New Didactic Strategies: 3D Modeling and Virtual Reality as a Cataloguing Alternative of Light Environments and their Application in Museums and Art History Classrooms

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The new interactive digital aesthetic has replaced the traditional "subject/artwork" relationship with a new conceptual vision "user/artwork" where the participation of the subject becomes important. The presence of light as an aesthetic resource configures hybrid, performative, participatory, de-temporalized and disruptive spaces that require deep reflection as a subject. Virtual Reality allows us to propose an alternative prototype cataloging of light environments. The theatrical dimension of these interventions is the key, because we speak of a tool that amplifies communication through access to referential worlds based on reality. This approaches us to this type of manifestations helping us to understand and experience these sensations through 3D models. These strategies of representation allow us to value these spaces, learning directly in a simulated environment in which the physical body becomes a priority element. In this research, a reflection and application work is developed with practical cases from the perspective of the philosophy of art and aesthetics (50 artists selected and their works). In them we can observe the displacement of the artistic object to the idea: aesthetic dimension, experience and perception of the subject. In addition, its reception, dissemination and research within the museographic practice is analyzed. This will allow us to examine its discursive, philosophical and theoretical content. The aim is to increase the value of this type of intervention by proposing a cataloging alternative that improves the reception and production of knowledge of these interventions. This is an interdisciplinary project that uses 3D visualization and Virtual Reality, tools of the current immersive and interactive strategies of the new Vanguard Museography, and proves to be very useful for its accessibility and didactic value in the field of heritage dissemination in museums and classrooms.

Key words:
Light Art Environments, Contemporary Art, Catalogs, Virtual Reality, Art History Didactic Resource.

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INTRODUCTION

Light as an aesthetic and artistic material has a great expressiveness. Like a resource, participates in the construction of the space lived by the spectator subject and establishes relations between both. As an artistic fact, it needs a deep understanding from the philosophical, semiological and phenomenological perspectives. These areas will help us understand how the visual phenomenon occurs in front of it [Rinaldi 2018]

Light makes space visible and dramatizes it. In these three-dimensional spaces the body moves and is projected actively, because the subject not only contemplates, but co-creates through his own experience and completes the work. It is a generative process where the spectator's own sensitive body means the environment based on the evaluation obtained from the reception. The lighting element encourages the intervention of the spectator and, with this, an aesthetic dialogue is established where an interactive process of interpretation is formed [Sánchez Vázquez 2005].

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In the 60s and 70s of the twentieth century new discourses appear about the use of light as an artistic language, materializing these assumptions with various interventions in museums and galleries. Contemporary artistic Installation and environments from Light Art and Minimal Art movements introduce novelties around the concepts of construction and spatial perception. These less visual and more conceptual forms establish a play of relations work-spectator where the senses are intensified. It is necessary to experience them in situ to live the aesthetic charge and obtain a complete reception of its meaning as an artistic fact. Artists like Dan Flavin, Bruce Nauman or James Turrell will be the pioneers of these movements.

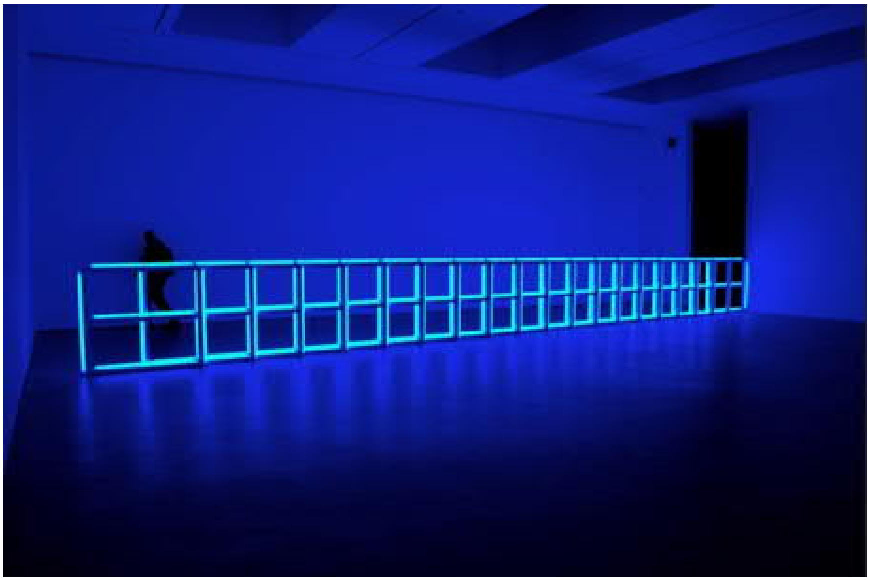

Fig. 1. Dan Flavin, Untitle (to Helga and Carlo, with respect and affection) – Installation view, 1974

DEMATERIALIZATION AND PERFORMATIVITY AS A SPACE APPROACH: THE BODY SUBJECT

Questioning the artistic object as a material element opens new paths in contemporary artistic production. Marcel Duchamp already did it with the Ready Made offering other lines of execution for the work of art [Parcerisas 2007]. The space replaces the object and is presented as content interrogating the viewer who has to intervene to understand what happens there. The Minimal was looking for an expression of subjectivity, a new aesthetic concept of multiple and polisensorial work of art where the viewer involved their senses. Contemporary Installations and Environments of Light posed this; spaces of aesthetic stimulation in real time where the visitor could be involved walking inside them. The expressive potential of these interventions is enormous, since the dialectic between the visible and the invisible offers the possibility of articulating meanings in a performative way [Ring Petersen 2015].

Dematerialization indicates the value of the work, not of its materiality, but because of what it means as an idea. The limits are dissolved offering the possibility of establishing extra-artistic links with it. It breaks with the traditional notion of mimetic and formal art. These artistic facts are understood as metaphors that must be executed in movement, with the body, in the same place where they exist. Therefore, the viewer becomes a constituent element of the work and, with his experience, completes the work [Liñán Ocaña 2009].

The performative is also multiple. It is a new way of expression with a huge phenomenological and intersubjective character. It depends on the position of the spectator, and his bodily activity as a receiver of experiences. Performative action is an aesthetic strategy linked to these interventions that influences the emotional that is the focus of conscious significance acquired within the luminic space (Fig. 2). This process is the key to understanding how the experience develops in the spaces of light; the spectator walks within it and the movement of the body makes it possible to receive the signals grosso modo. The subject performs sensory and intellectual operations that help him to interpret the aesthetic event. Light does not stop being a linguistic resource with a semantic load that has to be interpreted and perceived from the senses. Semiotics can explain this process in a much deeper way [Ring Petersen 2015].

The theatrical nature of these interventions offers us a type of aesthetic where the concept of set design expands. Light as a dematerialized aesthetic resource, together with the bodily presence of the obliged viewer in them, leads us to deal with the fact of the performativity of movement as an important part of the cognitive operations that take place in Contemporary Installations and Environments of light (Fig. 3).

Fig. 2. Example of James Turrell's Installation (left) and Lucio Fontana's Installation (right)

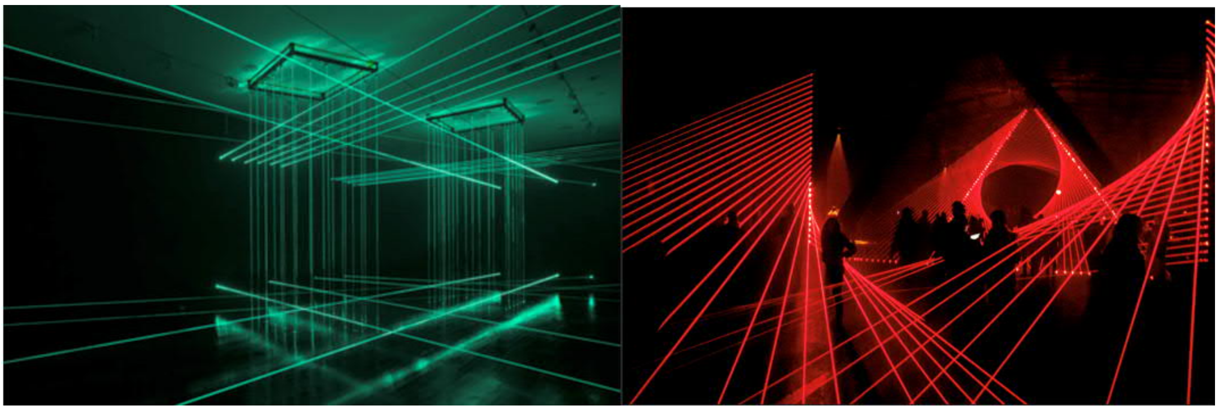

Fig. 3. Example of Li Hui's Installation (left) and Matthew Schreiber's Installation(right)

THE CATALOG AS A RESOURCE: NEW HORIZONS FOR AN IMPROVEMENT OF THE RECEPTION OF CONTEMPORARY ARTISTIC LIGHT ENVIRONMENTS AND INSTALLATIONS.

Fig. 4. Dan Flavin's Catalog. Series and Progressions. David Zwirner Gallery, New York, 2009 (left) and Ann Verónica Janssen's Catalog. Experienced. Galería toni Tàpies, Barcelona, 2009/2010 (right)

The role played by the cataloguing in the artistic and patrimonial sphere is difficult to ignore (Fig. 4). It is a necessary instrument to obtain knowledge of the artworks or cultural assets that have been exposed. Despite being a tool with centuries of experimentation and having changed relatively thanks to new technologies, it still falls short in some aesthetic approaches. Precisely, the development of new technologies, affect the conception of the catalog and its narrative possibilities. Hypermedia produces narratives and digital discourses that can improve the understanding of certain interventions due to their experiential and phenomenological character [Bellido Gant 2016]. The aesthetic component requires the active participation of the viewer for its understanding, therefore, the two-dimensional catalog (whether on paper or digital) does not respond to the demands of understanding these artistic facts. The formal description must be completed by an immersive visual experience that allows viewers to understand this type of three-dimensional, desmaterialized, performative and theatrical-theatrical manifestation.

Mediation requires actions by institutions that bring the user closer to the works of art so that the message is received and a connection is established, in order to understand, reflect, experiment and interpret the content [Santacana Mestre and Martín Piñol 2010]. Currently, most museums, galleries and cultural institutions offer their catalogs online reasoned, even so, these do not fully respond to the needs posed by three-dimensional interventions. The personalized aesthetic experience requires platforms that allow interaction but, above all, immersion as an added value. The spectator as an active participant of the work must intervene in the space, walk in it, make an aesthetic visit as an explorer of meanings. In these hybrid light spaces, the reaction comes from the visualization of the environment and physical experience in it [Martínez Sellés 2012].

Museum's physical space offers content to the user as the recipient of the work. The environment becomes private when the work-viewer connection occurs. This place is inhabited and transited based on its symbolic and dynamic power. It is necessary to be able to live, meaning and multiply experiences by enhancing the imagination. The interaction, interpretation and physical involvement of the subject in the work produces the phenomenon of reception; body as a receptor intellectual element intensifies the symbolic qualities of artistic intervention by establishing sensory relationships with the receiver [Aguilar 2010], "*…since it operates as an ambiguous territory where experience is versatile.*" [Merleau-Ponty 1945].

Light and color are the main features of works by artists such as Dan Flavin, Bruce Nauman, James Turrell, Keith Sonnier, Robert Irwin, Lucio Fontana, François Morellet, Christian Herdeg, Olafur Eliasson, Ann Verónica Janssens and others; complex proposals that are governed by sensation and perception. In these cases, the phenomenon requires the receptor and its experimentation in the place where its meaning occurs (the museum space). The perception of these elements refers to a concept or idea constructed by its scenery. Intangible references involve the visitor and invite him to travel through space in search of the construction of their own meanings in memory. It is something intimate and private, unique and subjective; a spacial and temporal dimension that is only perceptible by the subject himself, physically situated there.

The installation is in itself an artistic expression and has great spatial importance, since to transform the environment previously given by architecture [Maderuelo Raso 2003]. In addition, it has a temporal and psychological character and is determined by the interaction and the context of the viewer who enters it. They offer alternative and own symbolic words, new spatio-temporal dimensions, and meanings open to interpretation.

These works require, therefore, an active participation at a physical level and a deeper reading, not only of their formal elements, but of their meaning as aesthetic knowledge because they are places of experience [Abad Molina 2007]. This dimension, which the catalog can not pick up due to its two-dimensional character, means that the subject can not understand this artistic fact. Therefore, the catalog must be updated by using the tools that new technologies provide us.

WHY VIRTUAL REALITY?

Currently, we are immersed in a world with a large number of dimensions that we need to analyze. Minimal Art and, subsequently, postmodernism broke with the great stories opening the way to the multiplicity of meanings on which to reflect. The subject from the socio-cultural perspective seeks its identity through active participation in the construction of the global imaginary. Body acquires a fundamental role and, with this, it becomes a potential transmitter and receiver in communication [Soto Solier 2012].

Contemporary art transforms its procedures and offers new temporal and spatial configurations of experience. In these cases, the conceptual and formal limits are overcome, with great impact on the organization and perception of space. The action re-dimensioned artistic production and cognition becomes a key in the understanding of the artistic fact. Cognitive aesthetics no longer have to be linked to factual reality, but there is an ideal, in which the subject is capable of self-knowledge in the work [Marchán Fiz 2006]. New technologies help the subject to face it by expanding the doors of perception.

Dematerialization – that is a loss of physicality of the work – allows new media to create new forms of materiality (intangible) supported by information flows. With this, he liberalized the art world from its anchoring in reality [Fischer-Lichte 2011]. Now the viewer can experience the idea or concept in a self-sufficient and complete way in a new state of affairs. Performativity occurs with the action of the subject present before the work in its digital version.

Within the new technologies, Virtual Reality is conceived as a very direct means in terms of participatory experience. Its digital character, dematerialized as image (not real), theatrical and scenographic, as well as performative, is an enormously useful resource for the complete reception of all the formal and aesthetic elements of contemporary artistic environments and installations of light. Its processual, hypertextual, conceptual and open language is oriented to the interaction with the subject. In addition, its immersive capacity offers a perfect border crossing in which the perception merges with the device's own interface [Soto Solier 2012].

The Virtual Reality is able to configure communication spaces where the viewer can reconstruct senses from the semiotic point of view. The experience in the first person affects them (visually and corporally), giving them a greater capacity to understand the event lived in the present. The light fluxes of these interventions demand from the viewer perception strategies that establish connections in movement. That is to say, the corporal performative is constituted as a constant flow of understanding; the action converts the medium, in which it is, into discourse [Galanter 2003]. Presence is a type of phenomenon in which body-mind are inseparable from the signifier extracted during the process of experimentation of the place.

Spaces of light flows have an abstract and perceptive character not very different from the virtual space [Manovich 2013]. These new forms of representation with digital media and hybrid techniques, define types of behavior not far from what happens when the subject is placed within an Environment by Ann Verónica Janssens or a lighting installation by Yayoi Kusama, for example. There is an experiential and experimental level that configures visual and procedural forms within the projected three-dimensional stage design. The screen and the interface use information extracted from reality (encoded with algorithms and software codes) and imitate the experience of these interventions.

The virtuality does not stop being a visual metaphor of the reality where the subject looks for his identity.

The identity of the virtualized subject is fundamentally performative and extroverted, focused on the communicational process from which all value derives [...] the multiple discursive translations take a central value in a scene in which the subject conceives of himself as a vehicle of appearance, as a bearer of symbolic value.

[Deleuze and Guattari 2004].

From the perspective of the aesthetics of simulation that Claudia Giannetti [1997] presents us, interactive and immersive installations are created to a different degree, which introduces a dimension of subjectivity more in keeping with the 21st century.

