Abstract: Digital reconstruction and visualization of archaeological sites are beneficial not only for public edification and admiration, but they can also significantly contribute to the site interpretation process. By going beyond basic modeling scenarios, one can apply 3D analyses for accurately testing visibility and lighting parameters, among other aspects. Based on the results of these tests, further insights can be extrapolated about the lived experience of culturally specific ancient peoples. The case of a Roman “villa” at Apollonia-Arsuf in Israel presents the opportunity to apply these informal techniques to a household shrine, or niche-style \textit{lararium}, found within the building in order to ascertain sightline visibility based on the architectural plan and visual impact as a result of artificial illumination from ceramic lamps. This paper also considers how photorealistic visualizations aid in phenomenological areas of research through sensory archaeology and sense of place, which in turn encourages reflection on the political, social, and religious meanings of the built environment. When we combine the power and diverse applications of 3D visualization technology with decades of research about Roman architecture, culture, religion, and social norms, the result is a step closer to recreating archaeological remnants and, in turn, understanding the ancient experience.

Keywords: 3D visualization, visibility analysis, illumination, sensory archaeology, Roman Israel

1 Introduction

Within the archaeology community, there has been an unspoken division between the creation and use of 3D models based on 3D surveys (photogrammetry, terrestrial laser scanning, image-based 3D modeling, etc.) versus 3D models created from computer graphic modeling software. 3D survey data have been unflinchingly adopted and incorporated into the archaeological excavation process for data acquisition and analysis as a way of developing new methods of visualizing complex, fragmented archaeological data that enable researchers to answer specific research questions (Dell’Untó, 2014, p. 60). In contrast, 3D visualization of heritage and archaeological findings has been utilized generally in the context of communication to the nonexpert public. Due to its highly hypothetical nature, there has been a resistance of using...
3D (re)constructions for scientific academic research. However, studies in recent years have proven and solidified the use of realistic 3D visualization as a tool for positing and testing archaeological research questions (e.g., Beacham, 2020; Boutsikas, 2019; Dunn & Woolford, 2013; Ferdani, Demetrescu, Cavalieri, Pace, & Lenzi, 2020; Lercari, 2017; Lulof, 2020; Mickleburgh, Nilsson Stutz, & Fokkens, 2020) in tandem with creating visual media for public consumption. With this adoption into the research agenda, 3D (re)constructions can be applied not only to sites that already have 3D survey data, but also to sites that do not due to excavation work occurring before this technology existed as well as a potential lack of access and funding for 3D acquisition. Therefore, armed with only site plans, excavation notes, and the wealth of scholarly literature (Huvila, 2014, p. 43), it is possible to develop 3D simulations of a site and conduct robust research and analysis using computer-generated 3D models and the virtual environment.

By incorporating 3D approaches into the final stages of site analysis, archaeologists have at their disposal a powerful tool for the recontextualization of material remains in conceptually and methodologically unique ways. Akin to the principles of experimental archaeology, the overarching goal of computer-based modeling exercises is to test plausible scenarios rather than find a final or definitive answer to archaeological inquiries (Ellis, 2006, p. 284). The fundamental argument for regularly implementing 3D simulation to the study of archaeology is the recognition that real-life ancient people and the spaces they occupied were complex, dynamic, and ultimately idiosyncratic. For these reasons alone, it is certainly worth the effort to study remains in three-dimensional, reality-based simulations (Sanders, 2014). By flexibly reconfiguring existing data and conceptual frameworks into a more visually comprehensible and adaptable format, we are able to alter our perception of the past and systematically address ephemeral questions pertaining to the ancient lived experience. As an inherently interpretive and creative practice, attempts to simulate archaeological remains in 3D “initiates a process of thinking through doing” (Watson, 2015, p. 121). The results of such simulations will facilitate reflective analytical discourse regarding technical challenges and cognitive relationships in both the real and virtual realms.

In the field of ancient Roman studies, traditional historical and archaeological approaches have contributed greatly to our understanding about construction and use of interior spaces; however, these approaches are not without their limitations. Fortunately, these methods can be supplemented by the direct integration of 3D simulation and visualization into the interpretation workflow. To that end, a physically based 3D simulation of a 1st cent. C.E. Roman residence from the coastal site of Apollonia-Arsuf in modern-day Israel has been rendered to showcase the investigative potential of such digital experimental exercises.

2 Theoretical Framework

2.1 Controversies

Terminology within the virtual archaeology community lacks both consistency and consensus. There remains a tendency to use the word “reconstruction” to signify the product of a digitally constructed scene or representation of archaeological remains. Many believe this term is misleading due to the implication of absolute knowledge and understanding of the past. Clark (2010) advocated for another terminology, such as “simulation slice,” to communicate the hypothetical and time-specific nature of such simulations. In recognition of Clark’s arguments, Schreibman and Papadopoulos (2019) co-opted the common term and proposed the use of “(re)construction” in order to be consistent with the term’s popularity in publications as well as to highlight the ambiguity and hypothetical nature of the model.

