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# Virtual Reality (VR) interactions with multiple interpretations of archaeological artefacts

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**Abstract**

*Increasingly, the incorporation of 3D printed artefacts into Virtual Reality (VR) and Augmented Reality (AR) experiences is of interest to Cultural Heritage professionals. This is because virtual environments, by themselves, cannot convey information such as the physical properties of artefacts within the environments. This paper presents a methodology for the development of VR experiences which incorporate 3D replicas of artefacts as user interfaces. The methodology is applied on the development of an experience to present various interpretations of an urn which was found at the edge of a cliff on the south east coastal area of the United Kingdom in 1910. In order to support the understanding of the multiple interpretations of this artefact, the system deploys a virtual environment and a physical replica to allow users to interact with the artefacts and the environment. Feedback from heritage users suggests VR technologies along with digitally fabricated replicas can meaningfully engage audiences with multiple interpretations of cultural heritage artefacts.*

**CCS Concepts**

•***Computing methodologies*** → ***Virtual reality;*** •***Applied computing*** → ***Arts and humanities;***

## 1. Introduction

The best way to study and understand cultural heritage is to experience it in the closest way to the real world as possible. Experimental archeology is a field of relevance to this aim as it strives to expand our archaeological understanding of the past by recreating material culture, technology or lifestyles using the same materials, techniques, and strategies that are believed to have been used in the past through experimentation.

In recent decades, the number of open-air archaeological museums, reconstructions and experimental archeology centers is increasing. They appeared as a response to questions of researchers with regards to the lifestyle of past populations. They also represent a novel and immersive approach to present historical environments, artefacts as well as ancient ways of life to the general public.

In the United Kingdom, in particular, there is a tradition of making physical reconstructions of experimental buildings as well as activities, such as setting up crops, harvesting, preparing food, clothing and tool manufacturing.

As an example, Butser Farm in Chalton, at the South Downs National Park, is an archaeological research site which opened to the public in 1972 under the direction of P. Reynolds [Rey95, Rey99]. The farm, shown in Figure 1, became an international center of excellence for experimental archeology. This centre allowed the researchers to learn a lot about possible construction techniques and aspects of life in the Iron Age. The site constitutes an immersive environment in movement (e.g. buildings are added and repaired, there is livestock, cultivated fields).

Another example is Castell Henlys, [Ben10], which is an Iron Age fort, where buildings have been reconstructed on site by the archaeologists, using evidence recovered from excavations.

Beside these two major centres, there are many reconstructions for educational purposes which often present “empty” buildings in connection with local excavations. In these experiments visitors are in a way passive observers of the reconstructions.

More recently, with the rise of 3D technologies, several projects in the form of animated films, such as a 360° Iron Age roundhouse [Rob16]), or Virtual Reality (VR) experiences, like the 4,000 years old roundhouse at the British museum [RE16], have been created.

In contrast to physical environments, VR experiences have the





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**Figure 1:** *Buster Farm, Sussex (UK)*

potential to immerse spectators in environments which have a spatio-temporal dimension.

Interactions in VR are at the heart of the relationship between the user and the virtual environment, as they allow the user to interact with the digital world in an engaging way. However, this paper argues that incorporating physical interfaces into digital environments has the potential to enrich such experiences. This is because virtual environments cannot convey information such as the physical properties of artefacts within the environments.

To address this shortcoming, there has been a lot of interest in 3D printing technologies and their ability to reproduce heritage artefacts. These technologies take advantage of the wider interest on digital fabrication technologies. These are currently being deployed along with traditional manufacturing techniques to produce replicas which can allow users to physically experience artefacts with similar properties to the original. As such, technologies like the "smart replicas" are increasingly becoming popular as they enable people to combine the use of both physical and digital experiences.

This paper presents a methodology for the development of VR experiences which incorporate 3D replicas of artefacts as user interfaces. The methodology is applied on the development of an experience to present various interpretations of an Iron Age urn which was found at the edge of a cliff on the south east coastal area of the United Kingdom in 1910.

