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HISTORICAL IMPRINTS AND VIRTUAL REPRESENTATION ISSUES IN MID-BYZANTINE ACROCORINTH CASTLE

HUELLAS HISTÓRICAS Y REPRESENTACIÓN VIRTUAL EN EL CASTILLO BIZANTINO MEDIO DE ACROCORINTO

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Abstract:

Fortified architecture of medieval times in Greece is a research field with several challenges for the scholars such as the absent of plans and written sources. The current study investigates how digital documentation methods can contribute to the extraction of archaeological information from the actual material sources -the various building traces. This relation between survey and interpretation will be presented through the case of Acrocorinth Castle. The survey of a smaller area of the fortification between the 2nd and 3rd defence line of Acrocorinth was executed in order to create a three dimensional (3D) representation for the Middle-Byzantine Phase of the castle. The project was implicated in the frame of the creation of the web-platform ecastles.culture.gr for the promotion of fortified architecture in Peloponnese under the Hellenic Ministry of Culture (25th Ephorate of Byzantine Antiquities, Argolid Ephorate of Antiquities). In the present study the surveying method and the step by step graphic reconstruction will be initially presented. Subsequently, it will be analysed how the digital survey led to the gradual modulation of the castle's historic form and how the scenarios of building phases' evolution were made.

Key words: virtual archaeology, virtual reconstruction, data acquisition, documentation of cultural heritage, 3D reconstruction

Resumen:

La investigación de la arquitectura medieval en Grecia es un área que presenta varios retos para los investigadores, ya que no existen mapas ni información escrita. El estudio actual investiga cómo los métodos de documentación digital pueden contribuir a la extracción de la información arqueológica a partir de las fuentes materiales existentes –las varias trazas de construcción. Esta relación entre documentación e interpretación se presenta mediante el caso del Castillo de Acrocorinto. La documentación de una pequeña área de la fortificación entre la 2ª y 3ª línea de defensa de Acrocorinto se ejecutó para crear una representación tridimensional (3D) de la fase bizantina media del castillo. El projecto se desarrolló en el marco de la creación de la plataforma web ecastles.culture.gr con el objeto de promocionar la arquitectura fortificada en el Peloponeso bajo el Ministerio de Cultura Helénico *(25th Ephorate of Byzantine Antiquities, Argolid Ephorate of Antiquities)*. En el presente studio, se presenta el método de documentación y los pasos para la reconstrucción grafica. Adicionalmente, se analizará cómo la documentación digital condujo a la modulación gradual de la forma historica del castillo y cómo las diferentes fases de construcción fueron evolucionando.

Palabras clave: arqueología virtual, reconstrucción virtual, adquisición de datos, documentación del patrimonio cultural, reconstrucción 3D

1. Introduction

It is rather common place that despite the development of advanced techniques for 3D representation, every survey is unique and demands the tailoring of suitable representation methodology. The survey approach is also bonded with the specific aim of the survey. When working in situ the architect-surveyor has to cope with complicated problems of form, function, historic phases and construction in order to produce not only accurate but also comprehensive measuring results. The questioning that is molding simultaneously with the survey is the key-element to unlock the monuments' tale and can be confirmed with the numerical results of the surveying tools. The survey of Acrocorinth, part of the broader digitisation planning (Athanasoulis et al., 2015), was executed in summer 2015 by the architect-conservator writers Xeni Simou and Theodora Zirogianni during their occupation in the aforementioned project (Athanasoulis, Simou, & Zirogianni, 2016). Its main objective was to produce plans of the current condition of the monument and to develop a 3D representation for a certain area (Fig. 1) of the fortified complex. The questioning that arised through the documentation process was the cause for the conducting of this essay, that aims to display the interdependency of survey method and monument's interpretation.