Photorealism is also a controversial topic for virtual archaeology. Much like with terminology, increasingly life-like representations present a danger in educational settings because the higher graphic level implies a certain level of “historical truth” (Eiteljorg II, 2000). Proposed alternatives include “non-photorealistic” graphic representations that serve as an abstraction that “subconsciously underlines the
hypothetical nature of the [(re)construction]” (Roussou & Drettakis, 2003, p. 7). However, there is also a danger in making the model too simplistic or only representing unbiased scientific content (van Gool, Waelkens, Mueller, Vereenooghe, & Vergauwen, 2004). Additionally, Favro (2006) argued that “attractiveness is not a sin” (p. 332) and that the ancient inhabitants were themselves observers who constructed and appreciated their environments, albeit with different tastes than modern observers. Furthermore, she pointed out that simple, graphic representations may fail to generate interest in a lay public who expects a certain level of esthetics when interacting with digital (re)constructions. Beyond considerations for the lay observer, the expert or academic community has much to gain from the powerful visual impact of high levels of realism and accuracy in both the (re)constructive process and the final rendered output. Papadopoulos (2018) recognized this potential for 3D visualizations as “heuristic sources and working hypotheses in the production of archaeological knowledge, becoming part of a never-ending translation process, augmenting perception and providing stimuli to expand the interpretive vocabulary of the archaeological process” (Papadopoulos, 2018, p. 5).

Physically based rendering (PBR) is a method of 3D visualization whereby an algorithm accurately represents the interaction of light rays with surface matter (McDermott, 2018, p. 17). In the context of heritage research, this approach for realistic 3D visualizations can be utilized as an interpretive tool in combination with archaeological, historical, and architectural sources as one way to generate new perspectives on the site.

2.2 Visibility Analysis

Similar in scope and function to illumination studies, 3D visibility analysis is another invaluable method for testing hypotheses relating to spatial organization and social relationships. Attempts to decipher the latent messages of identity, status, power, wealth, and more in 3D require “insider” knowledge that no longer exists. Thus, a complementary approach is required to understand how the built environment was consciously manipulated in order to subconsciously affect others depending on their age, gender, social status, etc. One example of this type of study was conducted by Paliou, Wheatley, and Earl (2011) through the use of isovist and visibility graphic techniques adapted from Benedikt (1979) which were integrated into a 3D analysis of Late Bronze Age Akrotiri. The study assessed the visibility and social impact of wall murals located inside an elite residence from the eye-level perspective of a street bystander. Paliou (2014) later built on the results of this study to explore how Rapoport’s (1990) concept of Nonverbal Communication of urban spaces provided visual, olfactory, and acoustic cues about how human actors “consciously manipulate... built environments to promote their interests” (Paliou, 2014, p. 92).

These methods are particularly useful in the study of Roman architectural elements. Beyond practical considerations of space, Roman architects and clients intentionally designed interior spaces to communicate subliminal messages about accessibility and prestige. Wallace-Hadrill (1994) unequivocally stated that “the Roman house was a constant focus of public life” (p. 12) in which the dominus had control over his image through “a spectrum that ranges from the completely public to the completely private, and with an architectural language that seeks to establish relativities along the spectrum” (p. 17). He also pointed out that by gaining access to the more private areas of the domus, the visitor ascended in privilege and status as invited guest. This “architectural language” consequently facilitated the social function of publicly visible household decoration in the sense that “what matters are not the visual games played, but the associations evoked by the decoration: its power not of illusion, but of allusion” (Wallace-Hadrill, 1994, p. 25). Bergman (1994) was one of the first to analyze virtual decorative elements within a basic architectural simulation in order to investigate the mnemonic allusions of fresco panels from the House of the Tragic Poet in Pompeii. She investigated how an ancient viewer may have experienced the mythological panels through ambulatory movement and what cognitive triggers these depictions would have evoked about contemporary social themes. Similarly, Gruber and Dobbins (2013) utilized 3D modeling and lighting simulations to perform sightline analysis at the House of the Drinking Contest in Antioch, Turkey. One of their objectives
was to simulate unknown architectural elements, such as column height and spacing, to reveal an occupant’s line of sight in certain spaces that would hypothetically highlight certain features of the house. The authors also considered the ambulatory spectator, whose view changes as they move about the interior spaces.

2.3 Sensory Archaeology

Sense of place and archaeology of the senses are increasingly being applied to digital archaeology studies. This is due in large part to a recognition that phenomenological approaches contribute significantly to academic rigor. Holtorf (2017) explains this endeavor as a kind of time travel whereby our “imagination and embodied experience [facilitate a] credible...authentic experience about a past that could have happened” (p. 6). It is this recognition that our experience as a human being is the first step in reconstructing the past.

Sense of place involves much more than a collection of objects within a space. Rather, place is marked through atmosphere or esthetic qualities because it is “particular, unique, dynamic, and memorably related to other places, peoples, and events” (Champion & Dave, 2007, p. 10). This was proven by Pujol-Tost (2019) by means of a user evaluation study of a VR environment set in prehistoric Catalhöyük. She concluded that the different elements within the simulation (i.e., architecture, objects, sensory realism, and human characters) contributed differently to the user’s sense of place and learning (Pujol-Tost, 2019, p. 16). Therefore, in attempting to (re)construct archaeological contexts, the designers should consider more than just the physical remains and remember that these spaces were experienced on different perceptive and cognitive levels by the original inhabitants.

