

Making a new world out of an old one: in search of a common language for archaeological immersive VR representation

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Abstract. This paper addresses issues concerning the development of Virtual Reality representations of archaeological data from the viewpoint of the archaeologist and the educator, as these are seen through the authors' experience of constructing immersive virtual archaeology programmes for the broad public. Specifically, the issue of interactivity is approached through the user's position in a virtual space, the representation of space is observed in its correspondence to reality, and temporality is regarded both as represented and actual. Data accuracy and sufficiency are related to the assumptions and limitations of the representation.

1. Introduction

In the last decade, Virtual Reality (VR) representation has been regarded mainly as a set of new possibilities for various disciplines ranging from mathematical and biological sciences to Archaeology and the Fine Arts. However, specifically in the case of Archaeology, the absence – amongst other things- of clearly defined principles and goals has made the role of digital or virtual representation that of an expensive “extra” for scientists who have wanted to insert a more pleasant and engaging aspect in their academic work, or, at best, an adventurous trend to keep in pace with the most novel achievements of the IT field. The rapid progress of computer science hasn't allowed much time and space, especially for the more traditional disciplines, to formulate their own needs and priorities in an organized and methodic way. Thus, we observe an ever-growing number of VR projects related to Archaeology evolving independently while any consistency to a methodological and conceptual logic remains specific to each project and is usually self-justified.

From a technological point of view, development has been rapid and on going. New techniques have been mastered, their capacities are being mapped and pushed further, while relatively clear goals are set and followed. Common criteria for the relevance of the methods, the accuracy of the systems and software, and the fidelity and performance of hardware are being established [1][2][3].

As far as virtual reality applications are concerned and whom these applications are supposed to assist and serve, things aren't altogether clear. The lack of a common language, even when

narrowing down the VR representation on disciplines such as archaeology, seems to be the major obstacle for its application on a wider level.

In this paper we address a number of issues concerning the uses of archaeological VR representation for educational purposes, in connection with the methodological issues relevant to its creation and its scope. Our main concern is to identify some of its notional components, describe them, and propose a framework, in which they are functional. Our starting point is the experience we have gained through the collaboration between the History and Virtual Reality Departments at the Foundation of the Hellenic World, a cultural heritage institution in Athens, which combines research and public display of digital representations to a general public.

2. Virtuality, Representation, and Definition

What is archaeological VR or, in other words, the process of visualisation of archaeological data, has been defined clearly enough in the past few years [2][4]. In a nutshell, virtual archaeology may be described as a model that recreates a concrete or an abstract entity, captures its quantitative (and thus also qualitative) parameters, allows the study of its structure and behaviour, incorporates the higher degree of interpretation, and still leaves space for a subjective way of “seeing” it. By VR representation, in this paper, we mean a more or less immersive virtual environment, which is achieved by high-end software, specific equipment and high performance hardware, ranging for the time being from individual Head Mounted Displays (HMDs) to CAVE®-like and other larger audience projection-based installations [5].

Anyone could distinguish archaeological VR representation, according to its scope, to scientific, educational and representation created for pure entertainment purposes. Nevertheless, with the exception of some “edutainment” games, the limits between the genres seem fuzzier than in other, long time established media of information and knowledge¹.

It is commonly considered that VR can offer a great deal of help to archaeologists, mainly in terms of spatial understanding, human-landscape interaction patterns, temporal ordering of material remains and fragments assemblage [6][7]. To date, however, the use of VR in practice has barely crossed the boundaries of visualisation for archaeological research purposes that have been set in the past by other media (drawing, photography and traditional modelling). Though VR can provide, by far, the most accurate and most realistic medium for the representation of the past [8], we must still keep in mind that visualisation and representation are only some of the methods through which Archaeology achieves its own goal, that of *understanding* the past (*preserving* it became a mere consequence when it was realised that future generations may understand better or in a different way)[9].

Hence, archaeological VR representation seems to be most at its place when used for a fuller understanding of the past, sometimes by the archaeologists themselves in order to enhance the interpretative process, but most often by the general public and the non-specialists in a (formal or informal) educational context [10]. In this case, when development targets these specific groups of people, we may call it educational archaeological VR.