The paper is organised as follows. Section 2 discusses relevant work to interactivity using 3D printed objects in the heritage sector. Section 3 presents the methodology proposed, followed by section 4-6 which describe the historical, graphical and VR design of the Virtual Reality experience. Implementation and testing are presented in sections 7 and 8. Finally, section 9 presents a discussion on the project and section 10 concludes and suggests further work.

## 2. Related work

3D printed replicas of artefacts have been used for a variety of purposes when managing cultural heritage resources [SCP*14]. One of the latest developments is the use of replicas along with digital content to support interpretative experiences. Such applications constitute a novel type of interaction between the physical and the digital world. Usually, hardware is embedded in replicas which behave in intelligent ways and provide access to alternative digital content presentations.

"Smart replicas" are digitally fabricated artefacts that work as tangible interfaces, so that people can interact with them and trigger some response in the form of a reaction or behaviour [MDC*16]. EU project MeSch [PLB14] employed 3D printed objects to provide further layers of interpretative information for artefacts in exhibitions [Waa15, MDC*16].

Another relevant example is the Virtex system [CNP15]. For this project, researchers placed touch sensors inside two replicas for the exhibition "Keys to Rome" at the Allard Pierson Museum. When specific points on the replicas were touched, relevant storytelling content was projected on a screen.

Furthermore, [NGT*15] employed 3D technologies to digitise, model and process a steelyard and a granite weight model which were presented in a VR immersive environment of the Gallo-Roman villa Bourg-Saint-Pere in France. In particular, the granite weight was 3D printed and a tracking target was attached to it, so that the user could interact with the steelyard and perform a weighing activity.

In addition, replicas can trigger interaction without deploying any kind of embedded hardware into their physical form. Researchers used such a hybrid solution in the "Heritage together" project. 3D printed miniatures of megalithic monuments were placed on a multitouch table, acting as fingers and activating relevant interpretative information on the screen [MKR*15].

Another interesting example uses video mapping technology on the surface of three scaled-up replicas of cuneiform tablets to present information about the cooking recipes that are described on them [Stu17]. Another application from the same studio uses physical ceramic replicas, which are "enriched" with material from an augmented reality (AR) mobile application [SL16].

These examples demonstrate the interest of the Cultural Heritage community in the combination of physical and digital experiences. However, there are no existing guidelines or methods to build this type of applications. The following section will describe a methodology which enables a multi-disciplinary team to create rich experiences and test it with specific heritage environments.

## 3. Objectives and methodology

Typically, the main objectives of Virtual Reality experiences include:

- The presentation of artefacts and/or sites along the contexts in which they were created and used.
- The provision of enhanced interactivity.
- The enhancement of learning, understanding of visitors regarding the past, while providing an entertaining experience.
- The visualisation of artefacts and sites. The incorporation of physical replicas can enhance this visualisation by enabling the user to experience the physical properties of objects, including their size and shape. It also enriches this experience by involving other senses (e.g. touch) in addition to the users' vision.

The design and implementation of a VR experience, such as the one which is proposed in this paper, should be performed through a collaborative and multi-disciplinary process. In this case, two archaeologists, one digital heritage researcher, two computer scientists, one developer, and one graphic designer were involved.

The multidisciplinary collaborative process aims to guarantee the historical coherence of the application together with the feasibility of the developments, while developing an efficient organisation. It also allows to parallelize and collaborate between several tasks: design, implementation and testing. The methodology has three different design tasks: historical, graphical and Virtual Reality (VR).

Historical design is related to the iconographic research and documentation. The outcome of this process is the design of various contexts and interactions, and the later validation of graphic designs and implementations. Graphical design focuses on the digitisation and 3D modeling of the different artefacts, buildings and environments. The outcome of this process includes the assets which will be used for the replicas and the VR experience.

VR design creates a suitable technical setup which will be later implemented by developers. This includes designing the application and interactions as well as developing a suitable architecture for sharing the platform. Finally, the implementation stage brings all of these elements together and produces the application in incremental cycles and testing.

