

Reviving Karanis in 4D: Reconstruction of Space through Time

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Abstract: A virtual reality representation of a Greco-Roman house includes not only the reconstruction of architectural features such as the walls, floors, roof height and the materials used, but also material culture that was found in the house during excavation. These objects, now in various museum collections, have been virtually placed back in their original context. Most importantly, however, the three-dimensional VR model allows for a reconstruction of the use over time of buildings that have seen many modifications over a period of several centuries. The flexibility of moving away from showing very crude and generalized building phases, and instead enabling interpretations that include detailed developments at different time scales, is a great advantage of using VR.

Key Words: Virtual Heritage, Architectural Heritage, Re-contextualization, 3D modeling, Photogrammetry, Time Modeling.

Introduction

The Greco-Roman town of Karanis, located along the road from Cairo to Fayum City, Egypt, was a prosperous agricultural center in antiquity. This large town was mostly built of mud-brick town and lasted for about seven centuries, from the middle of the third century BCE to the end of the fifth century CE. At present, due to many factors, the site shows decayed mud brick walls where buildings have been exposed (BARNARD et al 2015) (Fig. 1). The preservation of organic materials in this desert site is excellent, Large scale excavations by the University of Michigan (from 1924-1935) have resulted in an abundance of archeological finds that reflect the daily life of this period and provide a wealth of information (BOAK & Peterson 1931) (BOAK 1933).

Of the more than 70,000 artifacts excavated, over 40,000 made their way to the Kelsey Museum and the rest stayed in Egypt and were distributed by the department of antiquities over different Egyptian museums. Besides the artifacts, the Kelsey archives hold many documents, photographs, maps, architectural drawings, and other materials from the excavation. Once the University of Michigan completed the excavations, the excavation trenches were not backfilled, and massive erosion of the exposed structures has occurred since the 1930s. In 2005 the URU Fayum Project restarted excavations. New technologies such as GIS, 3D scanning and photogrammetric documentation are used to record and preserve the site and address new research questions. The project systematically back-fills the recently excavated areas, while measures are taken to also protect some of the previously excavated structures (BARNARD et al 2015) (Fig. 2).



Fig. 1 – The Karanis landscape (Fall 2015) shows the massive loss of mud brick structures in the town (Photo by E. Elgewely)



Fig. 2 – Backfilling by the URU Fayum Project of granary C65, excavated by the University of Michigan in the 1920s (photo by E. Elgewely)

From 2D to 4D representation: Space versus time in heritage representation

The Reviving Karanis Project, which started in 2013, aims to produce new insights into the town of Karanis in the past. Two-dimensional plans, elevations and photographs are rendered in a three-dimensional virtual reality model. Adding time as a fourth dimension not only enables a reconstruction of the space in which the people of Karanis lived and moved about town, but also the time factor: urban developments, building modifications and use phases. Apart from data taken from plans and elevations of excavated structures, information has been added from descriptions in textual sources. Artifacts found within the buildings, but separated from their original context, have been placed back virtually to enable a better interpretation of the function of particular spaces. This is achieved through placing the archaeological finds “back” in the three-dimensional virtual reconstruction of the buildings of Karanis. The “virtual heritage” provides the context to better understand and appreciate the complexity of Greco-Roman culture. Virtual heritage enables an exploration of how past communities may have perceived and represented their physical and social environments. This includes non-material aspects such as symbolism, ideology and ritual (FLYNN 2007). The virtual model thus enables the examination and presentation of the town’s historical, social and urban contexts (ELGEWELY & WENDRICH 2015). It also enables a way to show interpretations in the classroom or to the general public (SANDERS 2008).

A three-dimensional virtual reconstruction of the buildings of Karanis, based on plans and elevations of the excavated edifices provoke new questions. The “virtual heritage” provides the context to appreciate the complexity of Greco-Roman culture. Virtual heritage enables an exploration of how past communities may have perceived and represented their physical and social environments. This includes non-material aspects such as symbolism, ideology and ritual (FLYNN 2007). It also enables a way to show interpretations in the classroom, or for the general public (SANDERS 2008).