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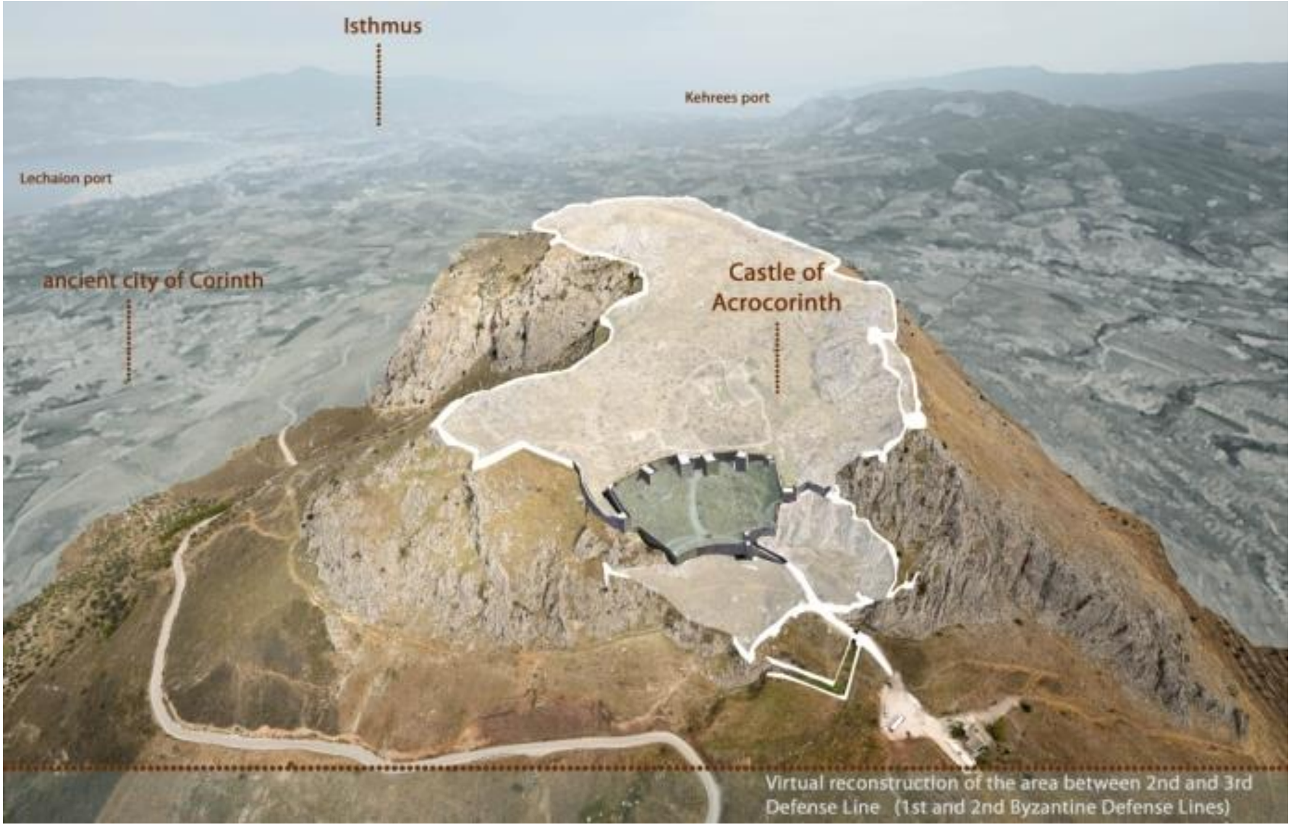


Figure 1: General view of Acrocorinth with indication of the survey area between the two Byzantine Defence Lines.

2. The case study

Acrocorinth Castle crowns the abrupt cliff that rises by Ancient Corinth, a city of major importance in Ancient Greek and Byzantine times. The selection of building the city by the Isthmus was crucial for the flourishing of Corinth and played a critical role for the controlling of the military passage ways of Peloponnese Peninsula and the maritime routs on either side of the canal (Carpenter, Bon, & Parsons, 1936).

During the ancient times from 7th century BC to the Roman destruction, Acrocorinth functioned as the Acropolis of the city (Carpenter, Bon, & Parsons, 1936). At the extended fortification project of Justinian in Peloponnese (6th century AD), Acrocorinth was largely developed as a part of the overall fortification plan of the Peloponnese. In the Middle Byzantine Period (843-1210) intensive urban and fortification development is taking place, following in a large scale the ancient wall understructure (Athanasoulis, 2014). During the post Byzantine times, Acrocorinth's conquerors apply their own alterations to the fortification according always to war technology trends, alterations that form in a big scale the contemporary view of the castle (Athanasoulis, 2014). After the Frankish Principality acquisition, Venetians and Ottomans execute major fortification works (Andrews, 2006). The castle was finally abandoned after the Greek Independence War and its last siege in 1823.

The castle in its contemporary form consists of three successive fortification lines with three gates respectively and runs a perimeter of 3000 m. The current formation of the castle, as previously mentioned, is a long-time process, a huge Byzantine fortification based on an ancient basis that has been extensively transformed in Post-Byzantine times. The 3D representation concerns the Middle-Byzantine Acrocorinth's visualisation of the area between the 1st and 2nd Byzantine defense lines (Fig. 2). The chronological period of the representation was selected in order to restore castle's peak-point construction time. It was also chosen due to the relatively big existing structural elements that permit the re-imagination of the Middle-Byzantine phase.

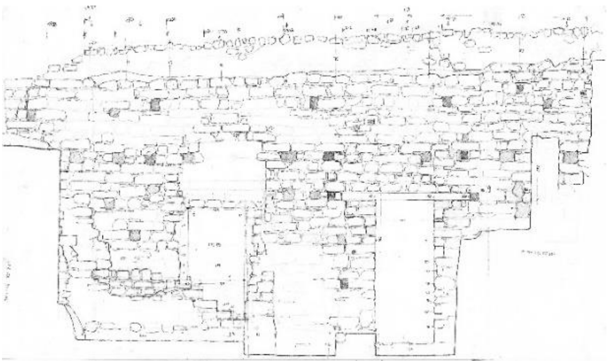
Figure 2: Area between 1st and 2nd Byzantine Defence Lines.

