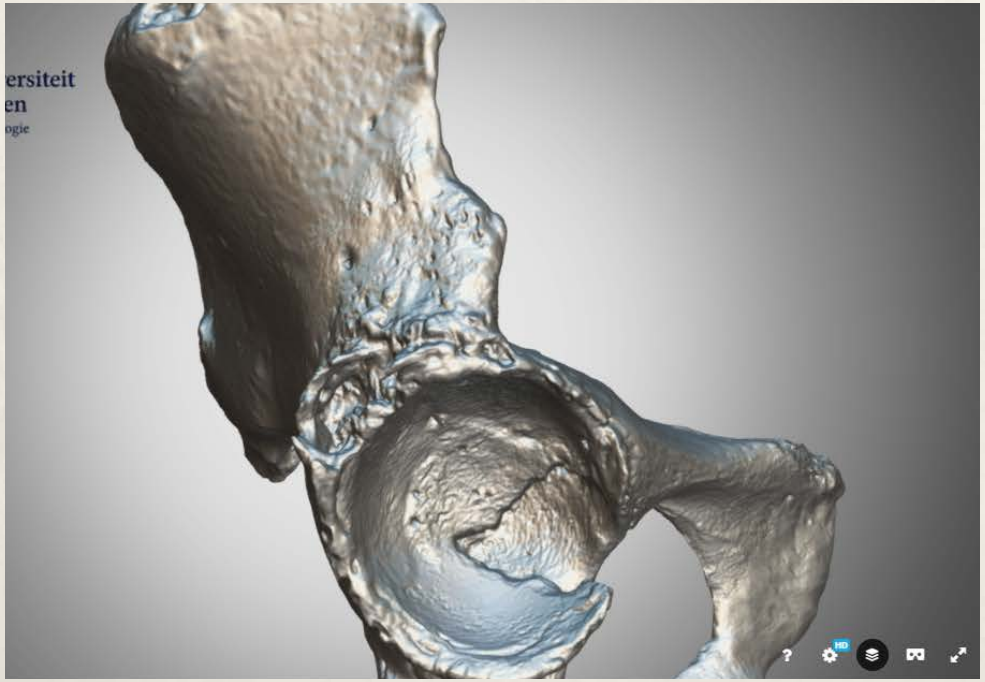


Adult, Female

59.6K triangles, 29.9k vertices

Right Pelvis

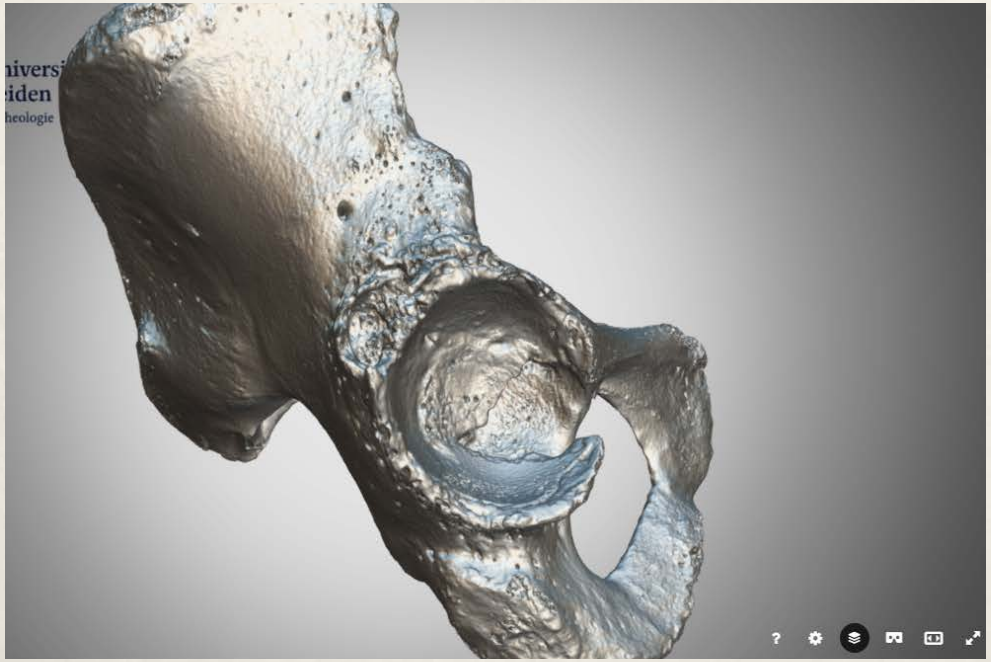
Laser Scanner: Next Engine Ultra HD Scanner



Adult, Female.
Pathology present.
1.6M triangles, 1.1M vertices

Right Pelvis

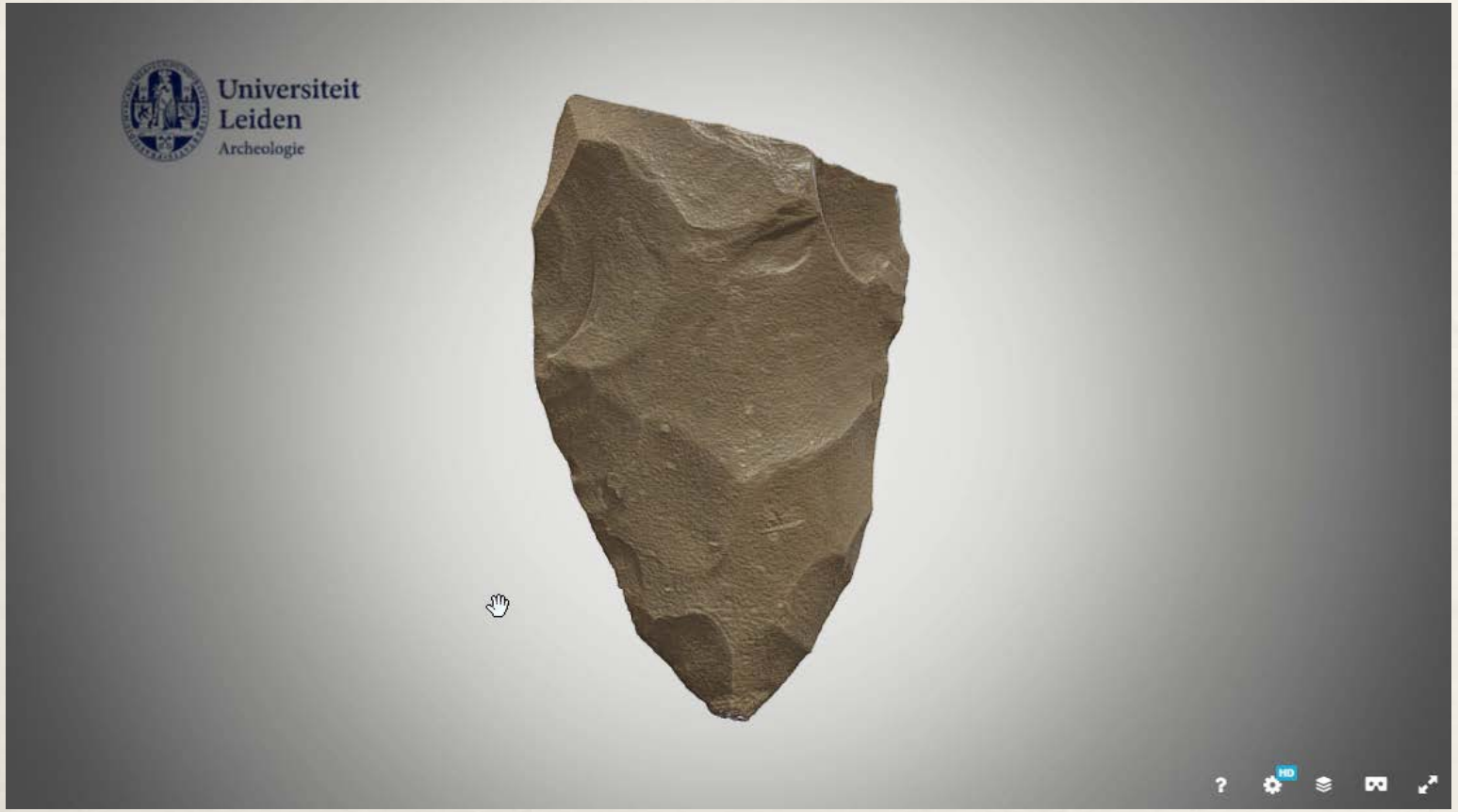
Structured Light Scanning: Artec3D Space Spider



Adult, Female.
Pathology present.
1.2M triangles, 662.3K vertices (decimated)

Lithics

Structured Light Scanning: Artec3D Space Spider

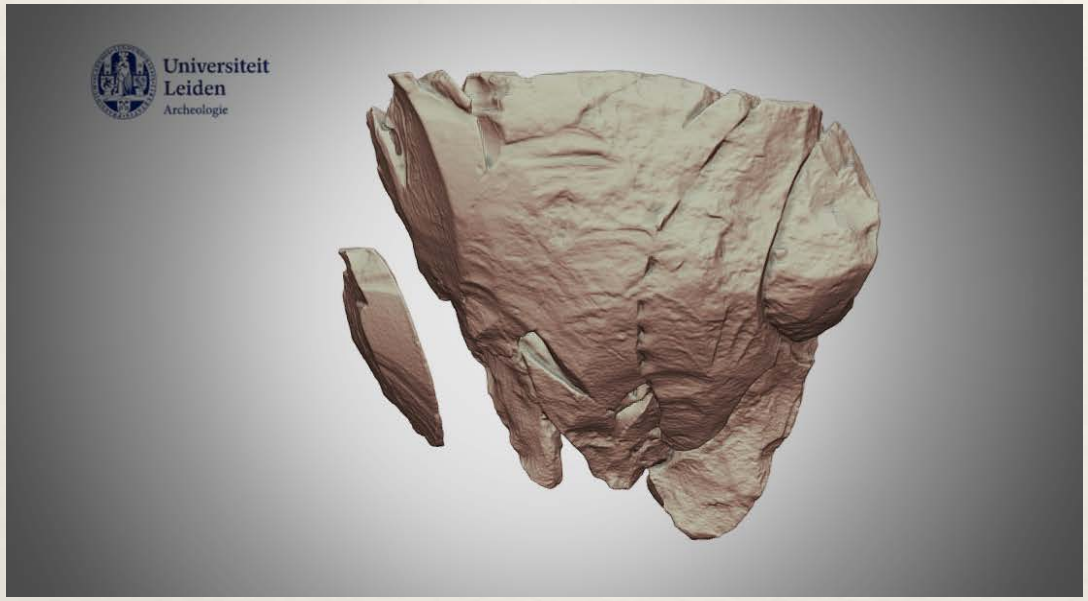


Solutrean flint biface.
1.7M triangles, 927.4K vertices.

