Computer applications in archaeological pottery: a review and new perspectives

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Abstract

In previous years many publications about computer applications in the field of drawing, classification and analysis of archaeological pottery have been presented in different congress by different researchers.

This paper will review and analyze the most relevant works published until the moment. It will focuses on computer applications which oriented towards the graphical visualization and analysis of data relevant to archaeological pottery.

The intention is to order and systematize the previous mentioned pottery data and to review those publications which almost relevant to archaeological computerized systems.

This review and analysis will introduce the methodology that it is used in the CATA project (Archaeological Wheel Pottery of Andalusia in its acronyms in Spanish). The procedures used in the CATA project for the representation, archiving, analysis and retrieval of data concerning pottery vessels and their fragments.

The main aim of the CATA project is to provide a scientific tool for the analysis of pottery findings in the geographical area of oriental Andalusia. These findings will be introduced into a database with documentational and graphical capabilities for visualizing pottery fragments and vessels. The objective is to create a generalize tool which can be applied to any kind of ceramic founded in any geographical location.

Keywords: Archaeological pottery - Review- Methodology

I. Introduction

Pottery material tends to be the most abundant type of archaeological finding. The study of these materials is key elements in understanding the level of sociological development of a definite culture and often is useful in determining the functional uses of the areas in which they are found.

The classification of pottery findings must first be described according to manual drawings. The presently used procedures give rise to the need of new methods for documentation, classification and analysis of archaeological pottery findings.

This paper will deal with the methods that different publications have introduced for automated representation, reconstruction, classification and archive of archaeological pottery findings.

II. Drawing and representation of pottery shapes

Archaeological understanding of pottery material has largely been based on the graphical representation of findings. This representation has allowed the possibility of obtaining data and logical results as a previous step towards a more concrete knowledge in any field which concerns archaeological studies.

The basis of archaeological drawing radicates in the extraction of a complete profile from a collection of shapes or the extraction of this same profile from complete vessels. The profile permits the reconstruction of complete pots by rotating this profile 360º.

Traditionally a template is used to graphically describe the profile and caliper is used to measure the thickness of various points in the profile. The angular orientation of the profile is calculated in a manual way.

Concerning the work centered on the rotational evaluation of pottery profile fragments the following efforts should be noted: Halir and Flusser [HF97] proposed a method where by 2.5D representation of a pot can be reconstructed based on the symmetric nature of manufacturing pottery which is created by a potter's wheel. A fundamental prerequisite is the correct orientation of the shapes before a volumetric representation can be generated. The idea of this process is that of a properly oriented sherd the intersection of the sherd's surface with the projected laser plane should form a circular arc.

In recent years Willis, Orriols and Cooper [WOC03] have further developed the analysis of pottery profiles to create an algebraic model capable of generating a 3D surface area representation of pottery vessel shapes.

Other approaches whose principal aim is to generate a 3D model of vessels from shapes [CM02] are based on the estimation of spheres and curvatures, assuming that for each point of the surface, the center of the sphere of principal curvature corresponding to the circles of revolution on the symmetric axis and in the methodology of the Hugh transformations.

Finally, the use of genetic algorithms is used to determine the correct axial angle of an orientation of a shape in order to extract a vessel profile [MTL03]. This system uses the current archaeological methodology of registering profile parameters (shape orientation, diametric measurement, profile generation, fragment graphic representation and other additional measurements). The use of genetic algorithms permits the addition of flexible data which adapts to the imperfections caused by the digitalization of pottery objects.

Recently, a new software called Profile Analysis Tool (PAT) has been developed to enhance the graphical drawing of pottery [LMM*06]. This system permits the extraction of a profile and shapes based on a 3D model. In general terms, the system does the following: creates a 3D matrix surface area, orients the fragment or vessel, generates the profile and semi-automatically estimates profile with measurements. This system is very efficient in alleviating all the manual steps necessary before a pottery artefact can be introduced in a computerized system.

III. Vessel reconstruction and classification

3.1 Reconstruction

Other investigations are focused on the reconstruction of pottery vessels based on shapes. The techniques used to synthetically generate the complete vessel are based on algebraic models and applied algorithms.

One of the methods used is a jig-saw-puzzle approach based on fracture line coupling [KS04]. In contrast, a similar approach is to orient fracture lines using a Bayesians approximation of fracture line coupling orienting the shapes relative to the profile's rotational axis[CWA*02].

Another method uses a 2-step approach to solve the puzzle. Firstly, an algorithm is used to match sherd coupling points in a 2D space similar to the proposal of Leitao and Stolfi [LS02] [LS04] .Secondly, the previously mentioned 2D model is transformed into a 3D projection using synthetic virtual geometric learning processes in order to match fracture line borders [KK01].

3.2 Classification

Durham, Lewis and Shenan [DLS95] have proposed a 2 phase fragment classification system. First, the derived pottery image is analyzed and then static grouping techniques are used to create classes of images known as image clusters. This method permits the classification of pottery by geometric form similarity.