The Virtual representation culminates the path of simulation throughout the History of Art in its extension as an experimental perceptive dimension. In it, the relativity of the observer is expressed [Weibel 2001]. Although it does not stop being a computational and algorithmic product, it can conceive creations without limits of space and time, since it helps to perceive this type of manifestations not only in museums, but also in the University classrooms of History of Art. Virtual reality is offered as a ubiquitous learning resource that helps to understand in a more profound way all the dimensions that these works possess, without falling into the strictly formal of the traditional catalog (dates, data, words, texts) facilitating the aesthetic experience total through the concept of presence.

The aesthetic experience of Virtual Reality creates unique experiences and develops new ways of apprehending the artistic object or fact [Carrillo Santana 2007]. It is about taking the imaginary of the techno-intelligent society to any area of its active life. New spaces of knowledge are opened, as well as forms of participation of art, democratizing access to culture and artistic education in general. It is the immersion of the Virtual Reality as a resource, one of the most extraordinary strategies when integrating the subject within the screen space, facilitating the mental and emotional reception of the representation, as well as the recognition of the scene as a charged place of meaning. The incorporation of the Light Art/Minimal Art manifestations into the field of the virtual screen makes it possible to reproduce reality completely, starting from a metaphor of representation that integrates the viewer, as they would in the 60s and 70s of the 20th century lighting installations of Dan Flavin, James Turrell or Olafur Eliasson, making him participate on site at any time and place where he is.

AN ALTERNATIVE OF CATALOGUING IN VIRTUAL REALITY. A NEW STRATEGIE TO CREATE KNOWLEDGE AROUND CONTEMPORARY LIGHT ENVIRONMENTS AND INSTALLATION: THE CASES OF DAN FLAVIN & ANN VERONICA JANSSENS

In this research, a reflection and application work is developed with practical cases from the perspective of the philosophy of art and aesthetics (50 artists selected and their works, including Dan Flavin, Ann Veronica Janssens, James Turrell, Anthony Mccall, Bruce Nauman, Carlos Cruz-Diez, Li Hui, Yayoi Kusama, Julio Le Parc or Lucio Fontana). One of the first results obtained is that of the *Untitle installation (to Helga and Carlo*, *With Respect and Affection*) 1974 by Dan Flavin. The reconstruction process is carried out through the data from the data of Series and Progressions catalog of the David Zwiner Gallery in New York (mentioned above). This prototype, which is still in the first phase of development, has been shown to the public at the New Tech Observatory held in July 2019 in Malaga, Spain. The director of the Picasso Málaga Museum tested the same, understanding the need to bring the experiential character of these artistic interventions to the user. The next step is the implementation of the information related to characteristics and its analysis from the historical-artistic, aesthetic and philosophical perspective for the construction of the virtual reality cataloging alternative as a didactic resource in museums and classrooms.

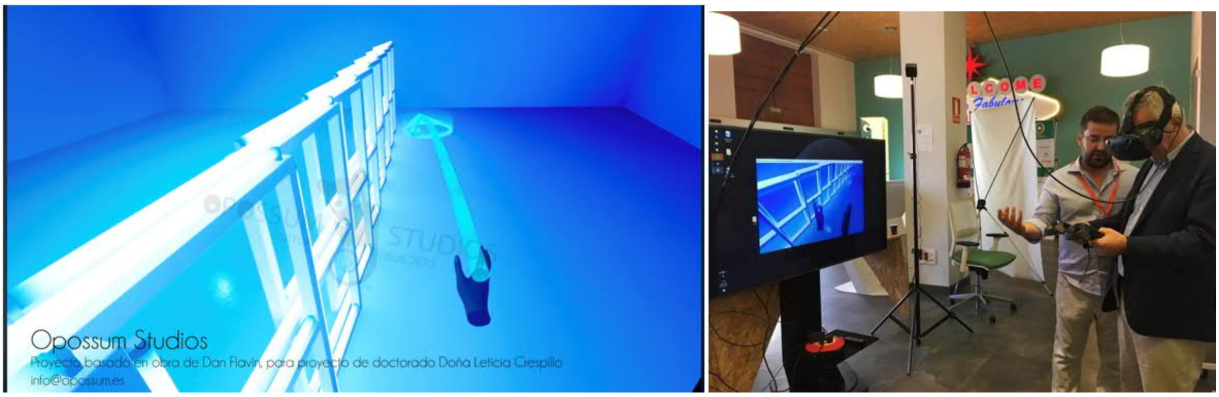

Fig. 5. Example of Virtual reconstruction of Dan Flavin's light Installation, Untitled (to Helga and Carlo, with respect and affection), 1974

Another prototype shown and developed is that of Ann Veronica Janssens, *States of Mind* (Fig. 6). The strategy of experimentation in situ and the presence of the spectator in these prototypes, seek only to improve the learning spectrum and creation of historical-artistic and aesthetic knowledge from the academic-scientific point of view. Art history needs to explain certain plastic phenomena that the traditional catalog cannot because of its two-dimensional nature. Therefore, among the didactic strategies offered through this doctoral research are: presence, movement in space, appreciation and aesthetic experience in situ, as well as complementary and scientific information that help to better understand the phenomenon of contemporary installations and light environments.

Some subjects who tested the prototype felt disoriented and terrified that they could not see, but they listened to other steps while walking through the installation. Others felt pleasure, calm and reflected on what was happening there. These experiences are also part of these manifestations. The subject must understand how he feels within them, to complete the descriptive information from his own unique point of view.

Fig. 6. Example of Virtual reconstruction of Ann Veronica Janssens's environments (first phase of the Phd. Research – Software Maya/Unreal Engine 4 & Photoshop). July, 18-19 New Tech Observatory. Authors: Opossum Studios Virtual Builters

In them we can observe the displacement of the artistic object to the idea: aesthetic dimension, experience and perception of the subject. In addition, its reception, dissemination and research within the museographic practice is analyzed. This will allow us to examine its discursive, philosophical and theoretical content. The aim is to increase the value of this type of intervention by proposing a cataloging alternative that improves the reception and production of knowledge of these interventions. This is an interdisciplinary project that uses 3D visualization and

Virtual Reality, tools of the current immersive and interactive strategies of the new Vanguard Museography, and proves to be very useful for its accessibility and didactic value in the field of heritage dissemination in museums and classrooms trying to answer the questions that have prompted me to raise this investigation, trying to give answers to the different questions about the aesthetic experience.

Regarding the art-artist-documentation relationship, almost 200 written (physical) catalogs and about 700 essays collected in these catalogs are being analyzed that allow me to establish a link between the artist's intentions, the registration of works and its documentation from the prototype that is currently being carried out. The study continues and there is still documentation to analyze. It is necessary to understand that the purpose of this research is not to replace the original work (that would not be ethical or professional and it is imposible at all), but to try to offer tools through new technologies that improve the understanding of these artistic interventions from the didactic point of view both for the museology and for Teaching in the classroom. It is specifically another way to visualize the contents and document them, because the main purpose of this investigation is to improve the way that the contents are presented and registered for the future. We must not forget that art is also cultural, historical and artistic heritage.

MUSEUM & UNIVERSITY: ANOTHER WAY OF LEARNING THE CONTEMPORARY LIGHT ART

Since the mid-twentieth century, movements such as Light art or Minimal Art, along with many others, present productions with an ephemeral or intangible character. They question the concept of art but they develop until the 21st century [Hernández Hernández 2011]. Currently, this type of intervention continues with new materials and a highly developed aesthetic character. Therefore, the museography must value these manifestations, disseminate them and create knowledge about them. From the pedagogical point of view, the cataloging and documentation of artworks and artistic events has continued to innovate and adapt to the new times. However, the need for a more exhaustive record that captures the aesthetic characteristics of a type of manifestation such as the one we are dealing with here, for its transmission and conservation, remains a necessity and a pending task.

Virtual Reality, in our case, makes all these registration elements available; can meet needs from the formal point of view (data, text, essays, descriptions), but also from the aesthetic field. Virtual reconstruction offers us the environment that emulates reality and the possibility that the viewer can intervene in it, in the first person. These new practices are necessary from the museographic point of view, since they revalue the user's own experience, diversify and multiply the discourses, make the user participate and recognize the importance of the context from the elaboration of a stimulating discourse accessible and open to anyone, approaching them to a new aesthetics and museographic ethics [Gutiérrez Usillos 2012].

The Semiotics of communication in the museum is a decisive element, since it is the receiver that goes to meet the phenomena that happen within the architecture itself. The lighting interventions have their own language, are open and can be filled with new senses. We must reflect on the need to create a semantic field where the work requires the visitor to signify himself [Hernández Hernández 2011]. Only then, it is possible that it manifests itself as a significant element. In addition, the ephemeral nature of these works, not only because of the intangibility of their main material, but also because they are in many cases site-specific, requires experimentation in front of the plastic discourse, so that there is a co-creative process.

The educational and knowledge creation objective of the museum can be extrapolated to the Art History University classrooms, when they approach this type of manifestations as part of the resignification processes of contemporary art. The museum should promote the patrimonial and artistic values of culture, making society analyze, see, experiment, criticize, reflect and be creative. In this context, sensitive and perceptive experiences should be linked to aesthetic learning [Terradellas and Angrill 2007]. Art is a language and, as such, requires a study for its understanding. The interpretation is determined by the dialogue between the subject and the spectator, especially in intangible or intangible interventions. The new museography must be open to the classroom and must rethink in relation to the transmission and generation of knowledge in the line of shared and participatory learning

Virtual Reality as a learning tool stimulates and potentially means, establishing relationships between subjects of knowledge, works and aesthetic attitudes. Thus, contemporary Enviroments and Light Installations, as process aesthetic and performative-experiential practices, are completed by the screen and the possibility of direct experience of the viewer in situ. Therefore, this technique, together with virtual environments, allows users to enter into any possible and impossible reality by activating the senses in those artistic productions that need interaction, immersion, body movement and cognition, providing meaningful encounter in a museum and, even, a classroom more in line with the needs of our time [Santacana Mestre and Martín Piñol 2010].

CONCLUSIONS

All these challenges posed by the current way of producing and consuming a visual culture so marked by context and always in constant change through strategies of hybridization, interdisciplinarity and technology, pose not only the configuration of new intellectual discourses, but also allow reinterpreting aesthetic constructions from other past times in an innovative way, achieving an unlimited expansion of our own knowledge and the contemporary exhibit tion field as "connectivity operator space", a concept he uses to refer to the new José Luis Brea museums in Simon's book Marchán Fiz referred to above and that places us squarely in the context of our immediate artistic and cultural contemporaneity.

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Visualization of the Past-to-Recent Changes in Archaeological Heritage based on 3D Digitization

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This paper is motivated by work at "Barbar Temple", which is one of the significant archaeological sites in the Kingdom of Bahrain. This site dating back to the 3rd millennium BCE belongs to the ancient Dilmun civilization which has a relation with the Mesopotamian and Indus civilizations. This remarkable site has been required to be protected and listed on the Tentative List of UNESCO World Heritage. The documentation of Barbar Temple has been started since the first excavations by a Danish mission in the 1950s -1960s. There is a possibility to grasp the changes and damages of the site caused by environmental or human factors over the decades by utilizing the photographs taken in the past. As a case study to apply 3D digitalization for protecting the archaeological site, this paper proposes a methodology for collation of the 'past photographs' and current physical appearance. The process of this method consists of three steps; 1) estimate 3D positions and the orientation of the camera by which 'past photographs' were taken; 2) make corresponding pairs between 'past photographs' and the 3D data of the current site; 3) render a CG (Computer Graphics) model of the current site from the viewpoint of the estimated camera position and orientation; 4) overlay the CG with the 'past photographs' on the same view. This paper applied the method to the 'pool' area of Barbar Temple, which was a pivotal facility of the temple with a sacred spring used for worship of Sumerian water god Enki. It was expected that the piled-up blocks of the stone construction surrounding the spring have caused strains on itself and changed its appearance. This methodology enabled us not only to grasp the changes in the whole appearance of this area easily but also to find the slight changes in the orientations of the stones quantitatively.

Key words:
Investigation history, Structure from Motion (SfM), PnP Problem, Photographic record.

CHNT Reference:
Naoki Mori et al. 2018. Visualization of the Past-to-Recent Changes in Archaeological Heritage based on 3D Digitization.

INTRODUCTION

Bahrain is an island country consisting of 33 islands with Persian Gulf Bahrain Island as the main island. Dilmun is the first civilization on this island, dating back 3300 BCE. This civilization flourished as a trade city connecting the Mesopotamia region and the Indus region. There are many ruins built in the Dilmun period like the world heritage Karat Al Bahrain on this island now. However, due to rapid urban development in recent years part of the ruins have been destroyed or disappeared. For that reason, activities to protect these ruins are being conducted mainly by the Bahrain Agency for Cultural Affairs.

The Temple of Barbar is the oldest temple ruin in Bahrain, built around 2200 BCE. This remain is a particular ruin which conveys aspects of the early Dilmun civilization, and it is registered in the World Heritage Provisional List.

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Currently, the Bahrain Agency for Cultural Affairs is planning to develop for the construction of the site museum mainly.

The Temple of Barbar was discovered by Denmark Corps headed by P.V. Glob et al. in 1954 and excavation work was done until 1962 [Andersen and Hojlund 2003]. After the excavation, the ruins were developed as tourist attractions by Bahrain authorities. At that time, slopes and walking paths for pedestrians, reinforcement of vulnerable parts of the ruins were carried out. As a result, the appearance in 2017 (Fig. 1, right column) has changed significantly compared with the survey record (Fig. 1, left column) at 1959.

For future conservation, it is desirable to repair these stones and relocate them to their original positions. However, although we can qualitatively confirm changes at the time and the current situation, we cannot confirm the actual minor changes. Therefore, in this paper, we utilize spatial and geometric information and associate the past with the present situation. By doing so, we aim to visualize the systematic support of visual verification work. Also, by projecting past research records on the present site virtually we quantitatively evaluate changes in past and present conditions.

Fig. 1. Photograph records taken in 1959 (left column) and 2017 (right column) at Barbar temple site

RELATED WORK

The data recorded by three-dimensional (3D) measurement is widely used not only for preservation but also for academic, educational and tourism purpose. CyArk[1], for example, a nonprofit organization in the United States, publishes a digital archive on the website that associates 3D data acquired by a laser scanner and photogrammetry and related academic information. A walkthrough system that allows free movement and viewpoint change within the created 3D space is implemented so that the user does not need to visit the actual place and can observe the object from a place that he/she cannot actually enter. In recent years, while the performance of UAV improves and the price drops, 3D modelling over cultural property structures and wide area is spreading for site management of the site and post disaster assessment [Brutto et al. 2014; Meyer et al. 2015; Themistocleous et al. 2014; 2016; Yasumuro et al. 2016]. These systems aim at information disclosure of ruins using 3D data and do not assume the support of constant maintenance and management of cultural assets. Besides, there is 4D modeling that adds the dimension of

[1] http://www.cyark.org/

the time axis to the 3D model as a method to grasp the current state of the ruins [Glowienka et al. 2017]. Rodriguez and his colleagues [2018] used “Structure from Motion” (SfM) [Tomasi and Kanabe 1992] which is a method of restoring the 3D shape from stored aerial photographs and photographs in order to analyze past natural disasters and landscapes changed in urban development [Pablo et al. 2018]. By comparing 3D shape information at different times, analysis over time is easy, and it is useful for future conservation and risk management.

METHOD

Overview

To grasp the difference between the past and the present situation of the site, the authors attempted to restore the 3D shape at the excavation in the 1960s, using the photographs described in the excavation survey report [Andersen and Hojlund 2003] and SfM process. However, recorded pictures did not retain sufficient lap rates, so they could not be restored. Therefore, a strategy that directly connects the present situation with the past photographs is necessary. In this research, we will reproduce the photographing position of the recorded photograph in the current 3D space co-ordinate. Observing the scenery from the same viewpoint enables to confirm and examine the differences over the time. Fig.2 shows the process flow of the proposed method. First, photogrammetry (SfM) and laser scanning are used for preparing the current 3D shape data. Next, giving the correspondences between the 3D points coordinates and their 2D coordinates projected on a photograph enables estimating the photographing position of the photograph. Rendering CG of the 3D shape data from the viewpoint of the estimated photographing position shows the current scene of the site viewed from the past photography viewpoint. By superimposing and observing the past and the current situation from the same viewpoint, it is possible to grasp the differences between them precisely visually.

