Definition and Construction of Parametric Archetypes of Archaeological Artefacts by means of CAD Techniques

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The present work represents a contribute to improve the classification and the recording techniques of archaeological artefacts. With a particular reference to the class of clay artefacts of Magna Grecia, a new method for the CAD representation of artefacts, based on the definition of 3D archetypes, has been developed. At first the method allows to use the same CAD archetype to build the virtual model of any type of artefacts, in particular of any vase with different shapes and dimensions; then, the method allows to upgrade the geometry of the model and to converge toward a representation of the real artefact more and more close to that experimentally obtained.

The proposed procedure is a valid substitute to the one, actually in use, to put the archetypes in the inventories that is essentially based on the manual development of the drawings through the use of shapes reproducing the object geometries. The great reduction of times in reproducing the artefact images and the possibility to operate classifications based on the similar geometric features used in the solid modelling activities, represent a reason of interest and of innovation for the Archaeology. These data can contribute to the solution of the problem of archaeological artefacts classification and recording.

The Sanctuary of Hera at River Sele Mouth: Typological Layout and Classification of the Black Varnish Pottery

"... beyond river Sele mouth, Lucania and the Sanctuary of Argive Hera, settled by Jason and nearby, 50 stadia far, Poseidonia..." (STRABO, Geography, VI, 1, 1). This way the Greek geographer Strabo, describing the Lucania district, mentions the Sanctuary of Argive Hera at river Sele mouth about 9 km far from Paestum, for many centuries one of the most important religious sites in Great Greece. In ancient times the river flow marked a natural boundary between the land occupied by Etruscan people settled in the Picentini Mountains area and the land where Greeks settled, at the beginning of VI century b.C., Poseidonia town and the Sanctuary of Hera at river Sele mouth. The river Sele area was initially sacralized through a mere altar made of earth and ashes. At the end of the V century b.C., Lucanians arrival brought drastic transformations: two new reception spaces and a squared building. After the latest roman era interventions and the successive neglecting, the sanctuary turned into a fenland.

In 1987, the Archaeological Bureau of Salerno, Avellino and Benevento Provinces starts up a new excavations season and a massive rearrangement work of these materials, coordinated by professor Giovanna Greco. A team of young archaeologists, first from University of Salerno and then from "Federico II" University of Naples, is given the exciting task to put in order what is left and reopen the famous cases; findings are still wrapped up in '30s and '50s newspapers or kept in tins and cigarette boxes, together with notes and lists drawn on bits of paper while excavating. The heap of objects is huge and a multitude of finding classes is identified:

Corinthian pottery, black-figure pottery, red-figure pottery, black varnish pottery, coroplastic. These findings, when their origin context can not be identified, have been rearranged in conformity with classes and organized according to a well structured typology. In this respect, particularly interesting is the study carried out on the black varnish pottery, which is one of the best supported classes within the Hera Argiva Sanctuary at river Sele mouth and attested by many thousands of fragments and hundreds of complete or restored items.

The significance of a typology arises from the necessity of creating logic series which, once chronologically organized, will allow the reconstruction of certain pottery productions, in order to define their specific peculiarities and identify their real characters. A typology is a fixed reference system and must be explanatory, descriptive and absolutely not interpretative. According to ceramist Ann Shepard (Shepard 1965), the study of vases shape can be faced from the aesthetic, functional or taxonomic point of view. In the first instance used criteria are too much subjective, in the second too much uncertain, therefore the most obvious approach is the geometric one. But even the geometric method offers a range of several possibilities resolving between two extreme solutions. The first one - not more than a mere procedure of first approximation - consists, for instance, of classifying truncoconical, bitrunconical, tritrunconical etc. shaped vases into different groups. The second one aims to decompose each vase, mainly its shape, into elements which can be codified and in case numbered through an analytic method. This last method has been followed by J.P. Morel in his "Céramique campanienne: les formes" (Morel 1981), a work that constitutes a turning point for the statement of black varnish studying and is not only an irreplaceable tool for this class settlement, but

above all a fundamental methodological base. The typology built by Morel, sole instance within classic pottery, lies on the hierarchisation at morphological level of evidences into categories, genres, species, series, types. Such system is an open one, that is any moment increasable thanks to several degrees of investigation allowing the insertion of new items into hierarchic groups. Therefore, this open method of classification allows not only a whole evidence arrangement without any forcing, thanks to the various hierarchic levels, but even a clarification and pointing out of significant similarities and differences.

