A DIGITAL APPROACH FOR THE STUDY OF ROMAN SIGNACULA FROM SYRACUSE, SICILY

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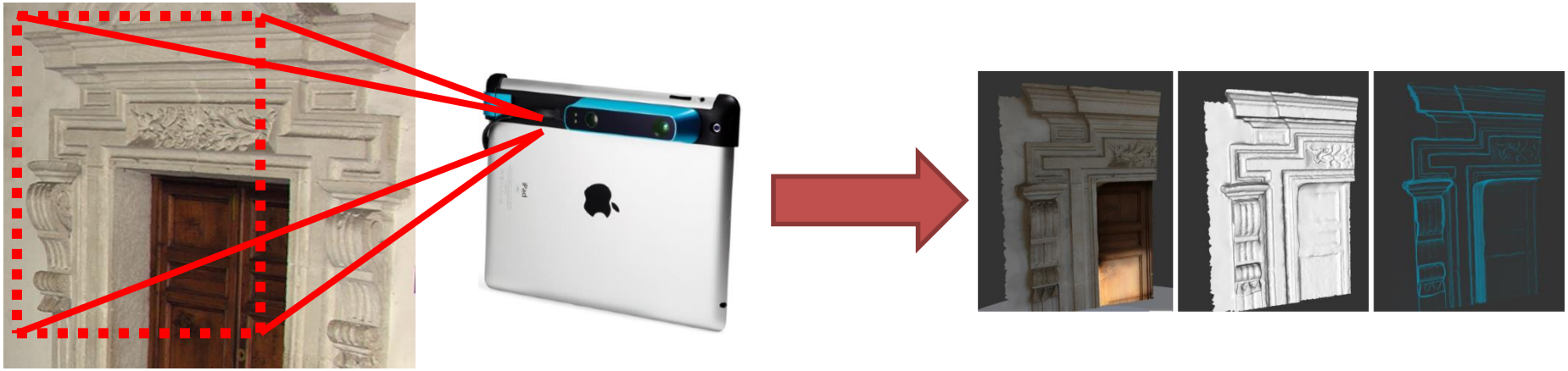
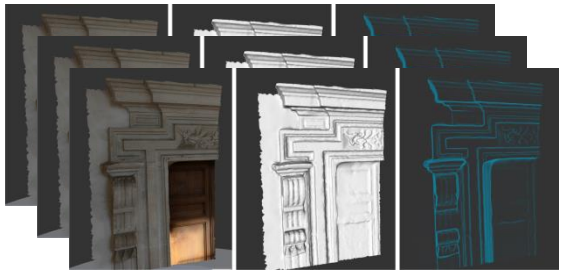
Motivation: Cultural Heritage Preservation



Multiple Digital Copies



Digital Restoration

Catalogue and Archive (monitoring purposes, …)

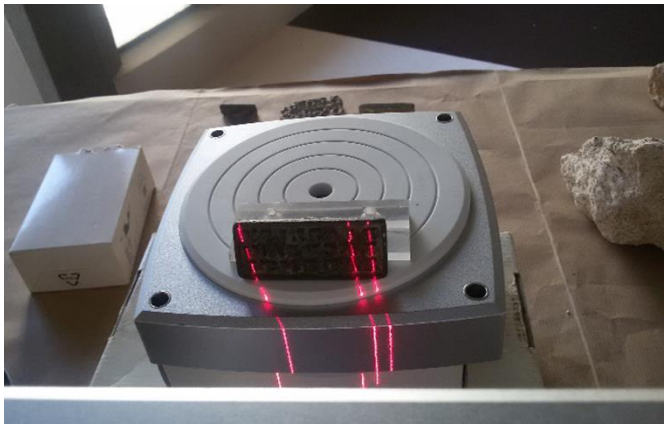
Project Definition

- Roman signacula collection from Syracuse, Sicily

- *Research questions:*
  - Given a 3D scan of a signaculum and a 3D scan of a print, is there a way to define an automatic procedure to assess if **the signacula matches the print**?
  - Given several 3D scans of different signacula and a 3D scan of a print, is there a way to define an automatic procedure **to select the most likely signaculum that could have made the print**?
- In other words: ***is it possible to identify unequivocally a signaculum by its impression?***