The following sections will describe each of these tasks. In order to present the methodology, we focus on the development of an experience of an Iron Age artefact and settlement on the south east coastal area of the United Kingdom.

## 4. Historical design

VR experiences can serve to illustrate the main contexts of the "life" of an artefact, its manufacturing context, its day-to-day usage, and its final use when it was disposed.

The artefact selected for this purpose is an Iron Age pot or urn. The artefact was probably used for different purposes during its lifetime and the VR experience aims to present this information.

In 1910, a child while playing found the urn at the edge of a cliff above the sea in Saltdean, which is located in the south east coastal area of the United Kingdom. The urn (see Figure 2), which contained pig bones along with the cremated human remains of a young person, came soon to the possession of the Brighton Museum and Art Gallery.

The urn is an important artefact of the collection of the museum, as it reveals important information about the life of local communities in the late Iron Age in the south east part of Britain before the arrival of the Romans. Even though there are no signs of a big agricultural settlement in the area (larger settlements have been found at the Hollingbury Hill Fort, Devil's Dyke Hill Fort, Kemptwon, Newhaven and Coldean; all close to Brighton), the urn and its contents indicate that some small agricultural and farming communities might have lived in Saltdean in late Iron Age. Such community could have been built near the white chalk cliffs overlooking the sea.

**Figure 2:** *Late Iron Age funerary urn from Saltdean, Sussex (UK)*

The urn is a late Iron Age pot (probably 1st century BC) which was thrown on a wheel. It has a rounded body and a short narrowed neck. Its body features curvilinear designs which are usual in Sussex in the two centuries BC, before the arrival of the Romans. Roman invasion started from the southeast of Britain in 43 AD and expanded to the rest of the island gradually [Har74,Cun78]. Its design possibly reflects influences from Belgian tribes and people from Brittany who had moved into the area. The pot is of dark brown colour with the exception of some lighter areas. These are the result of oxygen leaking during the firing process of the pot or parts of the surface that have abraded. It also seems that burnishing has been applied on the darker areas of the pot to give it a leather-like appearance [Tom12].

In order to provide multiple interpretations related to the artefact, three contexts for the presentation of the urn were selected. These are described in the following sub-sections.

### 4.1. Context 1: Manufacturing of the pot

The first context refers to the manufacturing of the urn in the external space of an Iron Age pottery workshop. Archaeological data suggest that pottery production became part of commercial enterprise in the late Iron Age centuries. Especially in the south parts of Britain, the potter's wheel was probably introduced by tribes who came from the Continent (Belgian tribes and people from Brittany). The introduction of such equipment and knowledge allowed the production of relatively larger quantities of pots with better shapes [AA82,Cun95].

### 4.2. Context 2: Storage pot in cooking activities

The second context aims to support the user in understanding how the urn could have been used as a storage pot in daily cooking activities. These activities take place in the internal space of a small Iron Age round hut, which is a common type of built house in south Britain at that time.

The hut along with some more huts could have been part of a small farming and agricultural community, placed near the edge of the cliffs in Saltdean.

The round huts were made of timbers which were interwoven with wood. The resulting wattle walls were then covered with a mixture of clay and other materials in order to protect the construction and the interior from the rain. The roof was densely thatched so that water did not enter the inside of the house. However, it was possible for smoke from the central fire to “escape” the house through the thatched roof without the need for an opening or chimney [AA82, Cun78, Cun95].

### 4.3. Context 3: Funerary pot in burial site

In the third historical context, the urn is used as a funerary pot. Even though the urn might have been produced in order to “host” the cremated bones of a person, it could have been made as storage pot and later used as burial pot.

When the pot was found, it contained the cremated human bones of a young person along with pig bones. The bones were not in good condition and were fragmented into pieces. The urn was located on the edge of a cliff and no other artefacts were found around it [Tom12]. The hypothesis in this context suggests that the urned cremation would have been placed in a small pit or under a small barrow surrounded by a shallow ditch, as these were common practices in the late Iron Age [Har74].

The design of the graphical content for the development of these contexts will be presented in the following section. This will be followed by the design of the interactions within each context.