Lithics

Next Engine Ultra HD Laser Scanner: Refitting

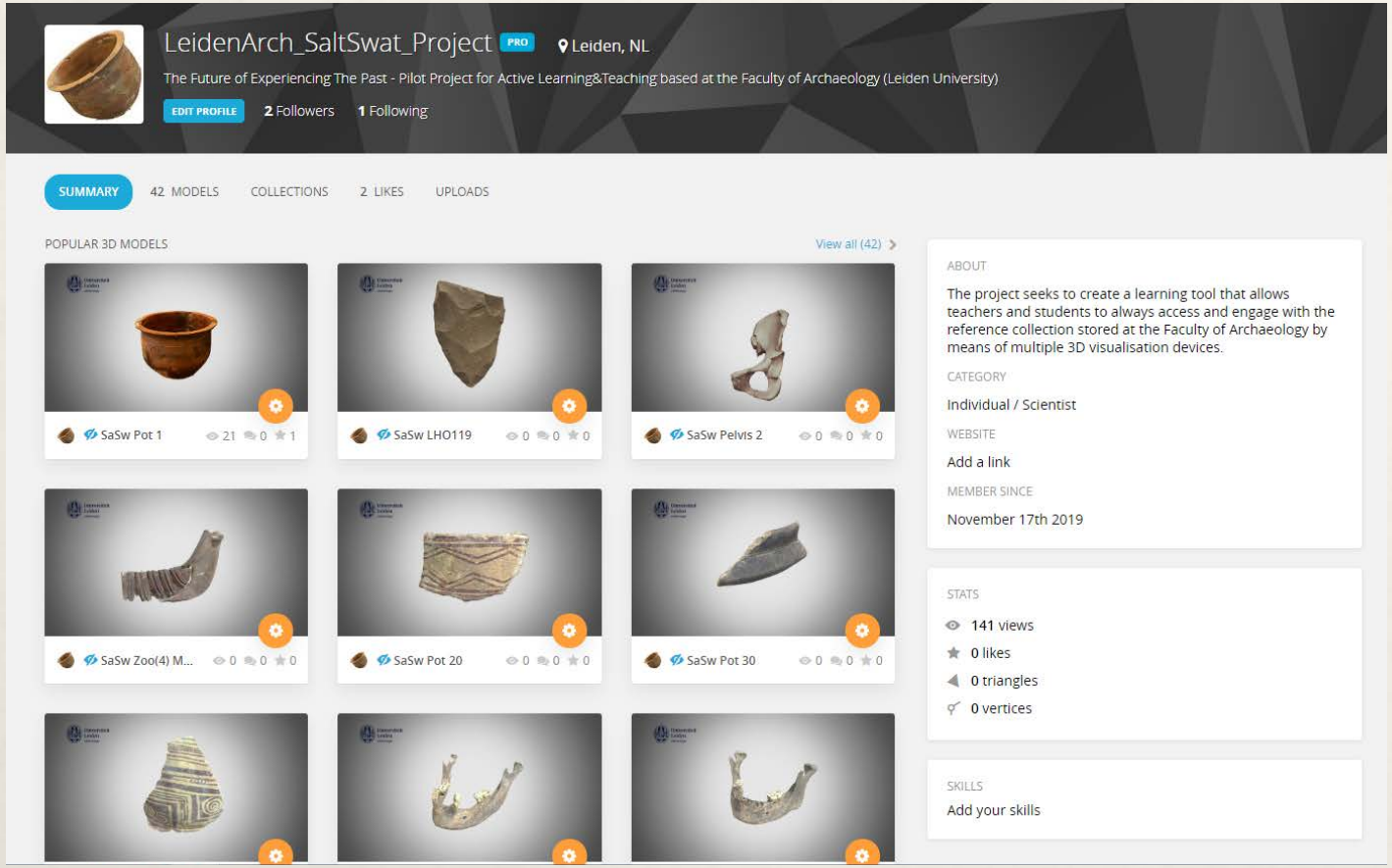
- Demonstrate striking and refitting
- Animation created on Blender



Flint core and flake
4.9M triangles, 3.3M vertices

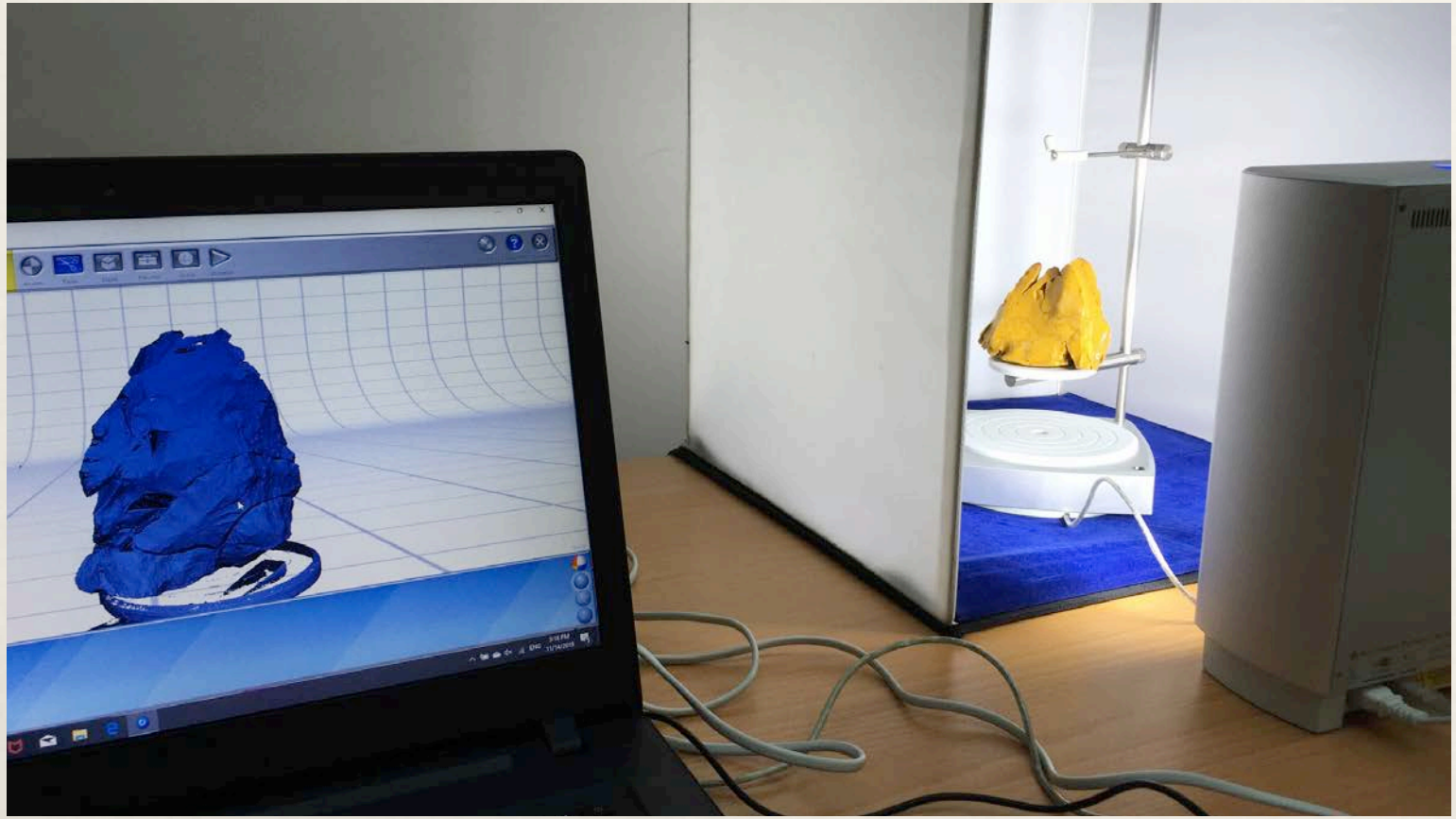
Visualization Methods

- Sketchfab.com
  - Professional account: Private models, undownloadable
  - Brightspace
- Ethical approval
- Wider audience



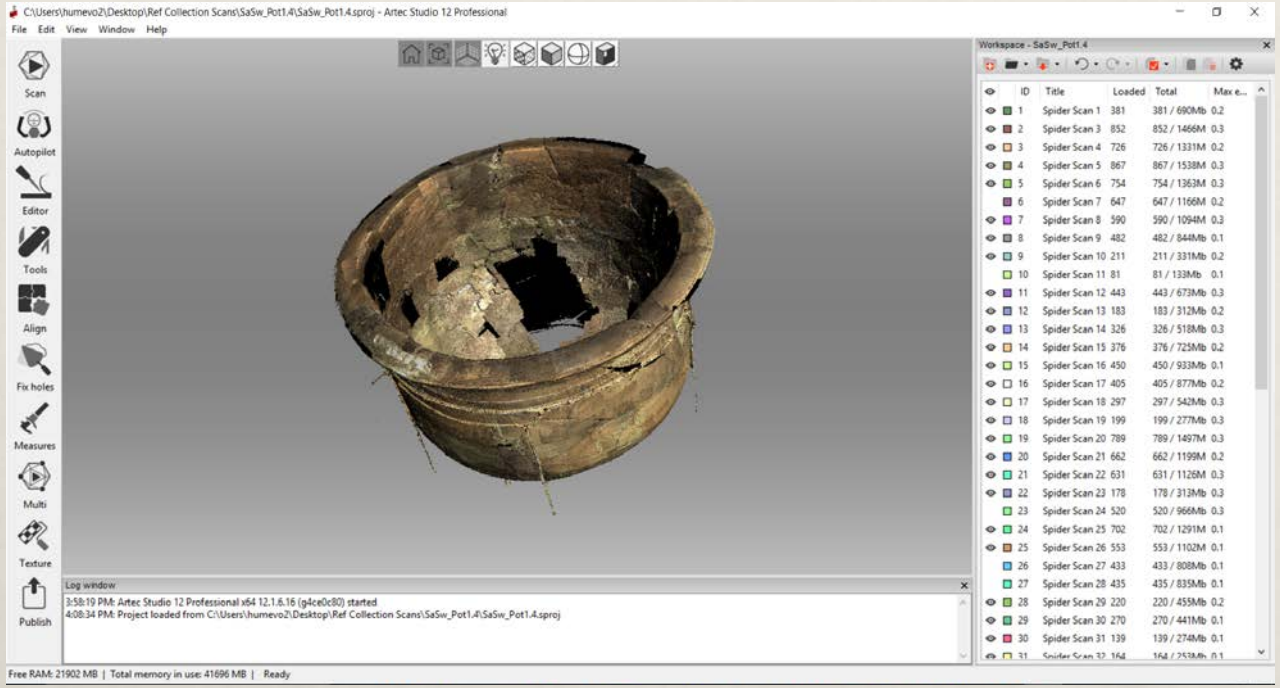
Results

* 285 3D Models
  * 32 ceramics
  * 24 bones
  * 229 lithics
* Photogrammetry
  * Cost effective
  * High resolution texture
  * Long processing times = low resolution mesh
* Next Engine
  * Cost effective
  * Higher resolution mesh/ low res. Texture
* Artec3D Spider
  * High resolution models
  * Fast processing times
  * Expensive