¹ For instance there is no particular concern about this distinction in the field of conventional publishing, although the volume of ‘popularized’ and often unreliable editions in archaeology has increased spectacularly during the last decade.

3. Interactivity

Interactivity is one of the most important properties in any virtual world. Nevertheless, a distinction may be made between mere navigation in a virtual space and active participation of the user in what happens in it.

In the first case, the user adopts a kind of “God’s Eye” position: he may see everything, go everywhere, pass through anything but does not intervene nor have the ability to modify the environment in which he evolves. He is a *divine wanderer*². The majority of cultural heritage virtual worlds have been designed on this principle, as was the first VR representation of the Hellenistic city of Miletus in Asia Minor, created by the Foundation of the Hellenic World.



Figure 1: Users act as modern archaeologists by assembling the virtual pieces of vases in an immersive VR programme.

In the second case the user may act either as an extraneous factor to the virtual world or as someone from inside. In any case the user adopts a role which may be contemporaneous or not to the virtually represented world. In a different VR programme produced by the FHW in which the user assembles ceramic sherds in order to restore ancient vases, the user acts as a modern archaeologist who is external to the world represented by the vases themselves (Fig. 1). On the other hand, in the “Magical Wardrobe” programme which is set in a young woman’s room in Classical Athens and in which the user’s goal is to help her get dressed for a grand feast, the user may identify himself with the character’s mother, her sister, her nanny or her slave, being thus an integral part of the represented world (Fig. 2).

² The word ‘wandering’ may be more accurate for this situation than ‘navigating’. Navigating sounds more like a technical description of the process, than its essence. The analogy in a classical learning situation should be the difference between ‘studying’ and ‘reading’.

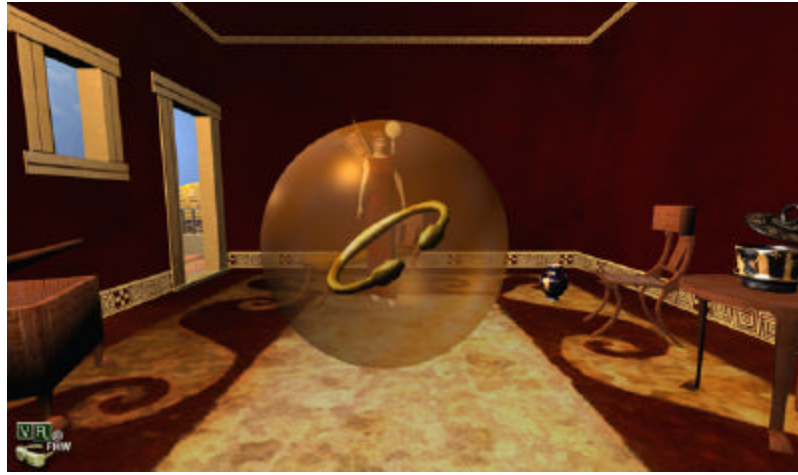


Figure 2: A first-hand view of a scene set in Classical Athens in which the user helps a virtual character wear her jewelry.

4. Space

Space and the choice of space represent a decisive factor in all educational virtual archaeology projects. The representation of space may be approached in different ways which of course have not clear-cut limits between them, but they may appear in hybrid or multiple combination forms.

In a first approach, most commonly encountered in scientific visualisation applications, space is not defined. Spatial perception obviously occurs due to the presence of objects, but nothing indicates to the user where he or she is transported (Fig. 3). Anything about the place is then sheer speculation by the user.