Groups description constitutes the typology base, for its aim is reporting pertinent criteria - primary or secondary - opposing different groups within the given set (that is a hierarchically superior group). The preliminary definition of this set, itself a part of a superior one (and so on until the category, first subdivision within the set of black varnish pottery), let us forget repeating, for each constituent group, the elements that such group shares with the other groups in the set. For instance, the factor distinguishing each category from the others is the presence/absence of handles. But this is the only identifiable and absolutely definable characteristic; in fact the other levels - genre, species, series - are characterized and differentiated by formally dissimilar factors for each category. "Type" is instead a model shape which one or more "samples", associated by some morphological characteristics, have been related to: two vases will never be identical, but what matters is the ideal model followed by their creator. According to Morel, a typology's subject is then the items shape, while a classification consists of organizing items within classes, and a class is the set of technical characteristics associating vases created by the same workshop or by a group of similar workshops; consequently, class stands for Morel as production stands for other scholars. Following a precise theoretical choice in distinguishing types, he does not take into account either decorations or any other factor but morphological. In consequence, the whole typological system lies on the "similarity" criterion and consists of gathering morphologically similar vases or distinguishing them according to significant dissimilarities. Particularly relevant is calculating proportions, which can be extremely important and interesting in order to define a series within a site production and, above all, in the view of its formal and chronological evolution.

Therefore such a project, aiming to recreate the whole vase from the single fragment, can only arise the strongest interest in an archaeologist tempting to restore through traditional methods the shape of vases from fragments, in order to put them into a wider typology pursuing the reconstruction of production centres and historical contexts (Caputo 1999, Di Gironimo 2001, De Napoli 2001, VV.AA 2003).

DEFINITION OF DRAWING ARCHETYPES BELONGING TO CLASSES OF SELECTED ARTEFACTS

The classification of archaeological artefacts, that today is essentially based on the manual development of the drawings, can be improved thanks to the availability of parametric CAD systems. In fact, the use of CAD techniques and the

knowledge of significant geometric characteristics of the artefacts have induced to formulate a new method for the CAD definition of virtual archetypes representing classes of selected artefacts.

According to the present method the virtual archetypes have to satisfy two Functional Requirements. At first the possibility to use the same archetype to build the CAD models belonging to any type of artefacts, in particular of any vase with different shapes and dimensions. The variability taken into account is always related to that one of the black varnish pottery examined in the previous section of this paper. Besides, the choice of using a unique typology of archetype is related to the possibility to take full advantages of a parametric-variational CAD modeller (Patalano 2001).

The second Functional Requirement of the virtual archetypes consists in the possibility of upgrading the geometry of the model and converging toward a representation more and more close to that experimentally obtained. This requirement is related to the starting data set (clouds of points) necessary to build the CAD models, but also to the specific aim foreseen for the models. If the data acquisition from the archaeological finds is manual then the number of datum points is not so high. On the opposite, if it is possible to perform an automatic acquisition, a more detailed profile could be favourable. Finally, if the CAD model is due to perform a comparative evaluation between different reconstruction techniques is better to use the maximum level of detail; if the main goal is the visualisation and the model exchange by internet is better a lower level of detail with lighter files.