Traditionally, study of the senses through archaeology has relied heavily on sight and vision, resulting in an ocular-centric approach to the study of the past (Jay, 1996; Macgregor, 1999). However, Betts (2011) recognized that academic study can go beyond the visual and kinesthetic (physical movement of walking) senses to also encompass how vision and movement interact with the sounds, smells, and tastes of a city, which are potentially dependent on the individual (gender, age, status), period (calendar date, time of day, season, year), geographic location, and even the sociopolitical environment. Platts (2020) also advocated for archaeological studies that consider the “full corporeal immersion within a building” because vision acts in conjunction with other bodily experiences that “could be manipulated as a further means for displaying personal power and wherewithal” (pp. 2–3). Within a VR environment of the Villa of Boscoreale, Beacham (2020) explored how some of these sensory qualities can evoke an ancient lived experience. Virtual movement through a (re)constructed space offers viewers the opportunity to “engender a great variety of cognitive, psychological, and emotional reactions” (Beacham, 2020, p. 49). He stressed that this is only possible “when we are able to consider [Roman domestic environments] as complex, carefully integrated, spatial, decorative, and social ensembles, fashioned by their ancient artists and patrons, often with great subtlety and esthetic sophistication” (Beacham, 2020, p. 55).

2.4 Illumination

“The culture of light” permeated ancient daily life and was both functional and deeply symbolic (Lapp, 2017; Tal & Teixeira-Bastos, 2012). In recognition of this, accurate light simulations of ancient spaces using computer graphic techniques have been used in the last two decades to test hypotheses relating to task performance (Dawson, Levy, Gardner, & Walls, 2007; Masuda & Yamada, 2004; Papadopoulos & Earl, 2009; Papadopoulos & Sakellarakis, 2013) and visual perception and cognition (Beacham, 2020; Boutsikas, 2019; Gonçalves, Magalhes, Moura, & Chalmers, 2009; Gruber & Dobbins, 2013; Papadopoulos & Earl, 2014; Sundstedt, Chalmers, & Martinez, 2004). Other studies recorded and quantified the spectral properties of the flame from different ancient lighting vessels and fuels (Chalmers, 2002; Devlin & Chalmers, 2001;
3 The Lararium at Apollonia-Arsuf

3.1 Lararia and the Household

In the 1990s, a late first century CE Roman period peristyle building was discovered off the Mediterranean Coast of Israel outside the medieval city of Apollonia-Arsuf. As a result of the original construction method, two well-preserved arched niches were found in the bedrock wall of the eastern section of the building. These niches and the space they occupy have been interpreted by the principal investigators as a lararium based on comparisons from Pompeii and Herculaneum (Roll & Tal, 2008, p. 140). Lararia, or domestic shrines, marked the location(s) within a private home or establishment where daily and special occasion offerings were made to a variety of deities, household spirits, ancestors, or other religiously significant figures (also referred to as Lares, Penates, Genii) (Orr, 1978). Foss (1997) provided an sociopolitical distinction between Lares and Penates; the former were gods of the living family and the latter were the gods of the ancestors (p. 198). Foss also sees a connection between slaves, the kitchen, and Lares because Lares traditionally protect and bless the food, slaves prepare the food, and both have “temporary, present-active roles in the continuation of the household” (ibid, p. 217). Giacobello (2008) expands on this by proving that there were frequently two lararia in an elite Roman household, the “primary” one is found in kitchen contexts and a “secondary” one is found in threshold spaces like atria, gardens, or cubicula. Bodel (2008) likewise argues that this distinction between primary and secondary has to do with the inclusion of slaves as members of the family household—the “primary” shrine can be considered the shared “household” shrine where general household Lares were worshipped, while the “secondary” shrine was a “private” shrine for personalized familial worship of the Penates (p. 266).

Lararia within the residence acted both as a locale of ritual activity and a decorative architectural feature to be visually experienced along the aforementioned public-private spectrum by Wallace-Hadrill. In order to gain insight into these public and private manifestations of domestic worship, Rasmus Brandt (2010) used statistical analysis in his study of the location and visibility of lararia within residences from Pompeii and Ostia. He identified three methods in which lararia were placed in the public eye: directly in public spaces, e.g., atria, peristyle courts, etc.; along movement lines in which the private-public dichotomy became less rigid, e.g., dead spheres of public areas; and “on a deep-view (or long-view) axis, i.e., at the end point of the sight line, which runs through the house from the entrance door to the furthest wall” (Rasmus Brandt, 2010, pp. 76–77). In some cases, the dominus was placed in the middle of...
this deep-view sight line, which would have created a visually meaningful allusion to the household owner’s power as well as his piety. This was done for the benefit of the visitor, whose status was determined by his or her ability to access the end point of the line-of-sight. Brandt also noted that the lararia became increasingly more visible to visitors during the Imperial period, which resulted in architectural allusions being made about the symbolic link between the dominus and the Lares; a link that showcases the complementary roles shared by both the dominus and the Lares/Penates/Genii for protecting the interests and well-being of the household, with the former operating in the physical realm and the latter within the metaphysical or spiritual realm.