Because the model is interactive, we move beyond a static 2D representation to help better understand the ever accumulating archaeological and architectural data and to compare and analyze the results of the old University of Michigan excavations, as well as the ongoing work done by the present day URU Fayum project. When targeting a generation that has grown up with technology, an interactive digital approach helps to make the end-user excited about ancient cultures and aware of the implications of the evidence. The excavations of the University of Michigan in the 1920s revealed strata of well-preserved mud brick houses, some with paintings still on the plastered walls. These houses were the main source of many excavated papyri and ostraca which provided much information about daily life of Karanis non-elites (YOUTIE & WINTER 1951). Many of the buildings in Karanis were multi-storied, and formed blocks of buildings, which frequently developed through gradual accumulation and modification. Houses shared walls and often multiple houses shared a courtyard, although there are also examples of autonomous single structures. Most of the Karanis house structures comprised floors with three rooms, arranged around a staircase with a central brick pillar. Underground rooms were utilized for storage while a courtyard on the ground floor was the center of a significant part of the household activities. Shared courtyards had facilities such as animal pens, storage bins, bread baking equipment (an oven, mortar, and hand mill) and sometimes industrial features such as crushing platforms for olives and large stone olive presses (WILFONG 2014).

A number of houses in the northeast section of the town were used over a long period of time and were well-preserved. The 1920s excavators therefore deemed them sufficiently interesting to create and publish detailed plans and elevations of these multi-storied houses. All were built as part of what the expedition members called the “C-level”, which was estimated to have been constructed in the middle of the first century CE and proceeding through the first half of the second century CE (HUSSELMAN 1979). Habitation in most of these houses continued in later centuries, sometimes until the abandonment of the town in the early sixth century CE.

The first house selected for the 3D virtual reconstruction was named *house C45* by the Michigan expedition. It was a small house with an adjacent courtyard, in which hundreds of archaeological finds were uncovered between the year 1927 and 1929. Most of these items are in the Kelsey Museum storage while some of them stayed in Cairo and went to both the Egyptian Museum in the center of Cairo and the Agriculture Museum in the Dokki neighborhood of Cairo (ELGEWELY & WENDRICH 2015). The virtual reconstruction of the house C45 is based on the architectural drawings of the Michigan expedition which included a Master plan of the C - level area, photographs of the house when it was first excavated, in addition to the detailed plans and sections of the three stories of the house (Fig. 3, 4, 5). Autodesk AutoCAD was used to trace and redraw the sections and plans of house C45. The 2D CAD drawings were then exported to the 3D modeling software which (Autodesk 3D Studio Max), they were used as a reference in creating the low polygonal model by extruding the main exterior and interior walls.

