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INTEGRATION AND WORKFLOW FRAMEWORK FOR VIRTUAL VISUALISATION OF CULTURAL HERITAGE. REVISITING THE TELL OF ÇUKURIÇI HÖYÜK, TURKEY

MARCO DE TRABAJO DE INTEGRACIÓN Y FLUJO DE TRABAJO PARA LA VISUALIZACIÓN VIRTUAL DEL PATRIMONIO CULTURAL. REVISITA DEL MONTÍCULO ÇUKURIÇI HÖYÜK, TURQUÍA

Nika Lužnik-Jancsary[a,*], Barbara Horejs[b], Michael Klein[c], Christoph Schwall[b]

[a] Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology, Hohe Warte 38, 1190 Vienna, Austria. nika.jancsary@archpro.lbg.ac.at

[b] Institute for Oriental and European Archaeology, Austrian Academy of Sciences, Hollandstraße 11-13, 1020 Vienna, Austria. barbara.horejs@oeaw.ac.at; christoph.schwall@oeaw.ac.at

[c] 7reasons Medien GmbH, Sachsenplatz 4 – 6, 1200 Vienna, Austria. mk@7reasons.net

Highlights:

- Computer-aided visualisations bring hidden cultural heritage to life –an individual outcome for Çukuriçi Höyük, a tell settlement in Turkey.
- The interdisciplinary team combined data acquisition and communication techniques, interpretative approaches, and dissemination methods for achieving the best result.
- Integrative framework optimises the information and communication potential of virtual visualisations with the help of pre-defined workflow stages.

Abstract:

This article sets a framework for computer-based visualisations of cultural heritage sites. The project focuses on a workflow for a visualisation illustrated on a specific solution for the site of Çukuriçi Höyük, a tell settlement in Turkey. With the virtual presentation, an interdisciplinary research group tries to offer complex scientific results to the general public as well as to experts. The team utilised data acquisition and communication techniques, interpretative approaches, and dissemination methods. The three-dimensional (3D) outcome is based on a large amount of scientific data, usually available only via analogue or digital publications for a specialised audience. The work focused on constructed and personal authenticity to reach the viewer's feelings. As an interpretative narrative, the daily lives of the inhabitants were selected. A communication plan was constructed, and a video animation with narration and a musical background was selected as the most appropriate communication tool. The movie was divided into four chapters *(Introduction, Neolithic Period, Chalcolithic Period* and *Early Bronze Age Period*). A separate webpage was designed to provide additional information when the video is viewed online. The webpage was divided into tabs that describe each chapter and three additional topics (*Visualisation Process, Further Reading,* and *Credits*). The video was shared in different settings, e.g. at public talks and on social media. The process resulted in a complex workflow that consists of several stages: data acquisition, first interpretation, 3D model creation, communication plan, second interpretation, 3D model adjustment, and dissemination output. Each stage of the workflow serves as an example to show the types of nodes these parts can include. The result is a flexible framework with predefined process stages, which can be re-used for similar projects.

Keywords: interdisciplinarity; workflow; virtual cultural heritage; 3D visualisation; framework

Resumen:

Este artículo define un marco de trabajo de visualizaciones por ordenador de sitios patrimoniales. El proyecto se centra en un flujo de trabajo ilustrado por una solución específica de visualización del sitio de Çukuriçi Höyük, un asentamiento sobre un montículo en Turquía. Con la presentación virtual, un grupo de investigación interdisciplinar intenta ofrecer resultados científicos complejos al público en general, así como a los expertos. El equipo utilizó captura de datos y técnicas de comunicación, así como enfoques interpretativos y métodos de difusión. El resultado tridimensional (3D) está basado en una gran cantidad de datos científicos, normalmente disponibles sólo a través de publicaciones analógicas o digitales orientadas a una audiencia especializada. El trabajo se centró en la construcción y la autenticidad personal para alcanzar al espectador a nivel emocional. Como narrativa interpretativa, se seleccionaró la vida diaria de los habitantes. Se construyó un plan de comunicación y se eligió una animación de vídeo con narración y musica de fondo como la

[*]Corresponding author: Nika Lužnik-Jancsary, nika.jancsary@archpro.lbg.ac.at

herramienta de comunicación más apropiada. La película se dividió en cuatro capítulos (*Introducción, Período Neolítico, Período Calcolítico* y *Período de la Edad de Bronce Temprano*). Se diseñó una página web separada para proporcionar información adicional cuando el video se muestra en línea. La página web se dividió en pestañas que describen cada capítulo y tres temas adicionales *(Proceso de visualización, Lectura adiciona*l y *Créditos*). El vídeo se compartió en diferentes entornos, tales como charlas públicas y en redes sociales. El proceso produjo un complejo flujo de trabajo que consta de varias etapas: captura de datos, primera interpretación, creación del modelo 3D, plan de comunicación, segunda interpretación, ajuste del modelo 3D y difusión. Cada etapa del flujo de trabajo sirve de ejemplo para mostrar los tipos de nodos que estas partes pueden incluir. El resultado es un marco de trabajo flexible con etapas de proceso predefinidas, que pueden reutilizarse en proyectos similares.

Palabras clave: interdisciplinariedad; flujo de trabajo; patrimonio cultural virtual; visualización 3D; marco de trabajo

1. Introduction

Many interesting archaeological sites remain unnoticed by the public because of their inadequate presentation. This predicament is particularly crucial in the case of Çukuriçi Höyük since the site lies on private property in the middle of olive groves and it is not open for public yet; even if reached, there is nothing to be seen with bare eyes. These circumstances are also related to the early dates of the excavated settlements and the recovering and refilling of the archaeological remains. A team of experts working on the site of Çukuriçi Höyük set out to accomplish a dissemination approach with a broad reach-out potential.

