

The ArchAIDE Project: results and perspectives after the first year

F. Banterle¹, M. Dellepiane^{†1}, T. Evans², G. Gattiglia³, B. Itkin⁴, and M. Zallocco⁵

¹ Visual Computing Laboratory, ISTI-CNR, Pisa, Italy, ² Archeological Data Service, University of York, UK

³ Dipartimento di Civiltà e Forme del Sapere, University of Pisa, Italy

⁴ Blavatnik School of Computer Science, Tel Aviv University, Tel Aviv, Israel, ⁵ Inera S.r.l., Pisa, Italy

Abstract

The ArchAIDE project is a Horizon 2020 project that has the main goal to digitally support the day-to-day operations on the field of archaeologists. This allows them to reduce time and costs of delivering an accurate and quick classification of ancient pottery artifacts.

To effectively reach such ambitious goal, the project has several sub-goals: (semi-)automatic digitalization of archaeological catalogs, a mobile app to be used on site for live classification of sherds with the generation of a complete potsherds identity card (ready for print), and an on-line database with real-time visualization of data.

In this paper, we describe the work carried out during the first year of life of this project. The main focus is on the procedure for digitizing paper catalogs in an automatic way, and more precisely we will discuss: archeologist's methodologies, digitalization of text, vectorization of technical drawings, and shape-based classification of virtual fragments.

CCS Concepts

•Computing methodologies → Image processing; Graphics systems and interfaces; Machine learning approaches; •Information systems → Data management systems;

1. Introduction

The classification of pottery sherds is an extremely important task to understand vessels production, trade, socio-economics relationships, etc. However, archaeologists need an intensive training to learn required skills to properly inspect and interpret ancient sherds. Moreover, the classification activity takes a lot of time. This means that, especially in the context of rescue archeology, the work of classification and documentation of findings is not always completed.

The main goal of the ArchAIDE project is to provide tools to assist the archaeologists during their work on-site and off-site, in order to be supported during the classification and documentation phases. This has to be achieved without impacting on the consolidated workflow, and possibly using off-the-shelf hardware.

Pottery classification is an issue that has been already taken into account by Computer Graphics in the past. Nevertheless, almost all the approaches are based on a 3D representation of sherds, usually obtained with 3D scanning devices. 3D acquisition proved to be hard to obtain on-site, even using multi-view stereo matching approaches. Automated systems to collect and compare data have been proposed as well [KS06, Kar10]. However, their use is limited by the lack of standardization of typology definition and by the heterogeneity of input data.

In any case, most of the approaches have been based on the analysis and comparison of profiles [KS02, GKSS04, MG05], which have to be extracted from the 3D model of the sherd. Only recently, texture and color have been taken into account [MD13].

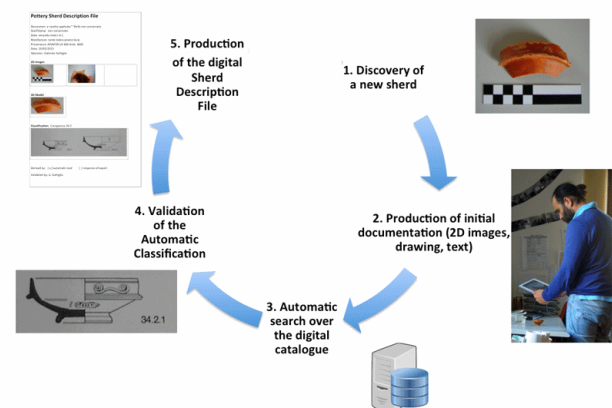


Figure 1: The ArchAIDE system pipeline

The ArchAIDE pipeline is shown in Figure 1: the classification will be obtained starting from images taken by archaeologists on-

[†] matteo.dellepiane@isti.cnr.it

site, and using different possible means, including the shape and the appearance. The whole system is supported by a database that contains both the description of the reference types (digitized starting from the reference paper catalogs), and a description of all the already classified and documented sherds. The database will be used by the classification algorithms, that will use the reference types information.

In this paper, we describe the current state of the project after a year of intense work. The main achieved goals are:

- A thorough discussion about the archaeological methodologies (on the field and in the laboratory) to assess the class of a pottery sherds;
- The definition of the common database to be employed for the project;
- A web-based tool for digitizing text from catalogs using the state-of-the-art in OCR;
- A tool for vectorizing technical drawings from catalogs using novel tracing algorithms;
- The initial population of the database;
- A tool for generating 3D models from vectorized technical drawings and a full pipeline for breaking 3D models using a 3D modeling environment.