3.2 Light in the Ancient World

Roman considerations for light and lighting devices operated on many levels, especially in terms of function, symbolism, esthetics, and social relationships (Ellis, 1995, 2006; Griffiths, 2017; Zarmakoupi, 2011). The ancient Roman architect Vitruvius (De architectura: I, II, 7) highlighted access to natural light as one of the main considerations in the planning of a construction as well as positioning rooms in relation to the sun, depending on the room’s functional requirements of heat and light (ibid. VI, IV, 1); he also implies that these functional placements (such as the dining room, i.e., triclinina) may change depending on the time of year (ibid. VI, IV, 2). However, the architectural evidence suggests that elite homes had rather dark interiors, especially in urban areas. This would make sense when we consider that “blanket” lighting was not an ancient concept, with shadowy interiors likely being the norm (Ellis, 1995, 2006). Indeed, there would have been a heavy reliance on lighting devices to illuminate indoor spaces and the number and quality of lighting devices would have been a clear indication of wealth and status in Roman society (Griffiths, 2017). However, the combination of architecture and light was used in “self-celebration, as a social filtering device, and as a symbol of power” (Carrié, 2017, p. 14). In these ways, light provided physical and cognitive cues within ancient residences to consciously or subconsciously guide social perception and behavior.

In addition to architectural manipulations, light itself was generally considered to be a medium to commune with the divine as well as the best way to represent it (Dieleman, 2012; Zografou, 2010). Moreover, votive light was used as an amulet of protection against darkness and the evil that lurks within (Lapp, 2017). It is likely for these reasons and more that many lamps are found in close proximity to lararia (Boyce, 1937). This happens to be the case for the lararium at Apollonia-Arsuf whereby excavations unearthed oil lamps with zoomorphic reliefs, i.e., a rooster and a bull (Figure 1), which suggest that the syncretic Greek-Egyptian deity Serapis (a fusion of Apis and Osiris) and possibly Helios/Apollo were worshipped at some time during the building’s occupational periods (Teixeira-Bastos, 2011). In a related archaeological context, this imagery was also discovered on lamp fragments excavated at the Shrine of Apollo in Tyre (Bikai, Fulco, & Marchand, 1996). The representation of Serapis on oil lamps is well-documented, including its correlation with Helios and sun worship (Budde, 1972, pp. 630–642; Derksen, 1978, pp. 296–304; Kiss, 1995, pp. 137–138;

![Figure 1](Rooster and bull reliefs from lamp sherds found near the lararium at Apollonia-Arsuf (Teixeira-Bastos, 2011, Plate 64, p. 287, Figure e and g).)
have been carefully and conscientiously of a have applied 3D simulation with PBR materials and accurate lighting scenarios to analyze a specific sources, analysis of archaeological data, ethnographical comparisons, etc. However, very few studies have been an important and longstanding Roman deity associated with amuletic light and *lararia*. She was frequently represented as a flame rather than as an anthropomorphic figure in paintings or statues (Orr, 1969). Within pre-Roman dwellings, the hearth was often placed in the midst of the house or near the entrance (Ovid, *Fasti*. 6.295) and acted both as the symbolic heart of the home (Sofroniew, 2016) and as a protective barrier to “guard the things deep within” (Gee, 2000, p. 118). Later, Roman *lararia* may have evolved out of this symbolic link between the early household hearths and private domestic devotion – using light in the form of votive lamps as a continuation of that connection.

This symbolic relationship with flame and the divine was eventually linked to the Roman state; Vesta’s *ignes aeternum* or “eternal fire” was kept alight by Vestal virgins in a common hearth (*focus publicus*) for the benefit of the Roman people (Stark, 2015; McElroy, 2016). Therefore, Vesta was one of many Roman deities who simultaneously served the interests of both individual families and the state as a whole. As the Roman state transitioned from Republic to Empire, piety and worship also evolved into a conglomeration of public and private religious obligations (Rasmus Brandt, 2010). As a result of this shifting ideology, the *lararium* increasingly became a complex staging ground of one’s individual piety as well as their loyalty to their family and the imperial state.

### 3.3 Lararia and the Archaeological Record

Archaeological examples of *lararia* are integral to understanding public and private Roman worship in residential contexts. Unfortunately, due to poor preservation of Roman walls of heights at or above eye-level, *in situ* evidence of *lararia* is rare outside of Italy. As a consequence, the base of knowledge surrounding Roman shrines rests on archaeological sites such as Ostia, Pompeii and Herculaneum, contemporary literary accounts, and decontextualized figurines.

Roman *lararia* can be understood from a multitude of different perspectives – architectural, religious, political, or economical – using any number of combined research approaches – e.g., examination of historical sources, analysis of archaeological data, ethnographical comparisons, etc. However, very few studies have applied 3D simulation with PBR materials and accurate lighting scenarios to analyze a specific example of a *lararium*. As argued above, *lararia* were an important aspect of the Roman residence and would likely have been carefully and conscientiously “staged” according to the owner’s values and ambitions. It is believed by the authors that lighting and visibility were considerations that went into the architectural planning of the building at Apollonia-Arsuf. The results and analysis of a 3D simulation of the building together with a combined approach of accurate illumination, visibility analysis, sense of place, and sensorial considerations aim to contribute to the relatively small body of research on Roman *lararia* as well as provide new insights about a unique and complex residential structure off the Mediterranean coast of Israel.