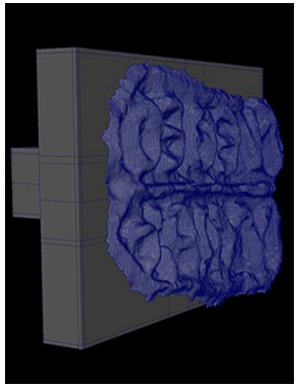
Signacula 3D Scanning

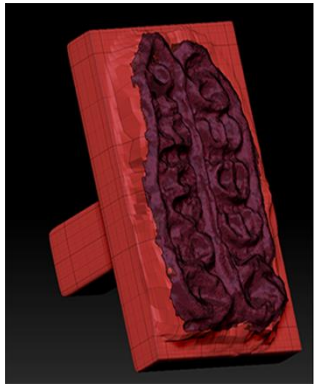
- Roman signacula collection has been digitized through *NextEngine* 3D scanner
- We selected 2 signacula as our case study:
  - Signaculum B, Inv#16191
  - Signaculum F, Inv#SN2



Processing of 3D models

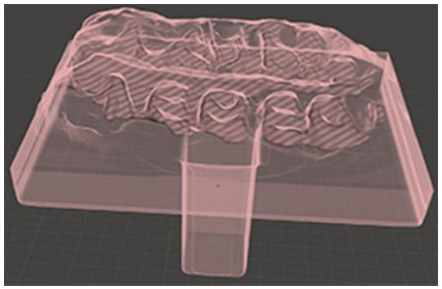
- 3D scan meshes were imported to **MeshLab**
  - Hole filling: *Surface Reconstruction: Poisson*
- Repaired meshes were imported to **Pixologic Zbrush**
  - Merging of Original and Poisson surfaces
- Merged meshes were imported into **Autodesk Maya**
  - Creation of a *support polygonal mesh* for 3D printing
- Meshes are imported once more to **Pixologic Zbrush**
  - Manifold check for 3D printing

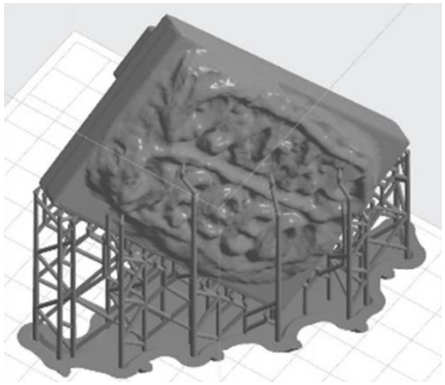


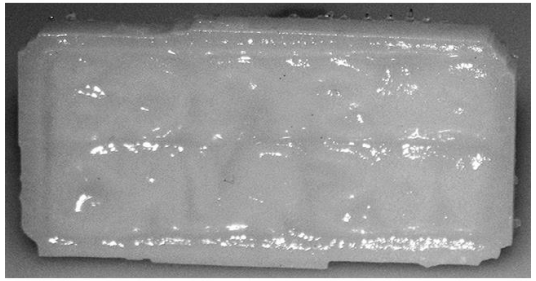


Signacula 3D Printing

- Processed 3D Models are imported into Autodesk MeshMixer
  - Manifold models have been cleaned:
    - Shells Separation + Delete of interior meshes
- 3D Printing on 2 different printers:
  - FlashForge – Fused Filament Fabrication (FFF)
  - Formlabs Form 2 Stereolithography (SLA)