Practical Challenges

* Time constraints
* Hardware available
* Size of objects

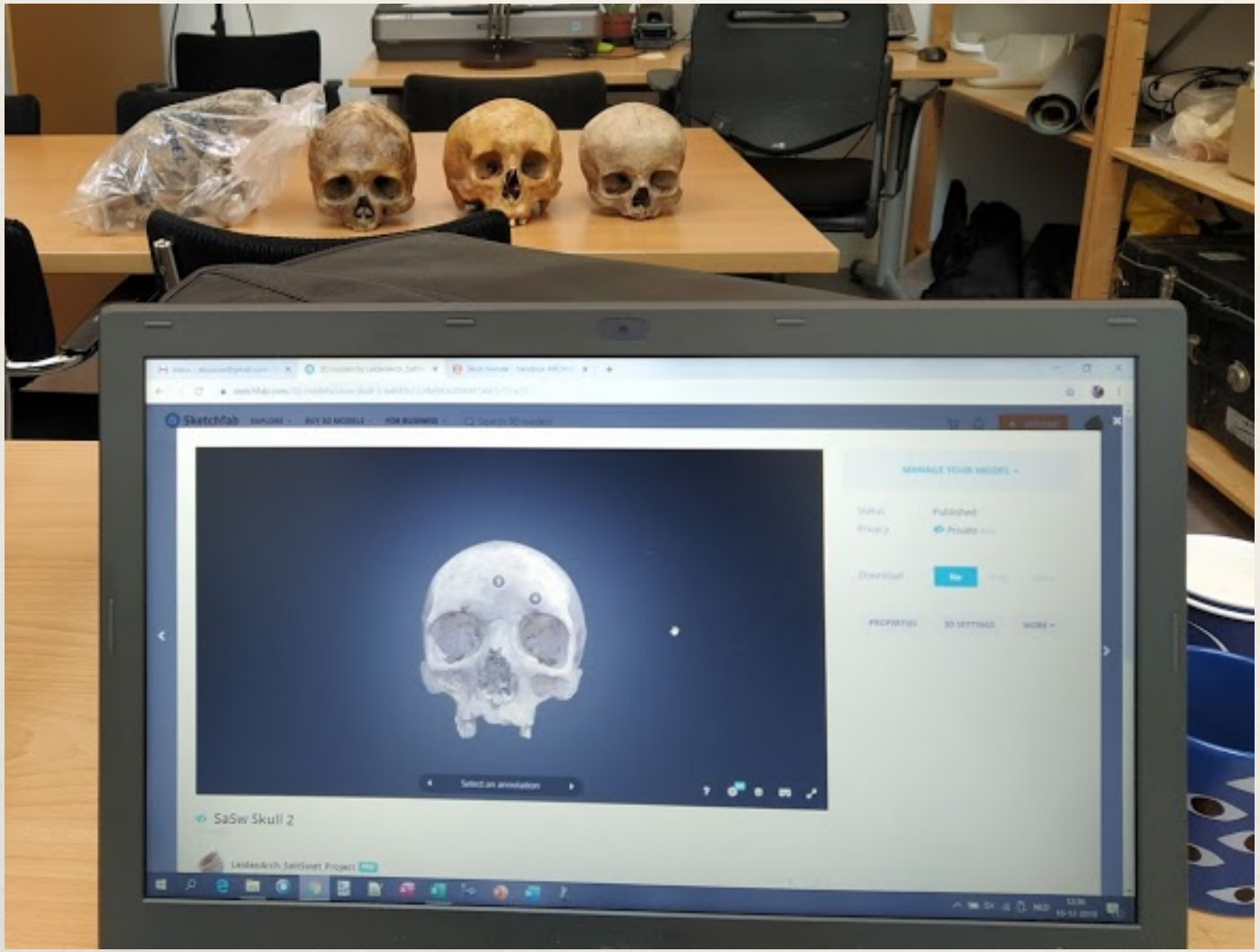


Challenges and results for active learning:
How this project will benefit researchers, instructors and students

* Mock lectures for Material

  Culture Studies and Osteology

* Student feedback:
  * Interactive ✓
  * At home study material ✓
  * Slow loading times ✗
    * Solution: decimation
  * Increased screen times ✗
  * Ethical ✓



Acknowledgments

* Dr. Rachel Schats, Drs. Martina Revello Lami, Dr. Marie Soressi
* The Center of Innovation; SALT/SWAT project
  * Cameron Hope & Wouter Kool
* Max Planck Institute EVA, Leipzig for generously lending us the Artec3D Spider
* Igor Djakovic for offering training with Artec3D
* Julius Pilzecker for research into formatting

CENTRE FOR INNOVATION
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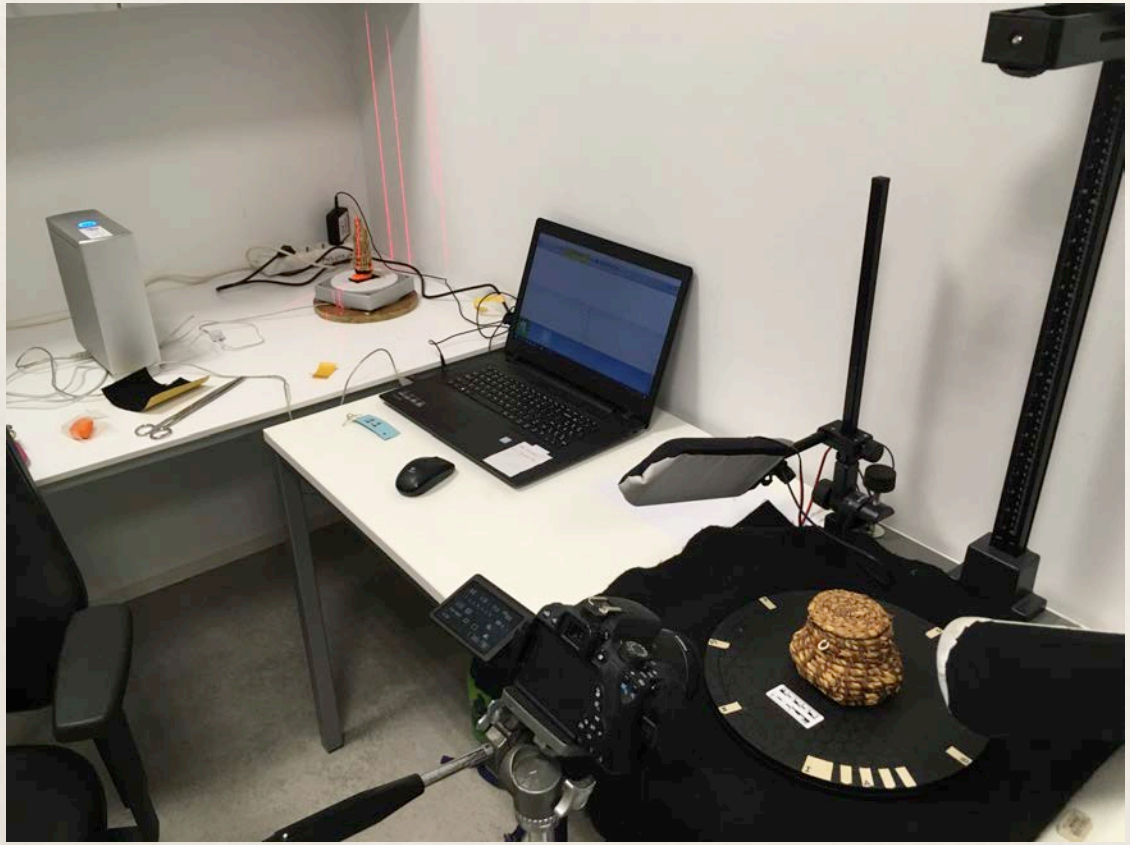
Universiteit Leiden
Archaeology

MAX-PLANCK-GESELLSCHAFT

Photogrammetry Tutorial: Image Capturing

Requirements:

* Camera (DSLR, smartphone) with high resolution (5 Mpix or more)
* Light source
* Turntable or ability to move around the object
  * Tripod (optional)
* Markers and scale bars (optional)
* 50-60% Overlap
* Stable position



Applications of Photogrammetric Modeling to Roman Wall Painting

A Case Study in the House of Marcus Lucretius in Pompeii

Prepared by Kelly McClinton for SunoikisisDC on Jan. 19 2021
Keywords: digital humanities; photogrammetry; roman wall painting; roman archaeology; 3D modeling; digital visual analysis

Overview

- Project Motivation
- Photogrammetric Modeling as Archaeological Illustration
- Project Background
- Methods and Materials
- Case Study Results
- Conclusion + Future Research Directions

Project Motivation

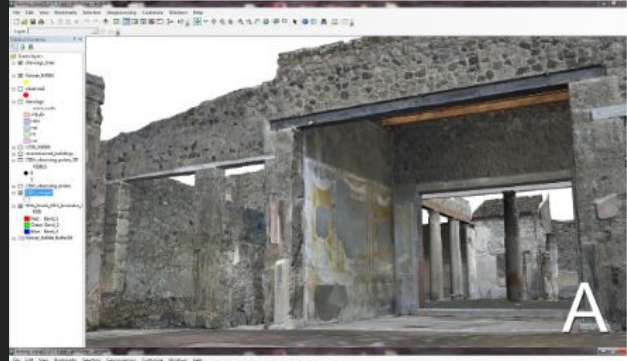
A (Digital) House of Marcus Lucretius

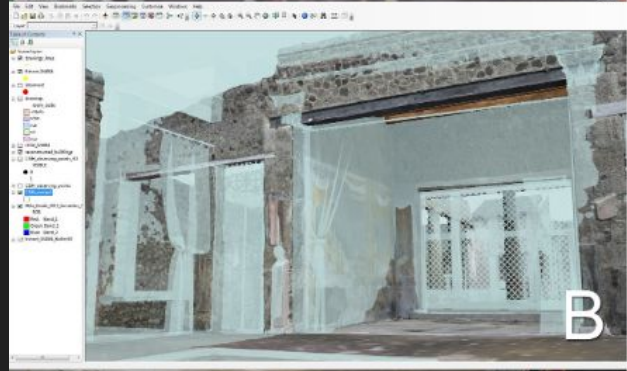
Photo Courtesy (left to right): Swedish Pompeii Project; photos for the 3D model on concession of the Ministero dei Beni e delle Attività Culturali e del Turismo, Parco Archeologico di Pompei (used by permission); Trentin 2019.

Reconstruction v. Photogrammetry?

Photo Courtesy (left to right): Photos for the 3D model on concession of the Ministero dei Beni e delle Attività Culturali e del Turismo, Parco Archeologico di Pompei (used by permission); Trentin 2013.

Pioneering Projects





Video Courtesy: Reconstruction of the House of Caecilius Iucundus by the Swedish Pompeii Project. Image Courtesy: Layers of Reconstruction in 3D GIS in Landeschi et al. "Enhanced 3D-GIS: documenting insula V 1 in Pompeii." Proceedings of the 42nd Annual CAA Proceedings, pp. 349-360. Archaeopress, 2015. See also: (Bergmann 2010, pp. 16–31; Fredrick 2014, pp. 464–65; Landeschi 2018, pp. 2–4; Opitz 2017, pp. 1206–7).

