Reconstructing Pompeian Households

David Mimno
Department of Computer Science
University of Massachusetts, Amherst
Amherst, MA 01003
mimno@cs.umass.edu

Abstract

A database of objects discovered in houses in the Roman city of Pompeii provides a unique view of ordinary life in an ancient city. Experts have used this collection to study the structure of Roman households, exploring the distribution and variability of tasks in architectural spaces, but such approaches are necessarily affected by modern cultural assumptions. In this study we present a data-driven approach to household archeology, treating it as an unsupervised labeling problem, that attempts to provide a more objective complement to human interpretation.

1 Introduction

Over the past century the goal of archeology has shifted from finding objects of artistic value to reconstructing the details of day-to-day life in ancient cultures. Reconstructing daily life is difficult as the evidence that would be useful was generally considered commonplace and unworthy of preservation by people at the time. Objects are gradually moved or disposed of; structures are renovated, repurposed or recycled for building materials. These ongoing processes make it difficult to make statements about specific points in time based on material evidence. A remarkable exception to this pattern is the Roman city of Pompeii in southern Italy, which was was covered in volcanic ash during the eruption of Mt. Vesuvius in 79 AD. As a result of its sudden, violent destruction, many aspects of day-to-day life in first-century Roman Italy were preserved in place as they existed at a specific moment in time.

The study of Pompeian households has until recently been dominated by analyses of architectural patterns and wall paintings, as these are easily available for study. Only in the past few years has a database of objects, which are removed for conservation immediately upon excavation, been compiled and made available by Allison [1]. This database, which is available online,[1] contains more than 6000 artifact records for finds in 30 architecturally similar "atrium-style" houses in Pompeii. Artifacts are annotated with one of 240 typological categories (coin, amphora, etc.) and which of the 574 rooms they were found in. Allison has used data about artifacts in their original context to challenge many common assumptions about the function of particular types of object, the use of particular spaces, and the consistency of patterns of use across different houses.

The relatively large amount of archeological information compiled in the Pompeian households database supports the application of statistical data mining tools. In this paper we apply one such tool, statistical topic modeling [2], in which rooms are modeled as having mixtures of functions, and functions are modeled as distributions over a "vocabulary" of object types. The purpose of this study is not to show that topic modeling is the best tool for archeological investigation, but that it is an appropriate tool that can provide a complement to human analysis. To this aim, we attempt to provide a perspective on several issues raised by Allison, that is, if not unbiased, then at least mathematically concrete in its biases.

[1] http://www.stoa.org/projects/ph/home

2 Context-driven estimation of artifact function

When artifacts are excavated, standard archeological practice involves removing them to secure storage for preservation. Although the location of artifacts is carefully noted in modern scientific digs, artifacts in storage tend to be analyzed in comparison to typologically similar objects rather than within their original context. As a result, questions about the use or function of particular artifact types have been based more on fairly arbitrary tradition and researchers' perceptions of what an artifact is reminiscent of than the types of objects found with the object. For example, Allison identifies two classes of artifact, the *casseruola* ("casserole dish") and *forma di pasticceria* ("pastry mold"), that were named based on similarities to 19th century household objects. She cites research going back more than 100 years suggesting that these items were not used in food preparation contexts, but finds that contemporary scholars still make this assumption due to their (modern) names.

In order to reduce bias of this kind, we explore the function of these artifact types using only cooccurrence data, without any reference to the actual typology of the objects. We reduce all 240 object descriptions to integers, and then apply a statistical topic model to detect clusters of object cooccurrence that may indicate functions. Note that we are still completely dependent on experts to classify physical objects into appropriate categories, but given those classifications we make no further archeological assumptions in training the model.

Table 2 shows object distributions from a single model with 20 "topics" or "functional groups." Functional groups are presented in descending order by average number of artifacts in left to right order. We train the model using Gibbs sampling, with 50,000 iterations, saving samples every 200 iterations.

Intuitively, if two objects share a similar pattern of use, they should both have reasonably high probability in one or more "topic". Given a model, we can evaluate the probability that two object types x and y will be produced by the same functional group, marginalized over functions, as $P(x, y) = \sum_t P(t)P(x \mid t)P(y \mid t)$, where $P(t)$ is proportional to the average number of tokens assigned to functional group t and $P(x \mid t)$ is proportional to the average number of objects of type x assigned to functional group t. Table 1 shows results for the two types mentioned previously. There is little to no connection to food preparation objects, supporting Allison's claim that modern names for these items are incorrect.