The planned presentation should be able to reach different audiences, from the scientific public to traditional museum visitors to millennial youth. Furthermore, it should establish a connection with the viewer and induce the urge to conserve cultural heritage. As already Tilden said in the 1970s: "Through interpretation, understanding; through understanding, appreciation; through appreciation, protection" (Tilden, 2009). With an established framework, the approach can be reused for other suitable cultural heritage sites.

For decades, it is already believed that cultural heritage should be interpreted in a way that it somehow relates to the visitor or viewer. Here, the term interpretation does not relate to the first archaeological interpretation of the archaeological remains (Copeland, 2004) but, as the Ename charter (2008) states, it refers to the full range of potential activities intended to increase public awareness and enhance understanding of a cultural heritage site. These can include print and electronic publications, public lectures, on-site and directly related off-site installations, educational programmes, community activities, and ongoing research, training, and evaluation of the interpretation process itself (16th General Assembly of ICOMOS, 2008). Therefore, passing on only information is not nearly enough; interpretation is an art, the main aim of which is not instruction, but provocation. Consequently, the recognition of the whole story should emerge in the observer (Tilden, 2009).

The considerable amount of data that accumulates during the archaeological research has to be presented to the public observer comprehensively and quickly to keep the viewers' attention. The data of different monument's stages have to be combined in the best possible way and presented easily and understandably. High-quality tools result in a higher quality presentation. Consequently, the interpretation and the receiving of archaeological information is also enhanced. Among different kinds of presentation, the virtual reconstruction and visualisation are gaining influence and importance since the early 90s of the 20th century (Reilly, 1991). This technique offers a unique dissemination approach that has an advantage over other, more traditional presentations. Here, ideas, objects and places can be presented in 3D virtual environments, embedded in their context. The technique allows gathered data and the interpretation of it to be presented in a visual setting, which places this technique among the indispensable interpretive approaches with valuable interpretive tools (Hermon, 2008).

Computer-aided visualisation offers a deepened insight into the cultural monument and is at the same time quickly comprehended. It can be presented on different platforms –embedded into a museum exhibition or presented to specific audiences at conferences, workshops or online. With this rare stand, it is the optimal choice as a foundation for vast outreach dissemination. –It dramatically impacts how the public perceives the site, and it has various distribution options. However, since the beginning of the use of virtual visualisation techniques for archaeological purposes, many well-founded concerns were raised regarding it (Miller & Richards, 1995). Consequently, heritage representation guidelines dedicated to the use of virtual tools for cultural heritage were constructed in recent years, like London Charter (Denard, 2009) and Principles of Seville (International Forum of Virtual Archaeology, 2011). ICOMOS briefly regulates these presentations in the Ename Charter (16th General Assembly of ICOMOS, 2008).

However, when constructing the interpretation, it is essential to remember that through it, the viewers want to experience a genuine, original experience of the specific cultural heritage site. Authenticity is, therefore, the key to an auspicious conveyance of the cultural heritage value. Tilden notes in his definition of interpretation that the contact with the original object builds the authentic experience (Tilden, 2009). As Howard states, this is hard to achieve in the absence of the artefact, e.g., when re-enacting historical events. Since the approach is modern, these re-enactments cannot be authentic and cannot evoke the same feelings as in the past (Howard, 2003). On the contrary, Hill and Cable (Hill & Cable, 2006) separate the authenticity of cultural heritage to *objective*, *constructed* and *personal authenticity*.

The most traditional is the *objective authenticity*, which is attached to the original objects. These are pieces of history that we have in front of us, outside or in museums, original artefacts and buildings. Due to its connection to the objects, it is very often limited by the conditions that these objects find themselves in. Further on, it has the possibility and an obligation to explain to the visitors which parts are original, and what are possible later additions and corrections (Hill & Cable, 2006). Due to the absence of the original object, virtual representations cannot have objective authenticity, although, when complying with the guidelines of virtual visualisation, accuracy and validity of the 3D objects can be assessed (Hermon & Niccoluci, 2018). Furthermore, they can build and expand the interpretation of the original objects. Augmented reality (AR) applications can superimpose more information and interpretation on the existing objects (e.g. (Andrade & Dias, 2020)).

Constructed authenticity emerges from copies of objects or even whole environments, which show something that used to exist or exists remotely. Sometimes these reconstructions can incorporate original objects also (Hill & Cable, 2006). These could be archaeological parks with reconstructed buildings from a specific period or also computer-based visualisation. Here also the multi-interpretation of the presented objects can be shown.

Unlike the previous two, that focus on the presented topic, *personal authenticity* focuses on the visitor's experience. When eliciting an emotional response, the experience turns real, forging a real relationship with the subject matter (Hill & Cable, 2006). Even though the authors mentioned above mainly refer to historical re-enactments, a computer-based visualisation is very similar in transferring the visitor over space and time and offering him a new perspective on the topic. Moreover, through the use of virtual visualisation, a new kind of authenticity with a close relationship to the original is built (Jones et al., 2018).

As shown, even though the computer-aided visualisation cannot offer objective authenticity, it can contain and elicit constructed as well as personal authenticity.

Furthermore, as the data is gathered and processed for the virtual visualisation, the digitization of the archaeological site incorporates a detailed 3D documentation, also. Together with the later virtual visualisation, this presents a valuable digital reproduction of the site, that serves as an essential record of the cultural heritage site in the case of its destruction.

When all the arguments in favour of it were considered, virtual visualisation was deemed the most appropriate method to present the archaeological site.