Pioneering Projects

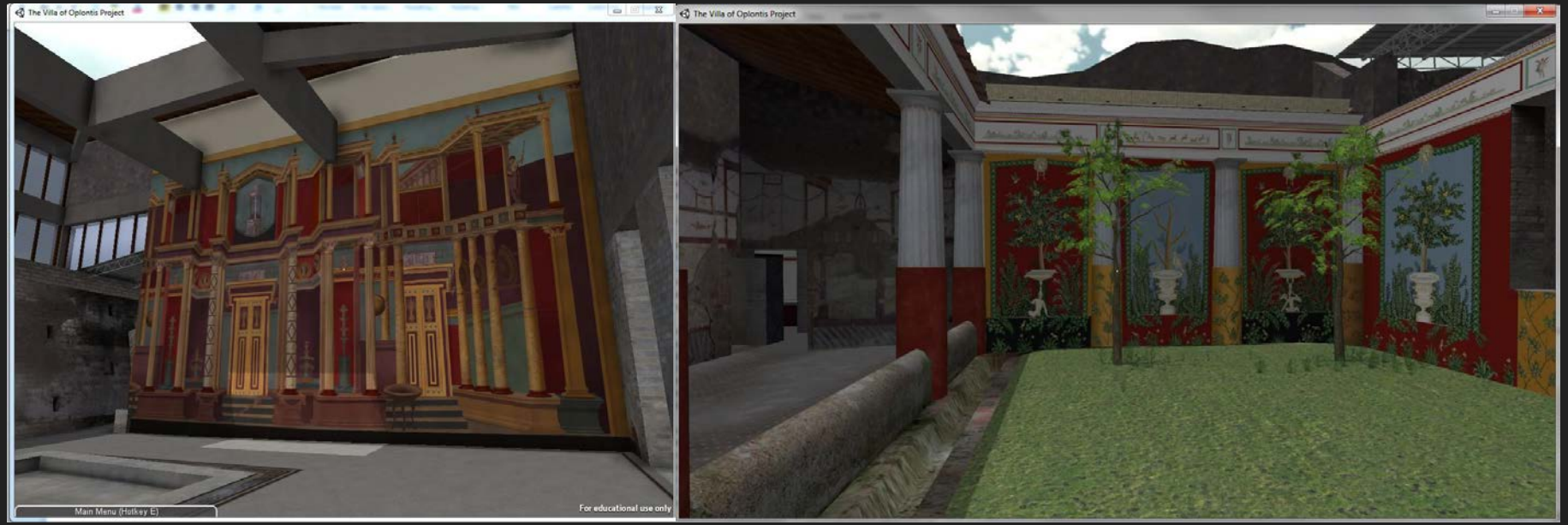
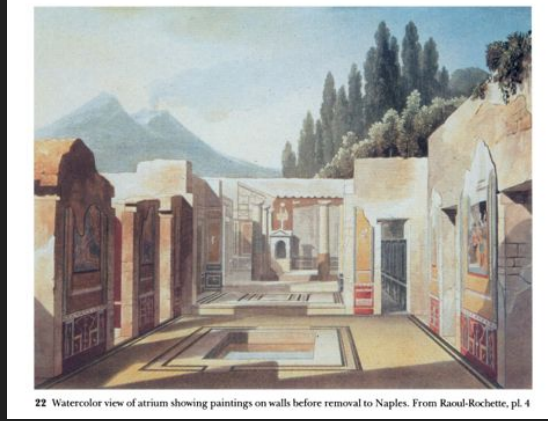


Image Courtesy: Screenshots from the 3D Model of Villa A in Unity. King's College London / Oplontis Project. At KCL: Professor Richard Beacham, Dr. Hugh Denard, Drew Baker, Martin Blazeby, Valeria Vitale. See also Clarke and Muntasser 2014, pp. 1–5, pp. 27–35, pp. 36–48; John R. Clarke et al. 2016, pp. 72–73.

Usefulness of Digital Models in Interpretation & Analysis

- Facilitating greater understanding of visual interactions between architecture and objects.
- Promoting the perception of unanticipated emergent properties.
- Highlighting areas where sources may conflict (if multiple sources were used in the creation of the 3D model).
- Elucidating the relationship of large- and small-scale features.
- Helping us to formulate hypotheses.



22 Watercolor view of atrium showing paintings on walls before removal to Naples. From Raoul-Rochette, pl. 4

References: Ware, Colin. Information visualization: perception for design. Elsevier, 2012. Images: Bergmann, Bettina. "The Roman House as Memory Theater: The House of the Tragic Poet in Pompeii." The Art Bulletin 76, no. 2 (1994): 238.

Usefulness of Digital Models in Interpretation & Analysis

Image Courtesy: House of the Vettii, Peter Stewart, CC BY-NC, 70 A.D. / House of the Vettii, Illustration by Balage Balogh.
References: Clarke 1991, pp. 1–2; Dwyer 2010, pp. 25–28; Elsner 1995, pp. 49–51; Gazda 2010, pp. 1–6; Wallace-Hadrill 1994, pp. 14–16

Method: Photogrammetric 3D Modeling

- Possible for a single person to capture and process the model components.
- Relatively low cost for equipment.
- Photorealistic model of the extant wall paintings and archaeological material.
- State photogrammetric model is a great starting point for further reconstruction, as it primarily captures the site as it appears today.
- It is then possible to “work backward” from there.

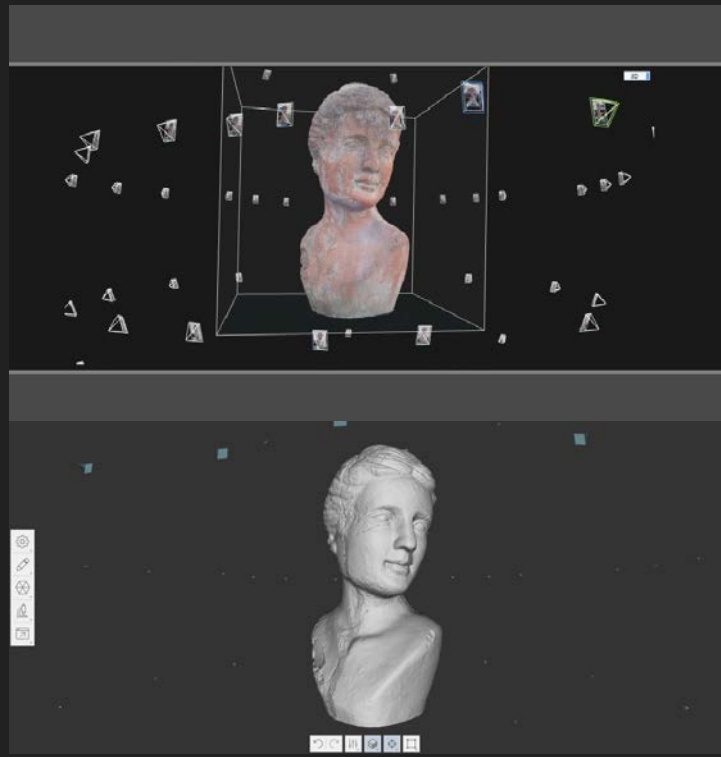
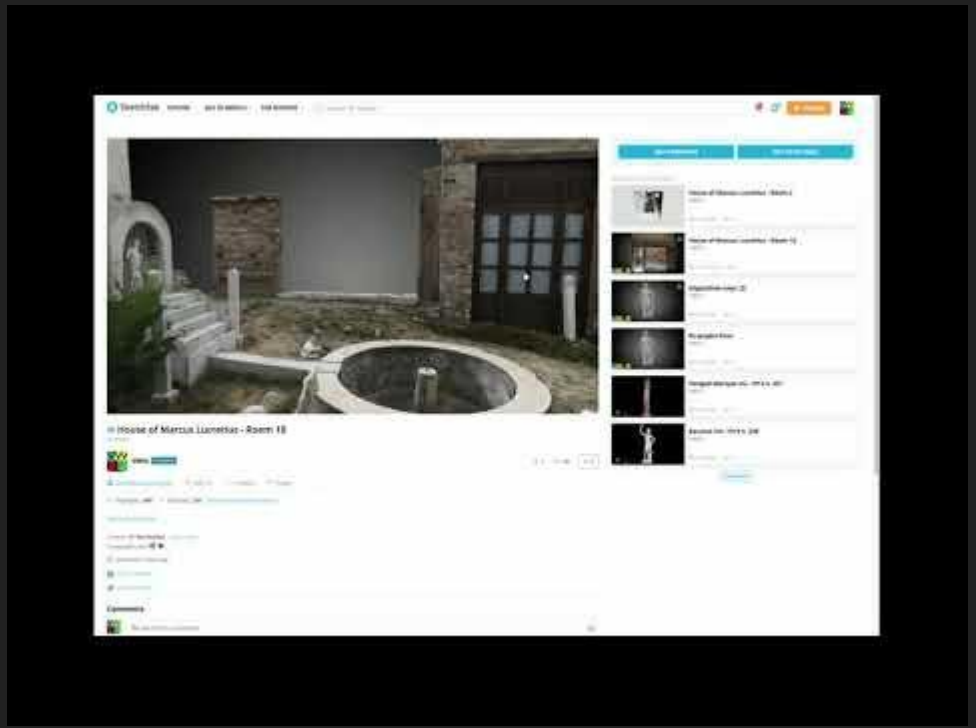


Image Courtesy: AutoDesk ReCAP

Photogrammetrically Modeling Domestic Architecture



- Nikon D850 with a Nikon AF-S NIKKOR 28mm f/1.4E ED Lens.
- Photogrammetric Targets
- Tripod / Monopod
- Camera Accessories

Image Courtesy: The House of Marcus Lucretius in Pompeii. Photogrammetry: Kelly E. McClinton. 3D model and photos on concession of the Ministero dei Beni e delle Attività Culturali e del Turismo - Parco Archeologico di Pompei. It is declared that no reproduction or duplication can be considered legitimate without the written authorization of the Parco Archeologico di Pompei.