### 4 Peristyle Building at Apollonia-Arsuf

The site selected for this case study is that of the Roman-period peristyle building of Area E, located on the outskirts of the Medieval settlement of Apollonia-Arsuf (Figure 2). The city had gained relative importance in Antiquity as the primary commercial and industrial center of the south Sharon Plain due to its natural safe anchorage in an otherwise inhospitable stretch of coastline (Roll & Tal, 2008). Roman-period
Apollonia-Arsuf appears in literary sources, e.g., Pliny (*N.H.*, V. 13.69) and Ptolemy (*Geo.* V. 15.2.), and was included on the *Tabula Peutingeriana* (Weber, 1976, Section X, 1U) as one of the official way-stations on the
cursus publicus (imperial road network) of Iudaea/Palaestina. Listed as Apolloniade on the map, it is located 18 km from Jaffa and 42 km from Caesarea Maritima.

The structure of Area E, at approximately 26 m above sea-level, is located on top of a small ravine that leads down to the ancient harbor. It is aligned to the four cardinal points and runs an estimated 24 m east-west and 21.50 m north-south (Figure 3). Because of the difficult location at the top of the seashore slope, the eastern end of the structure was carved out of the fossilized Tel Aviv Kurkar bedrock to a depth of 3 m and then leveled horizontally toward the west and the open sea (Roll & Tal, 2008, p. 138). It was constructed in accordance with the Latin foot (pes/0.2957 cm) using mainly large ashlars made from the local kurkar and laid as stretchers set in grey cement (Roll & Tal, 2008, p. 140). Finds from two superimposed plastered floors from Locus 1928 established a 70s CE construction timeframe and an estimated date of destruction and abandonment to 115 CE as the result of an earthquake (Roll & Tal, 2008, pp. 144–146).

The general layout is that of a classic Roman peristyle building with an open, central inner courtyard with a water channel for diverting rainwater to the west (Roll & Tal, 2008, p. 140). While the central courtyard was open, the interior corridors of the courtyard must have been roofed because there is evidence for 10 piers resting on a stylobate constructed of sandstone headers. Of the four interior corridors, the east-west one stretched the entire 24 m length of the building. The lower sections of the southern and eastern walls were carved directly out of the bedrock and plastered; robust kurkar headers of 0.60 m in length were then placed on top of this bedrock surface. Due to these solidly constructed walls, it is suggested that there was possibly a second story, at least on the east and south sections of the building (Roll & Tal, 2008, p. 140). Although the west side of the structure has collapsed into the ravine below, it is assumed by the principal archaeologists that the main visitor’s entrance lay at the western end of the

Figure 3: Building plan of Area E at Apollonia-Arsuf (Roll & Tal, 2008, p. 136).
east–west corridor (Roll & Tal, 2008, p. 138). As previously mentioned, a lararium is present at the eastern end of the same corridor and is indicated by two recessed and arcaded niches at a height of 2.35 m above the floor level (Figure 4). One niche faces directly to the west and, presumably, the main entrance; the second niche faces the southeastern most room of the building (Locus, 1777). Important to note is the assignation by Roll and Tal (2008, 2018) of the southern half of building as residential due to a finer quality of construction, as opposed to the northern half, where it was presumed domestic chores were carried out. Also, on this northern half of the building is a wide opening made directly onto the most northern corridor of the courtyard. This is believed to be a common entrance used for supply deliveries and for easy access to the exterior of the building for the purpose of domestic activities occurring on the northern half of the building. It is also plausible that the presumed western entrance could have been a solid wall with no door opening, thereby making this northern “service” entrance also the main visitor entrance. However, despite the damage to the western region of the building, there is reasonable architectural evidence to support the existence of a western entrance: the higher quality of construction for the southern rooms implies a social division (ibid); Roman building conventions whereby a dwelling may have multiple entry points with different uses (Platts, 2020); the western entrance would have the greatest distance from the culina and its kitchen smells – described as offensive by multiple Romans authors (Platts, 2020); finally, the proximity to the coastline and the harbor below the ravine on which the building sits (Roll & Tal, 2008, p. 138) implies this was a major desired trait in the building’s construction and so a west-facing orientation complies with this theory.

Initially, the peristyle building at Apollonia-Arsuf was interpreted as a Roman villa maritima due to domestic-related artifacts from the second phase of occupation, architectural elements, and its overall dramatic cliffside perch overlooking the sea, thereby projecting typical Roman elite qualities of “tranquility, privacy and leisure” (Galor et al., 2009, p. 9). As a means of explanation for the presence of such a unique structure to the area, Roll and Tal (2008) suggested that this was the result of an isolated Romanization process in which a wealthy merchant and his family had commissioned a Roman-style construction. Either the elite family was from the Italian peninsula, or they were locals who desired to emulate and adopt Roman conventions. While this hypothesis is plausible, the excavators’ revised interpretation takes a more nuanced perspective of the site (Tal & Teixeira-Bastos, 2012; Tal & Roll, 2018).