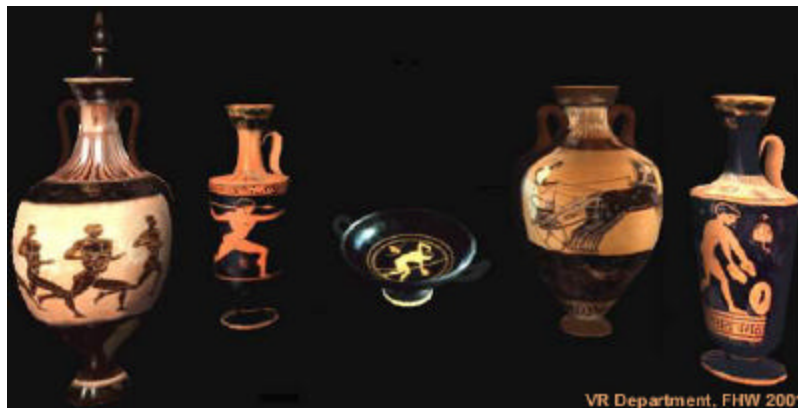


Figure 3: Ancient vases set in an unidentified space or “non-space”.

A second approach to space involves the well-defined but still anonymous space. The user may understand where he is (and often situate the setting in time), but cannot name the place, as it is built entirely on simulated data. We have then a fictitious space that fits in a general knowledge of a past reality, but does not represent any concrete place. This type of space is exemplified in the VR representation of the young woman’s room described previously. Based on the various objects or elements used in the space and on the action, the user may identify the virtual character as the daughter of a “metoikos”, a foreigner living in Athens or even situate the scene in the Classical period. The setting is virtually correct in all aspects. This abstract space nonetheless, with the reserve of a spectacular and improbable coincidence, never existed in reality (Fig. 4).



Figure 4: A fictitious yet relatively accurate space representing an abstract past reality.

A third approach to space and probably the most widespread and technically developed, is the representation of an actual, concrete space [11]. In this case, many assumptions still have to be made in order to recreate the space since no archaeological record may ever be complete. Nevertheless, the environment is built on a solid basis, where landscape and architectural indices, archaeological finds and historical sources provide too many elements to allow us to call the model “fictitious”. In the case of the reconstruction of the Temple of Zeus at Olympia, for instance, the reconstruction is based upon archaeological and architectural measurements, photographs of preserved remains, and suggestions made by the experts about its initial appearance (Fig. 5).



Figure 5: The accurate representation of a space, based on actual (real) sources.

In such cases, full exploitation of the archaeological data is required and even then a large space remains to be filled with assumptions based on a detailed knowledge of the cultural environment.



Figure 6: A surreal space composed by the representation of actual and fictional objects, details from Byzantine mosaics, and representations of real historical characters.

A last approach to space is represented by the surreal space. By ‘surreal’ here we mean settings and phenomena, which could not occur in the represented or in any other real world, but can very well serve educational goals. When the user is successful in reassembling the broken amphora, the athletes depicted on it come to life via animation and perform their sport. When the Athenian girl leaves her room in order to go participate in the Panathenaic procession, the wall becomes transparent and allows the user to experience the procession through the animated figures of the sculptures on the Parthenon frieze (Fig. 7). A totally surreal space has been developed for another educational VR programme produced by the FHW, in which the user is invited to navigate through details of Byzantine mosaics that, brought together in a fairy tale-like setting, attempt to give a feel and essence of what a Byzantine world may have involved (Fig. 6). This is the space of imagination, which should not stay out of any educational process [12].

5. Temporality

Temporality has two aspects in any educational VR application in archaeology. The first, common to all VR representation, is the perception and handling of time. Physically-based phenomena are compressed or extended in time, thus allowing users to move across long distances in a minute, through objects of the material world, against changes, fly anywhere and get back to the ground within seconds, and all these abnormal phenomena do not surprise them. It may seem obvious, but if all of us are today receptive to them, it is only because our perceptive and cognitive faculties have been trained from previous established time-based media such as film.



Figure 7: A surreal space: a wall opens in a Classical room to give view to the Panathenaic procession, as represented on the Parthenon frieze.