2. Interviewing Archaeologists: Methodologies and choices

The first effort of the project was to put together all the partners in order to find a way to map the current workflow of archaeologists in an automated system.

Typically, archaeologists spend most of their time to carefully unearth and brush ancient artifacts during an excavation. Little time is left for the classification of such artifacts (i.e., fragments or sherds) that is typically carried out in a laboratory after a further washing step. Moreover, to classify a pottery sherd on the field, archaeologists have the need to properly understand the shape of it, its original orientation (i.e., rotation axis), etc. Then, they have to retrieve the class of the found artifact from a catalog. However, several catalogs may be needed to be employed due to the fact that in the same geographical site several classes may be present. Finally, a description (type of class, location, estimated period, etc.) of the sherd must be compiled. All these steps make the whole process time consuming and cumbersome.

Hence, we realized that the first goals of the project were to:

- select a few typologies of pottery and define a minimal subset of fields to describe a type;
- define which are the shape and appearance characteristics that can be extracted from paper catalogs, acquired on-site using a mobile-based tool, and used by a classification system;
- eliminate the heterogeneity of the paper catalogs by building a common database of references;

Three typologies of pottery were selected: *Roman Amphorae*, *Terra Sigillata*, and Medieval Pottery. The choice of these typologies was intended to account for several important features for classification: shape, decoration, stamps, and fabric. A subset of the fields used for the typologies was selected to provide a description of types for the ArchAide database.

Additionally, in order to implement the shape classification system, we needed to understand which are the key geometric features

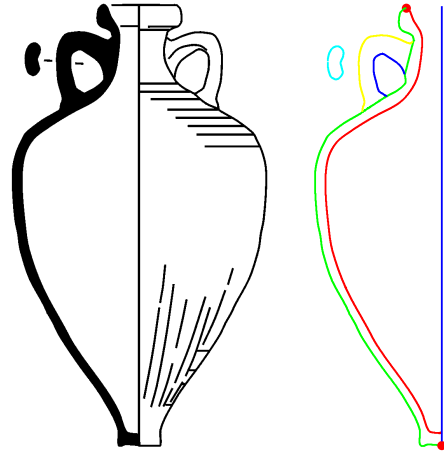


Figure 2: Features extractions from technical drawings: On the left side, the input drawing. On the right side, the vectorization of the input drawing with separated features.

that define a class. After long discussions with the archaeological partners, we selected seven features that are extremely important to classify pottery by shape (see Figure 2):

- *Outer profile* – green outline in figure.
- *Inner profile* – red outline in figure.
- *Handle outer profile* (if present) – yellow outline in figure.
- *Handle inner profile* (if present) – blue outline in figure.
- *Handle section* (if present) – cyan outline in figure.
- *Rim point*: the top point in the profile.
- *Base point*: the bottom point in the profile.
- *Scale factor*: the scaling value to bring all features to real scale.

All these features may be extracted not only from the drawings of the paper catalog (see next Section), but possibly also from images acquired on-site: Figure 3 shows a first prototype of an interface to extract profiles from an image of a sherd.

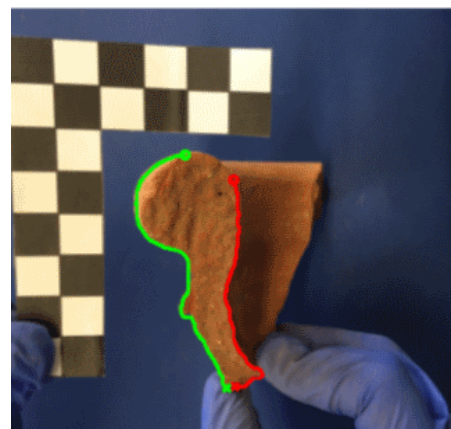


Figure 3: An example of profile extraction from acquired image.

3. Database: Text and Drawings Digitization

The classification and documentation system must be based on a reference database. Hence, starting from a page scan, by using simple heuristics and image processing, we can isolate and extract the drawings and the main parts of the text.

The extraction of text. A tool based on available Javascript OCR (Tesseract OCR [Smi07]) parses text from the page and returns lots of structural information such as lines and paragraphs. From these, we can isolate the different sections and formatting elements. Following the structure of the pottery type description used in the specific catalog, we extract the metadata. We can convert the page image chunks/columns into text. Then, we parse these data to create an information card. The drawings are cropped and further processed to extract the key features.