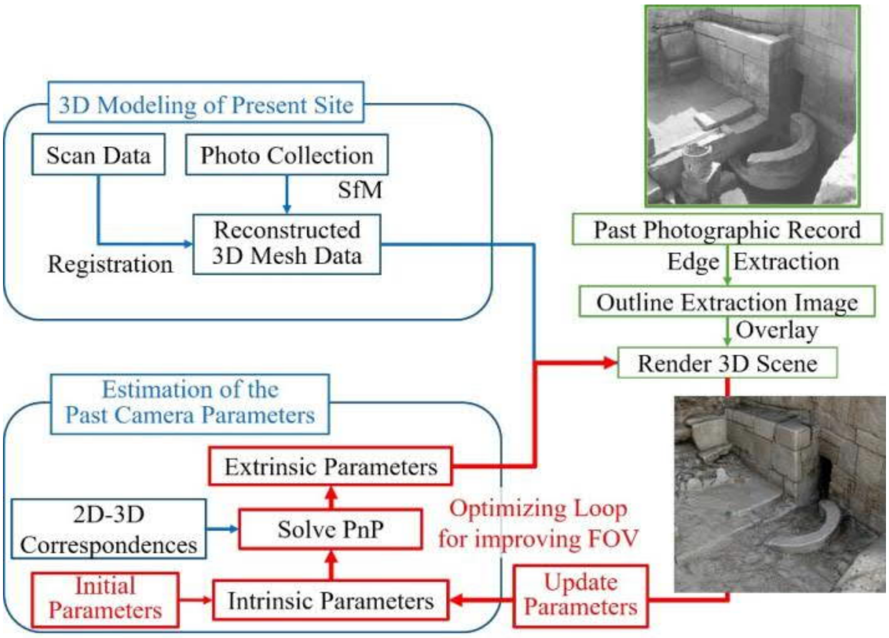

Fig. 2. Process chain of the proposed method

Preparing 3D Data

3D shape data is created using SfM. This technique is to simultaneously restore the 3D shape of the scene captured in the image from the multi-viewpoint image group and the shooting position of each image. In this research, the authors use multiple images taken with UAV. The 3D data created by SfM cannot restore the actual size of the object in principle. As a method of giving an actual size, there is a marker that can understand the scale and GCPs (ground control points) such as water marks and related survey points. By including a plurality of images reflecting these points, it is possible to give an actual size and geodetic coordinate system. Since GCP and markers were not arranged at the time of aerial photo-graphing this time, scaling and positioning are performed on the laser-scanning data which measured the same place, so that the actual size is given to the 3D shape data.

Estimation of the Camera Parameters Used in the Past Survey

In order to create a 3D model of the ruins, we attempted 3D restoration by combining a plurality of recorded pictures of the same part taken in the picture taken from 2017. However, as shown in Fig.3, matching with keypoints (ORB (Oriented and Rotation BRIEF) [Rublee 2011]) did not work correctly even in photographs taken from the same part and 3D shapes could not be reconstructed. Based on this fact, the authors decided to link the past with the present situation manually. We focused on a '"Perspective-n-Point" (PnP) problem' [Hartley and Zisserman 2004] to estimates the shooting position and orientation of a camera by associating a point (2D coordinates) in the image with a point (3D coordinates). The solution to this problem is to use the correspondence between one point in the 3D space and a specific point on the imaging plane of the camera. When a plurality of corresponding pairs is established simultaneously, the position and orientation of the camera can be uniquely determined. It is supposed to estimate the extrinsic camera parameters (shooting position and orientation) of the photograph from the correspondences between the 3D coordinates of the object and the 2D coordinates (pixel coordinates) of the image, and the internal camera parameters (camera projection characteristics). As shown in the Fig. 3 automatic correspondences between photographs cannot be found correctly, and it is difficult to use them for estimating the position of the camera automatically. Therefore, in this research, the authors manually give the correspondences between past photo and a rendered current 3D scene.

Fig. 1. Example results of automatically finding correspondences between a past photo and a rendered current 3D scene by natural feature points (ORB)

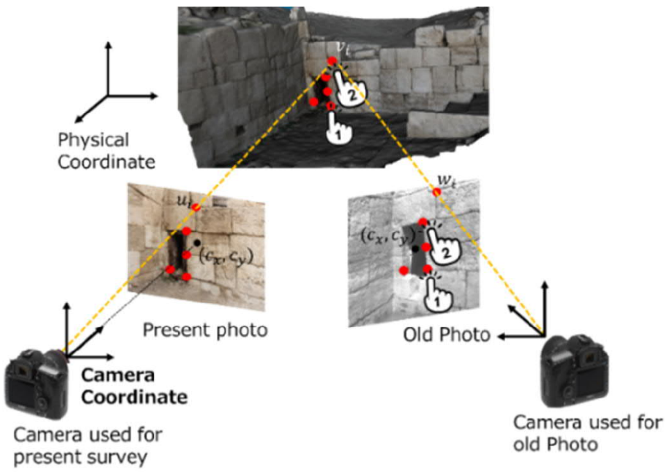

Fig. 4. A figure caption is always placed below the illustration. Short captions are centred, while long ones are justified. The macro button chooses the correct format automatically

Intrinsic Camera Parameters

In order to obtain the external parameters of the camera, parameters specific to the individual camera (internal parameters) such as the focal length of the used camera and the image centre are required. Camera calibration is to estimate internal parameters of a camera. This is generally known as a method of estimating internal parameters from the correspondence between images obtained by photographing a checkerboard as a visible reference pattern from multiple viewpoints and the reference coordinates of the checkerboard. [Zhang 2000] To estimate the external parameters of the recorded photograph, the internal parameters of the used camera at that time must be taken. However, information on the camera is unknown. Therefore, it is impossible to acquire internal parameters by calibration. So, in this research, the authors set the initial values of internal parameters and render, and then compare the results with the recorded pictures visually. Our process repeats adjusting the focal length value manually so that the current perspective matches past viewpoints, assuming that the effect of the lens distortion is small. To set the initial focal length parameters; f_x in the x- and f_y in the y-direction in units of pixels, f_x is obtained by $f_x = f * w_p / w$ (1), and f_y is obtained by $f_y = f * h_p / h$ (2), respectively. The parameter f is the focal length in mm, and w, h are the height and the width in the actual dimension of the image sensor plane. The parameters w_p, h_p are the width and the height size of the image in pixels, that is scanned image size taken from the printed photo from 1960. We assume that the camera used for the documentation in the 1960s was medium format in still photography. Referring to the format of *6 × 6* cm frame size or *6 × 8* cm frame size in *120* film, whose one side of the nominal size of the file is 56 mm, another side of the nominal size of the file is 77 mm, from which we derived the initial focal length value.

Photo Overlay

By applying the external parameters to the camera in the 3D space, the screen in which the current state is observed is rendered from the past photo-graphing viewpoint. By transparently superimposing the recorded pictures on this screen, the authors can visually grasp the difference between former and present time. When superimposing, in the original image, the 3D data behind and the color mix with each other, making it difficult to recognize the difference. Therefore, only the outline portion of the subject is extracted from the photograph, and the color tone is changed and highlighted. Alpha blending is used for blending during overlapping. In this process, a parameter representing transparency called an alpha value is required. However, in general, the image is composed of three channels of RGB, and does not have an alpha value. Therefore, a channel for storing the alpha value is newly created in the image from which the outline is extracted. Then, only the outline portion is made opaque from the color information in the pixel. As a result, only the information of the image to be displayed is rendered on three dimensions.

IMPLEMENTATION

3D Digitization

The authors performed 3D reconstruction of the entire temple using SfM processing software PhotoScan (Agisoft[2]) from about 900 images taken with UAV (DJI Inc[3]). Next, in order to give the actual size to the SfM data, positioning with the scan data obtained by measuring the same place with the laser scanner Focus 3D (manufactured by FARO) was performed. ICP (Iterative Closest Point) which is an available function in a free software CloudCompare[4] for point cloud processing is used for aligning two sets of point cloud; scan data and SfM data. Five pairs of corresponding points to be matched are selected from scan data and SfM data for determining an initial state. Then ICP finds the rotation, movement, and scale elements to minimize the residual in RMS (Root Mean Square) for fitting two sets of the point cloud. By aligning SfM data to the scan data as a reference, the current 3D shape data with actual size was created as a result. (Fig.5.)

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[2] https://www.agisoft.com/
[3] https://www.dji.com/jp/phantom-4
[4] https://www.danielgm.net/cc/

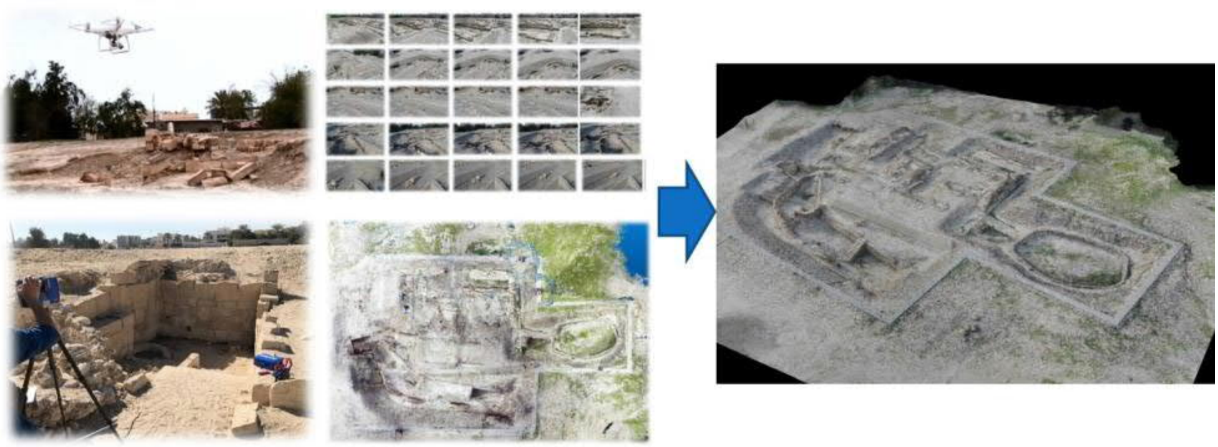

Fig. 5. 3D model generation: Reconstruction of the 3D geometry whose scale matched using ICP for photogrammetry (top) and laser survey (bottom) data by UAV

Position estimation of recorded photographs throughout the temple

In the survey so far, a plurality of parts corresponding to the photographic record at the time has been found. The authors applied the proposed method to nine recorded pictures of the remains at present. Using the formula (1) and (2), the focal length of the camera was determined as the internal parameter. As for the pairs of 2D coordinates and 3D coordinates, while checking the 3D shape, multiple corresponding pixel coordinates were selected from each recorded picture. Also, corresponding 3D coordinates were acquired by mouse picking. Past shooting position and orientation were obtained by solving a PnP problem formilated by the internal camera parameters and the set of 2D and 3D coordinates. Our implementation uses a function in OpenCV[5] for solving PnP problems with RANSAC (RANdom SAmpling Consensus) algorithm that suppresses the influence of outliers, considering that noise included in image data. [Fischler et al. 1981] Fig. 8 shows the result of plotting the photographing points of the recorded photographs at present by applying the estimated position and posture for each photograph.

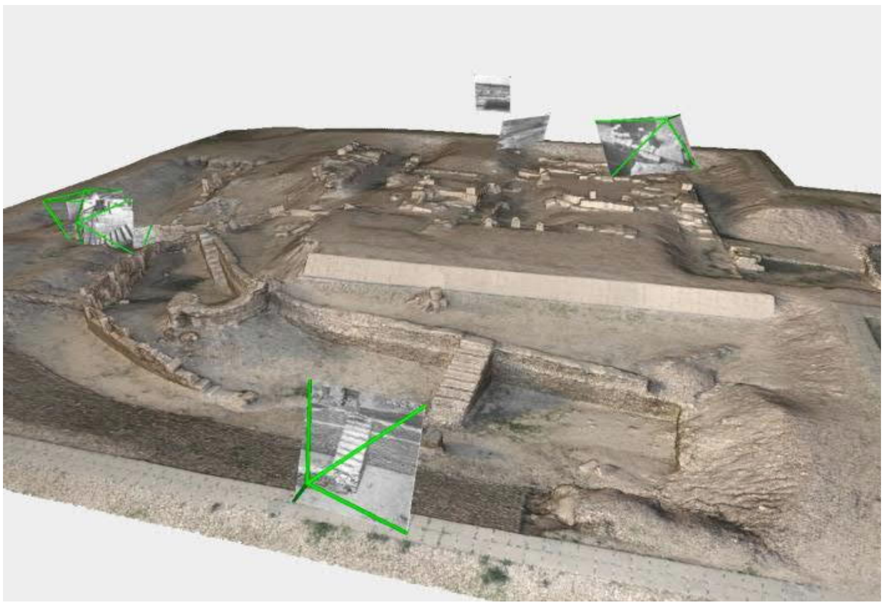

Fig. 6. Result of the past camera estimation in overall of the temple

[5] https://opencv.org/

Collation in local recorded pictures

As shown in Fig. 6, the shooting position of recorded pictures are estimated in the current 3D scenery. Then, the recorded pictures were superimposed on the 3D data, and the change between the past and the present condition was confirmed. In the following sections, this paper shows the applied results of the area of "pool" and "altar" in Barbar Temple. The pool is a symbolic structure for Dilmun culture, which shows the association with the Mesopotamian God Enki. The altar has unique stone arrangements, whose shapes are similar to the numeral 3. These areas are still left in the state close to the time of excavation even now.

Case study（Pool）

The authors targeted the south wall of the pool facility. Fig. 7 shows the process flow. Fig. 7 (a) shows the present situation of the pool represented by SfM data. Fig. 7 (b) shows the photograph of the south wall of the water storage facility taken in 1960. The width and height of this image are 700 pixels and 661 pixels, respectively. We used the frame size of 6×6 cm was adopted and the width of 56 mm and the height of 56 mm are set as nominal values for setting the internal parameters. For the correspondence between 2D coordinates and 3D coordinates, 26 points were selected for the same place in the recorded photograph and 3D data. (Fig. 7 (a) and (b)) The PnP problem was solved by using these two datasets. Fig. 7 (c) shows the result of rendering the screen observing the current situation from the past shooting viewpoint. To detect contours from recorded pictures (Fig. 7 (b)), the Canny function implemented in OpenCV was used. The Canny edge filter [Canny 1986] is a contour detector suitable for extracting continuous lines of objects' shape. Upon contour detection, the image was smoothed using a Gaussian filter to reduce noise. If the value of the kernel for the Gausiona filter is small, the noisy surface patterns of the stones are detected. So, the value of the kernel argument of the Gaussian function was manually adjusted for extracting the contours of the stones. Also, the threshold value of the Canny function appears was selected for extracting continuous contour lines, as shown in Fig. 7 (d).

To display only the colored part of the created image, a 4-channel matrix was created by adding OpenCV channel for alpha value. The first three channels copied from the color information of the image. For the last one channel, a threshold value is set for the RGB value, and if it is smaller, the transparency of the pixel is set to 0. Alpha blending is used to superimpose the contour images with transparency onto 3D data as viewed from the past shooting viewpoint. (Fig. 7 (e)) The angle of view of the camera at this time was manually adjusted so that the photograph and the three dimensions overlap precisely.