Importantly, when faced with the design of the computer-aided visualisation construction, a workflow was composed to take the full advantage of its communication and information potential (Fig. 6). Besides the already quite well-defined guidelines for a scientifically based virtual 3D model and the carefully studied archaeological data collection methods, the communication and the multifold interpretation approaches were additionally integrated with this workflow. The emphasis is on the relationships between the different aspects of the visualisation process and their effect on the composition of the virtual 3D visualisation. The project thus provides a novel framework for an interdisciplinary and integrative computer-aided visualisation practice. Even though the workflow presents the different case-specific process nodes, it gives special attention to the main stages and nodes of the process to emphasise its ability to be reused for many different projects, which confront the same challenge of optimising the virtual visualisation construction and thus also its results. Alongside, the various team member types at different stages also suggest the research team structure (Fig. 1). The emerged framework can help standardize the practice of the virtual visualisation content creation.

The first systematic investigations of Çukuriçi Höyük and its environment started in 2006, followed by several third-party funded international projects with large interdisciplinary teams funded by the Austrian Science

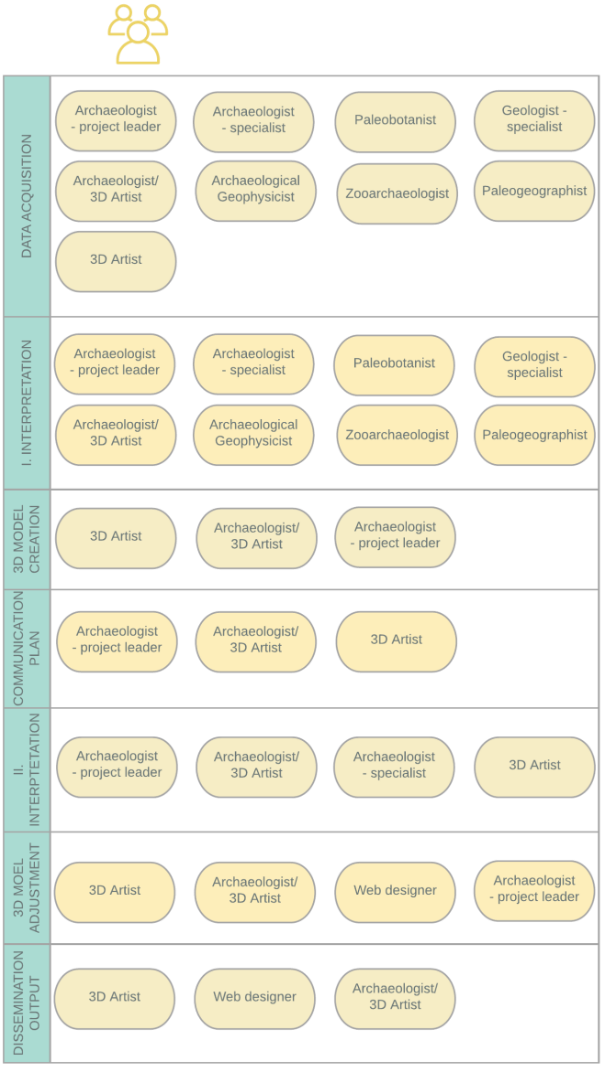


Figure 1: Types of interdisciplinary team members in each part of the visualisation process.

Fund (FWF) and the European Research Council (ERC) between 2007 and 2016 (project no. FWF P 19859, Y528, P25825, ERC 26339). Though detail aspects are still under research and analyses will continue, currently ca sixty articles and two books are published. These publications form the basis of the virtual interpretation (Horejs (2017) has a list of all appeared publications).

2. Methods

The project initially focused on two aspects: visualisation of the current situation and separate historical periods, and audio narration about the site. Additionally, also an online presentation was designed. On the dedicated website, the presentation can be accessed freely by the public and is further explained with the accompanying information. Whereas the visualisation and the narrative were much intertwined in its conception, the online presentation was designed last.

The project was based on an interdisciplinary approach. To acquire data, excavation of the site was a major source of data, but complementary research was conducted, too. A team of 3D artists that belongs to a company specialised in archaeological 3D animations and reconstructions was chosen to execute the visualisation. 3D artists were included in the project in the later stages, yet still during active research on-site. The core team for the computer-aided visualisation consisted of an archaeologist –the project leader, archaeologist/3D artist and a 3D artist. In different stages of the project, the core team and additional specific experts designed and evaluated the 3D visualisation (Fig. 1).

During the visualisation process, the team was meeting regularly to discuss and evaluate the progress, a designated fileserver was set up to share data, and emails were exchanged to discuss minor decisions. For the traceability of the decision-making process, emails, drafts and notes were saved. In the next sections, separate stages of the visualisation process will be discussed. In some parts, one section will describe multiple stages of the process. During the project, these stages were defined: data acquisition, first interpretation, 3D model creation, communication plan, second interpretation, 3D model adjustment, and dissemination output (Fig. 6).

2.1. Computer-based visualisation

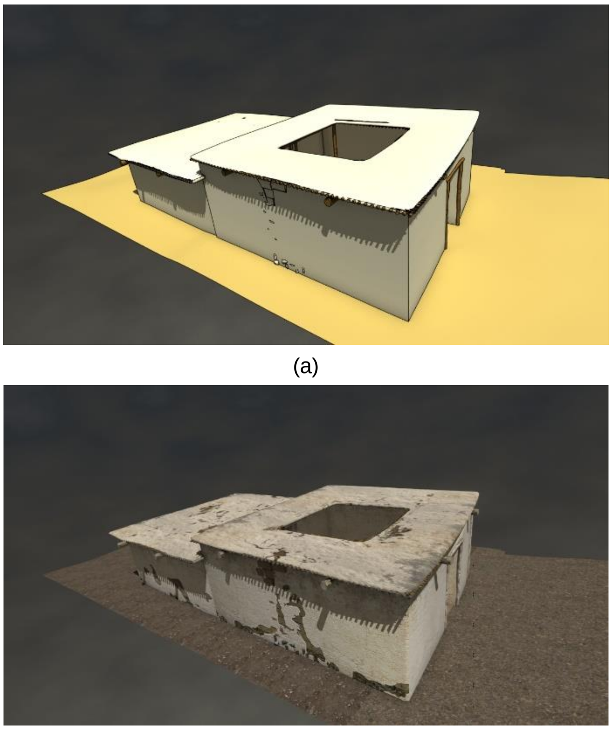
This section describes three stages of the visualisation: data acquisition, first interpretation (explanation and contextualisation of the findings) and 3D model creation.