3. Selection of survey method

The documentation methodology can be described as a complete geometric documentation comprising the triptych historical–architectural–bibliographic documentation (Ioannides, Georgopoulos, & Scherer, 2005), resulting in a full archive of 2D current condition plans that were later on elaborated to produce 3D model. The survey was developed with a combination of techniques, based essentially on total station rather than using extensively (a single more advanced) 3D laser scanning technology. This choice was driven by the specificities of the monument itself and the goal of the survey that demanded a very analytic interpretation of the complex's edifice. Beyond the educational goal of 3D virtual representation, the survey efforts of Acrocorinth focused on creating analytic plans of the existing situation, as part of an integrated project for the enhancement and restoration of the huge complex of Acrocorinth.

The acquisition of measurement data was, in essence, determined by the nature, the complexity and the location of the monument. Acrocorinth consists of a complicated multilayered construction with considerable altitude difference and hardly accessible areas or even places where the setup of a machine is impossible. Thus, tailoring of the survey method premised the solution of brain teasers connected with the peculiarities of the castle's structure and location. The digital survey was based on multiple techniques (Fig. 3) and required developing a methodology of seamless combination, filling gaps and avoiding overlapping (Remondino et al., 2009).

The EDM (Electronic Distance Measurement) technology with a Leica Total station TS06 model was extensively used for the measurement of general plans after sketching of the preliminary recording plans (ground plans, sections, unfolded elevations of the fortification walls) where a detailed list of surveyed points was kept. The blind areas such as openings and details were completed by detailed hand-measured drawings (Fig. 3).



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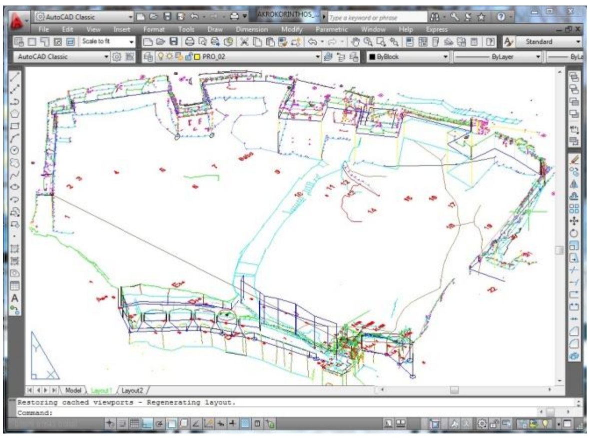

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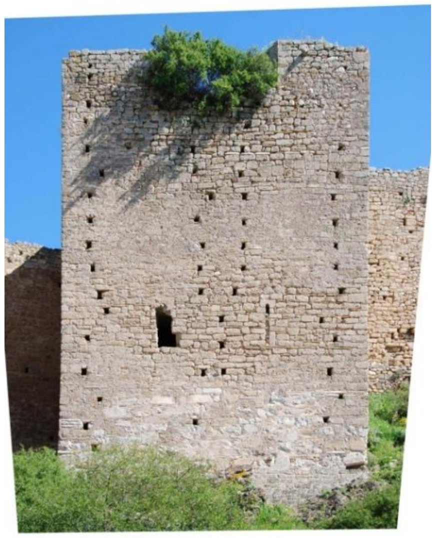

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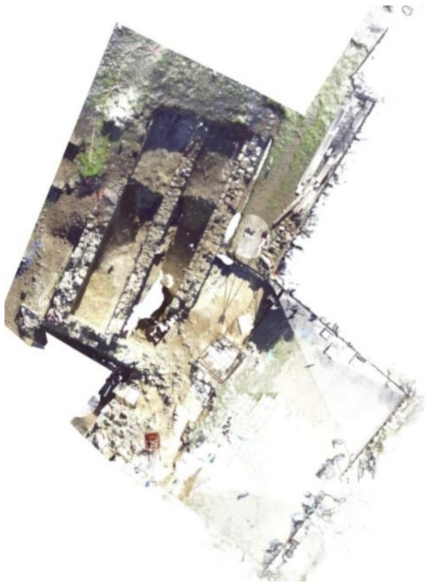

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Figure 3: Different survey data: a) hand measurements; b) total station 3D points acquisition; c) rectification of images; d) laser scanning orthoimage (Archive of 25th EBA, previous survey).

Then the image rectification processing for both inner and outer walls followed, based on the survey points and sketches.

Laser scanning data (Fig. 3) for geometrically interesting selected areas and interior spaces (El-Hakim et al., 2007) from previous and new surveys was exploited and linked to general plans by means of common control points. This laser scanning had been executed in order to capture both a tower's interior and a revealed building unit during excavation works in the last years. The laser scanning surveys were undertaken by colleagues of the 25th Ephorate of Byzantine Antiquities (EBA).

4. 3D reconstruction methodology

Because castles pose complications in their presentation in digital virtual reality formats (Finan, 2012) there was a necessity of tailoring a personalised 3D methodology for Acrocorinth.

