Computerized classification of large ceramic assemblages

A quantitative basis for relative chronology

Avshalom Karasik

The Computerized Archaeological Laboratory;
Hebrew University of Jerusalem
Who are we?

Uzy Smilansky
Leore Grosman
Avshalom Karasik
Ilan Sharon
Talia Goldman
Ortal Haroch
"Pottery is, however, the greatest resource of the archaeologist. For variety of form and texture, for decoration, for rapid change, for its quick fall into oblivion, and for its incomparable abundance, it is in every respect the most important material for study, and it constitutes the essential alphabet of archaeology in every land.

...to tie together sequences found at related sites in a region to form a master chronological sequence. This would enable any absolute dates determined from one site (for example through inscriptions, documentary evidence, and so on) to be transferred to other sites in the master sequence”

F. Petrie 1904
"Pottery is, however, the greatest resource of the archaeologist. For variety of form and texture, for decoration, for rapid change, for its quick fall into oblivion, and for its incomparable abundance, it is in every respect the most important material for study, and it constitutes the essential alphabet of archaeology in every land.

...to tie together sequences found at related sites in a region to form a master chronological sequence. This would enable any absolute dates determined from one site (for example through inscriptions, documentary evidence, and so on) to be transferred to other sites in the master sequence”

F. Petrie 1904
A Test Case – Torpedo Storage Jars

The assemblage: Torpedo storage jars from Hazor (53) and Tyre (24), that have been already discussed in the literature in regards to their similarity and its historical consequences.

The word of the Lord came to me: 2 Now you, mortal, raise a lamentation over Tyre, 3 and say to Tyre, which sits at the entrance to the sea, merchant of the peoples on many coastlands, Thus says the Lord God: O Tyre, you have said, ‘I am perfect in beauty.’ … 17 Judah and the land of Israel traded with you; they exchanged for your merchandise wheat from Minnith, millet, * honey, oil, and balm.

Ezekiel 27
A Test Case – Torpedo Storage Jars

A correlation matrix

Jar Index

Jar Index

Hazor

Tyre
A Test Case – Torpedo Storage Jars

- Tyre
- Hazor
A Test Case – Torpedo Storage Jars: Conclusions

• There is a significant morphological difference between the jars from Tyre and those from Hazor.

• Any theory that describes the commercial connections between the two sites based on the similarity of the jars must explain this independent dichotomy.

• For instance: it is possible that the differences are due to the fact that the two assemblages were drawn by two different draftspersons.

• The archaeological publications must progress to automatic digital documentation of ceramic.
High precision data acquisition using 3D scanners.
We have developed an innovative algorithm which automatically finds the symmetry axis of pottery fragments and extracts their profiles.
Final products – automatically produced print quality drawings
Final products – automatically produced print quality drawings with colored views
Automatic classification and typology of ceramic fragments

Parametrization of profiles:

\( s \) : Archlength measured from the top of the rim
\( x(s) \) : Distance from the symmetry axis (local radius at \( s \))
\( \theta(s) \) : Tangent angle
\( \kappa(s) \) : Curvature \( = \frac{d\theta}{ds} \).
Automatic classification and typology

[Graphs showing various metrics such as Arc-length, Radius, Tangent, Curvature, plotted against Arc-length.]
Automatic classification and typology

![Graphs showing various parameters such as radius, tangent, and curvature along the arc-length.](image-url)
Automatic classification and typology
Automatic classification and typology
Automatic classification and typology

Distance Matrix
Primary clustering:
Example: 755 Iron-age fragments from area G in Tel-Dor (Israel)
Detailed clustering:
Example: 380 Iron-age fragments from area G in Tel-Dor (Israel), that were already analyzed by Ayelet Gilboa (Haifa University).
Detailed clustering:
Example: 380 Iron-age fragments from area G in Tel-Dor (Israel), that were already analyzed by Ayelet Gilboa (Haifa University).

The 300 subtypes
Detailed clustering:
Example: 380 Iron-age fragments from area G in Tel-Dor (Israel), that were already analyzed by Ayelet Gilboa (Haifa University).
Discriminant Analysis of the results

[Diagram showing discriminant analysis results with axes labeled as Original type-codes and DA labeling.]
High resolution typology

Kefar Hananya: Late Hellenistic - early Roman pottery production center. Can one distinguish systematic style variations between different workshops in the same village?

In collaboration with Prof. David Adan-Bayewich (Bar Ilan University)
High resolution typology

E1 bowls

Main excavation area
Square O4

Cluster height
Discriminant Analysis

Chemical analysis
10 element abundances measured by neutron activation and high-precision X-ray fluorescence analyses

Shape analysis
Summary and Conclusions

This presentation describes a novel method for computerized ceramic typology and classification which is based on a numeric distance function between three mathematical representations of the profile.

Automatic classification can follow the traditional archaeological concepts of typological classification and even improve its resolution.

The classification procedure is fast, objective, reproducible and has no bias from subjective judgments.

Computerized classification of large ceramic assemblages can and should serve as a quantitative basis for relative chronology.
Thank you for your attention!