The settlement phases with the most data were selected to be exemplarily visualised: ÇuHö X for Neolithic (7th mill. BC), ÇuHö VII-Vb for Late Chalcolithic (4th mill. BC), ÇuHö Va, and ÇuHö IV and partially III (3rd mill. BC) for Early Bronze Age. For each period, only a selected area of the tell was visualised. For the period with the most data –the Early Bronze Age, though, an image of the whole tell was created. The visualisation of the prior periods was tackled from four different parts: terrain, architecture, artefact, and life reconstruction. All visualisations were scientifically evaluated. The visualisation process included continuous discourse between the team of archaeologists and the team of 3D artists.

Different sources were used to recreate the current and ancient cultural landscape. To give the impression of the area, a large terrain until the horizon was visualised. For this area, the model was obtained from the freely available digital elevation model (DEM) of Turkey (Tachikawa et al., 2011). This area did not have to be detailed as it served only as a backdrop. The excavation team measured the area of the tell in the years 2006 and 2009 (Horejs et al., 2011), and a reconstruction of its former size was created. This research served as the base for the visualisation of the tell in the historical periods.

In the year 2014, a model of the excavation area based on the Structure-from-Motion – Multi-View-Stereo (SfM-MVS) approach, e.g. (Cots et al., 2018; Furukawa et al., 2009, 2010) was created. The model was founded on ca. 2000 photos taken in September 2014. The alignment of photos resulted in several high-resolution point clouds, which were converted to textured meshes. The gathered meshes were appropriately combined and implemented in the tell model. The tell model was used as-is for the visualisation of the modern terrain. For the visualisation of the ancient surface, the terrain of the tell and the wider area was refined –the tell was levelled to the cultural horizon of different periods, and on the wider area modern features, e.g. roads, and buildings were removed. Some effects of natural processes were applied to the model to visualise the ancient appearance of the terrain. According to findings, the sea level was suitably raised, and two streams in an estimated position were added (Stock et al., 2015). The vegetation density and species were added according to concluded paleo-botanic studies (Horejs et al., 2011; Knipping et al., 2008).

The architecture is based on the found building foundations, analogies from the period, and traditional Anatolian architecture, e.g. (Schwall, 2018; Warner, 1994). At first, the architectural computer-aided design (CAD) models were reconstructed and evaluated (Fig. 2). The houses had a stone wall base and mudbrick walls. Very often, they also had support wooden beams that were positioned either on the inside or outside of the wall, or in the middle of the wall. The walls were covered in plaster. The roof was a construction of wooden beams with a net of smaller branches and straw-covered in mud. Some roofs had a central opening. According to the finds and analogies, an appropriate unique texture was designed to cover the house walls. Cracks were added to the plaster layer of the texture to show the mudbricks or stone base underneath.



(a)

(b)

Figure 2: Çukuriçi Höyük: (a) CAD model of a house; (b) The same CAD model textured.

If more hypotheses about the settlement were equally likely, they were correspondingly presented. Compared to the whole tell area, only a small part was excavated and geophysically prospected. For the organisation of the houses on the tell in the Early Iron Age, different tell sites were studied and then the known area was used and extrapolated in the predicted pattern.

Everyday objects –e.g. obsidian blades (Bergner et al., 2009)– that were found on the tell were visualised after structured-light 3D scans, models based on the SfM-MVS approach, or scientific drawings. To complete the partially preserved objects found on the tell researchers used analogies from similar sites. Some objects were more complicated as they were mechanisms, for example, the loom. For the loom, only loom weights were found and the position of the loom in the room. The reconstruction is based on analogies from similar sites and traditional loom in the area, e.g. (Britsch & Horejs, 2014).

Visualisation of the inhabitants posed the most significant challenge. The presence of the human factor contributes significantly to the understanding of the visualisation, yet the knowledge of traditional wear at the time is not satisfactory. To avoid misguided impressions, a presentation of the people in the form of a plane shadow was implemented. To stay consistent, animal species, that were found on the site, e.g. (Galik, 2013), were presented as shadows, too (Fig. 3).

2.2. Communication plan

To understand what kind of a story direction and design the final product needed, researchers defined the media channels for distribution of the visualisation. Besides the traditional illustrations alongside scientific and news articles, public talks (like conferences, workshops and lectures) and internal meetings, there was also a wish for an engaging stand-alone always available presentation of the site. Therefore, an independent website with a video was planned. Moreover, the video can be reused at other media channels –either embedded on internet pages or shown at talks.

2.3. Interpretative narrative

This section explains some 3D model adjustments and the design of the second interpretation. The interpretative narrative is the second interpretation of the findings that tries to give them a story.

The narrative of the tell inhabitants' daily lives was first conceived and later accordingly designed visually and with audio. Several animation clips were created from the visualisation and combined into a short movie. The movie is separated into four chapters: *Introduction*, *Neolithic Period*, *Chalcolithic Period* and *Early Bronze Age Period*. To connect different phases with today's situation and to keep transparency between the data and photorealistic visualisation, the starting point of the visualised time phases are 2D plans combined with a 3D model of the excavation trenches. The plans show the position and the extent of the data gathered so far. Later, the excavated artefacts are presented on their own before they are finally shown in the visualised environment (Fig. 4). The story is narrated by the project leader in German and English and comprehensively connects the visual presentation. The narration takes us on a journey through time, from the broader context of the history of the area to the present-day tell, where we dive into its rich and long history. As the video shows different stages of the tell development and 2D plans, the audio story flows without interruption. Complementing the story is a majestic musical background as music causes an additional emotional response, often with a rewarding effect (Goldstein, 1980; Mori & Iwanaga, 2017; Morris & Boone, 1998; Sloboda, 1991). The story ends by intriguing the viewer with further secrets that are buried in the inconspicuous tell, waiting to be discovered.