The intermediate step between the survey of the current condition and the virtual representation of the Mid-Byzantine phase was the careful analysis of the possessed material, either those that came from the meticulous survey or those derived from indexing of historic archives, plans, representations and pictures. Doubtless, the demanding process of building phases identification as well as the material recognition maps (Fig. 4) was essential in order to comprehend the structural layers. That resulted to the discrimination of the initial Byzantine parts that remained intact through the ages.

This investigation became more assiduous for peculiar elements or construction specificities that arised questions of original form and function. The deeper observation on structural state problems for instance could reveal the generator cause behind a possible collapse that happened due to instability or human factor and was responsible for extensive reinforcements on the masonry.

Then followed the synthetic phase of creating 2D graphic reconstruction plans. The representation was equally based on the existing indicators on the masonry of the castle and the assumptions created by comparisons with similar elements.In order to reconstruct the parapets, the graphic restoration was completely following the traces of previous building phases, if these were apparent or subjacent to posterior constructions. Where the parapets were missing, the supplementation of the superstructure was completed by keeping the general proportions of similar battlements of the castle.

Despite the fact that advanced 3D laser scanning technologies have been developed, the 3D model construction followed a synthetic process. The adopted 3D process was not such an automated technique as 3D data acquisition from laser scanning. During the 3D modelling procedure new questions arised, related with areas that were neither visible nor accessible during the 2D surveying and therefore not automatically resolved. The modeller had to go back and give an answer to questions of 3D spatial gaps. The 3D representation was made in Autodesk 3ds Max 2015 environment after inserting the 2D reconstruction plans (Fig. 5a). The system was using small number of polygons in order to be lighter and handy for touring options. For the rendering there was used a modified scaled pattern while for the understructure of ancient masonry mapping, the surfaces were unwrapped to create seamless corners. The final 3D touring outcome (Fig. 5b) was made in Unity WebGL in collaboration with a web developing company. Hot-spots of archaeological information were introduced to the 3D.

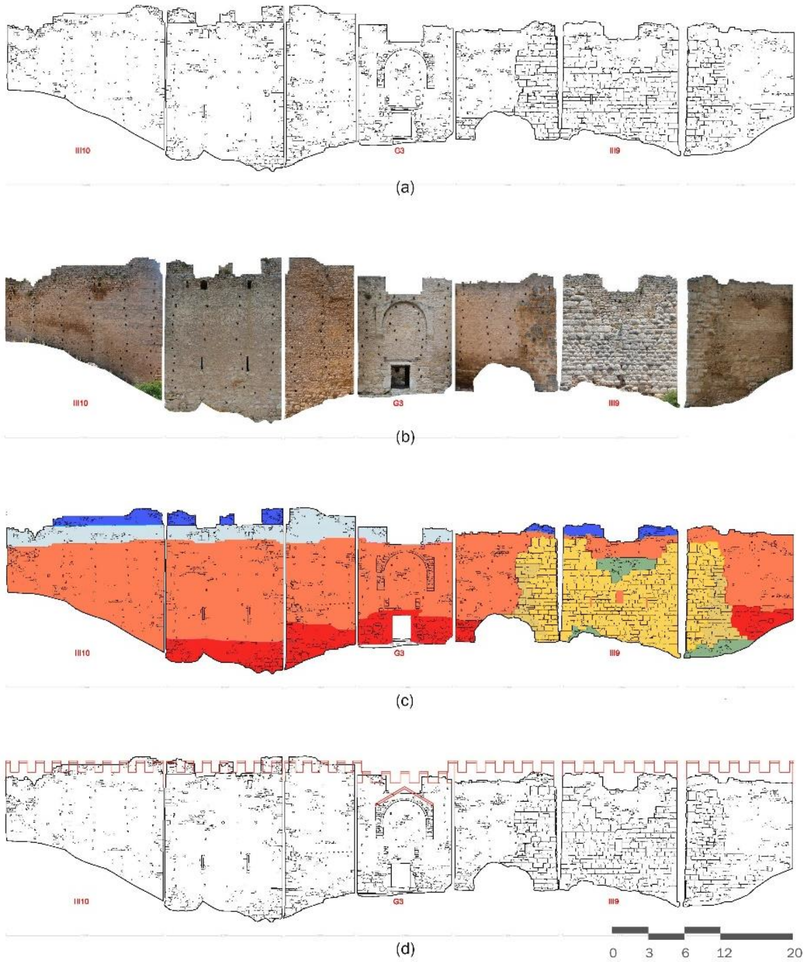
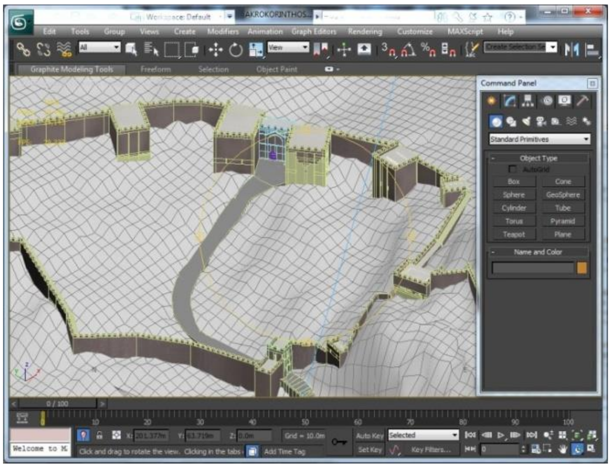


Figure 4: Analysis process from survey plans to graphic reconstruction: a) survey plans of the existing condition; b) rectification of façades; c) building phases' diagram; d) graphic reconstruction plans.