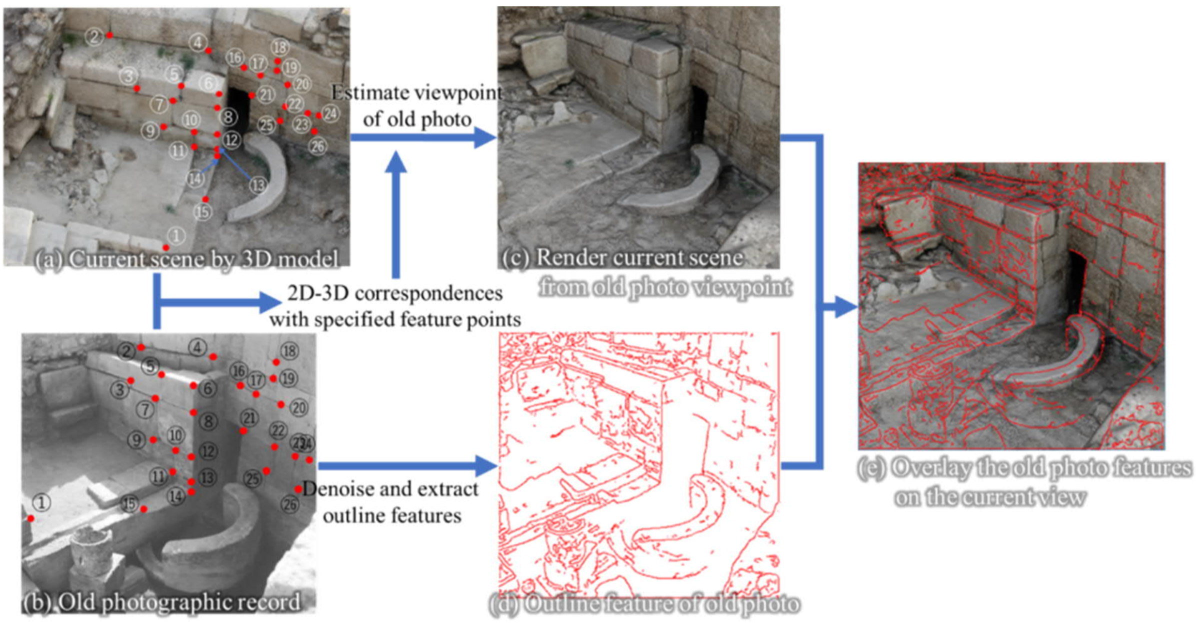

Fig. 7. Result of the proposed method

Case Study (Altar)

Fig. 8 (a) is a photograph taken from the south side of the observatory in the center of the ruins in 1955. The width and height of this image are 1083 pixels and 757 pixels, respectively. We used the frame size of 8 × 6 cm. A width of 77 mm and a height of 56 mm are set as nominal values for setting the internal parameters. The stone in the central part of this altar cannot be confirmed at present. Also, stones surrounding the altar are seen moving from the original position and missing. As in Fig. 8 (b), adjust the value of the Gaussian filter, Canny function so that the ridgeline of the stone is extracted, and extract the outline from Fig. 8 (a), (b) was generated. In addition, 17 points common to (a) are selected, and what is seen from the photographing position of the recorded photograph is Fig.8 (c). Fig. 8 (d) is the result of superimposing Fig. 8 (b) on Fig. 8 (c). As a result, we were able to visually grasp the minute difference between the excavation and the present situation, such as sediment deposition condition and stone defect.

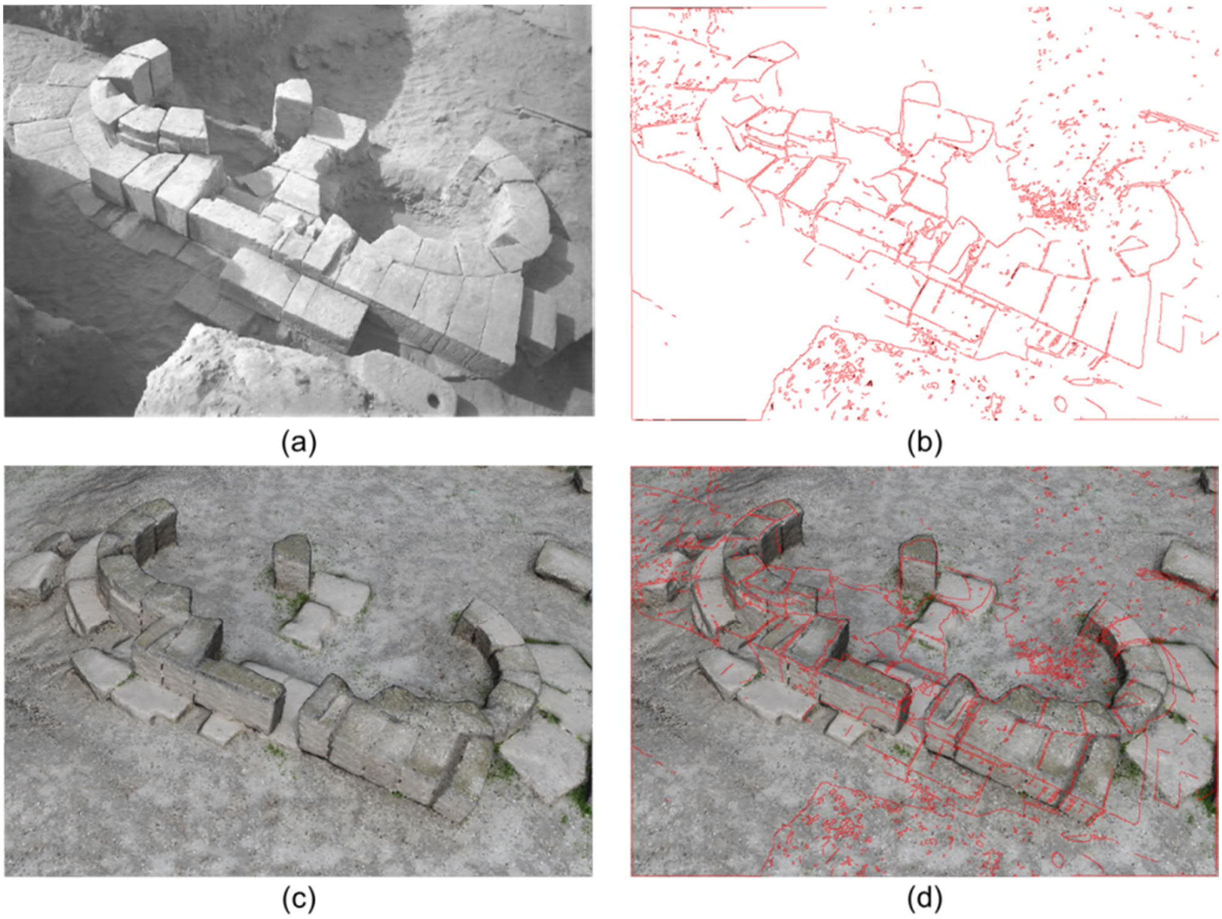

Fig. 8. Another result of the proposed method

DISCUSSION

By superimposing the photograph record on the 3D data, it became possible to confirm the differences from the past. However, it is difficult to read the amount of change only by overlaying the two views, and thus they are hardly applied to the next conservation and repair activities. Therefore, this paper showed the effectiveness of superimposing a virtual reference indicating the actual size. Putting an imaginary ruler in a place where a change was observed in the superposition result of the pool part, and the altar (Fig. 7 (e), Fig. 8 (d)) enables to assure the displacement of the stone. In Fig. 9, the virtual ruler is placed from the edge of the circular structure at the center, showing the change in the past and the present situation. As shown in Fig. 9 (right), it was found that the end of the circular structure moved 15 cm from that time. In Fig. 10, a ruler was placed on the stone which was in contact with the missing part in the recorded photograph at present. When the results were expanded, it turned out that the missing stone was 30 cm wide. Performing the quantitative evaluation can be used as a reference for the progression of degradation, whose information can prioritize the restoration work.

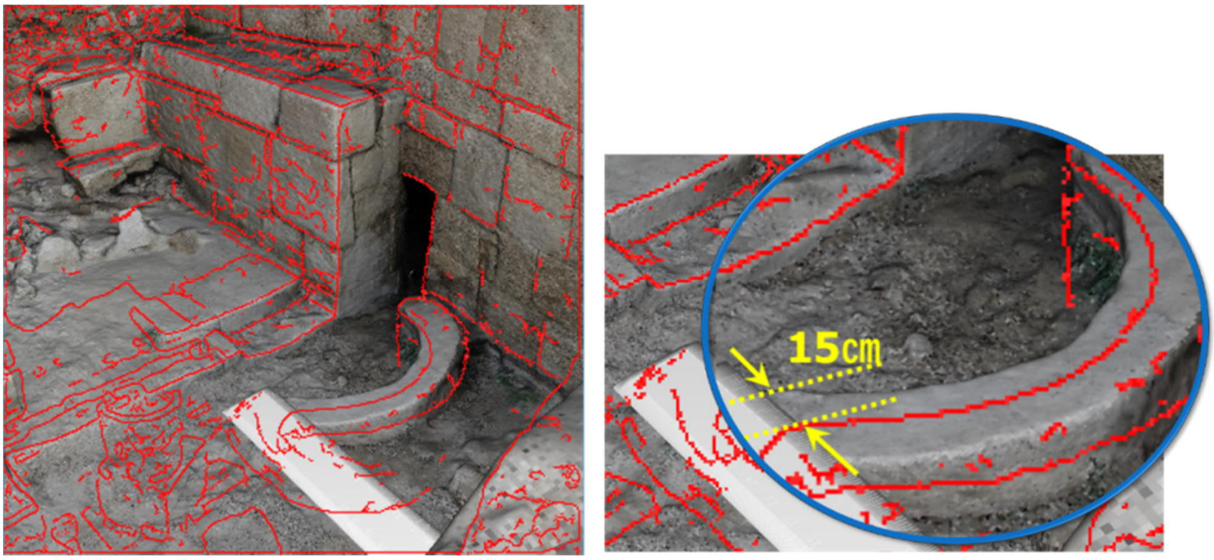

Fig. 9. Overlaid virtual ruler (pool)

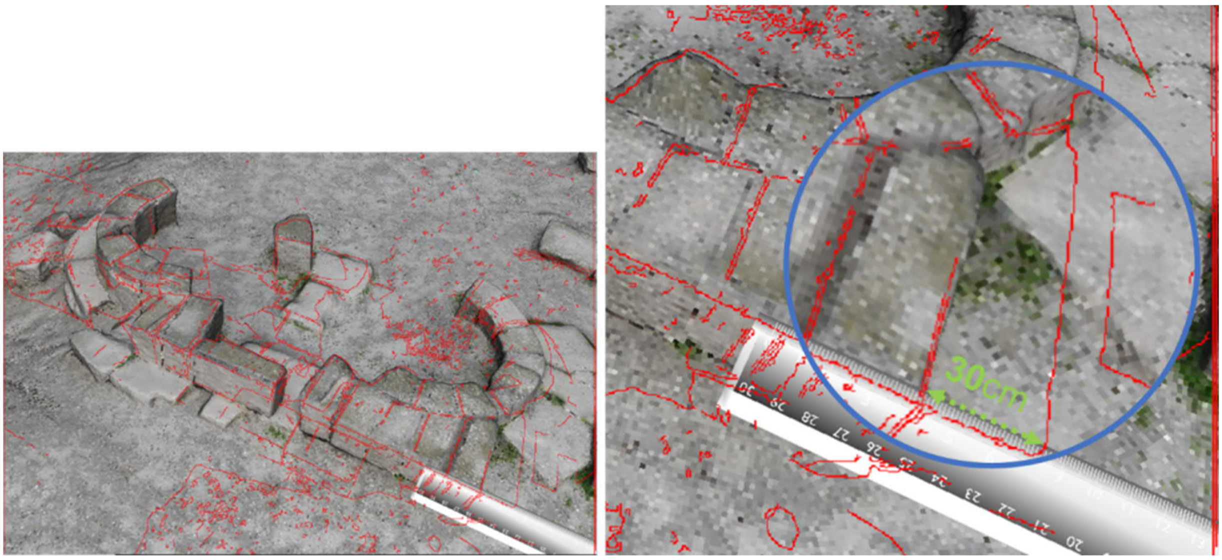

Fig. 10. Overlaid virtual ruler (altar)

CONCLUSION

In this paper, by looking over the measured 3D data from the viewpoint applying the past photographing position and the posture of the camera, it was possible to give the recorded photograph an actual size. The proposed method is capable of quantitative confirmation of temporal changes from the past that are physically impossible. Since the estimation of the camera viewpoint may contain some errors due to manual adjustment of intrinsic camera parameters, an optimization process to determine the parameters is planned for the next implementation.

Temple of Barbar is now being developed for site museum construction. However, due to improper maintenance management in the past, the present situation has changed considerably compared with that time. Therefore, using the camera position estimation, which is a primary method of computer vision, it is now possible to grasp and discover changes over time in the ruins. Future research required in this site is to construct CH-BIM for the creation of a framework capable of quantitatively measuring changes in arbitrary areas of ruins, improvement of reliability during measurement, and periodic management of ruins.

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Visualisation and Perception. Ephesos as a Modern Construct

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JASMIN SCHEIFINGER, University of Vienna, Austrian Archaeological Institute, Austria

The ruins of Ephesos were never completely covered by soil, and since their rediscovery extensive research and rebuilding activities have taken place. The UNESCO-World Heritage Site not only attracts millions of visitors every year but also represents an important centre of archaeological, conservation scientific, and heritage study research. The Ephesos of today is nevertheless not simply preserved, but instead is rather artificially created.

This paper presents a part of the ongoing research project “Construct and agency. The various stories of Ephesos”, which focuses on the fundamental reasons for the image of Ephesos as it is presented today. The research explores which parameters constitute or define the way the site is represented, and how and why this changed in the course of its long period of research. It questions the way the construct and agency of Ephesos are influencing the image of the site. Would this make the ancient life history of this archaeological site no longer disconnected from that of the archaeological park, but rather be understood as an artistic synthesis? The differentiated approaches to reconstruction of ancient ruins and their effect on the legibility of the site will be dealt with, as well as new methods in visualisation and issues concerning the commercialisation of heritage for mass tourism.

Key words:
Ephesos, heritage management, reconstruction, archaeological prospection, conservation science.

CHNT Reference:
Ilie-Iulian Ganciu, Barbara Rankl, and Jasmin Scheifinger. 2018. Visualisation and Perception. Ephesos as a Modern Construct

INTRODUCTION

Ephesos is one of the most important archaeological sites in Turkey, and is internationally sought out by both tourists and researchers. Since 2015 it is included in the UNESCO World Heritage list. The reasons for the national and international interest lie in the wide range of natural and architectural treasures and vivid reconstructions of archaeological structures.

The ruins of the ancient city of Ephesos were never completely covered by soil, and the interest of explorers was already aroused in the 15th century. The first excavations were commissioned by the British Museum in the 1860s, and these were continued by the Austrians from the late 19th century until today [Wiplinger and Wlach 1996].

The visual appearance and the perception of an archaeological site are the results of the disciplines who study them. Since the beginning, Ephesos was subjected to alterations by natural processes but also by human intervention. Intensive excavations made new structures visible and enlarged the information about the ancient city. Extensive rebuilding activities of ancient ruins and conservation interventions play a significant role on how the site is presented today. Additionally, the infrastructure changes done with the purpose of attracting more tourists lead to a radical alteration of the city’s appearance. Ephesos transformed from an untouched site into an archaeological park, which changed the visibility and legibility of the cultural landscape. Along with these changes, also the perception of the site has changed.