2.4. Dissemination

This section explains further 3D model adjustments and the design of the dissemination results.

As an optimal medium, suiting the desired communication channels, a video animation was designed. The short movie was implemented on a dedicated online page together with additional information (Fig. 5). Under the video, seven tabs are present that are titled the same as the movie chapters, as well as three further complementary topics labelled *Visualisation Process*, *Further Reading*, and *Credits*. In the first four tabs, features that appear in each chapter are separately described with images and text. The fifth tab explains the visualisation process step by step. Finally, the sixth tab lists additional reading recommendations, and the seventh shows the credits. The movie was referenced on the main page of the OREA institute as well as shared on social media, and online news magazines.

3. Discussion

The virtual visualisations of archaeological sites mainly focus on the design of the models themselves. However, to present the site in a way that maximises its information and communication potential, several additional approaches need to be included, too. These include site-specific communication planning and interpretative narrative construction. Consequently, a better targeted and more goal-orientated presentation is composed. When the objective was considered, the workflow was constructed, as already mentioned, of seven stages: data acquisition, first interpretation (archaeological interpretation), 3D model creation, communication plan, second interpretation (multifold interpretative approaches), 3D model adjustment, and dissemination output. Alongside the process, the process itself was documented, which is illustrated as a separate parallel node in the workflow.

Next paragraphs will provide argumentation for the chosen approaches and demonstrate their use in the project.

Even though multifaceted interpretational approaches are already practised, for example, in museums, galleries and heritage parks with interpretative guides, or even re-enactments, it is still uncertain if and to which extent they can be effectively incorporated in a short, cohesive and independent unit like a computer-aided visualisation product. Here, the original monument is most often not in front of us, the interpreter is mainly not present, and the presentation of the site is unattended by a real person.

To achieve the best result with computer-based visualisation, the interpreter should combine constructed and personal authenticity (Hill & Cable, 2006). The base for constructed authenticity is the visualisation of the data acquired during the research, and the visualised environments are the base for personal authenticity. All are connected through a narrative.

Moreover, to uphold the scientific principles, the computer-aided visualisation should follow the already specified guidelines for virtual archaeology, the *London Charter* (Denard, 2009) and the *Seville Principles* (International Forum of Virtual Archaeology, 2011). Also, Statham examined 30 other more general charters and identified several factors of value to virtual visualisation that were a recurring topic in said charters: multidisciplinary teams, objective-driven methodology and tools, careful documentation, authenticity, type of reconstruction and level of certainty, alternative hypotheses, multiple historical periods, respectful use of

Figure 3: A complete visualised scene from the Neolithic period.

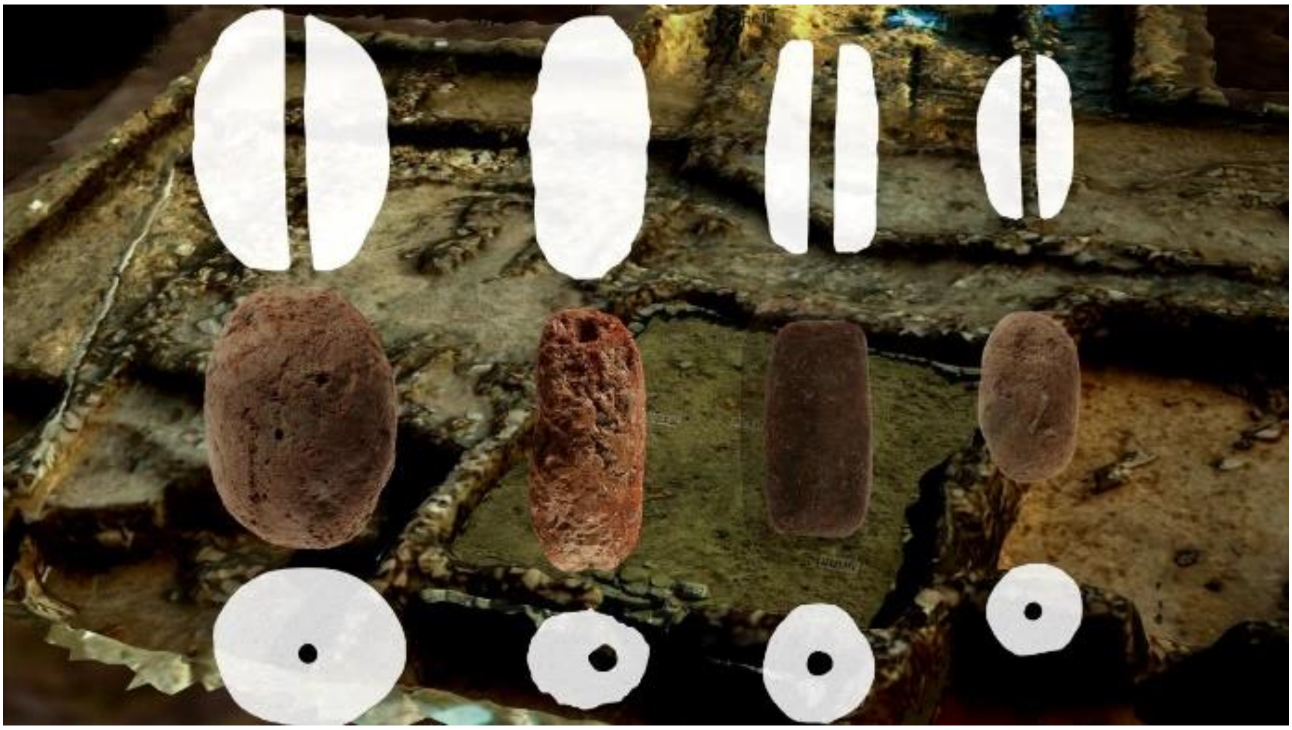


Figure 4: Presented artefacts (here, loom weights) before appearing in visualised scenes.