The extraction of technical drawings. This process relies on image processing techniques: the features presented in previous section are extracted using tracing methods, and they are then stored into an SVG file, which is annotated with semantic information. We use the profile to create a 3D model representing the pottery type. As the main body of most pottery is just a rotational object, we can easily create it by sweeping the profile around its axis. The handles are generated separately, extruding their cross-section along their profile, and then welding them to the main body geometry. The result is a watertight, single-surface, triangulated 3D mesh. Additional detail on the drawings processing can be found in [BID*17].

Figure 4 shows some results of this process. We believe that including both a 2D vectorial representation and a 3D model in the database is essential to cover all different needs of different communities. Even though archaeologists are the main target users for the database, these semantic-rich geometric representations may also be exploited by other communities for visual computing purposes.

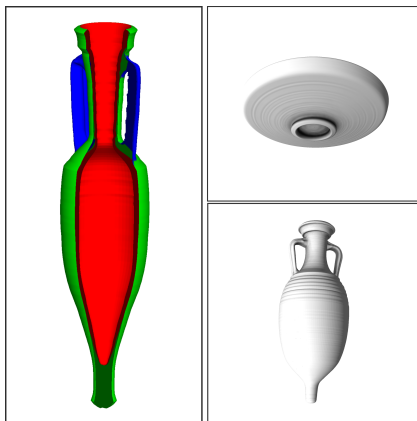


Figure 4: Three examples of 3D models generated from catalog drawings.

The database population. We have been filling a significant part of the database from existing archives provided by the project partners. We have migrated the data using JSON XML or directly with SQL queries. Other catalogs may need a semi-manual or totally

manual intervention by users, using the OCR tools described above.

During the implementation and population of the database, we put a major effort on the visualization page associated to each pottery type. In addition to the availability for download of all the associated files, all the important information is directly visible for interactive navigation and visual inspection using 3DHOP [PCD*15] (a platform for publishing 3D data on the web), that provides an interactive navigation of our records. A snapshot of a page describing a type is shown in Figure 5 [DCB*17].

4. Shape-based Classification: Virtual Fragmentation

One of the main issues in the implementation of the classification systems is the lack of training data: in order to build and train a classification system several thousands of examples are needed.

In order to overcome this problem, we decided to generate a training set by virtually “breaking” a 3D model into sherds. Using the “Cell Fracture” plug-in in Blender, it’s possible to generate an arbitrary amount of sherds that can be used to train and test a classification system (see Figure 6). Since the 3D models used are the ones extracted from drawings, also the shape features needed for classification (i.e. internal and external profile) can be extracted automatically. The classification system will be then refined with a number of real examples, that the partners of the project are currently producing.

5. Conclusions

This paper briefly presented some of the outcomes of the first year of work of the ArchAIDE project, which brought to a first important result: the creation a coherent database of types of pottery, which includes the information from the main paper catalogs for every pottery typology selected for the project. We aim at making the database available to the community, so that it may be used not only for archaeological purposes, but for any other use by other communities (i.e., 3D shape matching and retrieval).

Several tools dedicated to the automatic population of the database were created. The database will be the key component of several classification components, which are currently under implementation. The shape-based classification system uses the generated 3D models to train and test performances.

In the second part of the ArchAIDE project, the mobile and desktop app for the classification and documentation of sherds will be implemented and tested. The app will integrate the database and the classification components (including an appearance-based classification tool) that are currently under implementation and testing.

Acknowledgements

The research leading to this paper results has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 693548 (project ArchAIDE).

References

- [BID*17] BANTERLE F., ITKIN B., DELLEPIANE M., WOLF L., CALIERI M., DERSHOWITZ N., SCOPIGNO R.: Vasesketch: Automatic 3d