Table 1: Joint probability of two controversial object types with other object types. Objects most likely to occur with *bronze casseruola*, marginalized over 20 functional groups ("topics") are shown on the left: the first item solidly associated with food preparation is well down the list. Similarly, objects likely to occur with a *forma di pasticceria* are shown on the right, again showing no significant connection to food preparation.

	bronze casseruola
0.00036	door/chest/cupboard fitting
0.00035	glass bottle/flask/pyxis
0.00028	small glass bottle
0.00026	pottery jug
0.00024	bronze jug/jug fragment
0.00022	chest/cupboard fitting
0.00020	ceramic lamp
0.00018	jewelry
0.00016	pottery beaker/small vase
0.00015	coin
0.00013	pottery pot
	...
0.00010	table/table fittings/table base
0.00010	pottery jar/vase
0.00010	**bronze cooking pot/basin/pot/fragment**

(a)

	silver vessel/forma di pasticceria
0.00008	jewelry
0.00004	silver cup/bowl/cup fragment
0.00004	chest/cupboard fitting
0.00004	silver patera/casseruola/plate
0.00003	casket fitting
0.00002	coin
0.00002	bronze jug/jug fragment
0.00002	door/chest/cupboard fitting
0.00002	bronze or silver spoon
0.00002	chest fitting
0.00001	box/casket
0.00001	part of coin hoard
0.00001	small glass bottle
0.00001	hair pin
0.00001	ceramic lamp

(b)

Table 2: 20 “topics” derived from objects (tokens) in rooms (documents) in Pompeian households.

0.212	coin	0.193	door/chest/cupboard fitting
0.086	ceramic lamp	0.088	chest/cupboard fitting
0.070	small glass bottle	0.067	ring
0.061	door/chest/cupboard fitting	0.062	coin
0.058	jewelry	0.057	weights
0.033	architectural fitting	0.054	nail
0.165	pottery amphora/amphoretta/hydria	0.566	chest/cupboard fitting
0.120	pottery amphora fragment/lid	0.046	glass bottle/flask/pyxis
0.103	unidentified pottery vessel	0.043	chest/cista
0.095	nail	0.038	chest fitting
0.086	pottery jar/vase	0.028	cupboard
0.061	ceramic lamp	0.021	scales
0.194	glass bottle/flask/pyxis	0.142	pottery jug
0.116	small glass bottle	0.090	pottery pot
0.060	glass beaker/cup	0.069	ceramic lamp
0.055	small glass jar/vase	0.048	terra sigillata bowl/cup
0.054	jewelry	0.039	pottery cup/small bowl
0.042	small bronze/wooden container	0.035	bronze casseruola
0.184	pottery amphora/amphoretta/hydria	0.161	recess
0.126	building material	0.120	niche
0.106	stairway	0.118	hearth/focolare
0.076	impluvium/compluvium	0.114	latrine
0.060	puteal/puteal fragment	0.093	stairway
0.051	table/table fittings/table base	0.071	drain/pipe/tap/cess pit
0.176	bronze jug/jug fragment	0.323	part of coin hoard
0.070	bronze/iron lamp/base/fragment	0.212	jewelry
0.068	lampstand/lampstand fragment/candelabrum	0.205	human skeleton
0.047	bronze casseruola	0.028	architectural door fitting
0.043	amphora	0.019	bed/couch
0.037	bronze serpent-handled basin	0.017	bag
0.403	architectural door fitting	0.359	large sculpture/sculpture fragment
0.376	door/chest/cupboard fitting	0.073	fixed statue base
0.031	chest/cupboard fitting	0.068	fountain/fountain fitting
0.023	fixed seat	0.059	marble or stone basin
0.020	key	0.056	marble base/statue base/basin base
0.018	nail	0.048	table/table fittings/table base
0.368	ceramic lamp	0.199	jewelry
0.053	small glass bottle	0.113	silver cup/bowl/cup fragment
0.052	weights	0.102	silver patera/casseruola/plate/plate fragment
0.049	other statuary/sculpture/fragments	0.071	casket fitting
0.048	pottery beaker/small vase	0.045	chest/cupboard fitting
0.036	glass plate/tray	0.041	bronze or silver spoon
0.424	bed/couch fragment	0.137	pottery jar/vase
0.068	large sculpture/sculpture fragment	0.136	bronze cooking pot/basin/pot/fragment
0.062	bed/couch	0.066	hearth/focolare
0.061	marble slab/tondo/decorated fragment	0.066	tripod
0.031	door/chest/cupboard fitting	0.065	pottery basin/krater
0.024	pottery amphora/amphoretta/hydria	0.064	pottery large bowl
0.288	cupboard fitting	0.745	shelving/mezzanine/suspension nails
0.085	chest/cupboard fitting	0.024	recess
0.085	miscellaneous metal object	0.021	pottery amphora/amphoretta/hydria
0.075	cupboard	0.013	pottery pot
0.064	unidentified furniture	0.007	built-in cupboard
0.047	glass jar/vase	0.007	bronze/iron lamp/base/fragment
0.076	measuring equipment	0.355	vehicle fragment
0.050	iron or lead strip	0.309	harness
0.043	chisel	0.065	pendant
0.034	pick/pickaxe	0.029	coin
0.033	bone fitting/strip	0.022	cart/wagon
0.033	hook or knife	0.015	small glass bottle