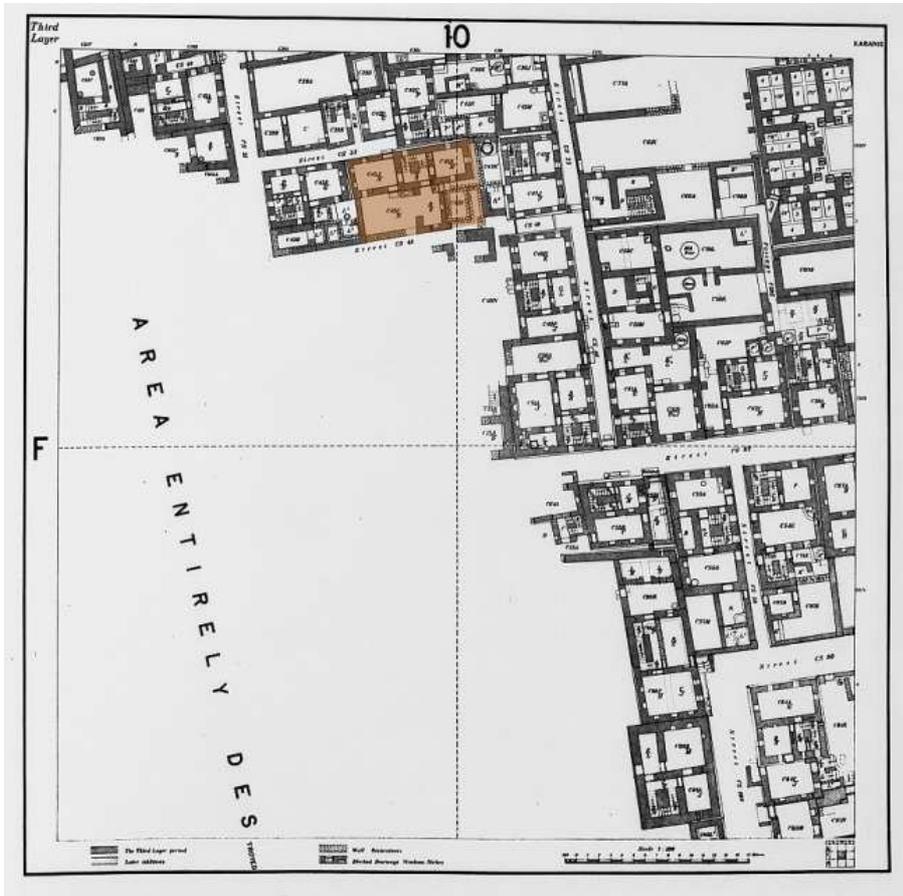


Fig. 3 – A Master Plan of the C-Level highlighting house C45 and the neighboring houses (Courtesy of Kelsey Museum of Archaeology)



Fig. 4 – A view of C45 A (northwestern corner), showing window in the southern wall of C45K below and above the sill of window of C45F. The doorway in the corner leads from A to B. (Courtesy of Kelsey Museum of Archaeology).



Fig. 5 –The few mud brick remains of House C45 (Fall 2014) (Photo by E. Elgewely)

Since most historic architecture is dynamic and has experienced distinctive periods of changes and improvement, a reconstruction is always faced with the choice of which particular phase to display. Most of

the reconstruction projects do not show the developments over time. Their static nature also prevents the possibility to include alternative theories, changing interpretations or updates.

In this project we use 3D modeling as an innovative tool by presenting different perspectives in the actual building reconstruction itself, such as visualizing the architectural phases through time (the '4D' element). An example of such a drastic spatial change, observable in several of the Karanis buildings, is caused by the accumulation of garbage and windblown sand, which causes a rapid rise of the street level. House owners would try to block out the street build-up and construct steps leading down to the entrance. When the increase of street level was such that access to the house became impossible the ground level rooms were abandoned, or used as storage, while a new entrance was made in the floor above, with steps leading down to the street. In several instances the multi-storied construction consisted of another house built on top of the old walls. Sometimes only the floors of the rooms on the street level would be raised and new windows and entryways developed at higher levels. Constant modification of standing structures happened concurrently with the building of new ones, so houses constructed in distinctive periods stood next to each other.

In house C45 several modifications can be interpreted as a way to cope with such a rise of outside ground level. The courtyard on the west, C, shared a common wall with the neighboring house C43L and was paved with rough slabs of limestone. Approximately 1.5 m below this courtyard floor was an earlier floor of mud bricks and mortar, stone steps often led from streets to entrance doors, or from the level of a courtyard to that of an adjacent room (Fig. 10). The large courtyard on the east, A, was shared with the neighboring House C47, which was most probably contemporary. The house proper consisted of two rooms on each floor, one on each side of the stairway unit. The main entrance was from street CS32 on the north into room J. By the late C level occupation the underground room Q was abandoned and the trapdoor entrance was hidden under debris. By this time also, the water jar stand in room B/C had been buried, as well as the steps leading from the courtyard C into room J. It was then that two small bins were built on the west wall of C. The dividing walls of the storage compartments in the eastern courtyard, shared with C47, were covered over in the late C level. The oven that had stood at the north end of the courtyard was also buried, and a bin with a storage jar inside it had been built over it. A new oven was built against the western wall. Remains of a red and black painting were found in a niche in courtyard B, the design at its bottom may be of a Christian symbol with a possible representation of the sun with rays (Fig. 11). None of these southern courtyards were in use in the B level. The second floor actually became the ground floor at this period, and if the ground floor of the C level house was in use at all, it could only have been as underground storage space. Only the tops of some of the original walls were still used in the top level (Fig. 6, 7). Such modifications have been illustrated by the University of Michigan expedition on the different architectural drawings and were then translated into the 3D model (Fig. 8).