Figure 4: Present day state of preservation of the lararium within the eastern corridor of the building (photo by M. Teixeira-Bastos).
This new insight hinges primarily on the similarity of Apollonia-Arsuf in construction, design, chronology, and artifacts to the ‘Ein ez-Zeituna mansio found alongside the Caesarea-Legio road leading from Caesarea Maritima to the Lower Galilee and the Jordan Valley (Glick, 2006). Besides having the same occupation period (late first to early second centuries CE), both structures were constructed to the standard Latin foot and were designed as nearly square peristyle buildings consisting of the central courtyard surrounded on all sides by rooms (Tal & Roll, 2018, p. 314). This parallel between ‘Ein ez-Zeituna and Apollonia-Arsuf prompted a reevaluation of the Apollonia “villa” with a focus on the regional military activity occurring during the first phase of its construction. As Apollonia-Arsuf is similarly located along a major imperial road network – that of Jaffa-Caesarea – the revised interpretation is that the peristyle building was initially constructed and used for a short time as a military mansio or some kind of way-station or statio to ensure Roman movements during the First Jewish War (Tal & Teixeira-Bastos, 2012, p. 109; Tal & Roll, 2018). Oren Tal, the principal investigator, argued that the decidedly Italian prototype and inclusion of a niche-style lararium was a design choice in order to provide “a venue that was architecturally familiar to them, a “home away from home” along the lines of a domestic architecture that they already knew in Italy, but here transposed to a land in which it was unfamiliar” (Tal & Roll, 2018, pp. 314–315). This theory is corroborated by the tendency for Roman military encampments to be well-removed from the corrupting influence of civilian life (MacMullen, 1963). Even though the peristyle building was not afforded the privacy and protection of a full Roman camp, its isolated location and Italian-style characteristics can be interpreted as an “enclave of Romanism,” away from city and civilian entanglements, which were believed to undermine loyalty and discipline (Haverfield, 1978, pp. 1494–1495).

As mentioned earlier, the lararium located at the eastern end of the main entrance corridor is the focus of the following re(con)struction. In order to formulate a plausible scenario, the timeframe of the simulation is that of its earlier occupation phase which began during the reign of Emperor Vespasian 71–79 CE, either during or after the First Jewish War in 66–73 CE. Within the theoretical framework outlined above, it is argued that the creative and investigative process of digital visualization provides insight about carefully crafted socioreligious perceptions as one enters the building and, in so doing, contributes to the discussion regarding the original function of the building, i.e., as a private residence or a military mansio.

5 Methods

Armed with these data about social, religious, and architectural conventions of the region and time period, a potential (re)construction of the building and its immediate vicinity was modelled, textured, and given direct and indirect lighting and various cameras were set up in first person perspective. The research questions being tested with this simulation are: What is the visibility of the lararium from different publicly designated locations? Does artificial illumination alter the lararium’s visibility? And, what kind of potentially evocative experiences would different individuals have encountered based on their social status, their location in the building, and the presence or absence of artificial illumination?

The villa structure was digitally (re)constructed following Roll and Tal’s (2008) publication, which provided a detailed description of the remains as well as a ground plan of the site (see Figure 3). After deciding on a physically based simulation of the first occupational phase (c. 71–79 CE), the model was textured and populated with Roman-era architectural features, props, and human silhouettes. As a stylistic decision, the military hypothesis was assigned to the simulation and generic Roman army standards, a silhouette of a seated Roman solider and anthropomorphic votive figurines were arbitrarily included in the scene in order to provide contextual and atmospheric elements to the scene. While the hypothetical props in the scene imply a bias towards an initial military construction and use of the building, it may be the case that the building was in use as a single-family domicile in the first phase of residence.

The virtual environment was further enhanced with natural and artificial illumination and finally rendered as high-fidelity still-images. The natural light parameters were derived from two High Dynamic Range Images (HDRI) that approximated the late-morning and evening sky environments from a dry coastal
setting. HDRI is useful for integrating real-world luminance into a rendered scene (Happa et al., 2010). For the artificial lighting of the lararium, it was also arbitrarily decided to place three Roman-style oil lamps on the protruding shelves of the two niches. The spectral properties of the Roman lucerne for this (re)construction were based on previous research by Gonçalves et al. (2009, p. 13), whereby the radiance (light intensity) and wavelength (color) of different olive oils were measured with a spectroradiometer.

The rendering of a series of high-fidelity images demonstrates how visibility of the lararium was affected by location within the building, time of day, and the presence of artificial illumination. Five eye-level cameras were placed in different public locations within the structure (Figure 5) and rendered three times using differing light conditions: Condition A is with natural light from late-morning and without the presence of any artificial illumination within the building; Condition B is with natural light from late-morning and with the presence of artificial illumination in the lararium; Condition C is with late-evening light and with artificial illumination in the lararium as well as throughout the public corridors and in the hand of a “servant” moving along the Locus 1859 corridor. The observer perspectives were set at about 1.6 m above the floor level to achieve an eye-level perspective. For the camera field of view (FOV), a 45° FOV was used; however, the human eye has a visual field (including peripherals) of about a 210° forward-facing horizontal arc and a 150° vertical arc (Traquair, 1938).