## 5. Graphical design

A variety of graphical visual assets are required to support the implementation of the different contexts. As the historical design suggests, the graphical environment for the VR experience is related to the historical period of late Iron Age. Thus, the design of the three different contexts relies on documented information on this period. The following subsections will describe how the visual assets for the urn and the Iron Age environment were generated.

### 5.1. 3D Digitisation of the Saltdean urn

The urn was scanned at the Brighton Museum and Art Gallery using the AICON Breuckmann 3d SmartScan scanner. One of the main challenges when acquiring the shape of the urn was capturing the internal surface of the pot. This has not been possible due to the narrowed neck and rounded body of the urn. Hence, 3D scanning only acquired some information around the rim and neck of the pot (apart from the external shape). The resolution of the 3D scan is of 0.1mm.

In order to reconstruct the urn and produce a watertight model that would later be 3D printed and used in the VR experience, the 3D modeling software Blender was deployed to fill in the internal part of the urn and some minor holes. The urn was also photographed and the images were used in MeshLab to map the textures on the 3D mesh of the pot. The resulting 3D model is shown in Figure 3.

The model of the pot was then 3D printed in full-size (see Figure 10) on a Raise3D N2 Dual Plus owned by the computer science research institute. This 3D printer is able to print a volume

**Figure 3:** *3D model of the funerary urn with texture as shown in the VR environment*

of 305mm*305mm*610mm, using a FDM technology with black PLA, which allowed to print the whole pot at scale 1:1 in a single piece.

### 5.2. 3D modeling of the Iron Age environment

The graphical environment also represents a small Iron Age settlement near the cliffs of Saltdean. The terrain data used for the area representing the settlement has been created based on terrestrial data of the location around Saltdean cliffs (see Figure 4). The terrain model was extracted from https://digimap.edina.ac.uk but the resolution was not enough to build the 3D model. After extracting the 3D level curves of this model, we built two models with Unity 3D terrain creator, one for far view terrain and the second for a near view render.

Trees, grass and fields were added in coherence with the historical aspect. However, we acknowledge that the VR landscape might not be exactly the same as the landscape in Iron Age. Nevertheless, the area with the sea cliffs, hills and deforestation is the closest that we could have to the Iron Age landscape. Hence, it has been used to provide the best possible representation with some compromise.

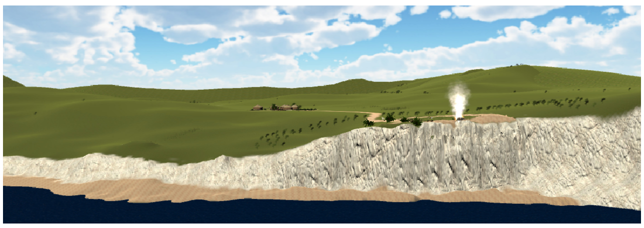

**Figure 4:** *Terrain 3D model of the landscape with the settlement and burial site displayed*

A set of huts were 3D modeled amongst the fields to represent the Iron Age settlement (see Figure 5). A burial site was also modeled close to the cliffs (see Figure 8).

Moreover, because our ability to create a lot of 3D models for archaeological hypotheses was limited, the graphical design work

**Figure 5:** *3D environment of Iron age settlement close to Saltdean's cliffs*

**Figure 6:** *Manufacturing context with potter's wheel outside of a round hut*

**Figure 7:** *Storage context in the domestic environment of a round hut*

for this project was optimised. To create the different visual assets, we used a variety of sources and resources:

- The modeling software 3Ds Max 2017 for modeling and editing the 3D models.
- The digital media company TurboSquid [KFH09] or CGTrader in Royalty Free License for royalty-free 3D models.
- Google images for textures.
- Unity particle generator to produce particle systems to represent the smoke and fire.
- www.textures.com [Wal17] to download textures which are then slightly modified with Photoshop.

## 6. Virtual Reality Design

The Virtual Reality experience was designed to offer a variety of interactions to users with contexts described in the following sections.