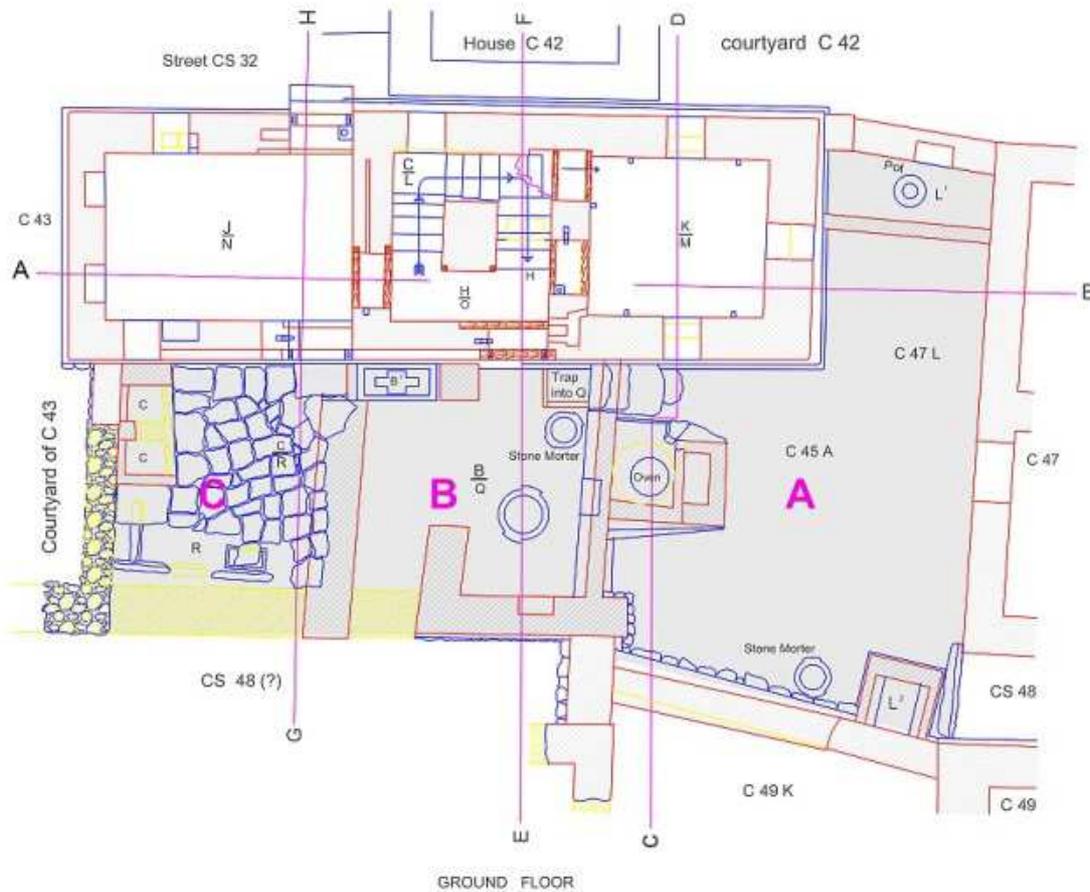


Fig. 6 – The CAD drawing based on plan of House C45 by the University of Michigan highlighting the courtyard areas A, B & C



Fig. 7 – The CAD drawing based on sections of House C45 by the University of Michigan which highlights the various modifications that took place on the house structure through time.