Like all archaeological heritage sites, Ephesos is a product of excavations and historical investigations and is now a significant commodity in the global tourist market. What is seen as unique, in terms of heritage and

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commodification, is placed in a global, comparative context. From this perspective, Ephesos is advertised as being the ‘grandest and best preserved ancient city found on the territory of modern Turkey’ (Lonely Planet)[1]. The advertisings go even further in claiming that Ephesos is ‘the best place in the Mediterranean to get a feel of what life was in ancient times’[2]. The advertisement used by the national companies, such as Turkish Airlines, manages to attract up to almost 2 million visitors every year, making it one of the most visited archaeological sites in the world.

HISTORICAL CONTEXT

Research in Ephesos started more than 120 years ago, when John Turtle Wood was commissioned by the British Museum to discover the *Artemision*. With the excavation of the first trenches in the centre of today's archaeological park, the visualisation of Ephesos began (Fig. 1a) [Wohlers-Scharf 1995]. At the beginning the activities were limited to excavations, and no stabilisation or conservation of the unearthed structures was carried out. The Austrian involvement began in 1895. Until the Second World War, the focus of the research was on large-scale excavations of the major monuments and the main outlines of today’s visible structures were revealed. In the course of clearing work after an excavation, fallen columns were set upright and architectural elements were moved or stored, but still no serious attempts were made to restore the monuments [Demas 1997]. The period after the Second World War marks the beginning of restoration, reconstruction, and presentation in a broader way in Ephesos [Demas 1997]. Reconstructions of prestigious monuments such as the Library of Celsus and the Gate of Mazaeus and Mithridates were carried out. In 1951 the site was officially opened to visitors [Demas 1997]. This represents a turning point in the decision making process in Ephesos, as tourism played a more important role.

At the same time the rising costs and complexity of archaeological excavations and conservation work required the assistance of private investors whose interests had to be catered to. The presentation of the ruined site through reconstruction work constituted an effective tool to attract and satisfy sponsors [Ladstätter 2018]. Gradually preventive conservation strategies of the monument inventory were performed, which culminated in the roofing of Terrace House 2 [Krinzinger 2000; Ladstätter and Zabrana 2014]. Due to the effort of presenting and mediating the ruined site, the development of tourism rapidly accelerated (Fig. 1b). Already in the 1980s Ephesos could count more than 2 million visitors per year [Zabrana 2015]. However, external factors can have a negative impact on the numbers of visitors, as the last years have shown, effects, like the global economic crisis or the political destabilisation, led to a variable amount of tourists in Ephesos [Ladstätter 2018].

a *b*

Fig. 1. Great Theatre, Ephesos a) before extensive excavation work; b) modern use of the theatre (© ÖAW-ÖAI)

[1] https://www.lonelyplanet.com/turkey/attractions/ephesus/a/poi-sig/1066097/360857, accessed on 4.02.2019.
[2] https://www.atlasandboots.com/tips-visiting-ephesus-turkey/, accessed on 4.02.2019.

WHAT DO VISITORS SEE?

Walking through the world heritage site Ephesos is an impressive experience which remains in the visitor´s memory for a very long time. But what does the visitor see? An ancient city, with streets, temples, and markets or a construct of the 20th century, with the attempt to convey antiquity?

Since 1895 excavations have been carried out by the Austrian Archaeological Institute and approximately 15 % of the entire urban area has been excavated in more than 100 years of excavations. If one were to double the years of excavation activities, still not even half of the city would be visible. As a result, a falsified picture of an ancient city is presented to the visitors. On the one hand, there is the influence of each excavation director, influenced by their own time and their specific interest in certain periods or monuments. On the other hand, it is not only about structures which cannot be seen because they are not yet excavated; it is also about inaccessible areas. There is a boundary around the officially accessible archaeological park, which excludes whole city districts and important monuments e.g. the East Gymnasium, Magnesian Gate, the stadium or the Vedius Gymnasium [Ladstätter 2018].

The way in which the tourists visualise and experience the site depends also on the type of tours that they join. Such group tours are often limited to specific buildings, because there is a focus on ‘must-see’ monuments; therefore tourists are shown a small selection of structures. By contrast, choosing an individual tour offers the possibility of having a more extensive and comprehensive experience (use of audio guides, guide books).

NEW METHODS IN VISUALISATION

Technological developments in archaeology offer the possibility of gaining information without the use of excavations. The new methods can identify archaeological structures hidden below the surface. The role of geophysical archaeological prospection surveys on ancient sites has increased in the past decades as it provides a non-invasive investigation of buried structures. Since 1995, 175 ha have been measured by geophysical prospection methods – via magnetometry and “ground-penetrating radar” (GPR). With the interpretation of geophysical survey results (Fig. 2) it is possible to reconstruct the city layout in general and the development as well as the alterations of the ancient city. Although the structures may not be visible to the visitors at first, there are ways to make them legible for them. Thus, researchers and visitors get an idea of what the ancient city really looked like.

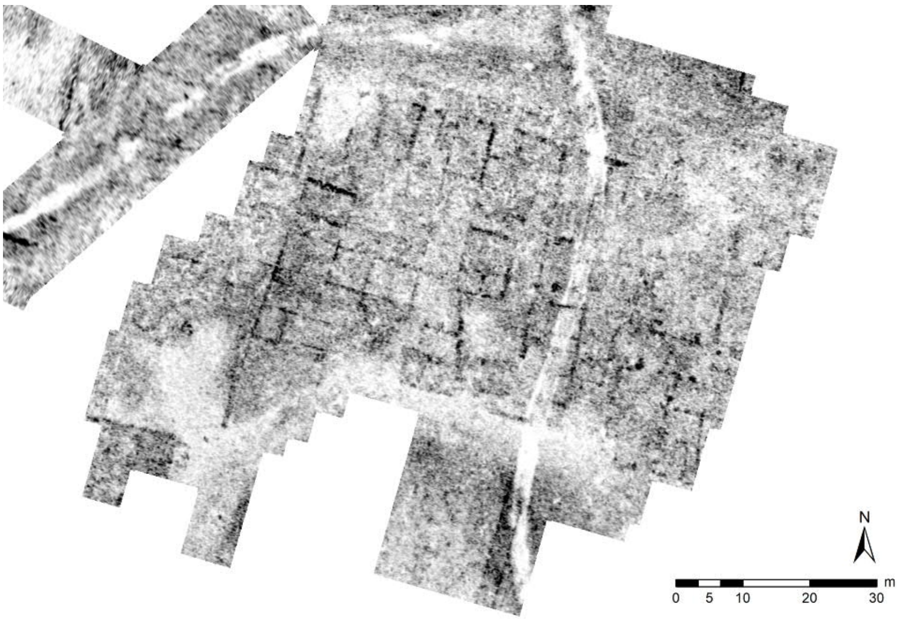

Fig. 2. Detail of the lower city quarter in Ephesos, GPR depth slice 60-70 cm; data collection and processing ArcheoProspections®, ZAMG (© plan: ÖAW-ÖAI/Jasmin Scheifinger)

A visual reconstruction of the city of Ephesos has been created in 2010 in a joint project between the "Austrian Archaeological Institute" (ÖAI) and the Technical University of Darmstadt[3] and is now available in the Ephesos Museum in Selçuk. Also a more recent project in Ephesos that dealt with visualisation started in 2017. This project[4] focuses on the 3D reconstruction of *tabernae* that were excavated in 2015 and the result was turned into an animated short film that came out in 2017. It is about the life cycle of the *tabernae* as well as their interior, and their findings [Schwaiger and Scheifinger 2019].

Such digital reconstructions and videos are only one way to use visualisations, which can broaden the perspective of the audience. Since digitalisation and new media have become part of everyday life, the field of archaeology could – and should – make use of the opportunities they offer. While some apps provide diversified information related to the archaeology of a country, like for the history and archaeology of Wales or the British archaeology, some sites, e.g. Pompeii, have their own app. The site Tel Lachish in Israel uses a mobile app, which shows i.a. real-time, on-site virtual reconstructions through an "Augmented Reality" (AR)[5] software [Kösebay Erkan 2018]. The aforementioned examples are models that are currently not part of the mediation of the archaeological park Ephesos but could be considered after further research.

MODELS OF PRESENTATION

Another important aspect of visitors' experience is the presentation of the visible monuments in the archaeological park and its surroundings. Those monuments constitute artificial constructs and are results of the long research activities in Ephesos. They are the products of decisions made by individuals on how to deal with excavated structures.

With every excavation new monuments are unearthed and interpreted. Dealing with those fragile structures has not just an effect on the status of preservation, but also a tremendous impact on the visibility and legibility of the whole site [Steudtner 2018]. Visualisations are made according to goals, values, and priorities which is probably why they are received so ambivalently within heritage management [Skrede et al. 2018]. Looking at the research history of Ephesos, this issue becomes clear.

The variety of approaches to the conservation and presentation has an immediate effect on the visual legibility of the ruins and it affects the way the archaeological information is perceived [Matero 2006]. In the case of Ephesos this plethora of approaches is clearly evident, since there is no uniform concept of methods or materials used for handling archaeological structures at the site. Most of the reconstructed monuments from the 20th century try to convey antiquity. Whether this mediation strategy succeeded is an open question and sparkes a vivid debate among scholars. The eclectic approach to the restoration and interpretation of monuments in Ephesos constitutes an organic and unplanned growth through time. It is the result of individual decisions made without reference to any overriding plans, guidelines, or framework for the site [Demas 1997]. The rationales or goals of reconstruction enterprises in Ephesos vary a lot, whether it is to further research, attract visitors, to make a philosophical or political statement, or to respond to a religious vision [Demas 1997].

Especially along the famous Curetes Street – due to excavation and reconstruction – even today an urban appearance can be observed. Along the Curetes Street models, of different kind of restoration, their motivation and their method can be studied [Koenigs 2017].

The differentiated approach can be illustrated in two examples, both on the Curetes Street. The first is one of the earliest reconstructions in the archaeological park, the anastylosis of Hadrian's Temple (Fig. 3a). The monument is to be presented as a harmonious whole and should convey an antique building. For this purpose, new artificial stone elements were made. These are recognizable as such and nevertheless fit optically into the structure [Demas 1997].

The second example represents a differentiated approach that can be found in the architectural collage of the Memmius monument (Fig. 3b). The depiction of an ancient building has been abandoned. The monument was

[3] The reconstruction was prepared for the exhibition 'Byzantium – Grandeur and Everyday Life' at the Kunst- und Ausstellungshalle der Bundesrepublik Deutschland in Bonn. [Kunst- und Ausstellungshalle der Bundesrepublik Deutschland GmbH 2010]

[4] For further information, see Jahresbericht [2017, 64 f].

[5] A. Bernardini et al. describe the benefits of augmented reality as "a mobile application [...] by using the localization services and some vocal comments, pictures, and videos, visitors could be guided in real time through many archeological sites, also hidden and inaccessible. [...] The results of an evaluation test which collected visitor' impressions and suggestions showed us that the mobile application allowed them to visit archaeological remnants in a more participative way but that most visitors were unable to deeply understand what they visited and in particular to imagine what relation the archaeological remnants had with the ancient urban landscape". [Bernardini et al. 2012, 354].

designed to present the fragmented nature of the structure and the history of collapse and destruction. The built-up original marble elements are neither installed in their original position nor do the newly installed components convey an ancient form. The additions are made of rough concrete cast in geometric abstract form [Schmidt 1993]. Even though in both re-erection processes the same material – namely concrete – was used intensively, the appearance differs tremendously due to the different theoretical backgrounds. Next to the variety of reconstruction methods one can find natural ruins and excavated structures with different degrees in terms of conservation treatments. The resulting construct which arose through time became part of the modern history of Ephesos and has value in its own right [Demas 1997], but also illustrates a great challenge in modern monument preservation.

a *b*

Fig. 3. a) Anastylosis of Hadrian's Temple, Ephesos; b) Experimental reassembling work of Memmius monument, Ephesos (© ÖAW-ÖAI)

In the end, all excavations and conservations are critical acts. The decision on what is conserved and how it is presented are a product of contemporary values and beliefs about the past in the present. The aspects of site conservation and the presentation of the ruins become more difficult when considering the demands of tourism and regional development for the larger physical and political contexts [Matero 2006].

THE NARRATIVES OF EPHESOS

The tourists' perspective consists of what they can see on site and storytelling. Archaeology is storytelling. Which stories, and why these are told in a certain manner, depends on underlying circumstances. In the case of tourists, these stories come from tourist guides, guide books, and audio guides, to which we can add a visual reconstruction of Ephesos that is presented in the Ephesos museum in Selçuk (not at the site). Although the last three are created in collaboration with experts of the ÖAI, the first one seems to be one of the most popular forms used.

Most of the tourist guides give a very brief tour, one that does not present the ancient city's true image. A guided tour in the ancient city has an average length of 75 minutes and focuses on must-see monuments that are strung together. Guided tours key highlights often include: Herakles Gate, Temple of Hadrian, Latrine, Celsus Library, private house, Theatre, Marble Street [Ladstätter 2018].

One can argue that this itinerary is also determined by the fact that some areas are restricted from the public, like the East Gymnasium and Magnesian Gate, as well as the stadium and the Vedius Gymnasium [Ladstätter 2018]. But at the same time the Terrace house, considered a hotspot of Ephesos, is visited annually by only 8,5 % out of the 2 million visitors [Ladstätter 2018], a fact that might be influenced by the additional entrance fee but might correlate with the brief tours offered by tourism companies. This behaviour could be seen also in light of modern tourism, as well as of leisure tourism, where archaeological sites are defined as the exotic touch of a vacation beside the sea, where short visits at sites are meant to entertain the tourists without boring them [Eres and Özdoğan 2018].

In their visiting experience often are included visits to carpet shops, pottery workshops, or 'historical themed malls'. Given the circumstances, tourists experience the consumerism aspect of the past through its transformation into mass-produced objects of modern material culture. In this way the site might not be perceived as a locus of the past, but rather as a stylistically differentiated place of modern consumer experience [Gazin-Schwartz 2004].

Another way of experiencing Ephesos is through pilgrimage tours. These tours focus on the religious aspect of the site and include landmarks such as Mary's church, Mary's house, theatre – where the Big Riot against Paul took place – St. John Basilica and the Seven Sleepers, the latter is not open for visits.

With all restrictions considered, the site of Ephesos is still a site rich in monuments, but the focus of mass tourism is on its landmarks and not on the historical reality. Visitors see not only artificially created monuments, but also monuments from different periods put together with no differentiation (Fig. 4). The Hellenistic-Roman metropolis shapes the image of Ephesos and seems to display all other aspects of the ancient city [Ladstätter 2018]. It has to be added that the late antique and Byzantine structures were of no interest in the early years of excavations, the focus was on phases of the Hellenistic and Roman imperial period. Which led to a destruction of most of the Byzantine and late antique remains within the city centre. The presentation of Ephesos is not representative of any single period and is completely anachronistic. An example of that is how the tourist maps treat all the buildings as being contemporary.

Fig. 4. Touristic use of the Curetes street, 2009 (© ÖAW-ÖAI/Sinan Ilhan)

CONCLUSION

The excavation and conservation activities conducted in the last centuries in Ephesos have led to the transformation of the city from a natural landscape with ancient ruins to an archaeological park utilized for mass tourism. During the century long transformation from abandoned ruins to a tourist mecca, Ephesos has borne silent witness to the vicissitudes of 20th century archaeological and restoration theory and practice and to the growth of the tourism industry in Turkey.

The Ephesos of today could be seen from two different perspectives: one of a ruin of an ancient city which represents the testimony of a multi layered past; and from a consumerist perspective, where monuments, squares, and streets could be rented for festive dinners and concerts. Is the site keeping its value as an authentic document of the past or is it heading towards a Disneyfied version of antiquity? The scientific community has to be aware of the fact that every treatment made will influence the way Ephesos is preserved, presented, and perceived. At the same time it has to regulate the misuses of the site caused by mass tourism which in the long term can affect the preservation of the site.