The second aspect is related to how accurately time can be situated and defined. The degree of precision varies from total uncertainty to a very precise moment, when the represented virtual world belongs to a well-documented historical period. In the case of the reconstruction of a traditional olive oil press, intended to illustrate the process of oil production in the late 19th or early 20th century, the setting was so abstract that it was discovered “après coup” that it can also apply to classical antiquity, since the oil production process in the Mediterranean world didn’t change for about three thousand years (Fig. 8). In this representation there is a high degree of temporal uncertainty. The city of Miletus is represented during its Hellenistic phase, but still it may be the 2nd or the 1st century BC.

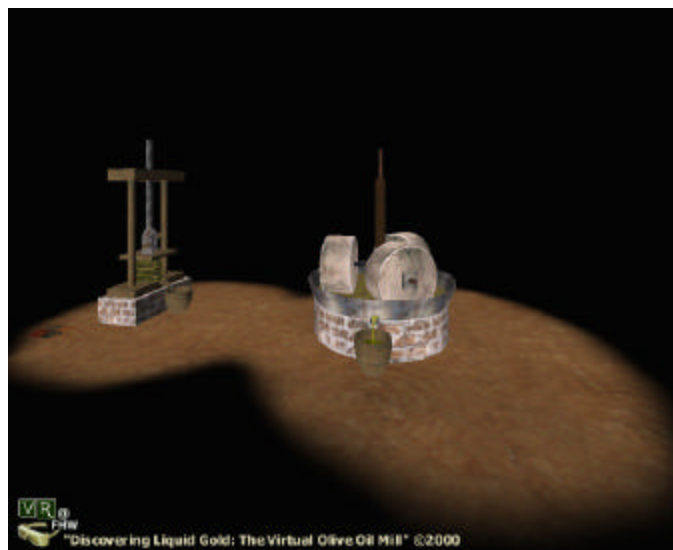


Figure 8: An olive oil press in a setting with high temporal uncertainty.

In another VR programme, the interior of the workshop of Pheidias, in Olympia, the time situation is much more precise. According to various archaeological and historical sources we may set the scene of the workshop, with the statue of Zeus when it was almost complete, a few years after 438 BC, and probably in 435 BC. (Fig. 9)[13]. Even higher temporal precision may

be obtained when we deal with historically documented events such as famous battles, crowning of kings, religious festivals etc.

6. Assumptions and limitations in representation

A multitude of technical assumptions begins immediately with the intention to represent a surface or a shape. They both have size and location; thereafter they may be represented as geometrical models. Various methods have been developed for the production of a model (polygon, parametric, solid modelling)[14][15][16]. But a crucial methodological approach is the difference between representing the extant archaeological remains and completing their missing parts. The first is an inductive job leading from the real object to its more or less abstract model. The second is a deductive job leading from the extant remains, according to the physical rules and through the analogy with similar objects, to a model of the disappeared reality.

Beyond the shape and the topology, other properties, which interfere with the final degree of realism, are colour, texture and motion. But even when we dispose all this information, we still are limited by the maximum of detail supported by the technology. When we have to represent a vase this is not a problem, but it becomes one as soon as we try to represent more complex and irregular shapes, which cannot be summarised in an assemblage of simple geometric solids, such as organic forms (statuary, plants, animals, humans etc.). Then some concessions have to be made with regards to the precision of representation. For example, in the case of the representation of the statue of Zeus at Olympia, we had to simplify anatomical details on the rendering of the limbs.