Smilansky, Karasik, Gilboa and Sharon [SKGS04] have proposed a computerized typological system in order to identify prototype vessels. This permits the observation of correlations amongst different pottery profiles.

Maiza and Gaildrat [MGO5] propose the use of an automated methodology to establish the relationship of relating a sherd to a known pottery vessel model. Using a genetic algorithm the probability that a shape belongs to a known type of vessel based on a reference model. Once the pottery vessel image is generated and reconstructed the similarity of the generated image is compared to other known images which enable the categorization and association of the vessel to a region or a given society.

One of the latest developments [BCT05] in the previously mentioned lines of investigation is the classification of pottery shapes using a combination of textures and colours. This procedure uses 5 vessels with a maximum similarity as a comparison point for the new vessel being compared. The precision of this method is 99% for entire pottery pieces and 70% for partial shapes.

IV. Information storage and Internet oriented query systems

During the 70's an increased focus occurred to find an adequate system to store and recuperate archaeological data, most of the efforts centered around computerized systems as applied to archaeological data. During this decade the most relevant works were those of Lengyel [Ley75] and Main [Mai78] which dealt with the storage and recuperation of archaeological data.

During the mid 80's, the ideas for the first techniques for computerizing pottery profiles were being developed by Hall and Laflin [HL84]. The main effort was focused on allowing the 3D modelling of pottery vessels and the storage of the data which compose these models in a compact and accessible way.

Others further developments in investigation occurred using the curvature of shapes and pottery vessels as a classification system for facilitating Internet oriented investigation.
At the beginning of the 90's, Lewis and Goodson [LG90] developed the Graphically Oriented Archaeological Database (GOAD project). The information base of this initiative included the storage of artefact text, graphics and images. This system focused mainly on the capabilities of storage, recuperation and global availability of archaeological information. Part of the importance of this project because it was one of the firsts to use Hugh transformations as a tool to couple and combine pottery forms.

In the mid 90's, Durham, Lewis and Shennan [DLS94] continued the above line of investigation with an artefact classification system called *Smart*. The system stores and uses information concerning textures as a comparison a method amongst vessels and shapes. Some of the results of this study are reduced query search times, that fixed scale and orientation should be used, and that the system should be extended to permit the coupling of objects based on visual and textural similarities.

Sablatnig and Menard [SM97] use a pottery classification system based on the attributes of the profile's curvature and the subdivision of the profile amongst base, rim and body. They also include in the categorization additives found in the clay, colour, decoration and other treatments. This analysis has two main objectives which are the reconstruction of the original vessel and a logical association of non associated shapes to types of "well known" pottery vessels which are stored in a database of known characteristics. The advantage of this approach is the reconstruction of entire vessels given few shapes and using partial information (rim, base,). A shape can be associated with a known type of pottery.

In this section, it should also be commented the role of information system data interchange protocols over the Internet. Extensible Mark up Language (XML) is playing a key role in facilitating the flow of archaeological data. XML permits a simple and effective manner of data interchange amongst heterogeneous databases in a reliable way.

Schurmans et al. [SRS*01] extract the geometric 2D and 3D characteristics of a pottery vessel for the classification of artefact forms and the later studying of uniformity and standarization of these forms. These forms are introduced into an extensible numeric library which references the previously mentioned geometries. This library is then exposed via Internet to researchers for investigation purposes. This technology allows the diffusion of both data and images using an XML schema. The external curvature of the vessel profiles are used as reference indexes for data retrieval purposes.

Liu et al. [LRS*05] also use geometric information derived from the curvature of the vessel profile to analyze pottery shapes. The information gained from the previous analysis is then available in an XML format and then exposed to the WWW for consulting and storage purposes.

V. Conclusions and future steps

As a common denominator in each of the steps concerning the study of archaeological pottery, it should be noted that 3D modelling of fragments and vessels constitutes a fundamental basis towards an objective and favourable systemization of pottery classification systems.

The above mentioned investigations demonstrate that in the field of archaeological investigation of pottery the collaboration between archaeologist and computer scientists permits the development of useful applications for drawing, classifying, storage and management of archaeological material and data. There is still the need for further development of information systems specifically target at using the full range of applied computation mathematics in archaeological pottery analysis.

The use of computational pottery systems exposed via Internet favors the unification and standarization of distinct applied methodologies. This is the reason why standarized archaeological data inter-change formats should be used and enforced for Internet knowledge base transactions.

CATA (Cérmica Aqrueológica a Torno de Andalucía): the project for "Andalusian Archaeological Wheel Pottery " is developing a methodology for the classification of pottery based on qualitative, quantitative, contextual and conservation metrics as a tool for further understanding of information provided by archaeological findings, and as a data interchange instrument.

The purpose of the project is to create an integrated system which contemplates the widest possible number of variables such as text, numeric, graphic (2D-3D) and geometric data applicable to the analysis of archaeological pottery. The orientation of the system will be open and easy to use for anyone who wishes to investigate archaeological Andalusian pottery using the Internet.

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