Method: Photogrammetric 3D Modeling: Equipment

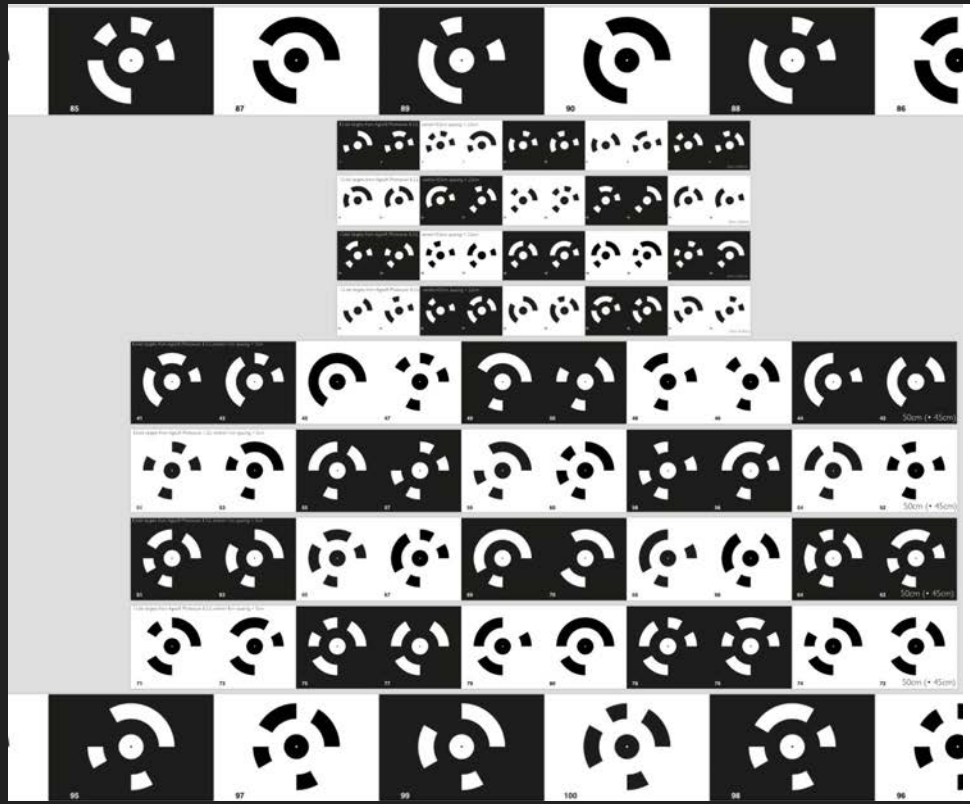
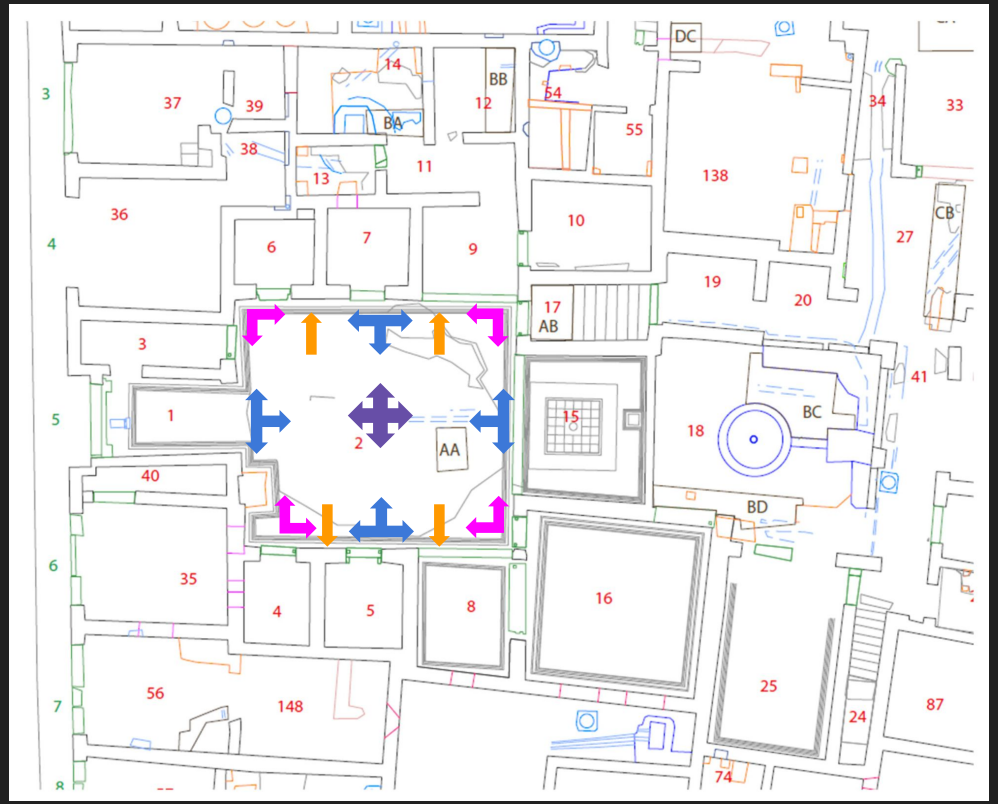


Image Courtesy (left to right): Photoscan / Benro TMA Mach3 Series Tripod (B&H PHOTO)

Method: Photogrammetric 3D Modeling (Atrium)



360 Degree Photo Capture

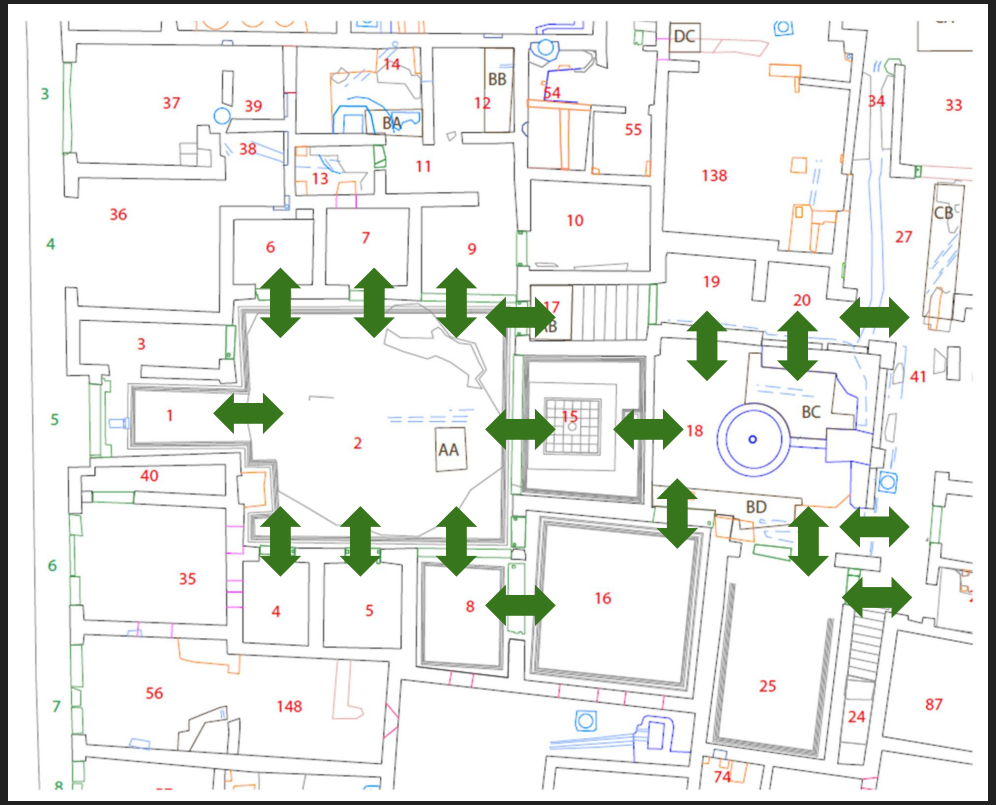
180 Degree Photo Capture

90 Degree Photo Capture

Detail Shot of Wall Painting

Image Courtesy: Expeditio Pompeiana Universitatis Helsingiensis + Indications of Camera Placement.

Method: Photogrammetric 3D Modeling



Connection Point to Bind the Individual Room Models Together

Image Courtesy: Expeditio Pompeiana Universitatis Helsingiensis + Indications of Key 3D Model Connection Points.

Some Interesting Case Studies

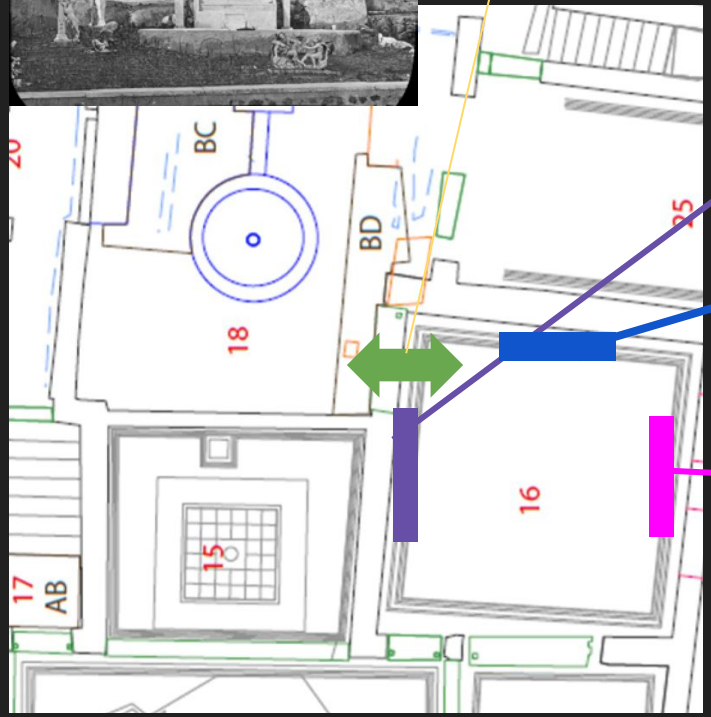
- Small, Dark Rooms
- Open Spaces, Uneven Lighting
- Reflective Wall Paintings (infuriating!)

The House of the Vettii

The House of Marcus Lucretius (Room 1)

The Villa of the Mysteries

Garden Window



1

2

3

Image Courtesy: Expeditio Pompeiana Universitatis Helsingiensis + photos on concession of the Ministero dei Beni e delle Attività Culturali e del Turismo, Parco Archeologico di Pompei (used by permission) + the garden in the 1920s, HEIR.

Comparing Sources & Documentation

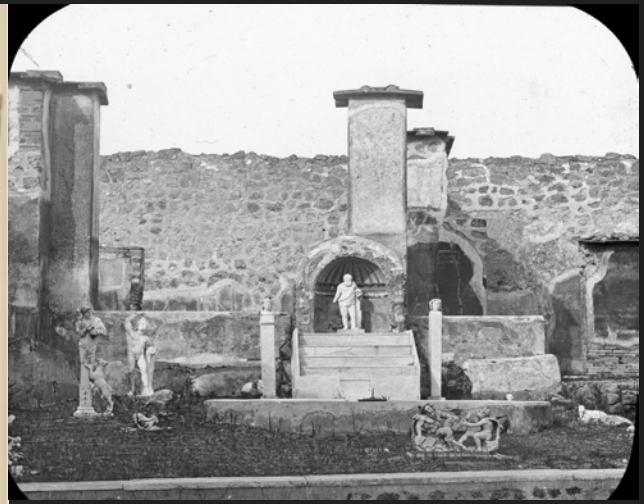


Image Courtesy: Marcus Lucretius' house, Pompeii, Italy. E. Breton in L'illustration: journal universel, Vol. 25. Paris: J.J. Dubochet, 1855. See also (Raoul Rochette 1852: 232-47, 296-304); Plan of a house at Pompeii: The House of Marcus Lucretius (IX, 3, 5.24). Illustration Courtesy: E. Falkener (used by permission; Falkener 1860, pp. 35–38); Slide Showing the Garden in the House of Marcus Lucretius, and the satyr and pan (now lost). Image Courtesy: Italy: "Pompeii: House of Marcus Lucretius, Garden, Italy." Accessed via the HEIR Database on 1/16/2019.

Usefulness in Interpretation & Analysis

- Digitally revisit the space.
- Visually re-contextualize several paintings that had been removed to the nearby museum.
- Digitally notate which paintings were located on which wall, and then consider how they interacted.
- Experiment with different viewsheds into the garden, and experiment with the current sculptural arrangement in the central garden.
- Comparing sources and documentation
- (More to come!)

