A web-based application that facilitates the preservation, study, and dissemination of ancient inscriptions and other archaeological artifacts.

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Outline

- Related Projects & Methods
- Motivation for the DEA
- Digitizing squeezes
- Automated epigraphic analysis
- Experimental Results-DEMO
- Digital Archaeology
Epigraphic Databases

- Electronic Archive of Greek & Latin Epigraphy
- Packard Humanities Project
- Ektypa at the Berlin-Brandenburg Academy of Humanities and Sciences
- The Center for the Study of Ancient Documents at Oxford University
Computer Methods

- Take pictures of squeezes.
- Easy and inexpensive
- 3D information is not depicted
- Problems
Computer Methods

- Take several pictures of an inscription using a device with different light sources.
  - HP labs, Tom Malzbender, 2001
  - Good relighting results.
Computer Methods

- Petroglyph digitization using laser scanners
- George Landon et al., Machine Vision and Applications 2006
Computer Methods

- Petroglyph digitization using laser scanners
  - George Landon et al., Machine Vision and Applications 2006

- Accurate results
- Very expensive.
- Must be carried to the site.
Computer Methods

- Reconstruct 3D scene from video.
- Kurt Cornelis et al. 2000

- Needs only a camera
- Good for large objects
- Inaccurate for details
- Cannot recover inscribed details
The Digital Epigraphy Toolbox

Our proposed method:
- Requires squeezes, not actual inscription
- Needs only a conventional scanner
- Inexpensive
- No need to transfer equipment in site.
Digitizing Squeezes

- Use a regular scanner
- Grayscale option
- Scan squeezes twice
Digitizing Squeezes

- This will produce a set of images like that:

<table>
<thead>
<tr>
<th>Light from the top</th>
<th>Light from the left</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Image 1]</td>
<td>![Image 2]</td>
</tr>
</tbody>
</table>
These images contain all the shading information needed to understand the local curvature of the paper.
By combining:
- Knowledge about the reflectance model of a paper
- The shading provided from the two scans

A computer can recover the 3D anaglyph of the squeeze
- This is known as “shape from shading”
Visualization 1

- There are several ways to visualize the reconstructed 3D surfaces
  - 1) Plot the 3D surface (can be rotated and zoomed by the user)
There are several ways to visualize the reconstructed 3D surfaces
2) Plot the height-map
   (dark intensities=deeper locations)
There are several ways to visualize the reconstructed 3D surfaces
3) Change the material properties etc.
Digitizing Squeezes

- So far, the steps of our method:

- Then we can perform post-processing steps for automated analysis
For each reconstructed inscription, we can automatically segment each letter or symbol.

The process is fully automated.

A box is placed around each symbol.

There may be few errors which can be discarded by the user.
Grouping letters

- The segmented letters can be automatically clustered into groups.
- Example:
  all ‘alpha’ characters are grouped together

This process can be first done partly by the user.

Then the computer can continue automatically by finding letters similar to those chosen by the user.
Registration of the letters

- The letters from each group are rotated and scaled automatically in order to overlap each other as much as possible.

This process is fully automated and it is known as ‘group-wise registration’.

The average character is also computed during this process.

The average depicts useful information about the letterforms.
Finally, the registered characters can be compared to each other by measuring the affinity between them. The computed affinities can be further used to construct a dendrogram.

The method is known as: Agglomerative hierarchical clustering

The computed dendrogram shows groups of letters with similar characteristics.

Useful for automated analysis.
The post-processing steps of our method:

- Segmenting letters
- Grouping
- Registration & Atlas construction
- Statistical analysis
Experimental Results

- We initially applied the proposed framework to:
  5 squeezes from five inscribed fragments (archaeological site of Epidauros)
Experimental Results

- Example of the two scanned images:
Experimental Results

- Example of the two scanned images:
Experimental Results

- Example of the two scanned images:
Experimental Results

- Example of the two scanned images:
Experimental Results

- Example of the 3D reconstruction
Experimental Results

- Example of the 3D reconstruction
Experimental Results

- Example of the 3D reconstruction
Experimental Results

- Example of the 3D reconstruction
Experimental Results

- Example of the 3D reconstruction

Details from the reconstructed surfaces
Experimental Results

- Examples of letter segmentation
Experimental Results

- Examples of letter grouping
Experimental Results

- Dendrogram of ‘epsilon’

Notice line extensions in the average image.

Notice a small group in the dendrogram with two ‘epsilon’ whose middle line is not touching the vertical one.

No other significant sub-groups were formed.
Experimental Results

- Dendrogram of ‘alpha’

Look at the shape of the computed average.

No significant sub-groups were formed.
Experimental Results

- Dendrogram of ‘sigma’

Look at the shape of the computed average.

No significant sub-groups were formed.
Experimental Results

- Dendrogram of ‘upsilon’

Look at the shape of the computed average.

No significant sub-groups were formed.
[θεοῖς παίσι]
{lacuna}²
[--- --- ---- --]υρί μηλ...α
[--- --- ---]νι Διός μεγίστου
[--- --- ---]γον Βρόμιον τε
χορευτάν
.....12..... Ἡ δُ' Ἀσκλαπιῶν υψήλης
翟[κτα]
[διοσ]ῶς τε καλείτε Διοσκόρους]
[σ]εμνάς τε
[Χάρ]ίτας εὐκλεεώς τε Μοίσιως]
DEA Demo
**Marble relief of a horseman**

**Description:** This relief of a galloping horse with a nude rider is a tour de force of almost excessively sensitive surface texture and exaggerated anatomical detail. Decorative showiness takes precedence over organic unity, in a style often found in classical works of the 1st century B.C. The piece may copy one that was well-known in antiquity, for two others are preserved that show an almost identical horseman followed by another rider on a horse with the same pacing gait.

**Date:** 1st century B.C.

**Period:** Hellenistic

**Culture:** Greek

**Material:** Marble, Parian

**Height:** 45.7 cm

**Present location:** Metropolitan Museum of Art

**Credit:** Rogers Fund, 1907

**Metropolitan Museum of Art ID:** 07.286.111

**metmuseum.org ID:** 130008463

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Conclusions

Advantages:
- Convert paper squeezes into a digital format
- Easy copy and distribution of the squeezes
- Create libraries of 3D squeezes
- Use different viewing angles and shadings
- Compare letters and compute statistics

Drawbacks:
- Some details of the inscriptions are not captured by the squeezes, such as depth.
- Very large squeezes are hard to be scanned.
An efficient approach to performing 3D reconstruction and analysis

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Databases of Archaeological Artifacts

- The Louvre Museum
- The British Museum
- CLAROS, University of Oxford
- The Google Art Project
Digital Archaeology

Digital Epigraphy and Archaeology Project
Digital Worlds Institute and Dept. of Classics, UF
Tampa Museum of Art
Digital Archaeology
Seal of the University of Leipzig
Future Directions
Future Directions
Thank you
- http://www.digitalworlds.ufl.edu/angelos/lab/DEA/
- http://www.digitalworlds.ufl.edu/angelos/lab/DEA/museum/