the heritage and community engagement (Statham, 2019). Successively, following the guidelines of good heritage interpretation practice (Derde & Ludwig, 2016; Ludwig, 2015), from separate facts (like different artefacts or architectural remains), a wholesome story should be conveyed (Tilden, 2009). To direct the attention of the viewer, the interpreter chooses only a selection of the facts to deliberately convey a *whole* – a topic, or a theme (Ham et al., 2013). Practically, there are three main different kinds of source data upon which the computer-based model of the monument can be built. The first kind is *old research data* –excavation data, descriptions, depictions, and measurements; if the monument has since been destroyed, this is the only data available. The second kind is the *contemporary excavation data* that can be gathered with the computer-based model in mind. Finally, there are also models built solely upon the results of *non-destructive geophysical measurements*. The workflow for each of these instances has to be adjusted and optimised for the particular case.

In this specific case, excavation data was the primary source, but geophysical prospection and interdisciplinary research were conducted, too.

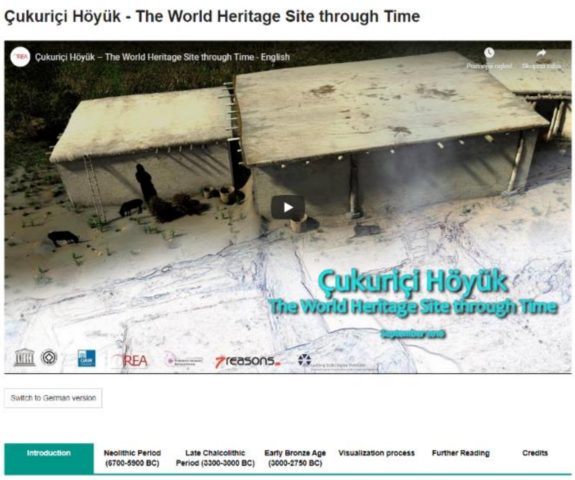


Figure 5: The starting page of the Çukuriçi Höyük movie.

Many different aspects have to be respected to generate a valid virtual representation. When striving for the best result possible, as in this case, the archaeological team is affected by the planned computer-aided visualisation in the conduct of their excavation research as they adjust the documentation techniques in a manner that helps the later virtual reconstruction (Howland, 2018). They create 3D laser scans of artefacts and excavation layers and take photographs that support the creation of SfM-MVS models, e.g. (Cots et al., 2018; Furukawa et al., 2009, 2010). Furthermore, the inclusion of 3D artists at a sufficiently early stage of the research project enables the team of 3D artists to visit the site during the excavation time. Seeing the site and the material first-hand, and having the time to conduct additional research on the topic, brings the team of 3D artists a more in-depth insight into the site, which results in a higher-quality output. A constant discourse between the two teams during the visualisation process allows incorporating much-needed feedback from both sides (Lužnik & Klein, 2016). Effective communication between the scientific team and the team of 3D artists is often a challenge when creating 3D models; therefore, a person knowledgeable in both fields is of great value. During this project, a core team of an archaeological project leader, 3D artist and a person knowledgeable in archaeology and 3D design was in frequent contact throughout the project. This setup provided a better balance between the expectations and possibilities, and research approaches and artistic impressions.

It is important to stress that there are two very different notion terms connected with computer-based models: *reconstruction* and *visualisation*. The *reconstruction* is the act of rebuilding to the original state (Merriam-Webster.com, 2019a), and for the most part, due to lack of sufficient data, it is unknown what the original state looked like exactly. Reconstruction is, therefore, arduous to achieve. The scene can also be visualised (Merriam-Webster.com, 2019b), formed according to hypotheses in a way that makes it possible to imagine how it looked according to the best knowledge at the time.

In this case, to create a believable impression, the data was treated imaginatively when creating the computer-based models. The unknown data was filled in according to the present hypothesises to create a wholesome representation. Still, unnecessary details without sufficient background were avoided or replaced by cognitively acceptable approximations. For instance, instead of 3D humanoid models, 2D planes in the shape of people were used. The realistic visualisation has a caveat of being non-transparent; yet, the viewers prefer in some instances, the photo-realistic visualisation to non-realistic visualisation (Isenberg et al., 2006). Therefore, it is important never to leave a photo-realistic visualisation unattended: at talks, it should receive additional explanation by the presenter; online and in museums, it should be accompanied by additional explanatory information. To some extent, its background data can be already embedded in the final resulting media.

Fitting communication techniques ensure that the message gets across as the authors intended. The field of communication theory is complex and not necessarily steered towards cultural heritage. In mediated communication, it is important to be aware of possible communication barriers and strive to avoid them. The communication may fail on any of the steps of the process, also due to physical, semantic and psychosocial barriers (Lunenburg, 2010; Macnamara, 2009). When using media, making a connection between the verbal and visual input is of paramount importance. As information is best recalled if the verbal and visual input is happening at the same time (Mayer & Anderson, 1992). Further, one of the most important characteristics of communication is interactivity (Quiring, 2016); in cultural heritage that could be direct communication with the present expert or providing interactive features for a standalone function of the presentation.