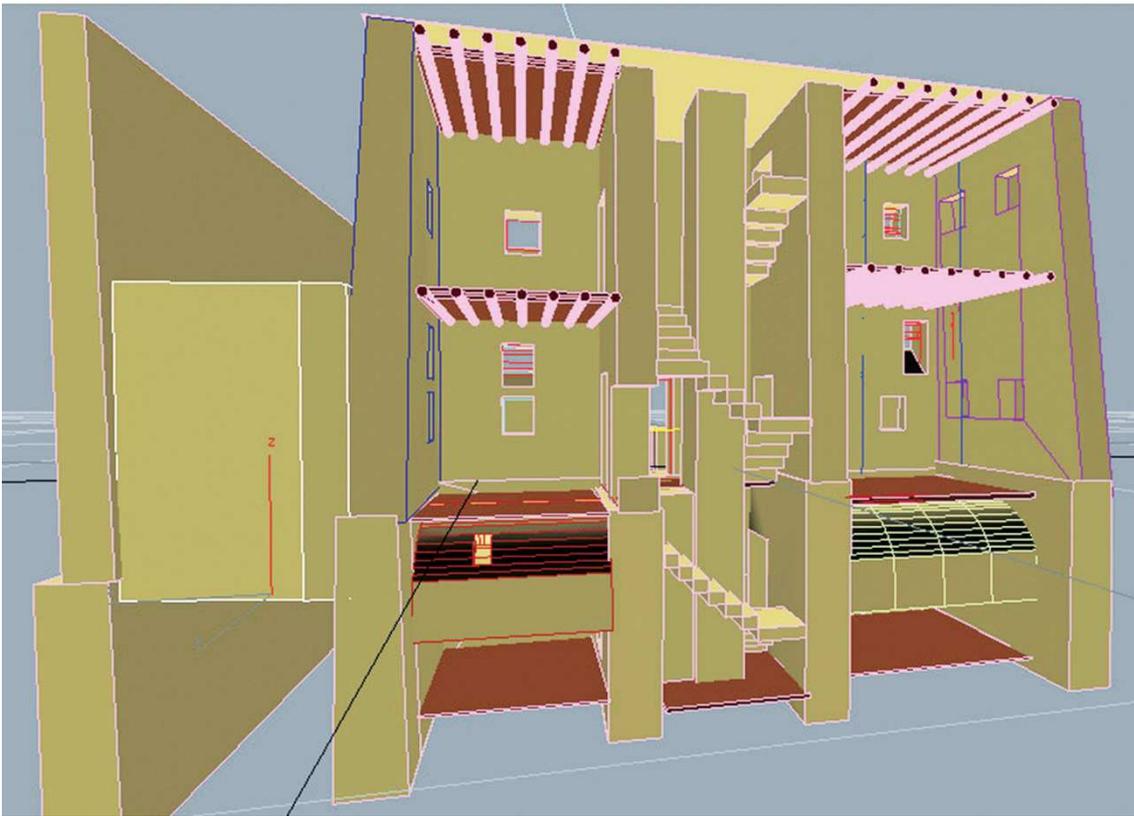


Fig. 8 – the 3D model of house C45 showing the interior structure and different stories

Apart from showing the development of the house, ample attention was also given to representing the building materials. This allows for a better understanding of the selection of materials for different parts of the house over time. Stone was rarely used because of the expense. Apart from the two Roman-period temples at Karanis, which were built of locally quarried stone, it was sparingly used in domestic architecture, and when it was, it consisted mostly of re-used stone elements from earlier buildings. It was utilized with some consistency for the outside stairs, as threshold from the road to the entrance of the house, or from the house into the courtyard, and to strengthen or protect building corners. The walls themselves, however, were built of mud-brick, which was economical and would have been manufactured nearby. On the inside of the house, bricks were set in horizontal courses, but on the exterior they were bedded in a concave foundation. This method caused the outer walls to appear to sag, but was in fact a well-tested method of building firmly on sand. Wood from local trees such as sycamore, palm and acacia were also used for house construction. Flat roofs, ceilings, and floors were generally built of closely spaced rafters made of palm trunks. Wood was likewise utilized widely in windows, doorways and cupboards. Different images of materials used in the exterior and interior finishes were collected to be used as texture maps for the 3D model. Much of this information came from the database and photo archive of the ongoing URU Fayum Project excavations. Mental Ray renderer, which is a high-quality 3D rendering software built-in 3D studio Max, was used to cast and simulate realistic daylight (Fig. 9).

Apart from showing time as a factor of time-of-day or time-of-year, something which can be successfully approached with rendering software, the power of VR reconstructions is that the interpretation of both short-

term and long-term developments can be brought into the model. Using a time line or series of time switches particular architectural changes of the building over time can be shown. Even if the date of building modifications is unknown, usually the order in which developments happen can be reconstructed. The granularity of such a visualization depends greatly on the quality of excavation and recording.