### 6.1. VR context 1: Manufacturing of the pot

In the VR environment, the pottery workshop is represented as a round hut with a potter's wheel that is located in the external area of the hut (see Figure 6). The user can interact with the potter's wheel to make it rotate. The wheel is made of wood and its round disk is pivoted on a spindle which rotates in its socket. Around the wheel there is mud and clay which is deposited on the ground.

### 6.2. VR context 2: Storage pot in cooking activities

When entering the hut, the user sees the internal space of the domestic environment with the furniture of the time, such as the wooden beds with the animal skins, the wooden shelves with several pots on them and the central fire with a cauldron above it (see Figure 7). The fire, a central element of the house, would have been maintained day and night in order to provide warmth, light and a place to cook for the people living in the hut.
The interaction here happens when the user pours the content of the urn (some kind of grains or seeds, such as oats, rye, millet, spelt wheat, emmer wheat, barley and einkhorn wheat that were cultivated in the Iron Age) into the cauldron on the fire in order to make food. The user can also interact with a rotary quern stone by pouring seeds on it. The stone starts its rotating grinding movement and produces flour.

### 6.3. VR context 3: Funerary pot in burial site

The VR environment represents a funerary place located near the small Iron Age settlement and close to the edge of the cliffs above the sea. A small number of barrows surrounded by shallow ditches serves as the local cemetery. A small pit on the ground has been opened there and is ready to "receive" the urn with the cremation (see Figure 8).

## 7. Implementation

The VR experience was developed using the cross-platform game engine Unity to display and interact with the pot in historical contexts. The VR application is deployed on a HTC Vive headset and integrates a VIVE tracker for the position of the pot. The 6D tracking of the headset and of the tracker allows the user to naturally move in a dedicated physical space which can be set up to 5mx5m, and to interact with the virtual environment.
The design of this application was done on several computers running Windows or Linux and the main Unity development was done on a Mac OS X 10.13 with SSD and 16Gb RAM. The ver-

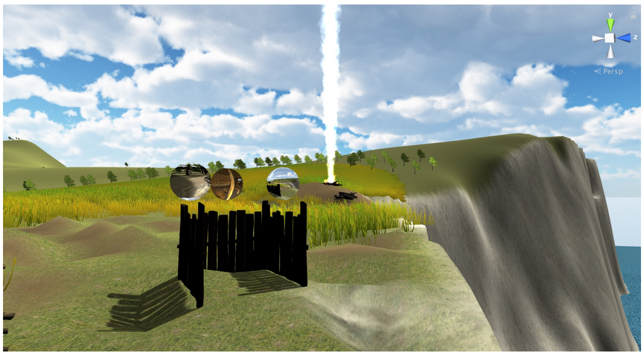

**Figure 8:** *Funerary context near the edge of the cliffs with the burial mounds*

sion of Unity used is "Unity 2018.1.6f1" for development. Testing was done on a PC DELL PRECISION 5820 Intel Xeon W-2104 (4 cores, 3,2 Ghz, 8,25M cache), 16Gb DDR4 2666 MHz, SSD 256Go 2'5 SATA, Graphic card Nvidia Geforce GTX 1080 8GB, running Windows 10, an HTC VIVE and one HTC tracker. The application contains a 500Mb 3D scene size. The performances were about 50 Frames Per Seconds but should be improved with textures optimization and baked lighting.
The VIVE tracker was attached on top of the 3D print of the pot (see Figure 10) and the 3D model was positioned in the virtual environment to fit the position of the physical pot. This allows the user to move and rotate the virtual pot in his/her hands, with a direct physical feedback.
The user starts the experience wearing the headset and handling the tracked copy of the pot. He/she is first positioned in front of an empty scene with three floating spheres representing the three contexts to visit (see Figure 9) and has the virtual pot visible in his/her hands (see Figure 10). To access one context, the user touches the corresponding sphere with the pot and is teleported instantly to the context. Once in a context, the user can naturally

**Figure 9:** *User initial view within the VR environment: three floating spheres representing the three contexts to visit*

walk in the dedicated physical space and can interact with different elements through the position of the pot. In each context, an area is dedicated to the access of the other contexts with the same metaphor of floating spheres.