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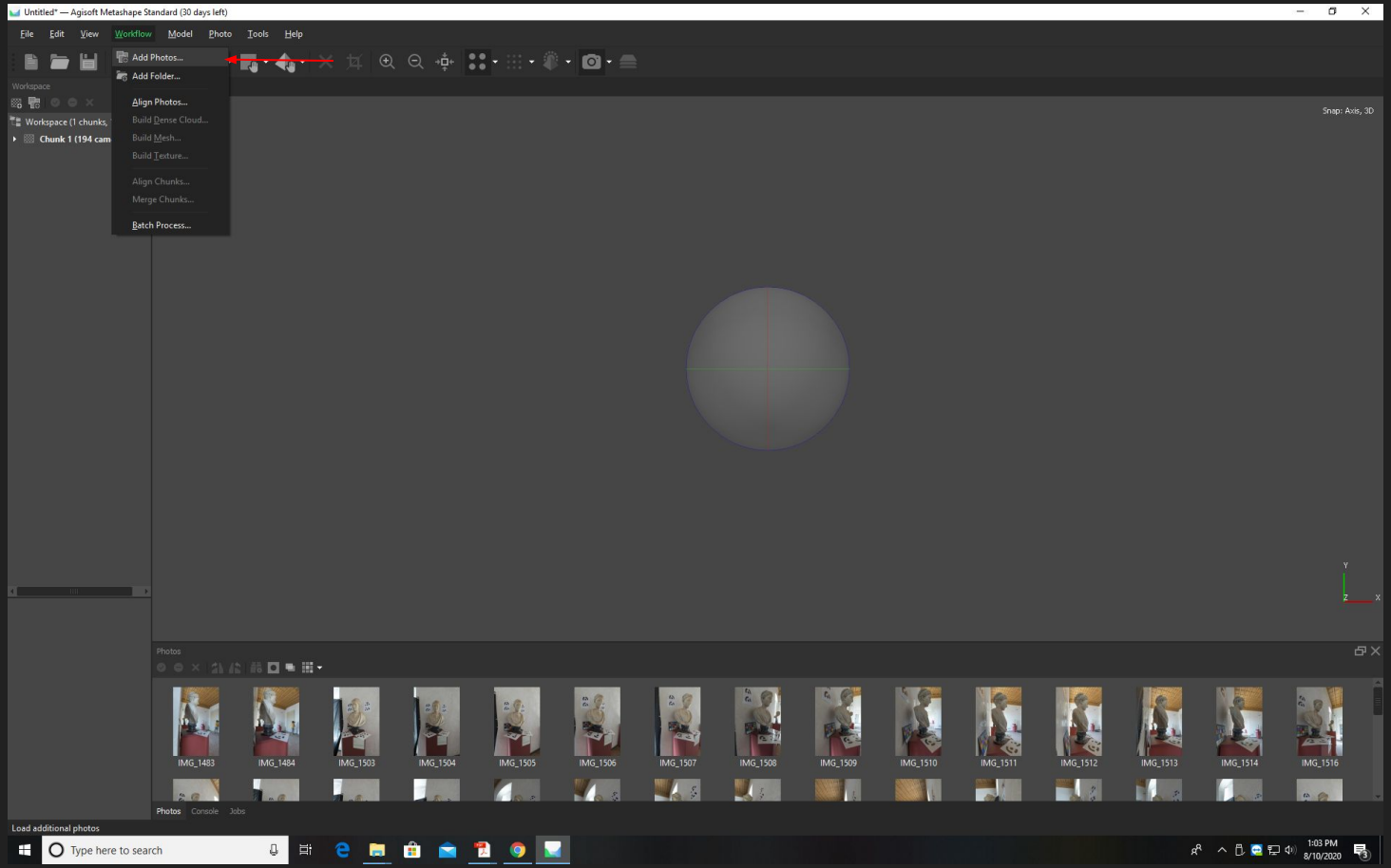
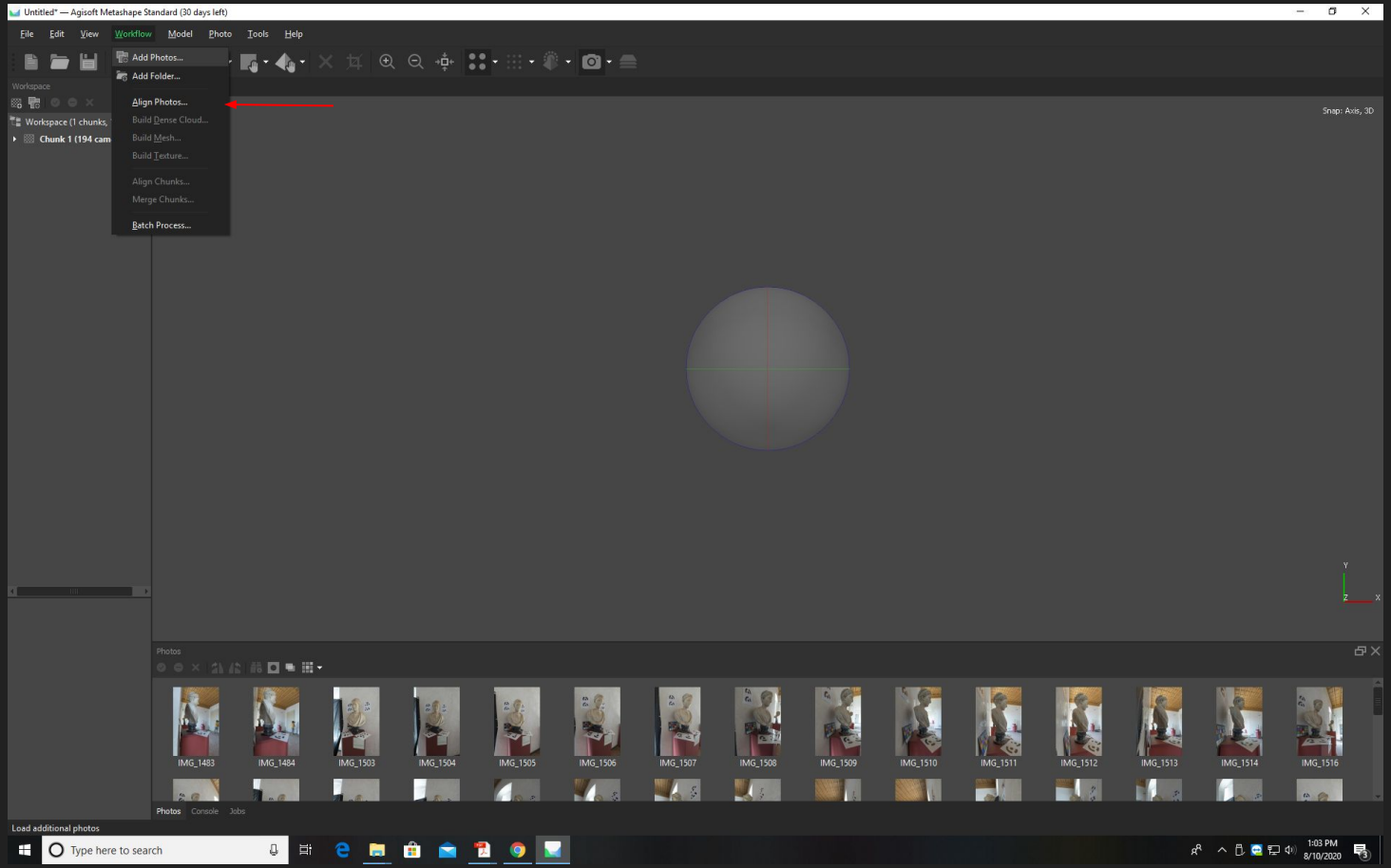
Now Onto Photogrammetry Processing!