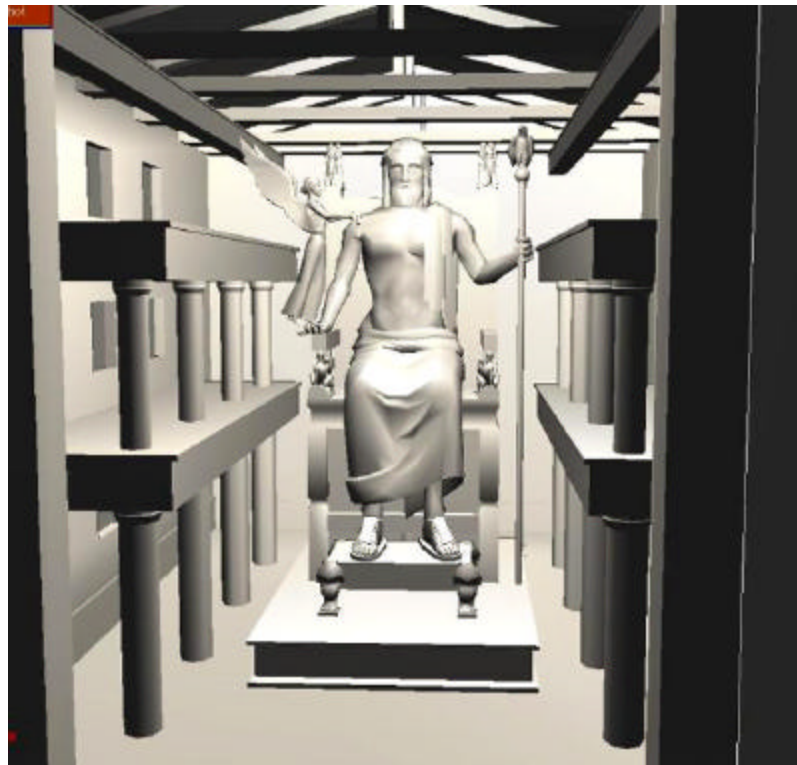


Figure 9: The workshop of Pheidias, in Olympia, a setting with relatively high temporal precision.

In programmes developed for immersive VR displays such as the CAVE® where tracking systems are used to provide a single-person point of view, perspective is often rendered by means of deformation of the shapes, which in turn affects the degree of realism. A slight blurring of the edges occurring on very distant or very close objects undermines the verisimilitude. But the virtual journey and the six degrees of freedom in the movement of the camera/user's view compensate for these inconveniences.

Another important assumption relates to the incorporation of time (3D+1D). Although time may be perceived as the changing pattern of the modification of shape, it cannot be measured without an internal "counter". If the sun stands always in the same position the user feels as being in a time-insensitive and virtually lifeless environment.

This brings us to the problem of the light. Changes in the lighting conditions are perceived by the human brain, as motion, position, texture or color. Hence, the use of light serves mostly interpretative purpose [17][18]. The simulation of natural sunlight, for example, may be proved inaccurate for the features of an archeological VR application. In such cases, omni and directional spotlights are used to show off the particularities of the architecture and/or the landscape.

Last but not least, a dynamic archaeological model includes various forms of interaction in "real time". Stratigraphy is one of its most common applications, where superimposed archaeological layers are removed according to the user's choice [19]. In a VR reconstruction of Troy, the Homeric city in Asia Minor, buildings may be gradually 'switched-off' according to their degree of uncertainty, until the user is presented with a model of the actual remains [20]. In the room of the Athenian woman described previously, objects can be handled and transported thanks to an interaction device that allows for natural "grabbing" and "moving". The development of haptic and force feedback interfaces will allow users to feel some of the physical properties of the objects, and eventually even help the users in experiencing more of them (mass, weight, temperature, inertia, texture, compliance, deformation mode).

7. Data accuracy and sufficiency

Archaeological VR is essentially a visualization of the archaeological record, but the record itself is subject to aging and changing [18]. For example, older views concerning the objects carried by the women participating in the Panathenaic procession had to be combined with newer investigations (clay or silver hydriae), traditional and widespread reconstructions of the statue of Zeus to be emended according to historical sources and modern views (size of the Nike), century old confusion about the acroterion of the Temple of Zeus at Olympia to be carefully handled (resemblance with a similar free standing commemorative sculpture by the same sculptor).

In the case of the statue of Zeus, we had to test and challenge a freshly expressed theory according to which transparent glass plaques covered the whole drapery of the statue. Issues that may not affect a traditional representation, like a drawing, in VR are exigent and ask for a solution. Before lending the archaeological record to a VR interpretation, archeologists must interpret it for themselves. And even when the interpretation is successful, they still have to keep up with its completion. Was it a staircase or a ladder that led to the lateral ramp in the Pheidias workshop? Researchers may not know for sure, but if it must be represented, let it be done according to the highest probability.