The role of various stakeholders and their functions in this process has to be considered in order to avoid issues of misrepresentation. The way the site is perceived varies depending on the narratives presented. Adding new research results, such as the development of reconstructions of ancient ruins and new archaeological evidence, create new narratives which can lead to a better understanding of the artistic synthesis that Ephesos is nowadays.

For a functional management of the site, conservators, archaeologists, and heritage managers should act as a joint enterprise. The great challenges, but also chances for the research activities at Ephesos in the near future are dealing with new approaches in tourism, a sustainable preservation concept, as well as the implementation of new methods in archaeology.

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The Church of St. George in the Kyrenia Castle in the North of the Island of Cyprus: Bringing out the Shape of Architecture

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The contribution focuses on the digital documentation of St. George's church, dating to the Early Byzantine Period, close to the Roman fortress of Kyrenia in the north of the island of Cyprus. In medieval times the Kyrenia castle became a focal point in the defense of Cyprus, being increasingly fortified, first in the Crusader period, then by the Venetians and the Ottomans, when it has incorporated within its defensive structures the church of St George of which today only the central dome covering is perceived from the outside.

A digital survey campaign was carried out, integrating the morphological data coming from laser scanners with the texture of photogrammetry, so to be able to study the church and its architectural features; the textured 3D model was used both as a three-dimensional space fruition system through digital platforms, and as an informative base necessary for the graphic restitution of technical architectural drawings to build-up cognitive analyzes.

The adoption of a three-dimensional model is useful to understand the distributional complexity of the architectural volumes that hide the Church of St George. It is beneficial for the visitor in the context of virtual museums, and appropriate to obtain traditional 2d drawings as a base to analyze the construction techniques for a stratigraphic-evolutionary study of the building that, together with a careful analysis of historical sources, allows to understand the development phases of the church in relationship with the enlargement of the castle's defensive structures.

Key words:
Digital Survey, Kyrenia Castle, North of the island of Cyprus, St. George's Church.

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Rolando Volzone et al. 2018. The Church of St. George in the Kyrenia Castle in the North of the Island of Cyprus, Bringing out the Shape of Architecture.

KYRENIA CASTLE AND THE ST. GEORGE CHURCH: HISTORICAL FRAMEWORK[1]

The island of Cyprus, thanks to its natural resources and its strategic position at the crossroads of three continents (Africa, Asia and Europe), has been exposed to different cultural influences. It has been conquered by several civilizations which have dominated the eastern Mediterranean area in different periods: it turns its own history very rich. The island was settled by Mycenaean Greeks and it was subsequently occupied by Assyrians, Egyptians and Persians, the Arab caliphates for a short period, the French Lusignan dynasty and the Venetians, which were followed by Ottomans between 1571 and 1878 [Mirbagheri 2009].

Kyrenia (*Girne* in Turkish) is the main town of the homonymous district, and it is situated on the north coast of Cyprus, between the ancient cities of Lapethos and Macaria, about 30 km from the capital Nicosia. In the middle Byzantine and in later sources, the city and the port are mentioned [Papacostas 1995]. Wilbrand of Oldenburg, bishop of Paderborn and of Utrecht, by attending the orders of Otto IV, Holy Roman Emperor, to prepare the Fifth Crusade to the Holy Land, writes down in 1211 the *Itinerarium terrae sanctae*, important historical source on the crusades and crusader castles, where he describes *Schernis* as "civitas parva, sed munita, castrum habens in se muratum et turritum": a small town well-fortified which has a castle with walls and towers. The description underlines the two key elements – the harbor and the castle – which are strictly linked to the history of the place, dating back to the Prehistoric period.

[1] The chapter "Kyrenia Castle and the St. George Church: Historical Framework" has been written by Rolando Volzone; the chapter "The Digital Survey Campaign for the Analysis of the St. George Church in Girne" has been written by Federico Cioli; the chapters "The Problems in the Survey and Different Methodological Approaches" and "Archaeological and Interpretive Analysis" have been written by Matteo Bigongiari.

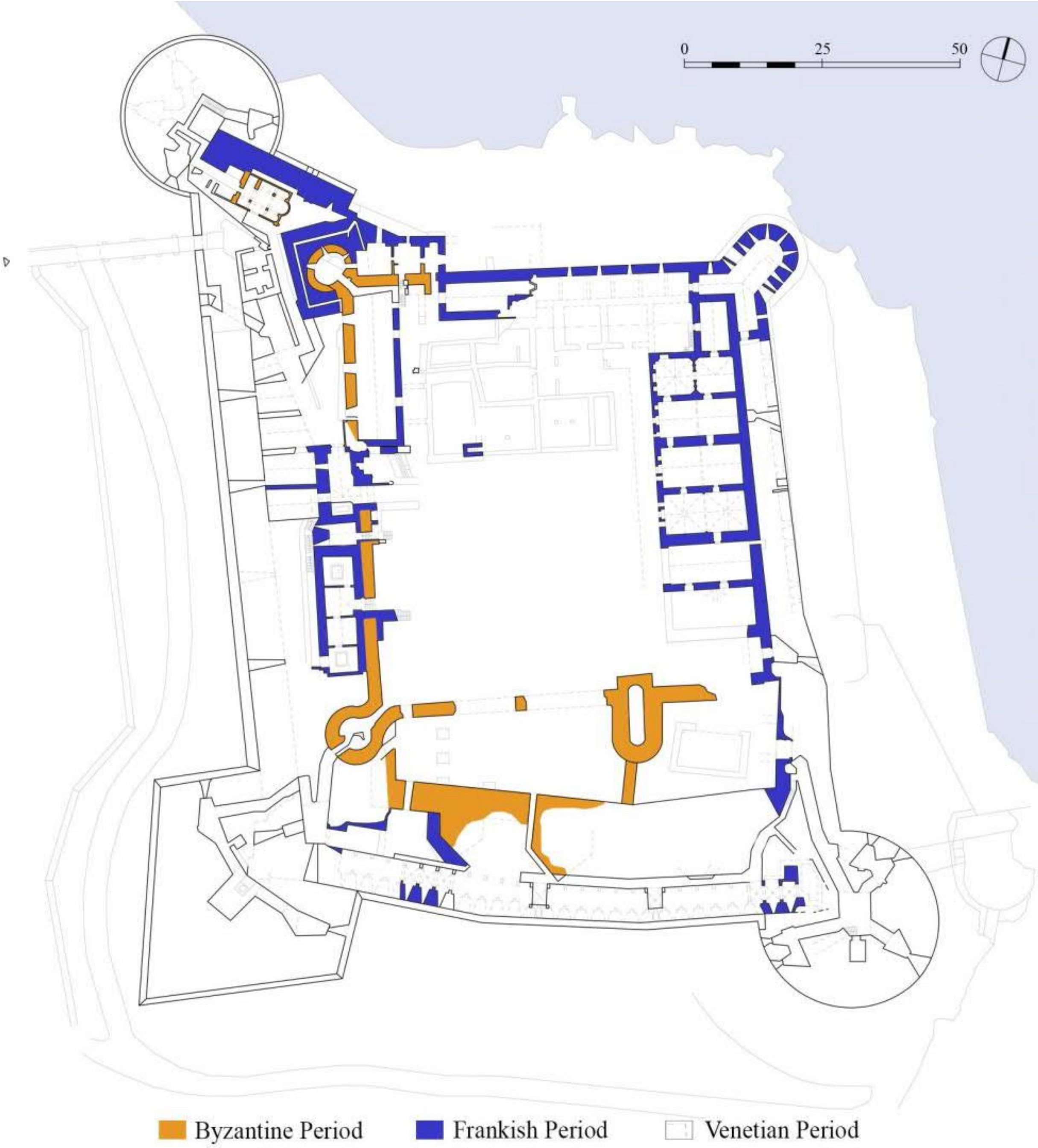

Fig. 1. Kyrenia Castle and its alteration along the centuries

The Kyrenia castle is located at the east end of the harbor. The exact date of construction of the castle is unknown. Explorations, carried out in the castle area, reveal traces of the Hellenistic and Roman Period. The original castle was built in the 7th century A.D. by the Byzantines with the purpose of defending Kyrenia against Arab raids. The remains of the castle are the result of its alterations in different periods (Fig. 1): Byzantine Period (330-1191), whose fortifications were generally built to accommodate armored knights and archers [Camiz et al. 2016]; Lusignan Period (1192-1489), the French Catholic dynasty whose major contribution to the island's architectural landscape was the importation of the French ecclesiastical styles of the 13th and 14th centuries [Given 2005]; Venetian Period (1489 - 1570), at which time Kyrenia was reconstructed, mostly when gunpowder – for cannons and general artillery – came to the use, and these main weapons were adopted for the war [Dreghon 1985], and high curtain walls with numerous openings as gun ports were built. The conquerors employed various techniques to modify existing previous parts or to build stronger ones of the castle, to protect themselves from attacks [Camiz et al. 2016]. What we see today is mostly a consequence of reconstructions and additions made by the Venetians, who built over a crusader fortification from 1540 to 1544. The castle was altered; thicker and higher walls were built, with more and stronger battlements and deeper ditches and moats. Part of the original 7th century Byzantine castle is still evident in the west and south sides; its medieval remains are in adulterated conditions: the original plan was a rectangle large court surrounded by ranges of buildings against the four curtain walls. At each angle there were large square towers, of which that on the north-east angle was planned diagonally to the rest [Jeffery 1918]. It was during this period that important monasteries and churches were built, many of which still exist. It is important to underline that the term Byzantine, as used in the eastern Mediterranean, corresponds to the late Roman period (330-1100). It began when the Roman Empire split up into two halves, the first one at east, centered at Constantinople, and the second one at west, with Rome as the center [Dreghon 1985].

Fig. 2. The Chapel of St. George: interior view

The best example for this period is the Byzantine church or chapel, later known as St. George of the Donjon, dating from about 1150 A.D. From the castle gate, by crossing the fortified Venetians wall, through a narrow vaulted corridor, it is possible to reach the church (Fig. 2). The door left to the tunnel opens to the rooms where the church servants spent their daily lives. De Mas Latrie [1874] publishes the will (1406) of Lady Pinadeben of Ferrara, widow of Anthony of Ferrara, who mentioned the “chapele de Sainct Jorge du Donjon” [Enlart and Hunt 1987]; the German classical archeologist Ross [1852] mentions the “Capelle mit vier Marmorsäulen” (the chapel with four marble columns); in 1865, the architect Edmond Duthoit, who accompanied the Count Melchior de Vogüé in a scientific mission in Cyprus, describes

> *“une petite chapelle sur plan byzantin avec coupole au centre. Les colonnes AA' sont en marbre blanc avec chapiteaux antiques”*

(a little chapel with a byzantine plan and a dome in the middle, with two columns A and A’ the ones near the apse, in marble whit ancient capitals) [Bonato 2001].

Fig. 3. Exterior (on the left) and interior (on the right) view of the dome

The chapel is located at the foot of the north-west tower. This tower has a square outline and ~~has~~ inside a stone staircase which snake figures decorating the interior walls. During the time of the Byzantines and the Lusignans, the Chapel of St. George was outside the castle perimeter, and, it was enclosed when the Venetians extended the defenses with new fortified walls (Fig. 1), according to the plan of the 13th century castle made by Jeffery [1933]. It has a cross-in-square layout, with a central dome supported by four columns, and the apse east-oriented. This main semi-circular apse is flanked by inscribed apses where, according to Papageorgiu [1965], traces of fresco decorations were preserved. It is also the case of the church of Christ Antiphonitis, remarkable for the frescoes on the walls and on the pillars [Jeffery 1918]. The structure of the Saint George Chapel was built in ashlar masonry, and is nowadays the unique surviving example of the four-column type in Cyprus. The columns and capitals are made of white marble, probably coming from an important building of the second century, as are the *crustae* of the floor, with remains of *opus sectile* paving, dating between the late 11th and the early 12th century [Megaw 1974]. According to Jeffery [1918], the chapel was used as a burial during the late medieval period: the sepulchral memorials in village churches – imitating the ones in town churches – were common until the end of the 16th century. In the Venetian period, the original dome was removed, the church was utilized as a passage to the north-west tower and the narthex was filled with masonry. Amongst these, there is an interesting gravestone of the 16th century with the usual form of shield containing the inscription “QUI IACET ALUISE DEMEDICI DA BEEGAMO CHEEE”, mentioned in the will of Donna Pienadabene of Ferrara. The scarped rock on which the church stands was the site of the north-west corner tower, which is still evident. It is at the intersection point of the western curtain wall with the line of a northern one, still visible at several places. This north-west corner tower, second only in importance to the round tower must, from the shape of the rock foundation, have been rectangular in trace, unusual at that period, but giving better flanking fire along the west curtain wall.

A brick dome was erected subsequently – between 1910 and 1930 – after years with a roofless church [Enlart and Hunt 1987, Gunnis 1936], and the north-west column was replaced by a wall. In 1938, the filling behind the apse and the west part was removed, revealing the narthex. In the early 1950s the wall in the place of the lost north-west column was replaced by a column brought from Nicosia and a capital from the castle precinct [Papacostas 2015]. The modern brick dome was replaced by a stone dome with eight recessed windows (Fig. 3).

It was presumably inspired by the domes at Church of Christ Antiphonitis (Christ who responds) and Panagia Theotokos Church (Fig. 4). The first one was built in the 12th century, and it is located at 1.5 km south-west of Kalograia in the Kyrenia district; its dome – nowadays with an irregular shape, due to damages occurred during the Cyprus earthquake of 1222 – has twelve windows, built in regular courses of good ashlar masonry, and it is supported by eight columns – the only surviving example of this type in Cyprus. The second one, as suggested by the architecture and style of fresco decoration, is dated of the early 12th century, and it is located in Trikomo, a town in north-eastern Mesaoria in Famagusta district; its dome drum was built in isodomic courses of good ashlar masonry with twelve arched and recessed windows.

Fig. 4. On the left side: Church of Christ Antiphonitis, August 2016, © Gerhard Huber; on the right side: Panagia Theotokos Church

The church of St. George was one of the most significant spaces, due to the particular features of this building, which shows the historical phases of its evolution and lies into the defensive wall, being placed between the Venetian wall of the 16th century and the medieval wall of the 14th century [Dreghorn 1985]. Nowadays, only the central dome covering is perceived from the outside, and, in order to bring out the shape of the architecture, it was necessary to start a digital survey campaign. It is necessary to analyze the construction techniques for a stratigraphic-evolutionary study of the building that, together with a careful analysis of historical sources, allows understanding the development phases of the church in relationship with the enlargement of the castle's defensive structures, particularly its interaction with the north-west tower.

THE DIGITAL SURVEY CAMPAIGN FOR THE ANALYSIS OF THE ST. GEORGE CHURCH IN GIRNE

The study of the volumes and of the architectural features of the St. George Church required a digital survey campaign that integrates the morphological data coming from laser scanners with the information on the characteristics of the materials acquired through the use of "Structure from Motion" (SfM) methodologies. The most distinguishing feature of this building is to be encompassed into the city's defensive walls, maintaining two of the original facades: this makes it more difficult to survey and clearly redraw the "image" of this architecture.

Between the 6th and the 13th of May 2018, the workshop "Reading and Designing the Kyrenia Castle" took place in Girne American University in Cyprus. The workshop was planned thanks to a collaboration between the Girne American University (Department of Interior Architecture), the Department of Architecture of the University of Florence and the Department of Interior Architecture of Özyeğin University. The workshop involved fifty-six students of the three universities, which were divided into groups in order to cover the design and digital survey topics under the guidance of their tutors. The main topic was focused on the Archeological Museum inside the Castle, which needs a new distribution scheme for the interior rooms. The digital survey conducted using range based and image based instrumentation, produced 360 laser scans, 1900 aerial pictures, 30.000 terrestrial pictures, and low altitude pictures acquired using a telescopic photographic system 3DEYE (Fig. 5) [Camiz et al. 2018]. Despite the attention given to the Ancient Shipwreck Museum area, the digital survey involved also several parts of the Castle, of which the Church of St. George was one of the most significant.