A movie is a perfect communication tool to convey a topic within a narrative. The narrative is the heart of the presentation: its role is to convey the message in an inspiring manner. It is the interpretation of the shown data and best conveyed on a personal level while interacting with viewers. With the aid of virtual visualisation, the past can be presented in great detail. An additional essential emotional communicator is music. Music provokes rewarding emotional responses, like chills down the spine or even tears (Goldstein, 1980; Mori & Iwanaga, 2017; Morris & Boone, 1998; Sloboda, 1991). For videos, an emotional musical background is a reliable choice. On the other hand, for virtual environments, ambient sounds might have a higher impact. They can impact the feeling of ‘being there’ and help to recall the position of objects (Davis et al., 1999). Combination of ambience sounds and emotional music is also possible and can bring an even greater effect (Salselas & Penha, 2019).

In the selected heritage site, the viewers should be provoked to imagine the way people lived on the tell of Çukuriçi Höyük in the distant past. The narrative explains how the tell hosted generations of inhabitants that led a seemingly simple daily life, with basic tools, such as knives and fishing nets, and weapons, like slings, and a diet consisting of a variety of local seafood. However, at the same time, they developed sophisticated processes such as weaving and metalworking and established an economic network with nearby and far away communities. In the video, the animation shows the visualised settlement phases and also includes clues about the scientific background in the form of plans and the model of the excavation field. In the narrative, the visualised artefacts serve as clues about the previous cultural eras. At first, presented individually, they can later be found as building blocks in the visualised environment of the narrative. The audio narration focuses on conveying the story of the settlement. To share the narrative on a personal level, the project leader herself tells the story of the tell. To heighten an emotional response, majestic music, which culminates at specific points, plays in the background.

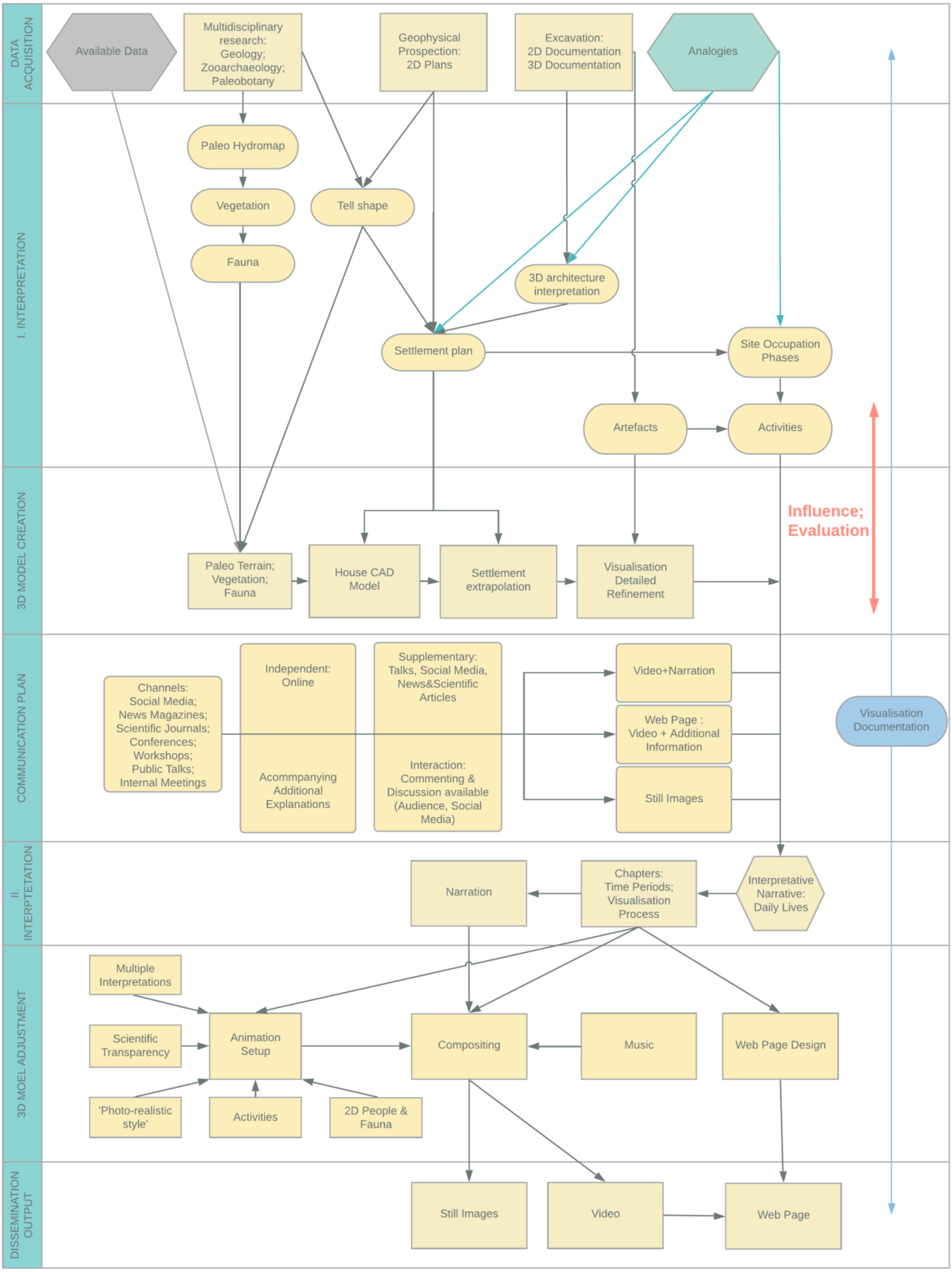


Figure 6: 3D visualisation workflow of the Çukuriçi Höyük project.