**Figure 10:** *Testing the 3D printed urn with tracker interactions*

The interactions were implemented for each context. In the manufacturing context, the rotation of the wheel is triggered by a collision of the user's body or pot into a collider represented here by a green cylinder and invisible during the user's experience (see top of Figure 11). In the storage context, two interaction zones can be triggered (see middle of Figure 11). The first one is the fireplace where the content of the cauldron will boil when the user pours the content of the urn into it. The second one is the rotary quern where flour will be grinded when the user pours the content of the urn into it (see Figure 12).
In the burial context, the interaction zone is represented by a small pit on the ground where the user can put the urn with the cremated bones and see an animation (see bottom of Figure 11).

## 8. Testing

The VR experience was tested with members of the team throughout the development. Feedback and suggestions for improvements were collected and fed into subsequent implementation cycles.
Further user testing was done with the curator and digital manager of the Brighton Museum and Art Gallery. The feedback was very positive, as they saw great potential of such application in order to engage and educate visitors about Sussex's local history. They liked in particular being inside the round house and being able to see the fire and how the objects were set to show the use of the pot. There was further discussion on the use of gaming metaphors for providing an educational experience to users based on this type of experiences. Although gamification of this type of VR experiences is technically possible, it created divided opinions amongst the users and it was beyond the scope of the development. Hence, the best way to incorporate game's metaphors was left as further research.
Further testing of the application with visitors will take place in the Archaeological Gallery of the museum. The evaluation will deploy both quantitative and qualitative data collection methods in order to record and analyse the effect of the proposed solution to engage and support audiences in the interpretation of archaeological artefacts.

**Figure 11:** *Colliders used to trigger interactivity within the different contexts*

**Figure 12:** *Falling seeds from the pot into the rotary quern*

## 9. Discussion

### 9.1. Methodology and VR experience

The methodology proposed in this paper reinforces the need for collaboration between disciplines, in particular archaeology and computer science, with cross-issues and reciprocal needs. This was particularly obvious and crucial during the design phase. Within the development of the VR experience, it is important to produce an open and evolving project whose data is shared between the different research institutes.

Very often, similar projects on cultural heritage are driven by archaeologists, curators or historians and implemented by private companies. In this case, all the digital 3D assets and code remain generally the property of the private company and further evolutions must be negotiated. The cost of a VR system in the context of a museum can arise. However, this must be compared with a physical reconstruction of sites. These sites are very difficult and costly to maintain because of the construction techniques used. In addition physical reconstructions are subject to security constraints such as the addition of emergency exits, security and accessibility equipments that undermine the authenticity of the reconstitution.

The fact that the Saltdean urn is used as the centre of the VR experience allows to document several contexts and functionalities. The urn works as a witness of activities and often of different places. Contexts explain and support the interpretation of the pot's manufacturing, its primary use as a storage pot and its reuse as a funerary vessel. Thus, the pot documents its context of manufacturing at the potter's workshop using a specific manufacturing technology. It further documents the context where it is used as a storage container related also to cooking activities. Finally, after being removed from the household, the urn is reused in the third context as the receptacle of cremated remains.

The 3D modeling of the site and its houses is based on a realistic representation of Iron Age round huts in Britain, as documented by archaeological research. It must be acknowledged that the 3D virtual environment could not test architectural techniques as the physical reconstruction allows it. However, the advantage of a VR environment is that it makes possible to test several hypotheses simultaneously about the artefacts and their contexts.

The same principles were followed for the reconstruction of the landscape where the funerary and domestic occupations are implanted: more than being confronted with the strict reality it was important to be immersed in a compatible environment, correlated with the various data from geographical and archaeological sources.

Hence, VR environments allow the passive "spectator" to become an actor because they become the driving force of certain interactions. Such interactions trigger intellectual interpretative processes from suggestive elements that exist in the virtual space and are observed by the user/participant.