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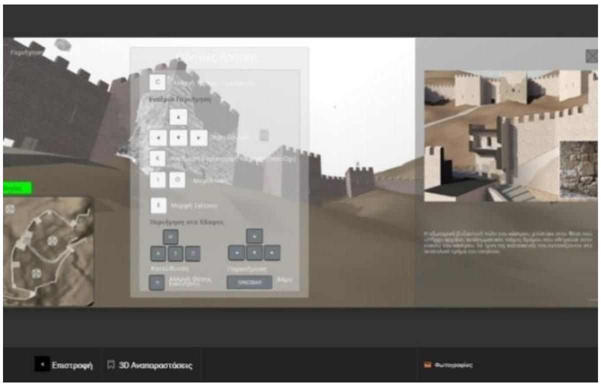


(b)

Figure 5: Modelling process: a) in Autodesk 3ds Max 2015 environment; b) final 3D tour in Unity with pop-up info windows operated by Dataverse Ltd.

5. Accuracy issues

Accuracy in surveys dealing with visualisation purposes is depended on different specialists' approach on heritage (architects, archaeologists, computer vision experts and engineers) and the accuracy requirements should be defined based on the survey purpose and targeted public (Santana Quintero, Neuckermans, Van Balen, & Jansen, 1999). Additionally, scale and accuracy are important properties of geometric documentation that should be carefully defined at the outset, before any action on the monument (Georgopoulos & Ioannidis, 2004).

Due to the fact that Acrocorinth's survey drawings were meant to be used for further conservation purposes the acceptable error for the general plans was defined from 1 cm up to 2.5 cm. These accuracy requirements determined to a certain degree the survey methodology. Laser scanning precision and 3D data acquisition was necessary in excavated areas of tower interiors, while at the same time photogrammetric 2D projected views were sufficient for the curtain walls survey and representation.

However, taking into account the educational purpose of the model and because a major part of the masonry was graphically reconstructed based on analogies, the accuracy requirements of the 3D modelling were lower. In order to reduce modelling polygons for the web engine 3D virtual reconstruction, some negligible inclinations and deformations were simplified that resulted in a generally accurate 3D model with maximum local errors of 8-10 cm.

Figure 6: South elbow tower traces of lateral walls.

6. Interpretation of survey traces

The interpretation of the monument can be perceived as the intellectual process of turning source material into conclusions (Pletinckx, 2008). Here follows, a descriptive apposition of specific details of the survey process of the castle. The interpretation methodology that has been developed based on specific building traces will be demonstrated in order to show how the aforementioned combinational digital survey efforts contributed to the overall reconstruction attempt.

6.1. Continuity and extension assumptions

Although relics standing scattered are incomprehensive, whether we investigate them as a part of a whole they become valuable. The continuity of a construction can be confirmed by the exact measurements and can lead to the drawing of the overall form. This was for instance the case in the gate of the southeast corner that was an obvious remnant of a previously existing elbow tower (Fig. 6). The accurate measurement and sketching of the small traces of the lateral walls made it possible to outline the exact form of the tower (Fig. 7). By prolonging these wall traces to the right direction a rectangular-shape tower resulted.

6.2. Completion with analogies

Extracting inferences through analogy of an already known sample is actually a tool and a whole philosophical approach, fundamental for archaeological science. Missing elements can be supplemented based on analogy that is a form of reasoning whereby the identity of unknown things or relations is inferred from those that are known (Ashmore & Sharer, 2010).

In the previous case of the elbow tower, the overall shape could not be assumed by field traces. Completely missing elements such as the exact lenght of lateral walls, the overall height and the crenelations shape were filled in by comparison with the standing towers that had been well preserved. The general width was proportionally estimated to the existing towers. Parapets' form and height was completed by following an acceptable height, defined by the neighboring curtain wall traces.

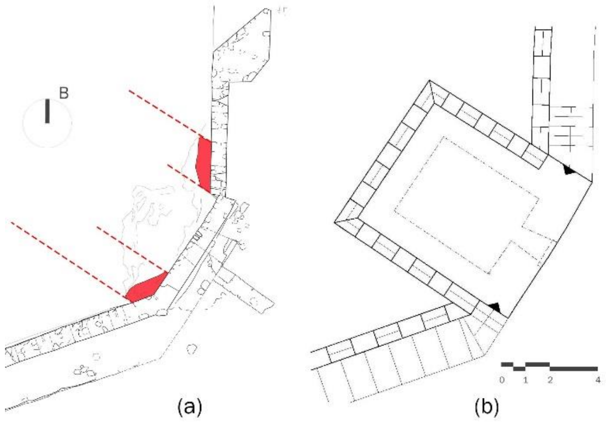


Figure 7: South elbow tower: a) ground plan of existing condition; b) ground plan of graphic reconstruction.