8. Toward an educational archaeological VR representation

Educational archaeological VR representation may be intended for children, the general public or students in archaeology. The latter group is usually -and rightly- treated as part of the scientific community. The first two groups are often associated, however their needs are not identical hence programme development should take into consideration different cognitive and pedagogical issues. We have to choose the right amount and depth of information, as well as to take into account the level of peripheral knowledge needed for the comprehension of the virtual world. If interactivity is involved, then we have to create a scenario adequate to the psychology of each group, to construct a virtual model acceptable by their standards of verisimilitude, and last but not least, to assist them with the use of (human) guides. Guides (educators or scholars) should be able to provide complementary information that can not be incorporated in the visualisation, initiate interaction and participation, and help explore the virtual world and provide an engaging immersive experience [10][12].

In the example of the representation of the workshop of Pheidias in Olympia, the target groups are students between the ages of 9 and 13. The scenario situates the users in the workshop of the famous sculptor on one of the last days of the work, just before the statue has been dismantled, transported and mounted again in its final location in the temple. In terms of interactivity, the users are invited to participate in these activities as 'insiders' or helpers who have been assigned the noble task of making some final touches on the statue, adding some gold elements and finishing it off. In this process, they may also discover the process of unscrolling elephant tusks and shaping them according to lead templates, the process of beating gold foil on wooden or natural (sea shells) templates, and the process of assembling these on a wooden core. These actions take place in the workshop, just next to the statue, giving the users the feeling of actively participating in the complex enterprise of building a chryselephantine statue.

As far as archaeological choices are concerned, the statue itself is represented according to ancient depictions found on coins and vases and in comparison with some fragments of known replicas. From these we chose the more recent among several varieties of archaeological reconstruction. We also had to take position in the debate concerning the gold surface and the use of glass.

The space and time variables are precise, but not so precise as to define time on a day-by-day timeline. The use of both variables raises questions relative to the assumptions needed for our target group. The use of time does not follow pragmatic norms, neither is it linear, but rather compressed: the users are invited to accomplish in just a few minutes, actions that in reality would have lasted several weeks. The space of the workshop has been modelled according to archaeological data (known ground plan and height) but some details, such as the number and position of the windows and the form of lateral ramps, are only archaeological hypothesis based on analogies with similar buildings. There are things for which an archaeologist may be indifferent, since they are not based on documented reality. But still these things are necessary if we are about to explain a site and its function, or a phenomenon, its causes and its consequences to a non-specialist. The represented world may well be virtual, but this in no way means that it should be incomprehensible.

Educational assumptions in archaeological representation are different from assumptions made for representations intended to serve scientific purposes. Such assumptions are quite frequent in traditional archaeological restoration, though they are often called 'esthetical' instead of 'educational' (in vase, statue or building restorations, for example).

The virtual worlds mentioned above as examples are built with the same method as any archaeological VR and with the strictest conformity to the data. There is however an important difference between VR worlds intended for use by archaeologists and educational ones. The

former are developed in order to assist the process of interpretation of a site or case by specialists. In this respect, the digital model contains virtually no assumptions, or it forms the final stage of a process where several varying assumptions have been subsequently tried and failed. Educational VR worlds incorporate the interpretations made by the specialists in order to provide the general public with a consistent and comprehensible virtual representation.

We believe that this blend may be more successfully accomplished when choices concerning interactivity, space and temporality are not random, but selected according to ones goals or, when one is aware of the limitations due to the incompleteness or the ageing of the data, and consequently consciously endorses the minimum of assumptions. Nevertheless, the challenge of preserving a balance between the higher-detailed accurate reconstruction sought by archaeology scholars and the more free-form, interactive, and engaging productions made for a general public is still a difficult one. Our core belief is that both these directions of implementation are equally important for stimulating and educating audiences on multiple levels. We are working towards the creation of this common “language” that can soundly combine, on the one hand, the performance and accuracy of the reconstruction and on the other, the educational and interactive capabilities that will enable viewers to explore from unique points of view and participate.

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