### 9.2. Digitally fabricated replicas for interaction

The role of the physical replica of the pot contributes considerably in terms of mediation and interaction. Having physical contact with the pot reinforces the user's relationship with the virtual environment and at the same time simplifies the interactions. There is no need of a complex device with buttons and joysticks to interact here. The visitor walks naturally in the dedicated physical space and interacts by moving the pot to different places. This makes the VR experience accessible for a wide range of cultural heritage audiences.

In addition, amongst the most important contributions of a digi-

tally fabricated artecfact in communicating cultural heritage information is its own material aspect. Materiality is recognised as a substantial component in the cognition process and thus in complementing a personally meaningful experience that enhances audiences' appreciation of cultural values [Dud10].
Therefore, it can be argued that the fabricated urn, apart from the possibility to provoke aesthetic appreciation, serves as a tactile object within a multi-sensorial activity that adds value to a whole cultural heritage experience. Viewing an object, feeling its weight and examining its shape through hands-on and sensorial interactions has the potential to change the landscape of cultural heritage experiences in ways that have never been possible before, due to the sensitive/fragile nature of collections and other limitations [BBDM13, LK13, ZNP*15].
At the current stage, the VR experience is tested with a replica printed using PLA, which is a plastic material. This choice is currently related to cost and safety reasons (as the plastic urn cannot be broken and harm the user). Evaluation and future work will examine the sensorial properties of the replica in order to find out how it performs with respect to the user's appreciation of the artefact. Depending on findings a more suitable replica can be produced in future to better satisfy users' requirements whether these refer to weight, texture, colors and so on.
Finally, the use of a physical object in conjunction with the VR interpretative presentation which refers to the original context where an artefact was made, the action of creating it, its original function and all the parameters that could define the "aura" of the object, can only contribute to form an "authentic" experience for the visitor. Such experience combines touch, vision and sound in ways that are as close as it gets to the spatio-temporal and sensorial elements of the artefact and its environment.

## 10. Conclusions and further works

The work presented in this paper contributes at different levels to the use of VR interactions for scientific mediation. First, it proposes a methodology for the development of VR experiences which incorporate physical replicas to support interaction with the environment. The methodology is deployed for creating a graphical reconstitution of a site of a specific period, the Iron Age, with a particular focus on the coherency of the representation. Second, it proposes various interactions and contexts related to the pot in the VR simulation in order to illustrate its different usages in this period. Last, it implements a physical interaction to enhance the relationship between the user and the artefact.
If the 3D graphical representation of the buildings or the landscape is only a plausible representation of reality, the Virtual Reality offers very interesting possibilities of implementation for the archaeologists as well as the visitor. Further work to enhance the environment includes the addition of domestic and wild fauna of the Iron Age, sound environments [Ene14], diverse meteorological realities, which may be of considerable importance in view of the location of the settlement. The seasonal changes with the evolution of the landscape-crops, the luminous impact within the architectural complexes according to the course of the sun constitute very important characteristics of everyday life [BPB*15, Red]. It is also possible to implement the celestial vault visible during the Iron Age.

Luminous design work may also be undertaken in the housing unit (direct or indirect light from the fire, use of additional secondary sources necessary in the evening or in case of bad weather to perform certain domestic activities), in order to evaluate the impact of fumes in the household (simulation). This restitution would make it possible to test different interactions, such as man/house, house/environment, man/environment.
The addition of a number of activities inside and outside the hut, such as pottery, weaving, winnowing, grinding or food preparation, can simulate domestic activities. This allows to have a perception of the inhabitants in their environment whether in the house, on the doorstep, nearby, but also different places such as the burial site, whatever the season, the weather, or the schedule of the day.
Finally, future work includes the evaluation of the system, which apart from the standard aspects related to user experience and particularly usability (as measured in terms of tasks, number of errors and other), will examine holistically a multi-modal system combining the physical interface of the artefact's replica with a VR environment. Such system does not just aim to be effective or efficient, but also fun, pleasurable and able to contribute to a unique and enhanced interpretative experience.

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