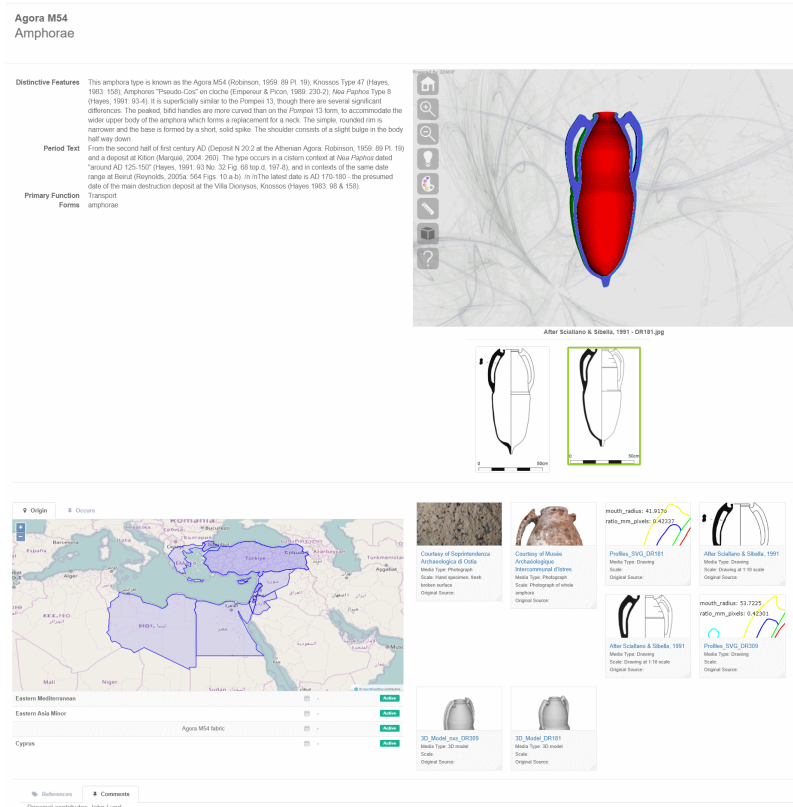


Figure 5: A snapshot of a page of the Database, showing the information associate to an Amphora type.

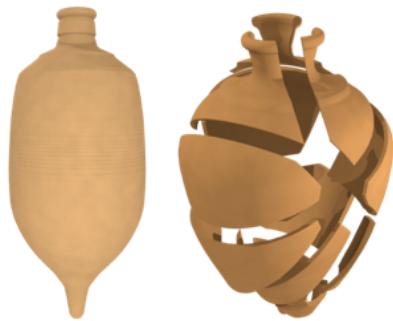


Figure 6: Virtual Fracture: On the left side, a 3D model of a vessel. On the right side, a virtually broken 3D model using the proposed pipeline.

representation of pottery classes from paper catalogue drawings. In *The 14th IAPR International Conference on Document Analysis and Recognition (ICDAR2017)* (Kyoto, Japan, November 2017). 3

[DCB*17] DELLEPIANE M., CALLIERI M., BANTERLE F., ARENGA D., ZALLOCCO M., SCOPIGNO R.: From paper to web: automatic generation of a web-accessible 3d repository of pottery types. In *GCH 2017 - Eurographics Workshop on Graphics and Cultural Heritage* (September 2017), Eurographics, (Ed.). 3

[GKSS04] GILBOA A., KARASIK A., SHARON I., SMLANSKY U.: Towards computerized typology and classification of ceramics. *Journal of Archaeological Science* 31, 6 (2004), 681 – 694. 1

[Kar10] KARASIK A.: A complete, automatic procedure for pottery documentation and analysis. In *IEEE Conference on Computer Vision and Pattern Recognition, CVPR Workshops (San Francisco, CA)* (June 2010), pp. 29–34. 1

[KS02] KAMPEL M., SABLATNIG R.: Automated segmentation of archaeological profiles for classification. In *Proc. of 16th International Conference on Pattern Recognition, Quebec City* (2002), vol. 1, IEEE Computer Society, pp. 57–60. 1

[KS06] KAMPEL M., SABLATNIG R.: *3D Data Retrieval of Archaeological Pottery*. Springer, Berlin, 2006, pp. 387–395. 1

[MD13] MAKRIDIS M., DARAS P.: Automatic classification of archaeological pottery sherds. *J. Comput. Cult. Herit.* 5, 4 (Jan. 2013), 15:1–15:21. 1

[MG05] MAIZA C., GAILDRAT V.: Automatic Classification of Archaeological Potsherds. In *The 8th International Conference on Computer Graphics and Artificial Intelligence, 3IA'2005, Limoges, France, 11/05/2005-12/05/2005* (<http://www.xlim.fr>, mai 2005), Dimitri P., (Ed.), Laboratoire XLIM - Universit   de Limoges, pp. 135–147. 1

[PCD*15] POTENZIANI M., CALLIERI M., DELLEPIANE M., CORSINI M., PONCHIO F., SCOPIGNO R.: 3dhop: 3d heritage online presenter. *Computer & Graphics* 52 (Nov 2015), 129–141. 3

[Smi07] SMITH R.: An overview of the tesseract ocr engine. In *Ninth International Conference on Document Analysis and Recognition (ICDAR 2007)* (Sept 2007), vol. 2, pp. 629–633. 3