Fig. 5. Representative picture of the digital survey campaign carried out with a laser scanner Z+F IMAGER 5006h

In order to understand the architectural morphology, it was necessary to elaborate an accurate plan of analysis and acquisition of metric and qualitative data. The analysis of the historical evolution of the Church of St. George is closely connected with the one of the castle. The understanding of the phases of construction of the building offers a new insight on the history of the architectural complex and of the whole city. The acquired data are a testimony of the current condition of the church and provide the documentation for in-depth analyzes. This allows us to describe the physical features, the characteristics of the materials and the conservation status of the single element of the architectural structure.

The integrated digital survey generated a quantity of data that required a discretization in the post production-phases, in order to provide useful and understandable drawings. The process of building the morphological textured 3D model starts with the planning of the survey and the establishment of a descriptive model. An IMAGER 5006h laser scanner by Z+F was used for data acquisition. The instrument was placed inside the 9x9 chessboard scheme deriving from the layout of the church, where a dome standing on four columns surmounts the central part. A dark corridor connects the church with the entrance of the castle, permitting the constitution of an overall model, which includes the upper path to the bastion from which the dome and the roof stand out. The survey of the Church of St. George required the specific acquisition of 16 scans, nine of which inside the building; two on the doorstep in order to connect the inside part with the corridor and with the exterior, while seven scans were used to restore the image of the external fronts. It has to be considered that the church is an integral part of the fortress and therefore the upper rooms and the dome were acquired and connected to the polygonal path of scans of the castle of Kyrenia. The lack of a topographic survey demanded an *in situ* registration and verification. The shaping of an overall polygon and of a partial polygonal was necessary to quantify the error in the readings [Bigongiari 2017a].

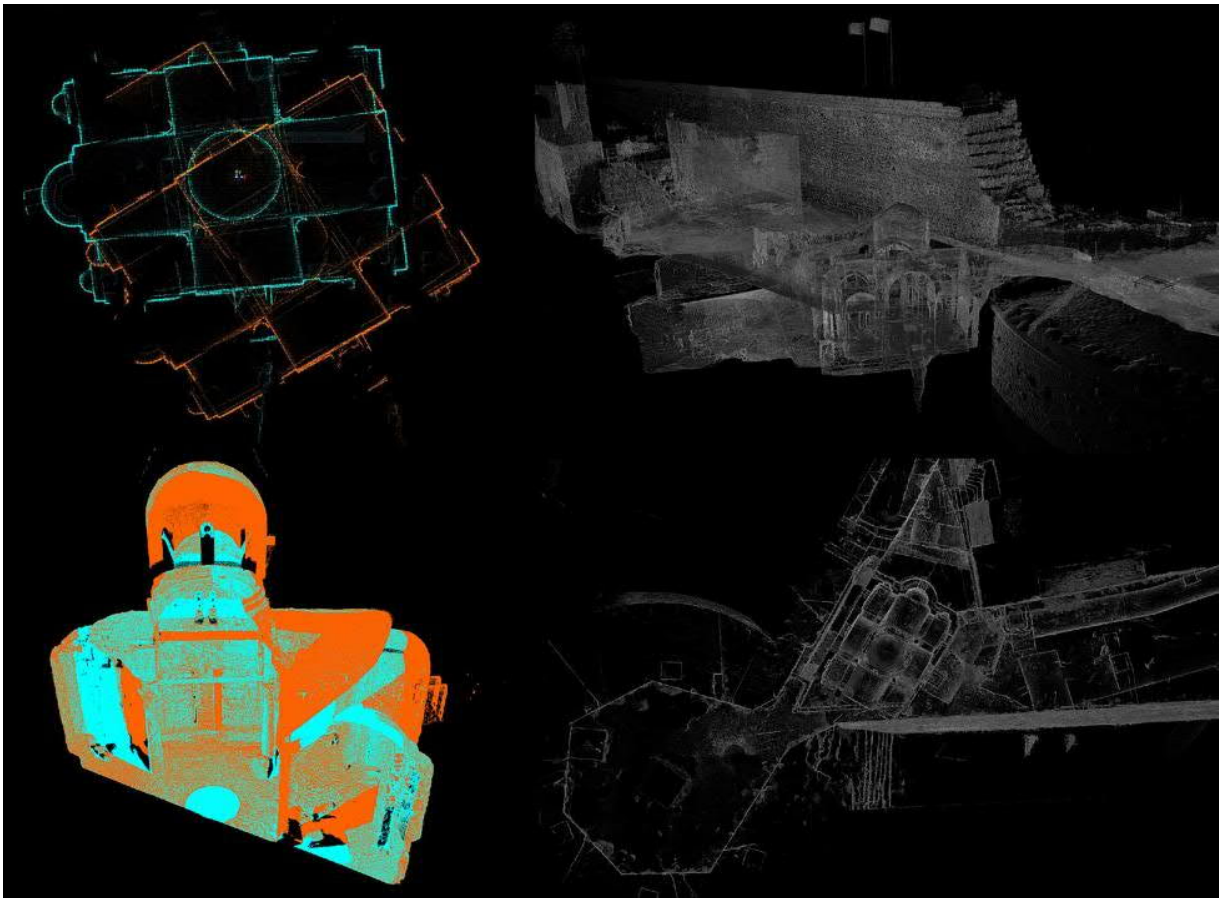

Fig. 6. On the left, procedures for the registration of the point cloud using the visual alignment. On the right: perspective view and general plan of the overall model of the church and the environment

The registration of single point clouds and the verification of data reliability is a fundamental phase that brings together the work *in situ* with the subsequent post-production phases. It is fundamental during the acquisition phase to provide the necessary superimpositions required for recording the data. The registration starts from the assumption that the scans use the same polar reference system. Through the rigid rotation of the clouds by using a visual alignment, the scans were recorded via cloud constraint, allowing to survey without using the black and white targets (Fig. 6).

Fig. 7. Two examples of pictures acquired with two different exposures

The SfM survey [De Luca 2011] was carried out using instruments with high resolution sensors and correction processes of the single shot. The purpose of the photogrammetric survey was to export the ortho-images of the facades, useful for the understanding of the masonry and its evolution. Thus, a detailed acquisition of the individual elements was not carried out, despite an overall relief that returned the architecture in its entirety. The survey was conducted during closing hours of the castle. Therefore, the short time available for the SfM acquisition required a planning that produced 193 photos for the exteriors and 125 for the interiors, following the checkerboard acquisition scheme used in the laser-scanner survey. In particular, the interior of the church was acquired with a Nikon D800e placed on a tripod, using a remote control for remote shooting and the self-timer in order to minimize vibrations, giving the possibility to increase shutter speed. The acquisition required the preparation of the environment, through the use of spot lights set at strategic points in order to give a uniform and constant lighting throughout the survey phase. In fact, the main problem was the strong contrast of light between internal and external parts of the Church and between the space below the dome and the rest of the indoor environment. The impossibility of fully compensating these variations required shots on various exposures that were then elaborated in order to create a single homogeneous photo (Fig. 2). The establishment of a photogrammetric 3D model has served to extrapolate the ortho-images, useful for restoring the image of the masonry apparatus. On the outside, the impossibility of maintaining a constant distance from the object led to the creation of a model of greater detail in the south-west part in spite of the north-east one. The morphological complexity of this architecture, incorporated into the castle walls, which can be joined by a poorly lit corridor and surrounded by narrow passages, did not provide the necessary overlapping points to be able to join the two models (Fig. 3). Despite the use of specific targets positioned at the opening on the north wall, it was not possible to combine the model of the exterior with that of the interior, which was then integrated with the point cloud obtained by the laser-scanner survey in order to establish an overall model. The new approaches to surveying, aimed at the acquisition of 3D data, partly facilitate the documentation process, but require careful processing to move from the three-dimensionality and completeness of the point cloud to the two-dimensionality and schematization of the drawings. The graphic rendering phase started from the management of laser scans using the *Cyclone software*[2], and then proceeding through a vectorization of the point cloud in the CAD environment.

2 https://leica-geosystems.com/en-gb/products/laser-scanners/software/leica-cyclone

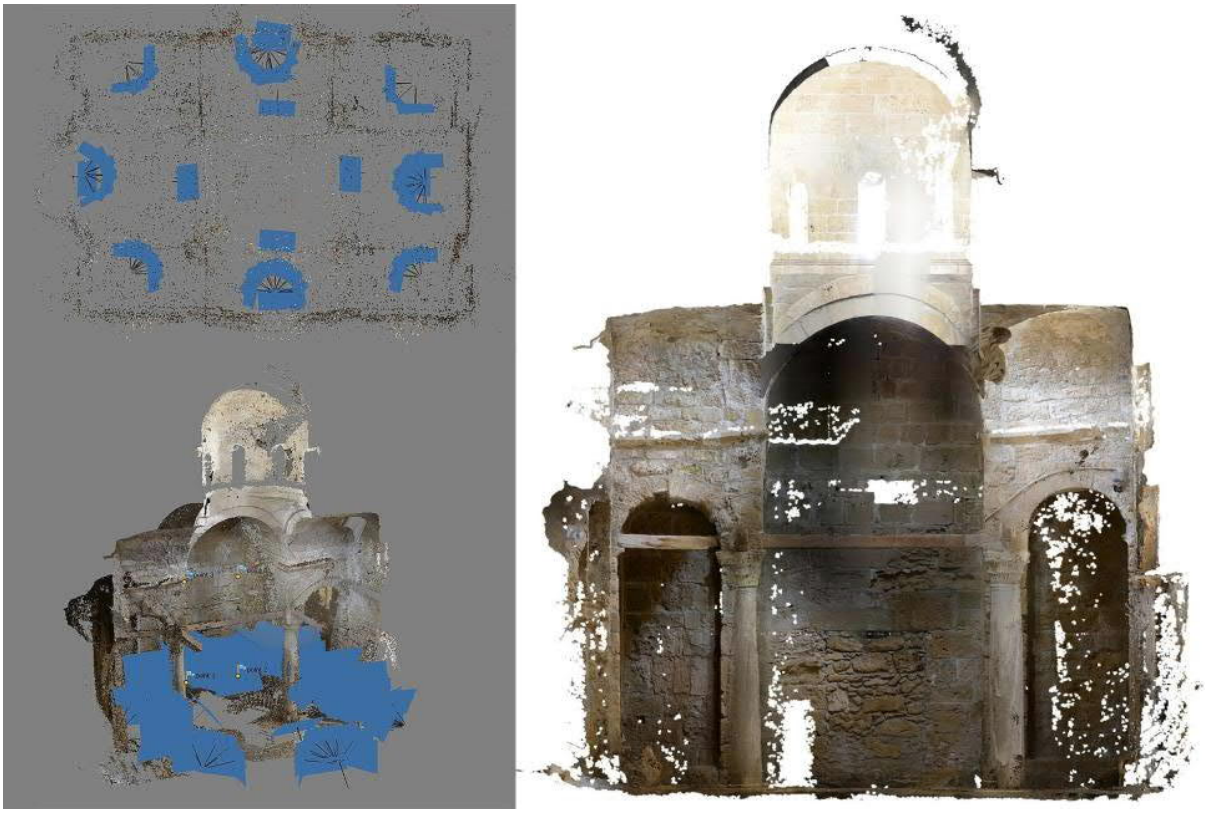

Fig. 8. The interior of the Church of St. George has been modelled using 125 high-resolution pictures. The model obtained by the SfM processing testify the presence of lacks and problems connected with the homogeneity of the texture.

The high resolution of the scans guaranteed to export detailed ortho-images from which it was possible to analyze, with the help of the ortho-images, the masonry and its evolutionary phases. The exported, oriented and scaled ortho-images, provided the basis of the drawings, through which it was possible to redraw the point cloud by tracing the main elements through closed polylines. Later the representation was deepened, characterizing the design of details and more specific signs, thanks to the integration of the information contained in the photographs. The drawings are in 1:100 scale, concerning the plant and the environmental sections, useful for the understanding of the relationship between the architecture and the castle. Then, plans, elevations, and sections in 1:50 scale have been realized, in order to facilitate the reading of the Church and serve as support for the study of the historical evolution of the building (Fig. 5). The integrated model is a database of implementable information, useful to understand and transmit knowledge regarding the architecture of the Church. In fact, in addition to the documentary potential of the survey, it aims to develop promotional tools, according to the overall idea of reorganizing the Kyrenia castle museum complex [Bianchini et al. 2018]. One of the aims of the workshop was in fact to develop a project for the redistribution of museum environments around the central courtyard of the castle. The Girne Fortress is a focal point of the city and of the harbor area and it has a great tourist potential. In order to be fully exploited according to the criteria of a cultural and sustainable tourism it requires an overall reorganization of the museum itinerary inside it. The data is therefore a knowledge base and a planning tool for a consistent development of the system, which takes into consideration all of its components, in a single path that reflects the essence and history of the place. The cognitive studies carried out in the church of St. George conclude in a series of images and models that can be used with VR and AR technologies to make it easier for guests to understand the complex building they visit. [Bertocci et al. 2018].

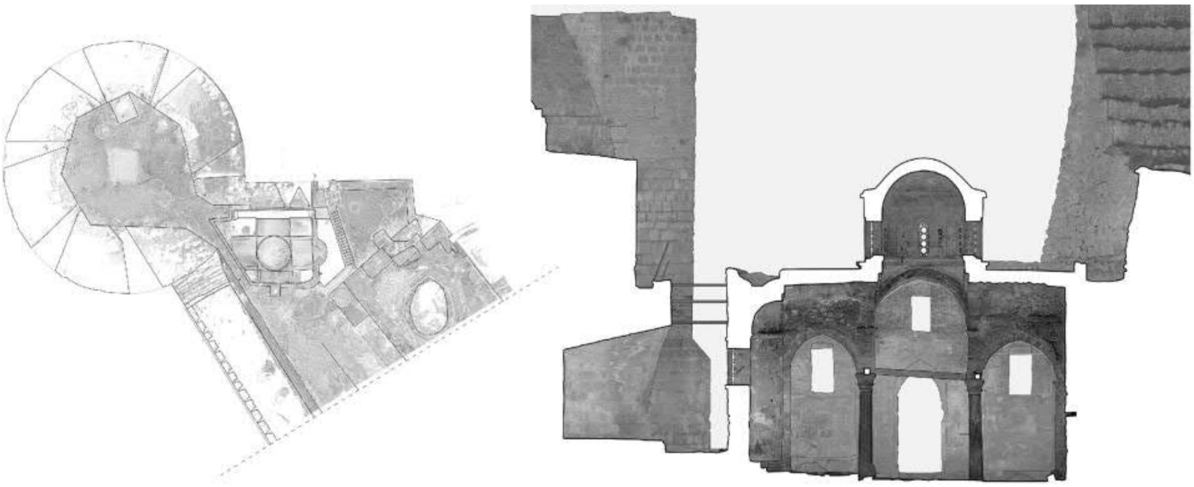

Fig. 9. General plan and detailed section of the Church of St. George with the support of the ortho-image derived by the point cloud of the laser scanner survey.

THE PROBLEMS IN THE SURVEY AND DIFFERENT METHODOLOGICAL APPROACHES

Since its first applications in the field of architectural surveying, the degree of innovation that SfM applications could bring to the disciplines of representation was evident: the possibility of creating three-dimensional models on which to apply highly reliable textures has greatly improved the descriptive capacity of both digital models and two-dimensional drawings. The need to have photographic ortho-mosaics is due to the demand to create a database of 2D graphic drawings useful to map the different types of analysis, from archaeological to material to the identification of decays. Up to that moment this requirement had nevertheless been satisfied through the use of photogrammetry software, calibrating the frames on the basis of the ortho-images from the point clouds [Pancani 2015], while for the realization of three-dimensional photorealistic models, useful graphic communication tools especially if they are intended for non-technical subjects, very simplified models were used on which to apply the textures of the various faces of the building starting from the ortho-mosaics of the facades [Bertocci et al. 2014].