It is hard to engage visitors on a personal level via the World Wide Web, as it is not possible to respond to viewers' questions instantaneously. One possible solution is to presume what the viewers' questions might be and to already give answers on the internet page. Also, as the video is shared on social media, people can comment on the content and receive a response, albeit usually with a delay. Research has shown that users often only take a glimpse of the content of the web page before they make their next step and that scrolling can present a usability challenge; though for content pages with longer documents, scrolling can be an advantage since the information can be read without page flipping (Weinreich et al., 2008). An informed internet page design, therefore, also plays a role in the presentation techniques. On the dedicated web page (Institute for Oriental and European Archaeology (OREA) & 7reasons Medien GmbH, 2016; Lužnik Jancsary et al., 2016), the animation was placed in a central position. Below the video, video chapters and additional information are divided into different tabs, which gives the viewer fast access to those parts that are of particular interest. The information in the tabs is accessible by scrolling; yet, the division into chapters reduces the length of each page and prevents a cumbersome viewing experience. Significant for scientific transparency is the tab about the visualisation process, which explains how the visualisation was created and therefore presents the extent of the known data.

To reach the general public, researchers shared the video on social media of involved institutes, providing people with the possibility to interact with the experts. The response was either liking or re-sharing the content. More response was seen on the personal Facebook page of the author, albeit personal, which reinforces the research, that it is difficult for institutions to gather a following and create a community on social media, which is primarily a media for individual people (Kidd, 2011). Although, the feat is not impossible if specialised techniques are used (Batarda Fernandes, 2018; Russo et al., 2008). A news article on the topic with the link to the video webpage was also published in an online news magazine, where it reached a wider audience.

Sharing of the visualisation online and at talks encourages the scientific and general public to discuss the outcome as well as the presented content. This provides further ideas, insights and evaluations.

A short video can achieve only that much, but the created content can be reused with minor amendments for a variety of formats to reach its full potential; besides still images and animations, there are augmented and virtual reality (AR/VR) applications, immersive virtual reality, online repositories and viewers, as well as 3D printing. The current format is light and quickly disseminated since it does not need additional specialised equipment. It can be shared on a variety of different platforms, ranging from scientific conferences to social media. The format is also well-suited for viewing on mobile devices. Further possible plans involve including the media in the local museum exhibition in Selçuk, as well as distributing the models with the use of VR, AR and immersive VR applications.

The main concern about the computer-aided visualisation is usually the accuracy and validity of the visualised content (Hermon, 2008; Hermon & Niccoluci, 2018; Roussou, 2002). Even if not always in the forefront, a significant purpose of virtual visualisation is dissemination. Therefore, the construction of the intended message and the mode of delivery is as vital as the evaluated visualisation. Striving for high quality interpretative and communication approaches and including them in the general workflow is, thus, a substantial enhancement for the final visualisation outcome.

As seen in Figure 6, the project resulted in an extensive workflow. When the 3D artists got involved in the project, there was a discussion about their role and what kind of a work process this will imply. In the course of the project, seven stages were defined. At all the stages, computer-aided visualisation was taken into consideration: in the first stage, researchers were striving to collect data in a 3D format; when constructing archaeological interpretation, special attention was given to 3D architectural interpretation; after the initial 3D models were scientifically evaluated, the most appropriate communication tools were selected; the interpretative narrative was adjusted to fit the communication tools and the 3D models to fit the communication tools and the interpretative narrative. In the end, the final computer-aided dissemination products were created. The particular nodes and their relationships can be inspected on the workflow diagram (Fig. 6).

As the project workflow was defined, a reusable framework emerged that can serve as a starting point for any virtual visualisation project. In the workflow, all the critical features of each stage have dedicated nodes that are connected. Separate is the node of the documentation of the visualisation process, as this action runs parallel to the visualisation process during all stages. In the workflow, it is also indicated that the constructed 3D model can affect the first interpretation of the finds. That is since the position and visualisation of all the data in a virtual environment can provide new insights and change the original interpretation. Additionally, scientific evaluation of the 3D model may result in an adjustment of the visualisation.

Each stage of the workflow serves as an example to show the types of nodes these parts can include. Thus, it is forming a flexible framework with predefined process stages. For example, in the case of different source data or communication goals, the nodes can be easily replaced, yet the workflow follows the same course. The framework is proposing an inner structure to the interdisciplinary research group, also. An advantageous asset in the core team is an expert knowledgable in the cultural heritage field as well as in computer-aided visualisations.

As such, the framework for virtual visualisation presents a valuable tool for project management, planning and execution.

4. Conclusion

Virtual visualisation of cultural heritage is an integral part of the present and future representation techniques in the field. Its diversity of techniques and tools makes it a very flexible presentation approach. It is essential that the narration of a particular site is daring, and that it shows a highly plausible version of the past to reach the observer. Several equally plausible versions can be presented at the same time to avoid a strong bias.

Moreover, if additional data become available, the original visualisation can be amended to fit the revised knowledge. The deeper the impression and understanding that the interpretation evokes, the tighter the emotional connection with the viewer becomes. This way, both the emotional and rational side of the viewer are addressed, which achieves the most profound effect.

In the case of Çukuriçi Höyük, close cooperation between the scientists and the team of 3D artists resulted in an insightful short animated story that is supported by a competent additional explanation of the archaeological findings as well as the visualisation process. Hopefully, the animation will reach many viewers on a personal level and encourage them to respect and preserve cultural heritage.

Even more pertinent is the established workflow with defined stages of the virtual visualisation project. It integrates archaeological data, communication techniques, interpretative approaches, dissemination methods and decision-making process documentation. This workflow provides an essential interdisciplinary framework for similar projects that can be with minor amendments applied to many different case studies. Optimistically, this framework can serve interested parties during the project planning and implementation stages. Consequently, it can help standardize the practice of virtual visualisation construction, in terms of the content creation, and how different stages of the construction process affect the composing of the virtual 3D models and environments themselves.

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