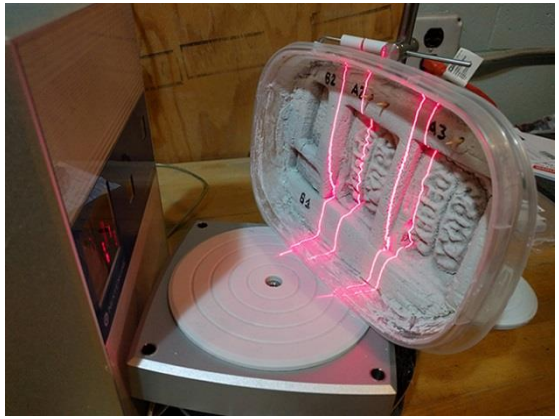


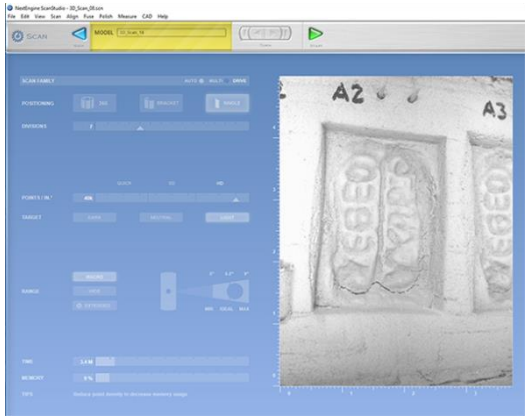
Creation of Realistic Print Replicas

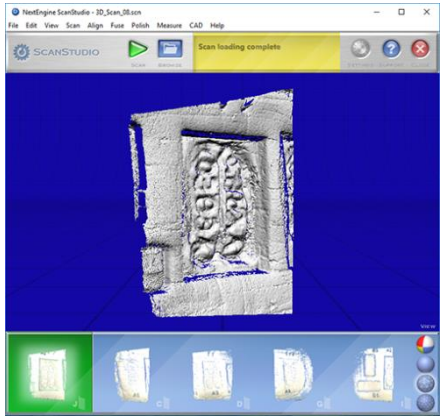
- We prepared a mortar as a mixture of gypsum and sand, with a proportion of 50:50
- We stamped the seals into 2 cases filled with mortar, applying a steady movement

Print Replicas 3D Scanning

- Digitization of print replicas has been carried out with 2 different scanners:
  - NextEngine (±0.1*mm* accuracy)
  - Sense (±1*mm* accuracy)

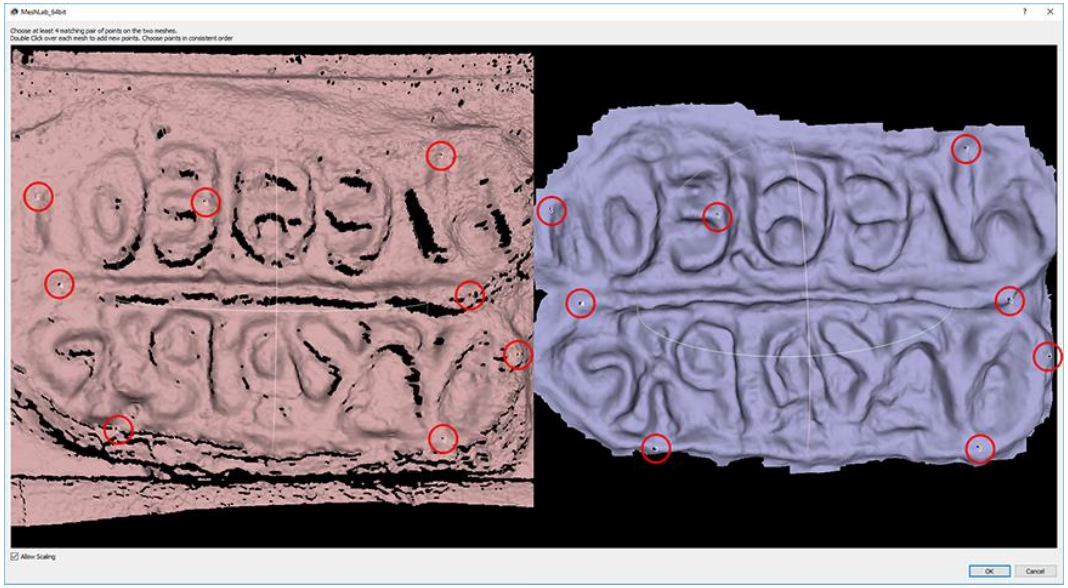






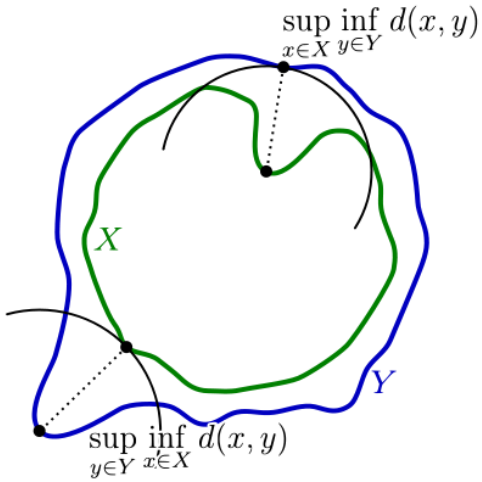
Signacula and Prints Alignment

- 3D models have been imported in **MeshLab**
  - The digital fit of the meshes is done with the *manual alignment tool* (for pre-alignment) and *Iterative Closest Point (ICP) procedure* (for final alignment)
  - In our experiments we selected 8 matching points
  - Then, we apply the filter *Sampling – Hausdorff Distance*