The locations of each observer/camera were chosen in order to attain a range of perspectives from different positions within the four public corridors. The first four camera views are directed towards the lararium, while the final camera (5) offers a perspective from the lararium itself. Camera 1 is from the perspective of one entering the building from the western end of the main corridor (Figure 6); Camera 2 is from that same east–west corridor but from a closer observer perspective, as if one was standing in front of the room of Locus 1830 (Figure 7); Camera 3 is from the perspective of one entering from the north of the building at Locus 1761 (Figure 8); Camera 4 is from a Locus 1859 perspective, as if one was leaving Locus 1937 and walking south (Figure 9). The Camera 5 perspective was rendered using only Condition B light settings and has a west-facing perspective, as if one was standing in front of the lararium (Figure 10).

Figure 5: Graphic representation of the locations of each observer/camera within the building (adapted after Roll & Tal’s, 2008 site plan).
6 Analysis

By creating different eye-level camera views within certain points of the building’s interior (Figures 6–10), it was determined that the architectural layout did not allow for axial views of the lararium unless one was standing in the main east–west corridor (e.g., Cameras 1 and 2) (Figures 6 and 7). The simulation demonstrated that the eastern end of the east–west corridor received no natural light, and because of this, it was a deemphasized space shrouded in shadows at all times of the day and night, thus creating a truly “dead
zone” within the residence. Therefore, it was determined that artificial light would have been necessary to illuminate this space, even during daylight hours.

With the introduction of artificial light into the (re)construction (Condition B), the difference becomes striking and quite provocative, as visibility and perception change completely from Cameras 1 and 2 locations (Figures 6 and 7). Observers from this east–west corridor would not only be able to see the illuminated niches, but likely their eyes would be drawn to it as they moved deeper into the building. However, observers from other points in the building (e.g., Cameras 3 and 4) (Figures 8 and 9) would not have had direct visibility of the lararium itself, nor would the artificial light from mansio have been sufficient to indicate the presence of a sacred space during the daytime hours (Figures 8b and 9b). In this sense, the lararium was well and truly hidden from those not directly standing in the east–west corridor. This could imply the intent on the part of the original building owner to assert a certain amount of control in terms of social accessibility. The visual impact of the semipublic location of the lararium can be interpreted as for the benefit of high-status residents and visitors rather than service personnel.

7 Discussion

This dichotomy of light and dark and the relationships between visibility and accessibility communicates a great deal about Roman values and social dynamics. The following discussion attempts to extrapolate possible social memories and emotions that the lararium would have evoked in residents and visitors alike. However, another layer of complexity is added due to the uncertainties over the initial function of the building. In such a case, cognitive perceptions of an individual observer change drastically depending on his or her occupation and social status, e.g., military personnel, wealthy merchant, servant, visitor, etc.

Following the initial interpretation of the structure as a private residence of a wealthy elite family, it is likely that the architectural placement of the illuminated lararium acted as an allusion to the dominus’ individual power and piety. The combination of an axial deep-view into a dead sphere with glowing lamps to light the space would have implied cultic practice occurring within the property while simultaneously revealing the link between the dominus and his Lares. In the context of an elite private villa, the lararium’s
location combined with light may have triggered for visitors a series of cognitive perceptions relating to accessibility, i.e., a casual acquaintance likely would not have been invited into the inner reaches of the visible space, but an honored guest might have been. Another possible reference could have even been to specific deities, e.g., Apollo, Serapis, Helios, or Vesta, represented with flame light, as the guardians of the inner sanctum of the residence or as the eternal flame of the Roman state.

The more recent interpretation of the peristyle building as a mansio for military officials, however, caused the location and light of this lararium to dramatically change our understanding of possible mnemonic triggers. As a military official arriving to the residence for the purpose of a short stay, the visibility and illumination of the lararium would not have been a subliminal message of exclusion, but rather a staging place for the official army religion. Haverfield (1978) described military religion as “a system of cultic observances prescribed for all army units wherever they may have been stationed” (p. 1473). Acting as a part of this system, he theorized that the religious use of space helped to orient these soldiers as they campaigned from place to place as well as to solidify their relationship both to the Roman Empire and to what lay beyond it (Haverfield, 1978, p. 1503). It was mandated that the center of every Roman camp contains an aedes, or sacred shrine, where the standards, the eagle, and a bust or image of the emperor were located. Additionally, numerous festivals to the imperial family and official Roman gods were observed (Fink, Hoey, & Snyder, 1940). Also, from the first century CE to the fourth century CE, a sacred vow was made solely to the emperor to ensure the army’s loyalty to him, rather than as personal forces for individual generals (Frank, 1969). Alongside official army religion, there were numerous unofficial military Lares or Genii worshipped individually by soldiers in private spheres, inclusive of Genii centuriae and legionis. Speidel and Dimitrova-Milceva (1978) discussed the unprescribed and spontaneous nature of this type of military cult worship as an attachment to one’s military unit as well as a feeling of identity and sense of belonging (p. 1546). Due to the semipublic nature of the lararium at Apollonia-Arsuf, it is more likely that only official military Lares and/or Genii were worshipped in this space. By understanding the intertwined ideology of military duty with religious piety, it is plausible that the intended allusions of the Apollonia-Arsuf lararium were related in some way to official military worship, thereby symbolically orienting and reminding the military personnel of their sacred duty to Rome.