6.3. Peculiar structural elements recognition

Another possible method for the interpretation is the recognition of peculiar indications on the construction that could possibly confirm a construction hypothesis. The southern tower (Fig. 8) was not fully excavated due to the existence of posterior adjacent historical structures on its back. The entrance to the southern tower was blocked by posterior additions. The significance of these structures did not permit to continue the archaeological excavations and the entrance investigation. Therefore there have been some unresolved questions on its initial form.

Survey revealed that a suspicious corner extruding from the parapets (Fig. 8a) could solve the accessibility problem to the superstructure of the tower. The metrical reconstruction was matching with the hypothesis of a straight line staircase attached to the towers platform. The precise measurement led to the design of a staircase that fits ideally to the given height. (Fortunately, excavation works in the tower north to the gate showed the existence of a similar staircase.)

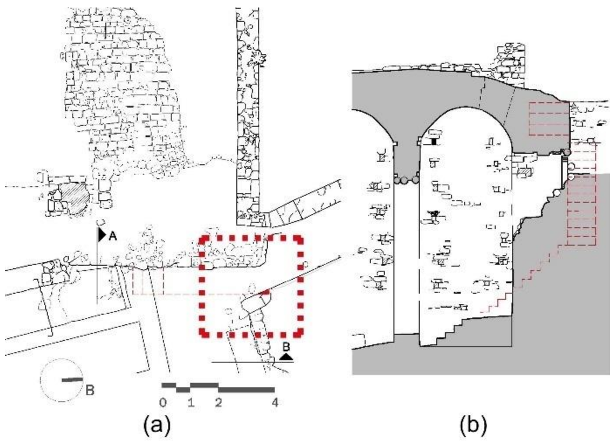
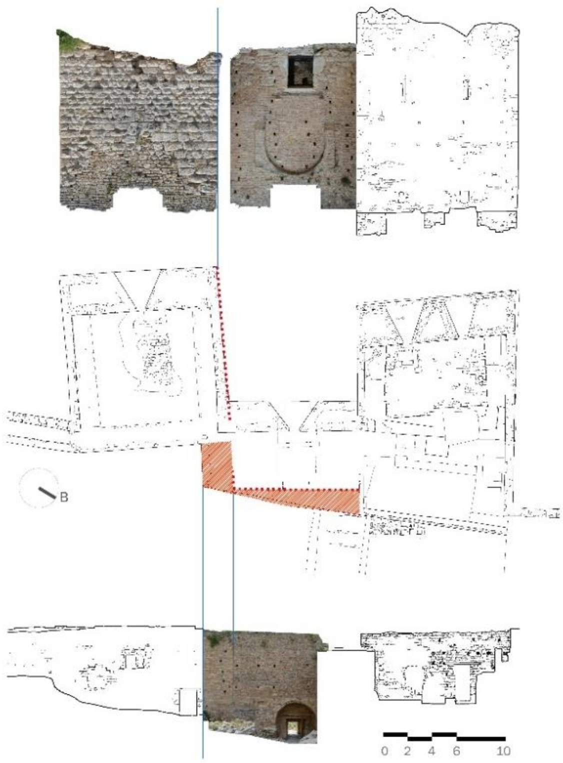


Figure 8: South Tower's survey plans with special indication of the staircase corner trace: a) ground plan; b) transversal section.

6.4. Corresponding joints or parallels

Survey data can be decisive for extracting valuable historic information. The survey's accuracy often defines whether joints and parallels are corresponding and correlated with a building phase or element. In the case of the 2nd Byzantine Gate that is a solid mass of great complexity due to the continuous historical transformation, the detailed measuring was decisive for the crystallisation of a convincing assumption. There was a vertical joint in the back, only visible in the elevation. The precise measurement of this joint showed that it was corresponding to the lateral walls of the adjacent tower. An observational visitor could possibly recognise different building phases. But how these were correlated and what happened actually?

The as-built plans were made, and then followed observation of the parallels, features matching (Fig. 9a) and simultaneous comparison of other prototypes. This led to the deduction that the Gate was initially a two-story tower flanked on either side by two towers in contact (Fig. 9b). The gate was protected by a portcullis mechanism.



(a)

(b)

Figure 9: 2nd Byzantine Gate Tower: a) ground plan and elevations indicating joints and parallels; b) final 3D representation.

In posterior period, when artillery platforms for cannons were made, the building was extended, crenellations were changed, the function of the floor was repealed and the built staircase leading to the floor was replaced by a ramp.

6.5. Rejecting and confirming scenarios

When other methods are inadequate the conclusions can come by a *"reductio ad absurdum"* technique. The interpretation needs the selection of the best solution between the range of suitable analogies (Ascher, 1961). The recognition of the most preferable solution, however, demands the development of several reconstruction hypothesis and the careful rejection of them one by one.