The first Functional Requirement implies the need of using reference planes, whose positions are modifiable, to locate the encumbrance of the artefact and the more significant geometries (the edge, the bottom, the foot). Therefore the dimensions used to locate the reference planes have to be taken into account during the CAD modelling of the archetypes.
The second Functional Requirement implies the need of using a set of datum points, whose number is modifiable, to "well represent" all the significant features of the artefact. This need imposes the use of a CAD tool that allows to change, in real time, the number of datum elements in use.

CONSTRUCTION OF THE ARCHETYPES BY MEANS OF A 3D PARAMETRIC MODELLER

The suggested construction of the CAD models foresees the creation of the principal datum planes corresponding to the longitudinal section plane and to the most significant features of the artefact: the top plane, the lower plane, the bottom plane, the foot plane and, finally, the edge plane. These planes are located from a reference depth conventionally established to the top plane. Then it is possible to create two series of initially equidistant datum points. The first series deals with the definition of the external profile of the meridian section; the second series with the internal one. The number of points depends on the availability of points coming from the acquisition of real artefacts. Two tables control the position of datum points through a couple of dimensions: the depth and the diameter of a datum circle. These tables can be filled in using text external files. The parametric characteri-

stic of the modeller in use allow to regenerate different CAD model through the changes of numeric values belonging to the tables.

Then the construction is increased through the profile sketching of the meridian section. The sketch uses spline curves passing through the existing datum points. A spline curve is a smooth, freeform curve that connects a series of control points. Changing any single control point will result in a change in the curve, so that the curve can pass through the new point (Bertoline 2002). This property makes this kind of curve able to satisfy the functional requirements above mentioned. The archetype arranged by the authors is able to automatically upgrade the profile once the datum points have been positioned using the tables. Once the profile is drawn, the system automatically upgrade a solid revolved feature that uses as axis of revolution the connecting line among the centres of the datum circles.
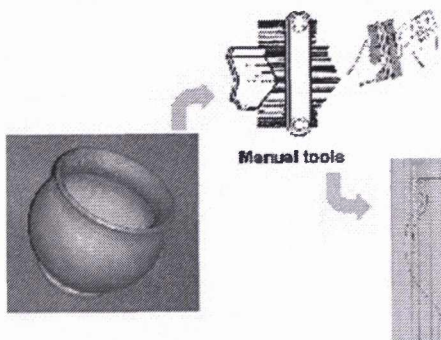
possible to build the profile by means of an unique spline curve that passes through both the external and the internal points. In particular there is a little straight line between the first external point and the first internal point, connected with the rest of the curve by imposing a continuity condition not only on the tangency but also on the curvature. In the lower part there are similar continuity conditions (Fig.2). The resulting solid model is shown in figure 3.

In order to show the potentiality of the modelling technique used the figure 4 shows the effect of a parametric modification on some datum points of the profile using the values contained in the guiding tables. A second case study deals with the reconstruction of the artefact in figure 5. In particular it is the one classified by Morel (Morel 1981) with the code number "1123a1". The CAD model comes from the characterisation of the same archetype by means of five datum planes and about eighty datum points. The figure 5 shows also the axonometric views of the CAD model.

Figure 1 Profile acquisition with manual tools

Figure 2 Profile description

CONCLUSIONS

The present work deals with the representation of archaeological artefacts. In order to improve the recognition and filing of geometries a new CAD modelling procedure has
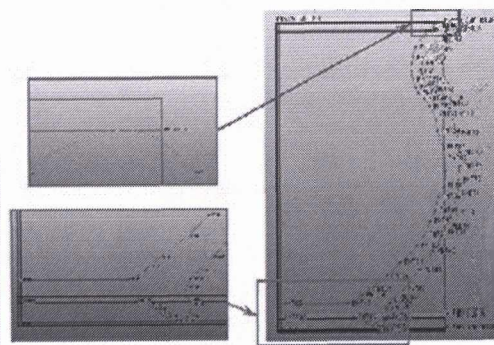
CASE STUDIES