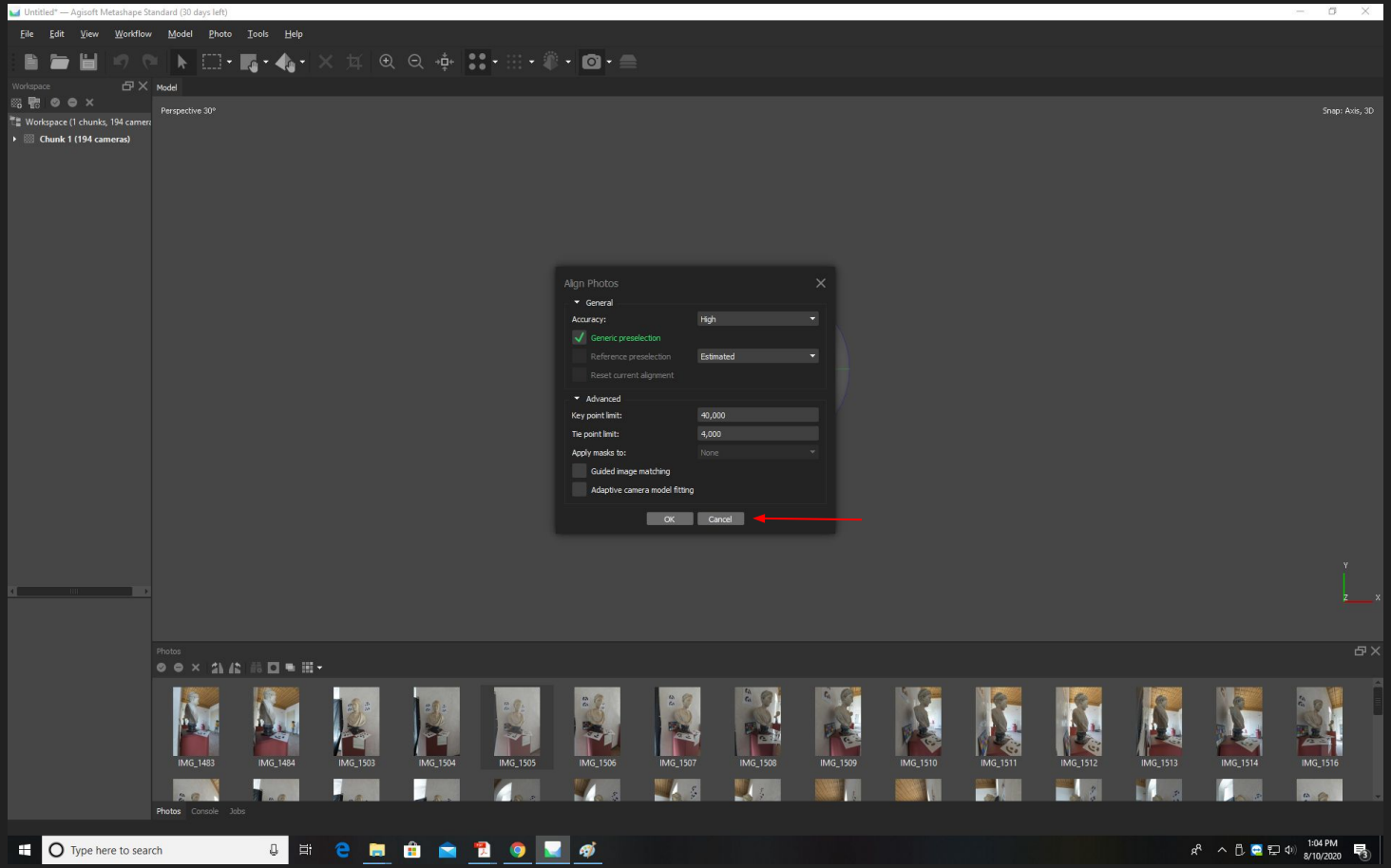
Step 1: Open MetaShape + Select Images



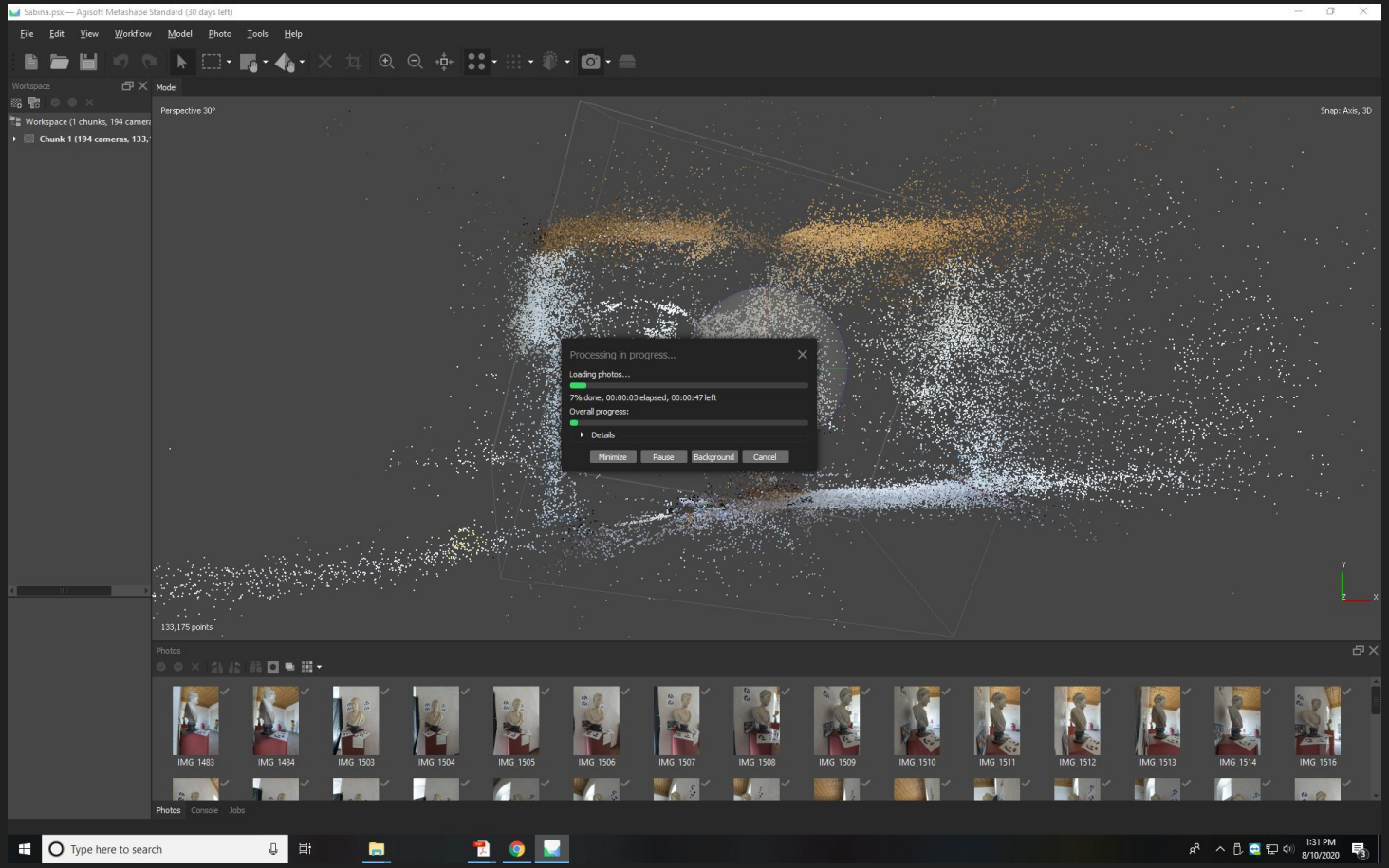
Step 2: Align Photos



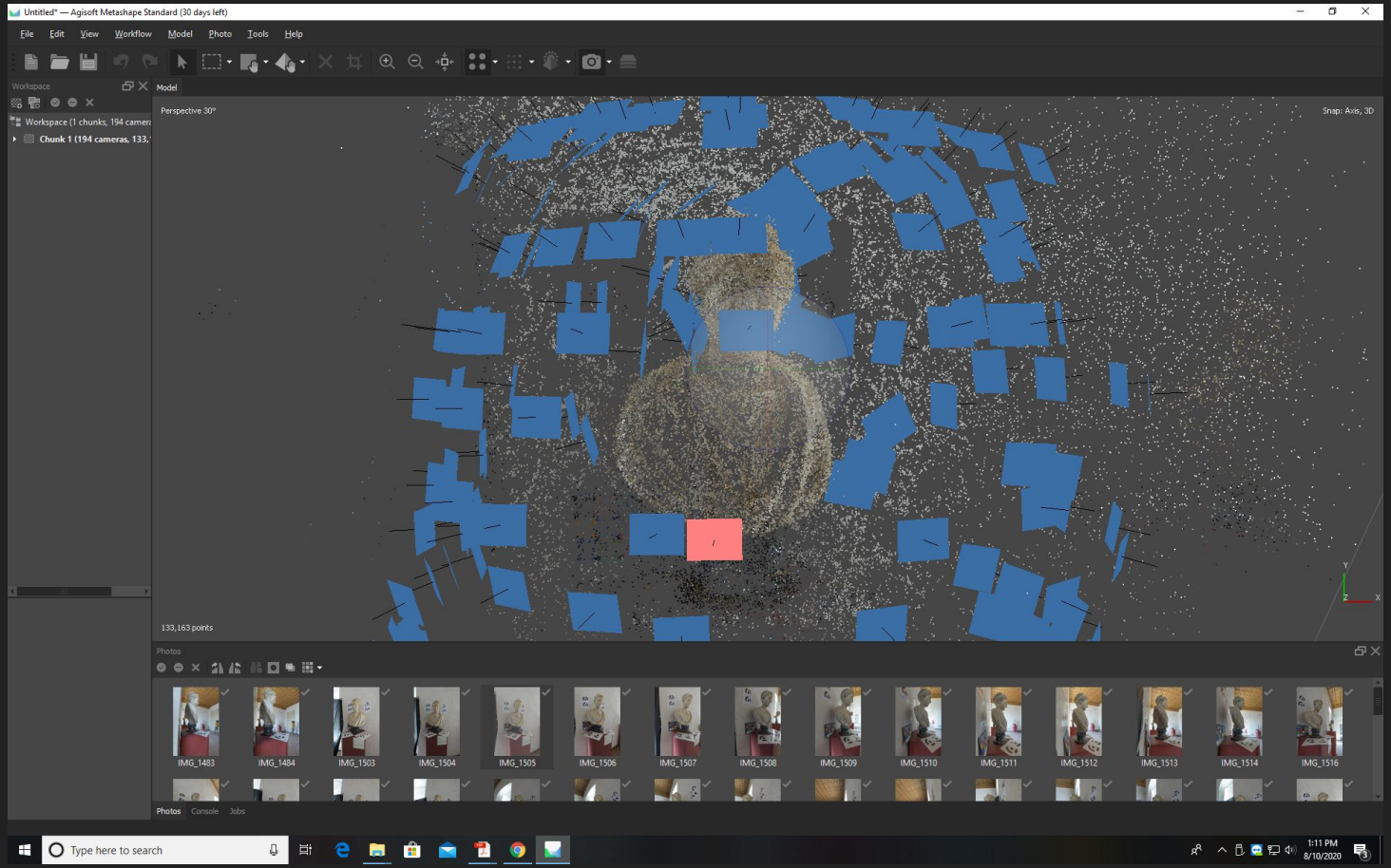
Step 3: Adjust Settings for Align Images



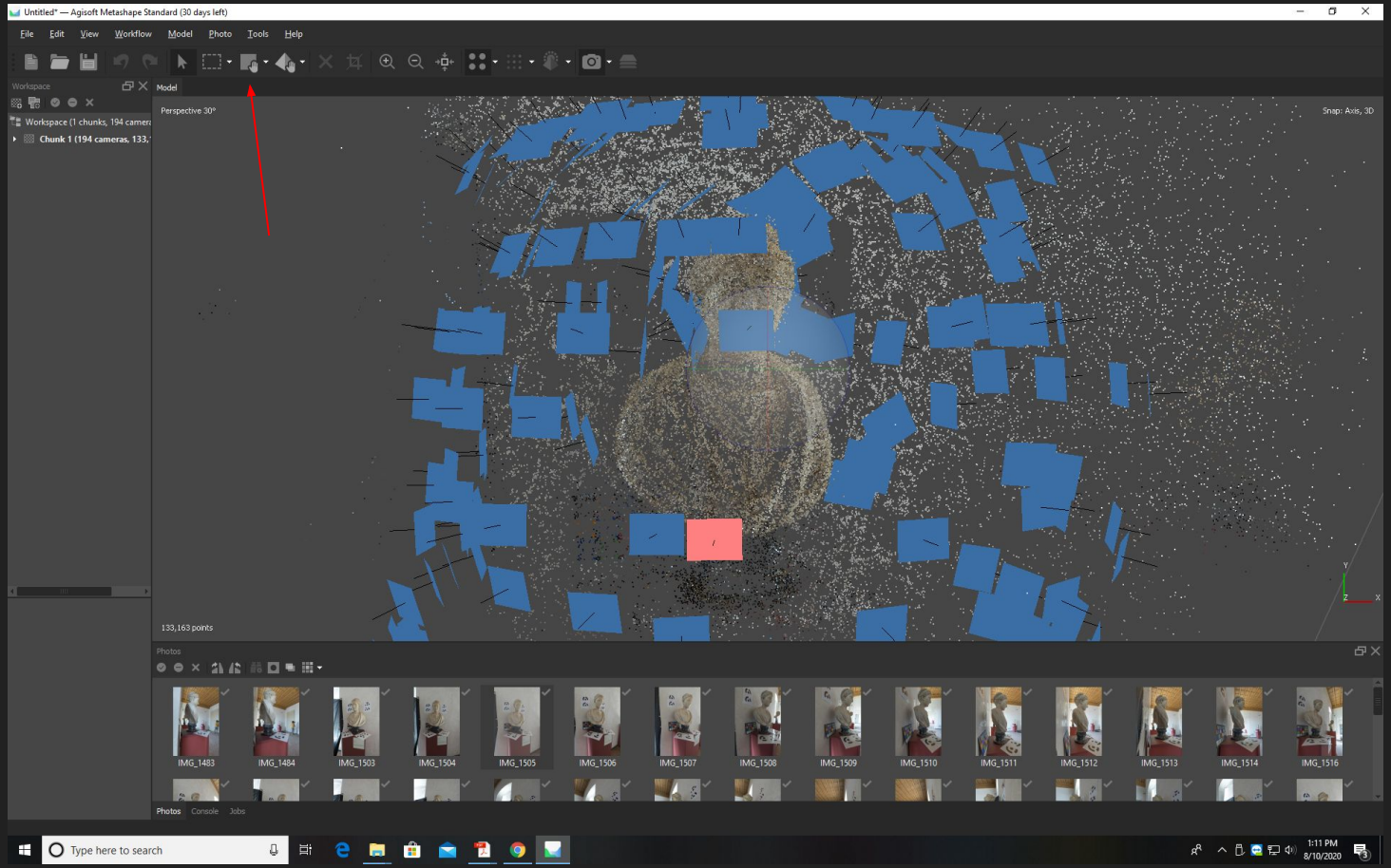
Step 4: Wait


Sabina.psx — Agisoft Metashape Standard (30 days left)
File Edit View Workflow Model Photo Tools Help
Workspace
Workspace (1 chunks, 194 camera
Chunk 1 (194 cameras, 133,
Model
Perspective 30°
Snap: Axis, 3D
Processing in progress...
Loading photos...
7% done, 00:00:03 elapsed, 00:00:47 left
Overall progress:
Details
Minimize Pause Background Cancel
133,175 points
Photos
IMG_1483 IMG_1484 IMG_1503 IMG_1504 IMG_1505 IMG_1506 IMG_1507 IMG_1508 IMG_1509 IMG_1510 IMG_1511 IMG_1512 IMG_1513 IMG_1514 IMG_1516
Photos Console Jobs
Type here to search
1:31 PM
8/10/2020