This method was used in the re-thinking of the 1st Gate in Byzantine times (Fig. 10) that was the most difficult and complicated riddle. Although Byzantine masonry conceives a big part of the gate's structure, the tower was always an object to successive modifications.

Figure 10: 1st Byzantine Gate external view, 25th EBA Archive.

The recognition of byzantine traces (Fig. 11) was not sufficient for understanding the buildings' evolution but it was the first step. Survey revealed strange wall inclinations, extrusions, discontinuities, hidden spaces, and incomprehensive areas, overlapping of architectural elements, badly executed and misleading previous restorations. Some of the questions arised were: What was the initial shape? What was the function? Where was the entrance to the floor?

The process of graphical representation of different initial versions tried to give answers to these questions and led directly to the creation of multiple possible scenarios that were finally one by one rejected for different reasons each, mainly based on construction (ex. not corresponding ground plan elements to façades, misleading deformations, typologically impossible assumptions, chronologically impossible solutions, etc.).

The most reasonable scenario prevailed in the end and resulted to the representation of a two-storied passageway-tower with a two-unit first floor accessible from the west platform (Fig. 12). Later on parts of the façades were restored and other reinforced with extra layers while a new entrance opened and disrupted the tower's shape.

Figure 11: 1st Byzantine Gate 2D survey: a) Byzantine parts in elevations, internal view; b) ground plan with indications of fragmented Byzantine surface.

Figure 12: 1st Byzantine Gate 3D graphic reconstruction.

7. General reconstruction view

The detailed surveying, interpretation and the 3D representation of the area between the west defence lines gives a quite concrete image of Acrocorinth during the Mid-Byzantine period. The two defence lines, exploiting the existing ancient masonry traces were articulated in a way of creating an amphitheatrically organised platform protected by towers and tall curtain walls (Fig. 13). Ancient and early Byzantine material had been reused in critical places of the construction as spolia.

The towers of the 2nd Byzantine defence line, accessible through the inner yard had a typical two vaulted units' interior configuration. The defender could enter to the level of loop holes through a built staircase descending to the interior of the tower from its back. The towers' roof platform and the curtain walls' parapets were accessible through built staircases attached in parallel to the backside of the walls.

The gates were opened as walkways in two-storied towers (Gate towers) and were protected by strong

Figure 13: Overall 3D view of the area between 1st and 2nd fortification lines in the Middle-Byzantine period.

adjacent provisions. The 1st Gate was positioned slantingly to the 2nd. This layout of the fortification allowed the maximum active defence of the entrance to the castle by the defenders (Athanasoulis, 2014).

The alterations made in the adventurous posterior periods were mainly executed in order to reinforce the construction and to install new war-technology provisions such as cannon platforms. Comparing to the northern part that was extensively reconstructed in the Post-Byzantine period, in the southern part the ancient and Mid-Byzantine material was better preserved. The elements subjected to successive interventions were definitely the gate-towers.

8. Assessment of survey's contribution to the interpretation and reconstruction process

We should admit the fact that digital methods provide like no others an indisputable accuracy, crucial in deducing conclusions about building's form. It is also evident that selection of survey methodology is a difficult and determinant task for interpretation. As shown in the case study of Acrocorinth, this surveying methodology and accuracy was indeed valuable in analysing the construction and indicating its borders. It was important for interpreting whether a wall declination for instance or a special structural element has been the result of initial construction, of later restoration, of weathering factors or has been caused by human destruction.

Without the photogrammetric methods the creation of precise thematic maps such as building phases, or material discrimination would be a laborious and time consuming procedure. The level of detail of the picture with a high resolution gives second-level valuable information. In order to comprehend the edifice, photogrammetry worked complementary to the eye-inspection that sometimes was extremely difficult due to physical obstacles and restrictions.

While elaborating the survey data in the office, fragmented site elements such as disrupted masonry could be reconnected due to the digital drawings' precision and could confirm the reconstruction hypothesis. On the contrary, cases like eye-illusions misleading to false drawings were rejected. In addition to this, the survey in unexcavated areas helped to identify surface elements, thus developing a surface investigation for further archaeological excavations.

“Virtual archaeology complements perfectly documentation and conservation efforts and even can act as an integration activity to bring all information together in a structured way” (Pletinckx, 2009). In general all the acquired data from this survey can be stored and connected with older and new surveys for future use when necessary.

For the 3D reconstruction the team employed a synthetic and subtractive approach for the Middle-Byzantine impression of Acrocorinth Castle. It was actually a rebuilding of selected historic elements, essential to make an integrated view of the monument. Unlike material reconstruction that is not an endless decision-making process, certainly dependent on space limitations, inadequacy of archaeological evidence, and restoration priorities (stability of the monument, safety reasons, new function, preservation for safeguarding the initial material, full reconstruction for educational reasons, symbolic restoration, etc.), the 3D archaeological reconstruction has to be as complete as possible in order to cover virtual tour options. In such a modelling of a specific historic period, the scholars had to give answers to the totality of the monument represented. As a result the assumptions were inevitable. When there is no evidence, 3D modelling is based on hypothesis on different degrees of likelihood (Georgopoulos, 2014). On the other hand the 3D reconstruction was a non-destructive way with great potentials. The collected and elaborated data can be reused for the proposal of different alternatives in the areas where the historic scenarios are weak. Current 3D representation is a tessel in scientific mosaic knowledge. Then, the possibility of transmission of a cybernetic model should allow the future communities of scientists to continue the study, correcting errors and suggesting new archaeological interpretations (Forte, 2011).