Photomodeling has considerably modified the methodological procedures for the realization of ortho-mosaics and digital models. From the survey point of view, however, it immediately became clear how the models obtained from the frames were not comparable, as regards the metric reliability, with the point clouds obtained by laser scanners: at first, we tried to contain the problem by using, in support of the models obtained from the photographs, points taken with more reliable instruments such as total stations [Gaiani 2015]. Recent software developments permitted to have lower metric errors and the ability to build models from large-scale photo datasets, things that were difficult until a few years ago.

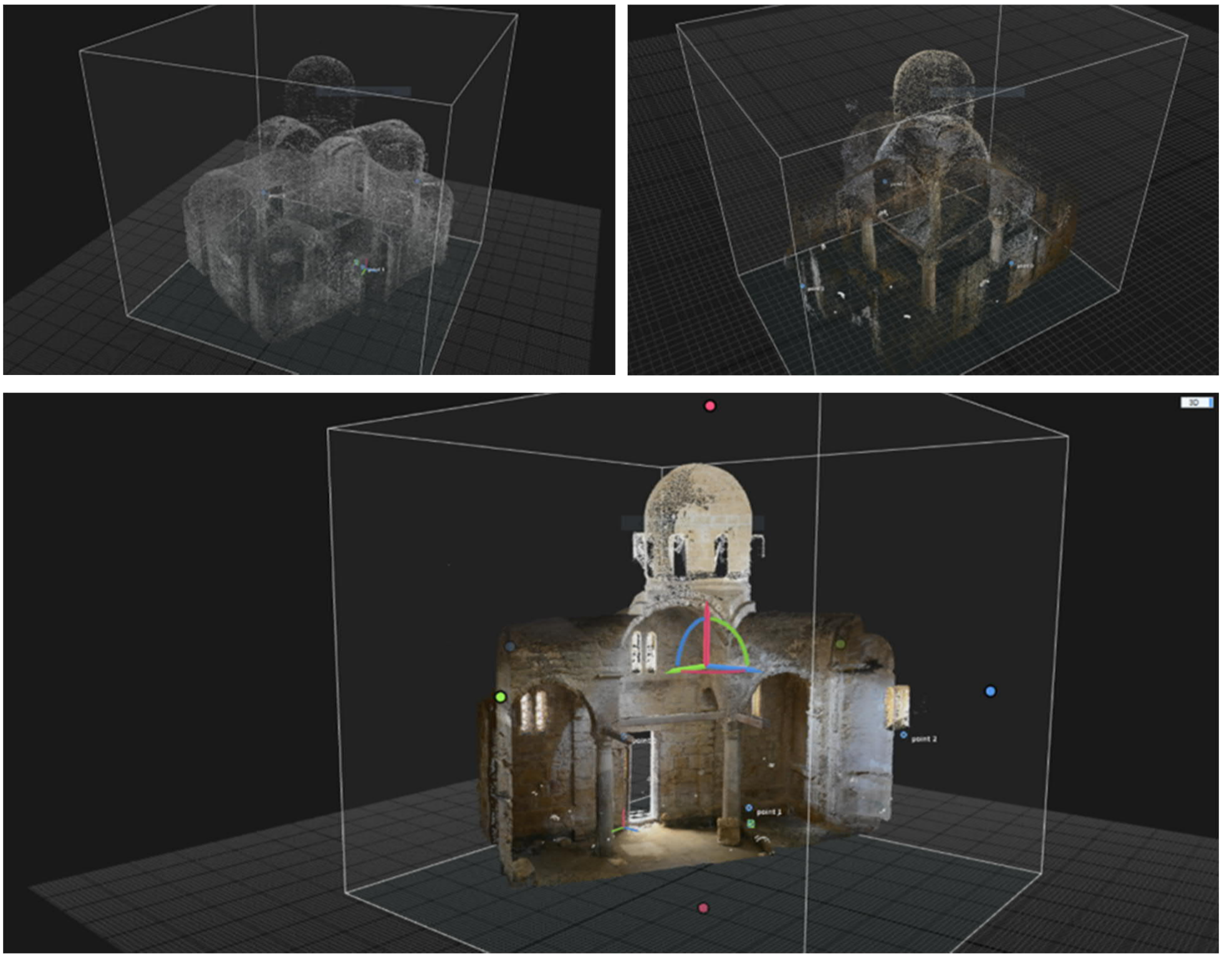

Fig. 10. 3D model obtained from the laser scans alignment (top left) and from the photographs (top right); the result is a complete 3d textured model that can be sectioned to realize orthophotos. (bottom)

The main reliability problem affecting photomodeling consists in its measurement mode: the frame comes from a passive acquisition method, that is, the camera sensor is impressed by light, doing nothing else but remaining exposed to it. Precisely for this reason it is not possible to determine the error that a survey can achieve before seeing the result obtained; this is decidedly different than the laser scanner survey, where the instrument sensor emits a light signal that is checked in order to test the results in the laboratory from which the technical data sheets of the instruments are made.

The success of a 3D photographic survey does not really depend only on the morphology of the building, the acquisition method of the photograms and the materials that form the architecture, but also on the lighting conditions of the object, both artificial and natural. These problems mainly lead to cause different effects: if on the one hand they cannot recreate a uniformly balanced colored texture on the other they can cause morphological errors due to the misinterpretation of badly lit surfaces (whether they are unduly underexposed or burned). It is possible to limit these errors in post-production by modifying some parameters of the frames, which is possible only if the shots have been made in .raw format, otherwise the pixel changes lead to obvious errors: in this way shadows and burns are attenuated and the white balance of the photographs can be uniformed among them, but inevitably the realization of a much heavier archive results.

Fig. 11. High resolution image from the3D textured model obtained combining laser scans and photographs

In the case study of the church inside the Girne fortress many of these problems have been found, especially within the church: the interior lighting condition is totally devoid of artificial light points, and is strongly influenced by the architectural typology, characterized by narrow and long windows that cause a strong overexposure of the areas near the window-frame; at the same time, the development of the fortification that has incorporated the religious building has led to a total absence of direct lighting from many of its openings, leaving the south and west sides of the building completely blind; finally, the central dome, illuminated from all sides, causes an area very much overexposed with respect to all the surrounding bays.

The photographs taken to create a three-dimensional model, have suffered from these problems and in fact in the development of the 3D model through the software *Agisoft Photoscan v.1.4.0*[3] have been highlighted significant morphological inaccuracies; mainly the errors are due to the lack of general lighting in the church, which obliged to make acquisitions with very slow shutter speeds and to use the tripod to avoid the shake-out effect, and to the presence of areas overexposed around the windows. The result of automatic alignment has highlighted these problems in several ways: the dense cloud point created in fact presented a lot of digital noise, in fact the sections of the cloud of points were not threadlike, but the software, due to the difficulty of correctly placing the points in space, returned very thick sections; moreover, due to the problems of overexposure many of the surfaces have not been correctly reconstructed: in this case they showed themselves with evident lacunose portions, due to the bad recognition of points, similar to when trying to reconstruct a plastered wall almost completely homogeneous from the color point of view.

An unsuccessful model would have resulted in a great loss of reliability and information; to solve the gaps within the model it was decided to use a different software *reality capture*[4] that allows to manage the data of the laser scans simultaneously with the photographic data. The program imports both the data of the scans, previously filtered and recorded (with the Leica *Cyclone software*), and the frames, afterwards and it tries to automatically align the data with each other; this is possible because laser data can be assimilated to frames, each scan can be considered as a panoramic view that is decomposed into a cube (6 frames) [Bigongiari 2017b]. If the pixel images of the scans and photographs are not automatically recognized, the alignment between the models can also be done through the registration with homologous points. The union between the two acquisition systems leads to great improvements: the three-dimensional reconstruction of a mesh model is not only based on the points calculated from the photographs, but mainly bases its morphology on the points coming from point clouds from the laser scanner and

[3] https://www.agisoft.com
4 https://www.capturingreality.com

integrates the missing data with the data coming from the photographic cameras. Obviously the laser scanner survey of the interior of the church did not suffer from lighting problems and this allowed to obtain a complete model; the correct overlapping of the two acquisition methods, assisted by control points (with an error of less than 1 px), allowed to realize a complete and textured model of the church, which can be sectioned and used to recreate high resolution ortho-mosaics.

ARCHAEOLOGICAL AND INTERPRETIVE ANALYSIS

Fig. 12. Final drawing of a 2D section of the church with the ortophoto taken from the 3D model, where it is possible to see the crusades pointed arches.

The survey was functional in this case to set the first considerations on the history and on the evolution of the building. Analyzing the walls it is in fact possible to advance hypotheses of phases of the construction periods; for scientific and methodological rigor, today we try to extract, for exposed walls no longer protected by plasters, the distinctive features of the masonry discontinuities (stratigraphic units) [Brogiolo and Cagnana 2012]; by relating the various stratigraphic units in relation to each other within the building, it is therefore possible to hypothesize the chronology of the interventions, relating to the historical sources.

In the specific case of the church of Saint John the contribution added by the survey leads to the identification of the evident reconstructions; it is still necessary to deepen these initial considerations with an in-depth archaeological analysis that supports and verifies what we saw in the first campaign inside the church.

The architectural typology is consistent with the Byzantine cult buildings: the central plan layout, oriented with the main apse to the east, fits perfectly into the scheme; the presence on the sides of the apse of two niches with small hemispherical caps, in the walls, one on the right and one on the left, symbolizes the *diaconicon* and the *prothesis*, two fundamental elements for the Orthodox liturgy (often in the larger religious buildings we find two rooms or sacristies at the sides of the central apse).

The plan of the church has been preserved over time, what has changed is the surrounding of the building following the changes in the fortification: in a first period in fact the church was outside the defensive perimeter, probably on the road access from the inhabited village to the castle. With the advent of the Lusignani, a crusading dynasty that held the lands of Jerusalem, the church of St. John remained at the service of the local population of the Greek rite, while probably a second church of the Latin rite existed inside the castle of Lusignani, identified by some in the vaulted hall, which ends in the corner tower at the intersection of the newly constructed wings, which presents a singular "Y" shape. The church has probably kept orthodox rites, which is why the Byzantine features are so evident today.

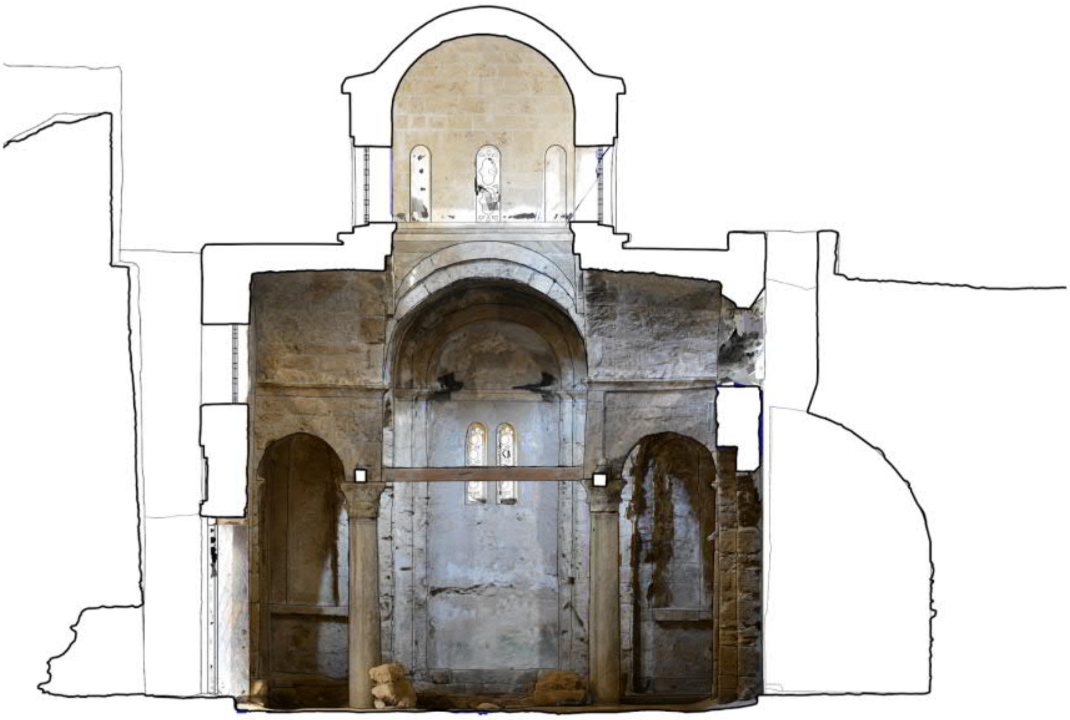

Fig. 13. Final drawing of a 2D section of the church with the ortophoto taken from the 3D model

The columns on which the arches are set are probably reused from a previous building; the capitals are also of spoliation and are of the late Corinthian order (after the 4th century?); one cannot certainly ascribe the origin of shafts and capitals to the same building: from what emerges from the drawings one of these does not coincide perfectly with the shaft on which it is laid. From plans and historical sources it is evident that a column was embedded in a wall, or was perhaps missing; the recent restorations do not allow us to understand the possible replacement of the column; evident traces of changes appear in the round arch that crosses the aisle, and probably from the wrong positioning of the tie rod. The entrance on the main façade of the church, which has not been digitally detected, remains today inside the circular tower that defends the fortress. The four columns are all bare, resting directly on the ground; this may be due to a subsequent modification that has led to the raising of the paving level; this solution can be considered a foresight in anticipation of seismic events, thus reducing the unsupported length of the vertical element; the same thing was found in other buildings occupied by the crusaders during that period: in particular the research group of LS3D (Landscape Survey and Design Laboratory), a joint laboratory between the University of Florence and Pavia, in 2014 took care of the digital survey of the Basilica of the Nativity in Bethlehem [Bertocci 2016]; the building was taken by the Crusaders who modified its layout to adapt it to its defensive needs; among the changes implemented, the paving was raised, an intervention that was not linked to the liturgical need to hide the Roman mosaic floors to avoid trampling on the sacred representations but for structural needs in a strongly seismic area. Surely the builders were aware of the problems caused by earthquakes as evidenced by the use of rods to contain the thrusts of the central dome: even if the wooden chains seem to be recent (it is not possible that the wood remains so well preserved) it is evident how the church has undergone strong earthquakes or structural sagging, and is especially visible from the inclination of the chains, which are not horizontal at all; in the same way the cornices that run around the aisles, interrupting in key of the arches except where there is the curve of the apsidal basin, have been affected by this movement and are not perfectly leveled.

You can easily notice the changes in the springer of some arches: the originals of the Byzantine period are round-shaped and because of the width of the spans are higher in the central and lower in the lateral ones; the south side of the central nave presents instead pointed arches, probably modified in the Crusader period, which are more slender than the others; on the same side also the openings have been modified and have pointed arches; this is particularly evident in the central opening, since the Venetians built the new wing of the fortification which incorporates the Byzantine church. The north side has an opening similar to the original type of architrave that is not in discontinuity with the walls and is visible on the west side, despite being walled. In this sense it is worth highlighting how the traces of openings on the walls were probably windows at first.

Lastly, the central dome has been recently built on pre-existing structures with evident changes, above all as regards the tholobate and the lower cornices, which have considerably cleaner and preserved walls, even with a lighter color than the rest of the church.

CONCLUSIONS

The results of the work presented here made it possible to realize the first digital survey of the church of St. George. The research has allowed us to recreate a database of information that combines both the morphological data acquired by the laser scanner and the material-photographic data in a three-dimensional work space; the three-dimensional datum has been traced to two-dimensional drawings that describe all the surfaces of the building: thanks to these data it was possible to understand the forms of architecture and advance archaeological hypotheses consistent with the stratigraphy of the walls on the evolution of the church.

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