Fig. 9 – left: light rendering of the 3D model of house C45, right: the model after texture mapping

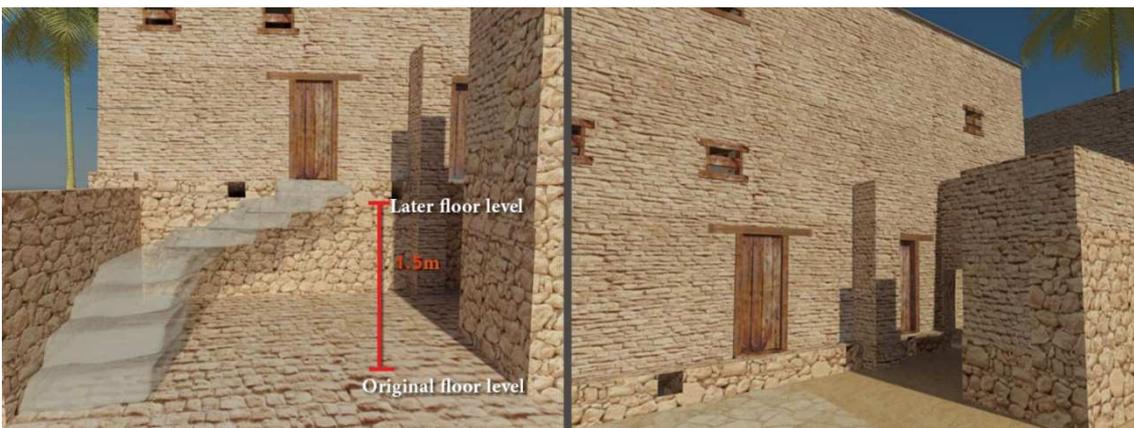


Fig. 10 – left: original floor level in courtyard C with possible stone steps, right: later floor level in the same courtyard



Fig. 11 – left: niche in courtyard B , Middle- the same niche after the painting was added in a later period, right: Photograph of the niche with painting Courtesy of Kelsey Museum of Archaeology

Virtual place-making

An understanding of space has multiple inflections and discourses relating to cultural context and perception (FLYNN 2007). Critics often blame virtual environments (VE) for evoking 'cyberspaces' but not 'place' because VE lacks richness of association, and limits the personalization of spaces. The virtual experience can be 'empty' and 'hollow', like stage sets if it lacks social and cultural presence (TAN & RAHAMAN 2009). The focus of 3D visualization of historical structures is not 3D modelling or creating stunning images, but an in-depth, systematic study of the sources, their assessment and correlation, proposition of most probable hypotheses, documentation of this interpretation process in a structured way, to finally produce visualization according to the requirements and context for its use. (BENTKOWSKA-KAFEL et al 2012). Therefore, in this study we have paid special attention not just to the building structures but to the objects found in the excavations, which can convey the daily activities and add meaning to the virtual spaces. Such archaeological objects are crucial sources of information on the constitution of religious, political and social identities.

A selection of Karanis daily life objects from the collection of the Kelsey Museum of Archaeology including pottery vessels, glass lamps, toys, rugs, wooden furniture, windows and doors, have been photographed to create photogrammetric 3D models. The items selected are mostly from house C45, although some objects were included from other C-level buildings. Agisoft Photoscan software was used to process the images acquired for each object which range between 50 to 150 pictures according to the size and the level of details of each object, and to create the 3D point cloud model. The final 3D models were then exported as OBJ files to 3D studio max to be merged and placed inside with the 3D model of the house, their position was determined with the reference to excavation photos of the house, as well as descriptions from the reports in the archives of the Kelsey Museum. (Figs. 12, 13).



Fig. 12 – Left: A terracotta oil lamp holder from Kelsey Museum Collection (<http://www.umich.edu/~kelseydb/Exhibits/Karanis83/KaranisExcavation/domesticlife2.html>); right: A 3D photogrammetric of one of the terracotta oil lamp holder from Kelsey Museum Collection



Fig. 13 – left: A section of the northern wall of C45K, showing a wall peg with rope attached (Courtesy of Kelsey Museum of Archaeology); right: The final photogrammetric 3D model of the lamp holder exported to the 3D model of the house interior to be placed in its original setting.

All paradata, the information based on which the model has been built and all decisions and interpretations that are part of its creation are made available with the model. This includes the basis for the different structural changes, the selection of materials and objects, as well as the location where the objects are placed within the house.

Conclusion

Digital technology has the potential to provide research and educational tools that combine, organize and make accessible a multitude of diverse materials and resources, such as the notes, maps, photographs and finds from Karanis. A virtual reality model includes these materials as part of the paradata that underlie the interpretation as reflected in the model. Bringing in the time factor creates a model that not only represents three dimensions, but also includes developments over time at different scales. It furthermore provides a reconstruction of the cultural context linked to a density of information, engaging the user in the virtual experience.

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