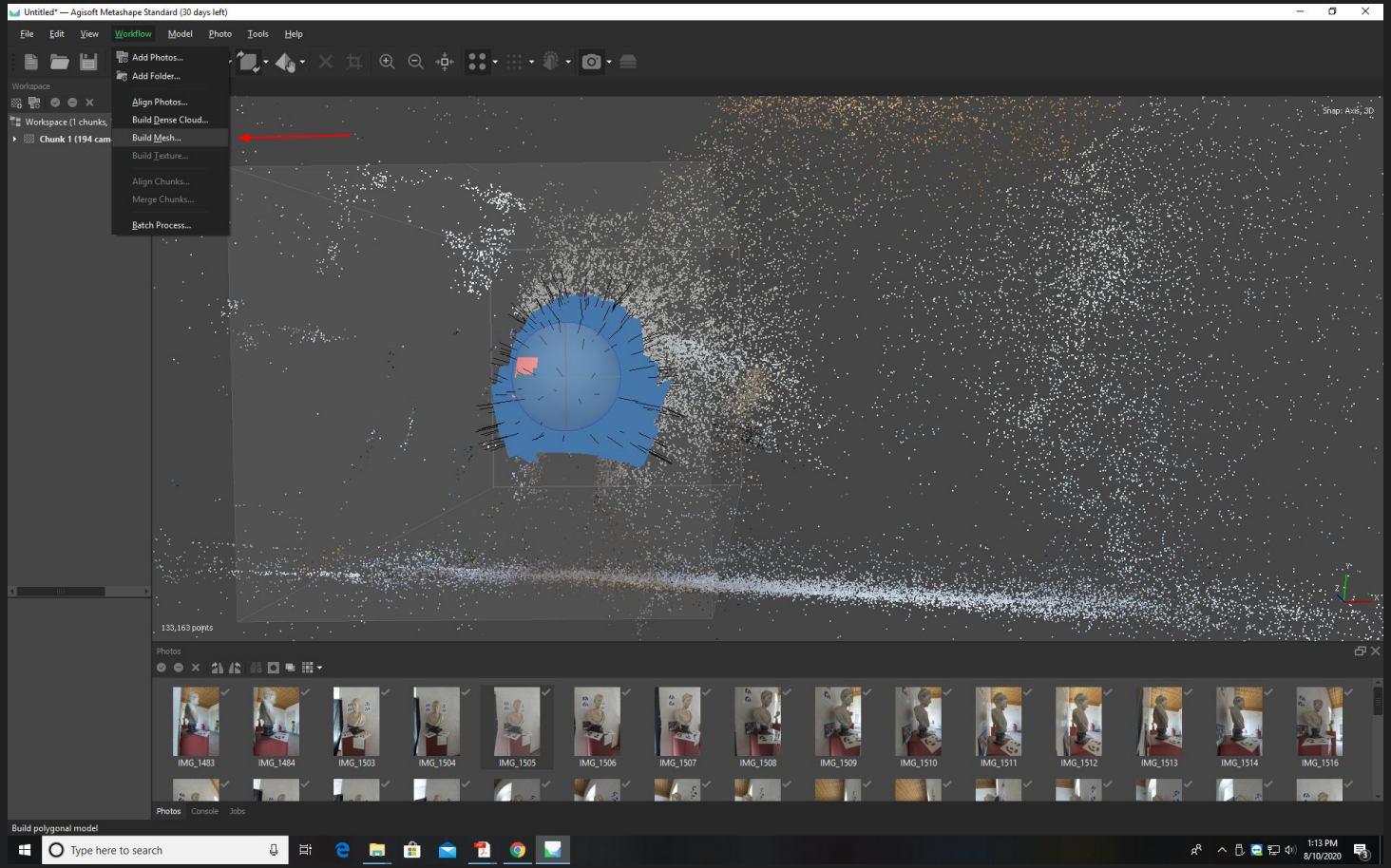
Step 5: Check Out Your Point Cloud



Step 6: Adjust Bounding Box + Orientation

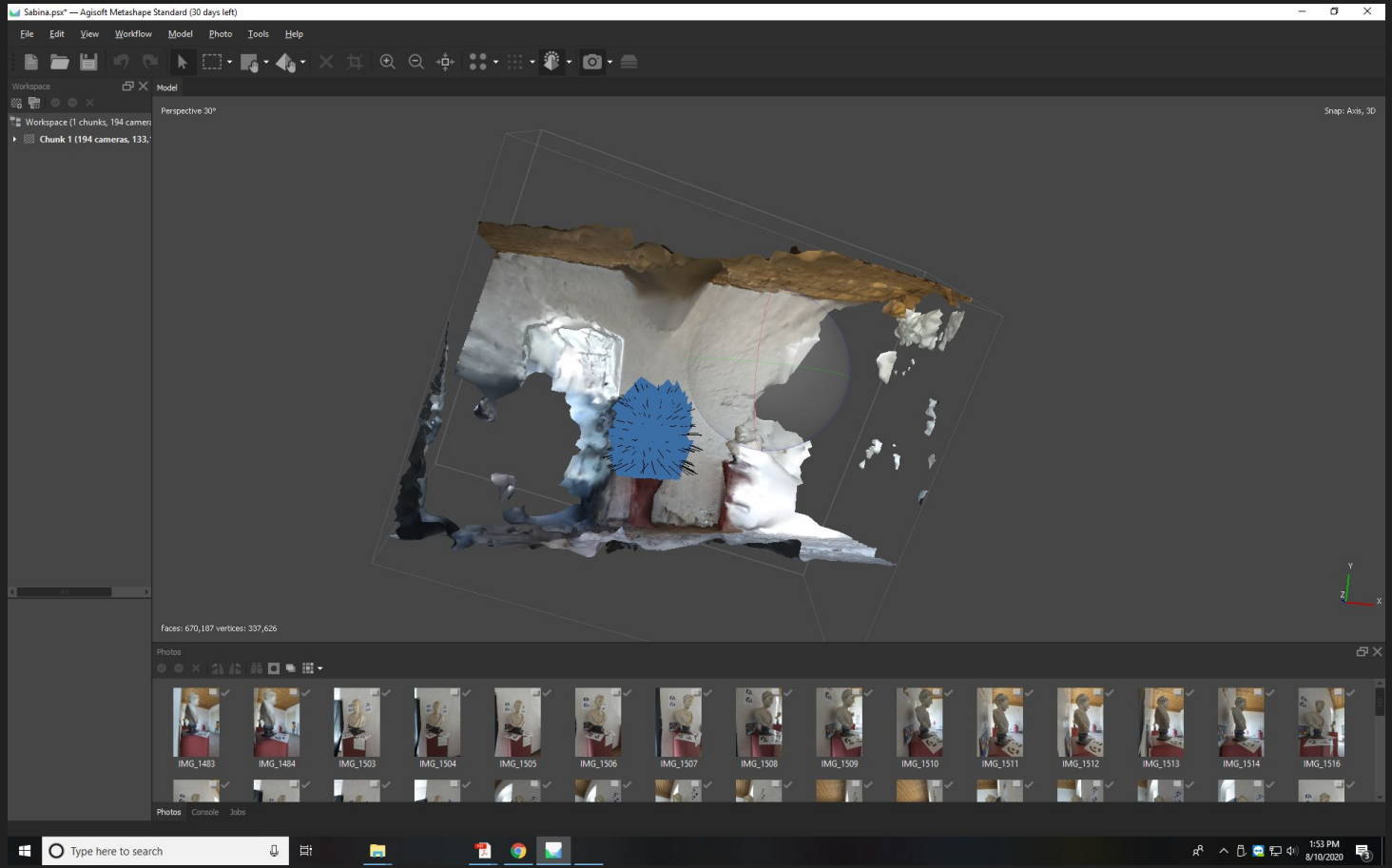


Step 7: Build Mesh

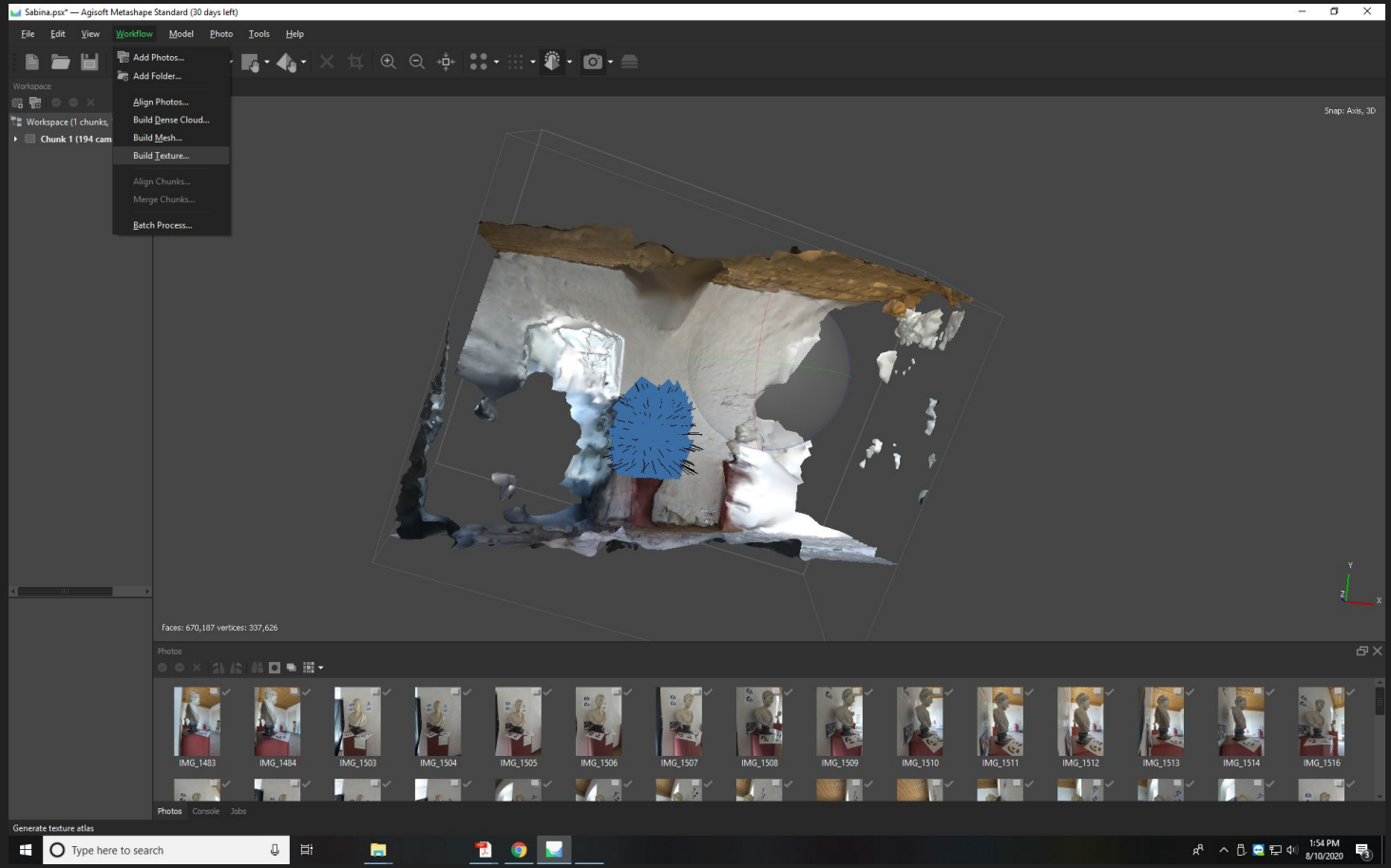


Step 8: Adjust Mesh Settings

Step 8.5: Inspect Your Model



Step 9: Build Texture



Step 10: Export for Editing in ZBrush