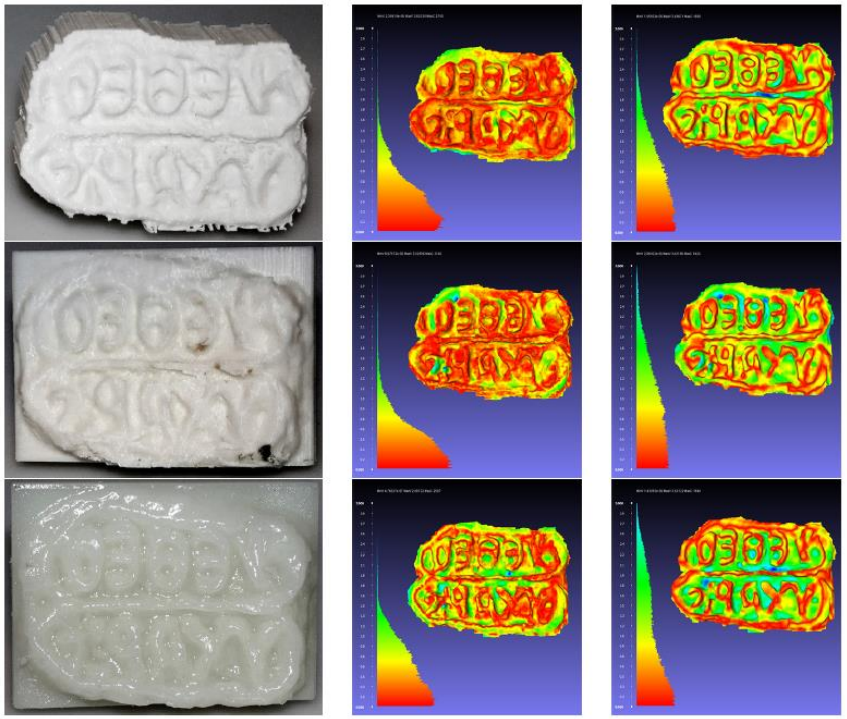


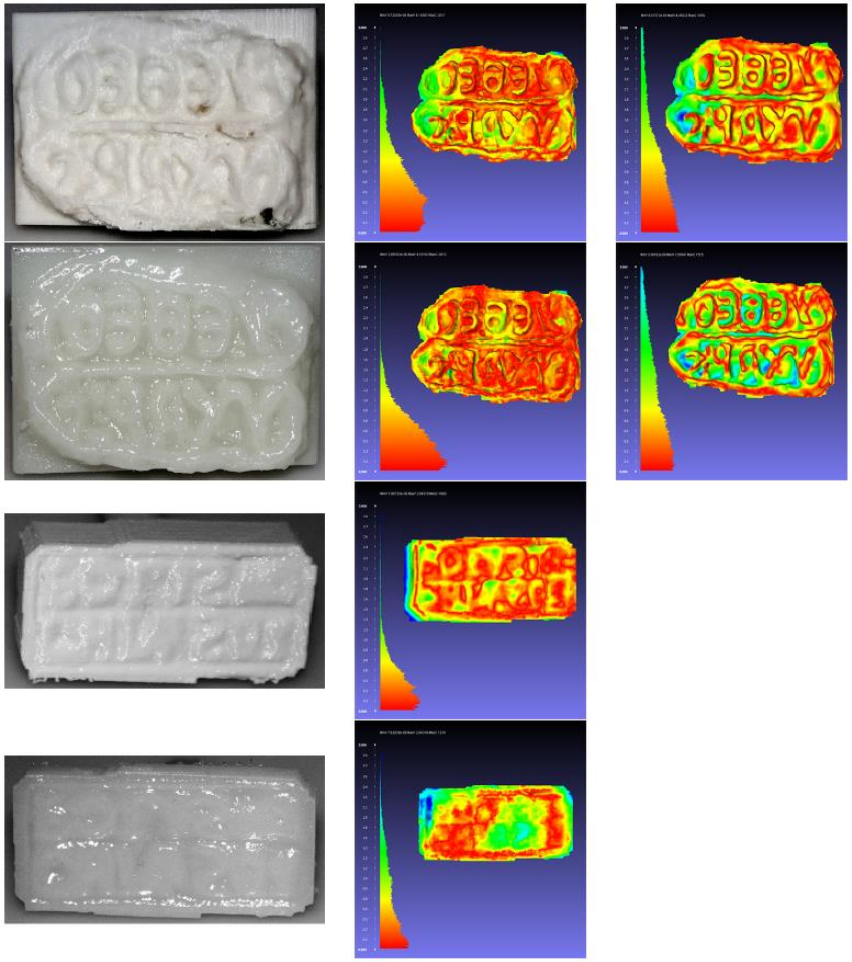
Definition of Hausdorff distance

- In mathematics, the Hausdorff distance, or Hausdorff metric, measures how far two subsets of a metric space are from each other.
- Informally, two sets are close in the Hausdorff distance if every point of either set is close to some point of the other set. In other words, it is the greatest of all the distances from a point in one set to the closest point in the other set.