Regardless of the identity of the principal residents located in the southern half of the building, there was a clear restriction of visual accessibility to the lararium for the supposed domestic staff located in the northern half of the building. Therefore, it can be argued that service personnel were not the target audience for the lararium. This may be an indication that the servants, as occupied locals, either were not worshippers of the Roman religion or were not under the privileged protection of the range of Roman domestic or military Lares. Based on the analyses performed, this was likely a deliberate decision made in the early phase of construction—either for reasons of exclusivity or as a conscientious consideration of Rome’s policy on religious tolerance. Furthermore, it is likely that the patron of the building designed the layout in such a way as to control and regulate access (Platts, 2020), while still maintaining a level of privacy as the considerable distance of the lararium from either entrance ensured that passersby could not clearly see, smell, or hear any potential ritual activities occurring at the shrine.

The placement of the lararium opposite the main entrance is also symbolically reflective, both for a visitor looking in and the protective spirits within looking out (see Figure 10). These deities have an unobstructed view of the entrance, the visitor, the sea, and the west. The allusion likely being made through the architectural language of decoration is that the Lares are strategically positioned to oversee and protect the entrance of the building, the interests of trade on the Mediterranean and, most importantly, Rome and her larger interests of imperial expansion. This visually impactful communiqué of both a divine and imperial presence was further enhanced by the cognitive understanding of the sociopolitical atmosphere of late first century CE Roman-occupied coastal Israel. Thus, it is suggested by the authors that this placement of the lararium was by design and intended for those residing in and entering the building to consciously or subconsciously know as well based on culturally specific insider knowledge.

Finally, visual elements are not the only way one engages with the world; rather, full corporeal immersion and bodily experience are critical for understanding activities and perceptions in ancient lived spaces (Platts, 2020, p. 3). Thus, in order to gain a further “sense of place” at Apollonia-Arsuf, we need to
consider other sensory elements beyond vision. For example, how would the peripheral sound of crashing waves and the smell of the harbor have influenced the experience of arriving at and entering into this place? Consideration of this experience leading up to the entrance allows us to broaden our scope beyond the walls of the structure by factoring into our interpretation the physical and social atmosphere of the residence. Additionally, the time of day and season would have perceptively altered one’s arrival, e.g., hot and dry, cold and windy, midday or evening. All of these and more factors could have contributed to the comfort and mood of an ambulatory individual as they arrived or departed this removed locale.

8 Conclusion

This paper is intended to only briefly explore a handful of topics and possible interpretations of the lararium at Apollonia-Arsuf through the use of creative and experimental physically based (re)constructions. It is hoped that the ideas, references, and arguments made here provide ample rationale for the adoption of both formal and informal analytical approaches of 3D environments in late-stage archaeological site interpretation. When performed with rigor, 3D virtual simulations add a nuanced understanding of specific sites based on the sum of the archaeological evidence, the ancient and modern literature on site-related issues, and the phenomenological considerations, all of which contribute to an informed, well-rounded interpretation.

Through the application of digital “experimental” archaeology, or (re)construction, an investigation and analysis of the visually evocative impact of the lararium at Apollonia-Arsuf provided insight into the potential desired effect for ancient visitors to the peristyle building. The digital (re)construction techniques employed in this research are relatively basic for those familiar with 3D modeling and illumination and can be easily replicated in further studies on Roman architecture as well as the built environment of other regions and cultures. Physically based experimental methods have a lot to offer their virtual counterparts and vice versa. What real-world experimental studies bring to digital (re)construction is, for example, a greater accuracy in software parameters, sound-bytes that can be added to the digital media, and an understanding of the human capabilities and processes of carrying out daily work and industrial activities. Conversely, digital (re)construction offers experimental archaeologists the opportunity to digitally test a (re)construction before precious time, money, and energy are expended on a physical project.

The careful design of the lararium at Apollonia-Arsuf reinforces our understanding of a Roman society actively concerned with nonverbal displays of status, power, and piety. Based on the results of the rendered images, it was determined that direct visibility of the lararium was only possible from the main entrance/east-west corridor and, even then, would have required the inclusion of lucerna to provide proper appreciation of the space. If the structure was built for use as a private domicile, then the allusion being made may have been one of private-public power dynamics. However, if the building was constructed for the purpose of temporarily housing military officials, then the visibility and warmly lit lararium may not have suggested exclusive access; rather, it would have evoked a sense of welcome, comfort, familiarity, and the knowledge that the residence was under the protection of a potential variety of Lares militares. The uncertainty of original inhabitants reinforces the importance of factoring in individual idiosyncratic perspectives to an interpretation. This is especially pertinent for Roman academic research, as Roman society was incredibly diverse in terms of ethnicity, gender, and social hierarchy. The complexity of the Roman Empire demands a tailored and robust approach to understanding the whole archaeological context, not only the physical built environment but also how these spaces were used and experienced by different individuals.

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**Abbreviations**

3D three dimensional  
2D two dimensional  
CE common era  
FOV field of view  
HDRI high dynamic range image  
PBR physically based rendering  
VR virtual reality

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