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References

Andrews, K. (2006). *Castles of the Morea.* USA: Princeton.

Ascher, R. (1961). Analogy in Archaeological Interpretation. *Southwestern Journal of Anthropology, 17*(4), 317–325. http://doi.org/10.1086/soutjanth.17.4.3628943

Ashmore, W., & Sharer, R. (2010). *Discovering Our Past: A Brief Introduction to Archaeology.* USA: McGraw-Hill Education.

Athanasoulis. (2014). *The Castle of Acrocorinth and its Enhancement Project.* Ancient Corinth: Hellenic Ministry of Culture.

Athanasoulis, D., Georgiou, A., Simou, X., Sfika, A., Klotsa, V., Zirogianni, T., …, Deligianni, E. (2015). Bridging monuments through digital repository and graphic reconstruction methodologies - The digital enhancement project of Argolid, Arcadia and Corinthia castles, Greece. *Proceedings International Conference Digital Heritage.* Granada: Spain. http://doi.org/10.1109/DigitalHeritage.2015.7413846

Athanasoulis, D., Simou, X., & Zirogianni, T. (2016). Historical traces' interpretation and virtual reconstruction-The case of Acrocorinth. In J. Lerma, & M. Cabrelles, *Proceedings of the 8th International Congress on Archaeology, Computer Graphics, Cultural Heritage and Innovation "ARQUEOLÓGICA 2.0" in Valencia (Spain), Sept. 5-7, 2016* (pp. 288–290). Valencia: Editorial Universitat Politècnica de València. http://dx.doi.org/10.4995/EMERGE2014.2014

Carpenter, R., Bon, A., & Parsons, W. A. (1936). *Corinth: Volume 3. The Defenses of Acrocorinth and the Lower Town.* USA: Harvard University Press.

El-Hakim, S., Gonzo, L., Voltolini, F., Girardi, S., Rizzi, A., Remondino, F., & Whiting, E. (2007). Detailed 3D modelling of castles. *International Journal of Architectural Computing, 5*(2), 199–220. http://doi.org/10.1260/147807707781515011

Finan, T. (2012). 3D castle reconstruction as interpretive modelling: The medieval Lough Cé Project. *Château Gaillard 2 : L'origine du château médiéval, actes du colloque de Rindern*, (pp. 45–49). Rindern, Allemagne.

Forte, M. (2011). Cyber archaeology: Notes on the simulation of the past. *Virtual Archaeology Review, 2*(4), 7–18. http://dx.doi.org/10.4995/var.2011.4543

Georgopoulos, A. (2014). 3D virtual reconstruction of archaeological monuments. *Mediterranean Archaeology and Archaeometry*, *14*, 155–164.

Georgopoulos, A., & Ioannidis, C. (2004). Photogrammetric and Surveying Methods for the Geometric Recording of Archaeological Monuments. Athens, Greece: FIG Working Week 2004.

Ioannides, M., Georgopoulos, A., & Scherer, M. (2005). Standards in cultural heritage: the missing grammar for the digital documentation of the past. *XX CIPA International Symposium.* Torino, Italy. Retrieved from https://www.researchgate.net/publication/237252815_STANDARDS_IN_CULTURAL_HERITAGE_THE_MISSING_GRAMMAR_FOR_THE_DIGITAL_DOCUMENTATION_OF_THE_PAST

Pletinckx, D. (2008). Interpretation management: How to make sustainable visualisations of the past. *Proceeding of the EPOCH Conference on Open Digital Cultural Heritage Systems.* Rome, Italy. Retrieved February 25, 2016, from http://public-repository.epoch-net.org/rome/09%20Interpretation%20Management.pdf

Pletinckx, D. (2009). Virtual archaeology as an integrated preservation method. *Virtual Archaeology Review, 2*(4), 33–37. http://doi.org/10.4995/var.2011.4545

Remondino, F., El-Hakim, S., Girardi, S., Rizzi, A., Benedetti, S., & Gonzo, L. (2009). 3D virtual reconstruction and visualization of complex architectures – The “3D-Arch” Project. *3D-ARCH.* Trento: Italy. Retrieved February 5, 2016, from https://pdfs.semanticscholar.org/cf87/2fdcede5f3860ff7928e6d0aaa6e4c58e74d.pdf

Santana Quintero, M., Neuckermans, H., Van Balen, K., & Jansen, M. (1999). *Accuracy in affordable technology for three-dimensional documentation and representation of built heritage.* Retrieved February 24, 2016, from https://lirias.kuleuven.be/bitstream/123456789/76035/1/vsmm99-santana-vanbalen-neuckermans-jansen.pdf