Signacula and Prints Alignment

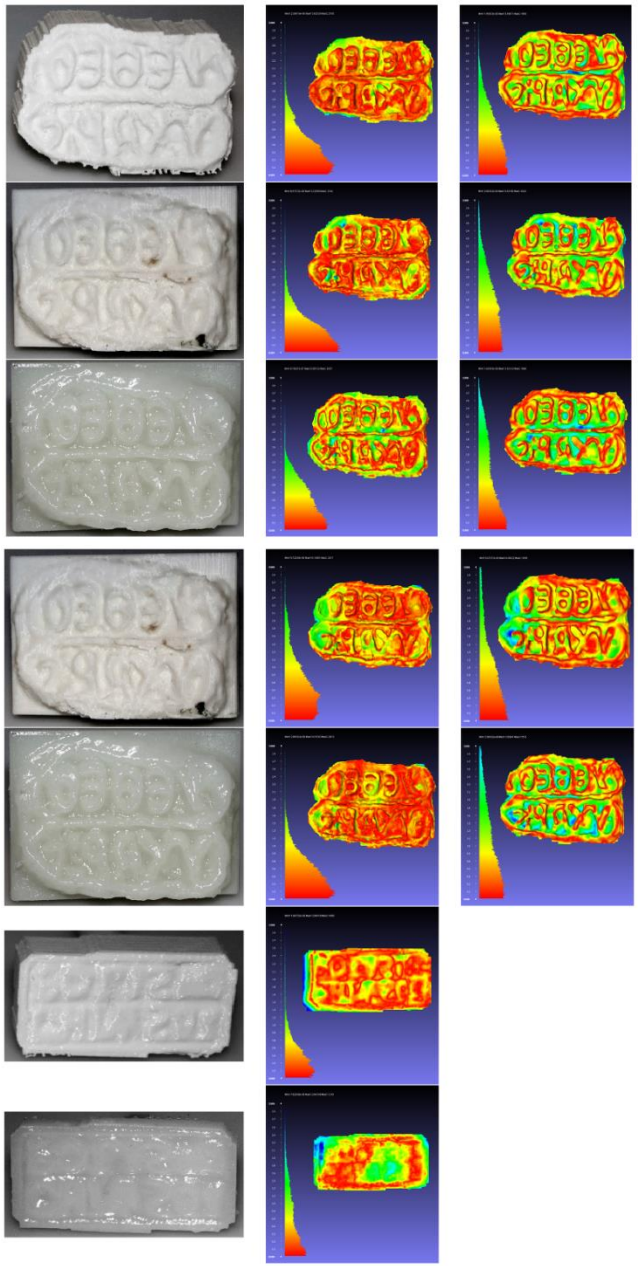




Evaluation

- Higher distance for meshes acquired by Sense3D
- Slight difference between seals printed in plastic and the ones printed in resin

- Hausdorff distance should not be used to ensure a match without any other cue
  - It should be used to reject clear mismatch, since it is very unlikely that mismatching prints and seals could obtain the same low-ranked distance values, as the one shown in the reported experiments



Conclusion

- The archaeological implications derived from the application of such innovative digital approach for the study of Roman signacula are rather significant.
- However, the test of the protocol on two specimens, even with promising outcomes, requires an extended experimentation period on a larger selection of artifacts.
  - The main goal of creating a virtual edition of *signacula* with 3D models metadata still remains an open option at the top of our research agenda, where extremely important becomes to design a **machine learning algorithm** for matching 3D meshes automatically in order to drop the manual exercise via the use of the Hausdorff Distance.

Future Works

- Test and compare other technologies (i.e, RTI imaging) different from the 3D scanning, which has been proved to be difficult for handling data and expensive for needed devices.
- Employment of image processing and visual features matching techniques based on depth-maps, which may substitute the more complex machine learning approach

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THANKS!

Any question?

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