3 Modeling room functions

The Roman houses included in the database show strong architectural patterns. The street entrance usually opens onto an large room with an opening in the roof. This "atrium" connects to an open garden area. Both large rooms are surrounded by smaller rooms. Much of the study of Pompeian households has involved identifying categories of rooms and assigning functions to them. Again, Allison argues that commonly held assumptions about such functions are incorrect. For example, the atrium is generally described as a formal space, in which the *pater familias* received his clients and distributed gifts from a large metal chest. Allison argues that the atrium was more of a utilitarian, industrial space. Similarly, a closed room off the atrium is usually described as a *cubiculum* ("bedroom"), but there is little evidence that these rooms correspond to modern concepts of bedrooms.

Before using an analysis of objects to provide information about the function of spaces, it is important to establish whether architectural room types have consistent patterns of object contents. The city suffered a severe earthquake 17 years before the final eruption, and was disrupted before and after the eruption. We use a likelihood ratio test to compare the hypothesis that the contents of all rooms of a particular architectural type are drawn from a single multinomial distribution over functional groups against the hypothesis that each room has its own multinomial. The log of this likelihood ratio is positive, indicating support for the "single multinomial" hypothesis, for rooms with clear functions such as entryways, kitchens, and bath complexes. The log ratio is most negative, indicating greater variability, for the atrium and garden areas. These results suggest that we should be careful in drawing conclusions. In addition, we applied a Dirichlet process clustering algorithm but did not find consistent clusters.

We can, however, attempt to rule out certain possibilities. Table 3 shows probable functional groups for several architectural types. Atria show evidence of utilitarian storage: large ceramic amphorae. The only type that shows significant evidence of objects related to bedding is type 11 (large open rooms with views of the garden); the cubiculum does not.

Table 3: Distributions of functional groups in common room types

	Type 3 (atrium)
0.279	pottery amphora/amphoretta/hydria, building material, stairway, impluvium/compluvium, puteal/puteal fragment
0.108	chest/cupboard fitting, chest/cista, glass bottle/flask/pyxis, chest fitting, cupboard
0.083	coin, ceramic lamp, small glass bottle, architectural fitting, jewelry
0.077	pottery jug, ceramic lamp, table/table fittings/table base, terra sigillata bowl/cup, seashell/conch/snail shell
	Type 4 (cubiculum)
0.122	recess, built-in cupboard, stairway, niche, unidentified fixture/mound
0.116	shelving/mezzanine/suspension nails, recess, pottery amphora/amphoretta/hydria, cistern head, pottery pot
0.092	coin, ceramic lamp, small glass bottle, architectural fitting, jewelry
0.065	pottery jug, pottery amphora/amphoretta/hydria, pottery pot, pottery jar/vase, pottery plate/dish/tray
	Type 11 (exedra, oecus, triclinium)
0.111	door/chest/cupboard fitting, coin, ring, chest/cupboard fitting, nail
0.109	recess, built-in cupboard, stairway, niche, unidentified fixture/mound
0.080	bed/couch fragment, door/chest/cupboard fitting, large sculpture/sculpture fragment, architectural door fitting, bed/couch
0.058	human skeleton, jewelry, part of coin hoard, bed/couch, bag

References

[1] P. Allison. *Pompeian households: an analysis of the material culture*. Cotsen Institute of Archaeology, 2001.

[2] D. Blei, A. Ng, and M. Jordan. Latent Dirichlet allocation. *JMLR*, 2003.