A first case study deals with the reconstruction of a vase whose typology is similar to one of the artefact described by Morel (Fig.1). The profile acquisition has been performed in a manual way with a profilometer. The bidimensional and usual representation of the vase has been drawn on a grid squared paper with only an half section to see the internal profile. At first, the archetype presents five datum planes in a default position. From the paper drawing it is possible to extract a certain number of relevant points for the external and the internal profile and to insert their coordinates in their respective tables. The relative distance between each point is function of the curvature of the profile. For example, when the curvature is small it is possible to give a relative big distance between adjacent points because the spline algorithm, in this case, works well. On the opposite, when the curvature is more accentuated it is necessary to reduce the distance between the points. Then it is
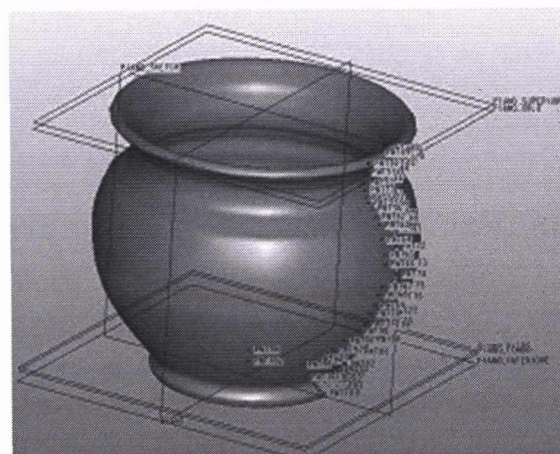
been proposed as a substitute of the one that is essentially based on the development of the manual drawings. The great amount of types have suggested the authors to take advantages of the modern parametric CAD system characteristics in order to foresee a procedure able to give a three-dimensional description of the artefact geometries. In particular, it has been proposed the construction of only one parametric archetype to give the availability of a solid model of all the artefacts belonging to a class or to a similar classes. At first the procedure allows to set the position of some datum planes in order to define the bounding box of the object and other characteristics of interest, used by the archaeologists for the clas-

Figure 3 Solid model

Figure 4 Parametric modification

sification. The initial reference planes, that are the planes of interest for the archaeologists, give the possibility to immediately visualize the height of the model and other significant positions. The construction of the datum points that control the profile's shape occurs in two steps: individualization of the number and characterization of the corresponding coordinates.

Figure 5 CAD reconstruction of the 1123 a1 from the Morel Classification

This procedure allows the construction of a database using 3D virtual models of the vases. The database will be used to perform the automatic recognition of partial fragment of artefacts. In fact, the mathematical knowledge of geometries can allow the use of searching algorithm based on gauss curvature comparison.
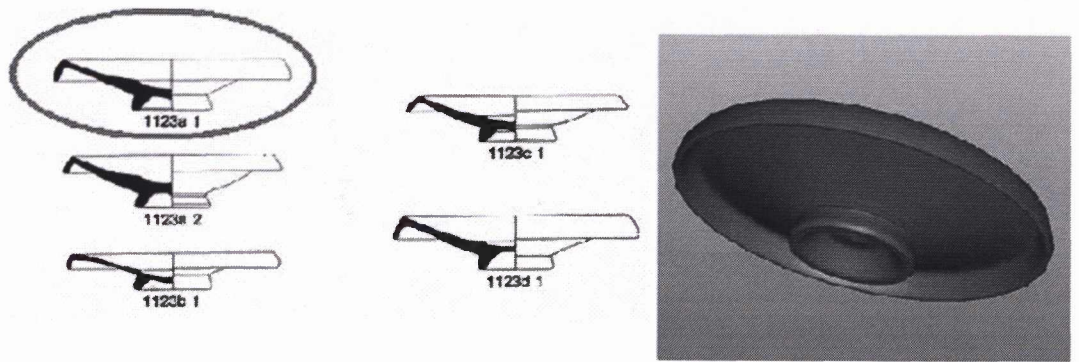
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