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Understanding Archaeological Site Topography: 3D Archaeology of Archaeology

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ABSTRACT

The current ubiquitous use of 3D recording technologies in archaeological fieldwork, for a large part due to the application of budget-friendly (drone) sensors and the availability of many low-cost image-based 3D modelling software packages, has exponentially increased the amount of 3D data of archaeological sites and landscapes. Various applications have advanced far beyond the experimental phase, such as the deployment of 3D surface recording for excavation interpretation, as a complementary data layer for prospection and as the basis for visualisation/presentation. Of particular attention here is the degree to which drone 3D recording can further advance the understanding of archaeological site topography. In this paper, current developments in the field of 3D recording will be discussed in the context of the 'Archaeology of Archaeology' approach, which is being developed at the University of Amsterdam. This paper is the result of a Round Table discussion at the CAA conference on April 5, 2023, in Amsterdam. The examples at the conference sessions clearly showed how beneficial it is when 3D recording techniques can be combined with other available information. In particular, the potential of old photographs was highlighted. Our experiences at Troy suggest that re-excavation of dumps and specific trenches and comparison of finds are also highly promising. In addition, considering the manifold possibilities of 3D hard- and software and the sheer quantity of the data available for a site such as Troy, several attendees to the session emphasized the necessity of a problem-oriented approach when researching and developing a platform as an access point, organising, and presenting collected information.

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1. INTRODUCTION

In archaeological fieldwork, 3D recording technologies are now a common appearance. This is not a new phenomenon per se, as 3D recording techniques such as laser scanning and photogrammetry have been applied in fields like archaeological excavation already for two decades (for early applications see e.g. Pollefeys et al. 2001). However, the current proliferation of 3D recording in archaeological fieldwork is to a large extent due to the application of budget-friendly (drone) sensors and the availability of many low-cost image-based 3D modelling software packages. This has exponentially increased the existence of 3D surface data of archaeological sites and landscapes, although often not publicly available. Nonetheless, these 3D data are applied in a variety of ways, such as the deployment of 3D surface recording as a complementary data layer for prospection and heritage management and to support excavation interpretation by modelling and visualizing aspects of a site (Dell'Unto & Landeschi 2022). Specifically for archaeological site studies and excavations, scholarly debates have developed about the interaction between 3D recording, paperless archaeology approaches, methodology and interpretation (e.g., Boyd et al 2021; Campana 2014; Caraher 2016; Jensen 2018; Roosevelt et al. 2015; Waagen 2019). A promising avenue of research is to explore how the understanding of archaeological site topography can be further advanced through new approaches and technology for 3D recording. In this paper, current developments in the field of 3D recording will be discussed in the context of the 'Archaeology of Archaeology' approach, which is being developed at the University of Amsterdam, with a specific focus on the site of ancient Troy in Turkey (University of Amsterdam, n.d.).

The Amsterdam Troy Project (ATP), which started in 2018, aims to study the relationships between archaeological methodology and knowledge about the monumental site of Troy in Turkey. Systematic archaeological research has been conducted at Troy since 1863. Best known are the excavations of Heinrich Schliemann, who connected the site to the Homeric epics and established archaeological fieldwork as an independent method. Since these early investigations, research has been conducted at Troy up until the present day. The many excavation campaigns over the course of more than 150 years were each carried out by archaeologists with their own goals, convictions, and strategies. Moreover, they worked in teams of labourers and specialists, sometimes up to 200 people altogether. Because of this, within the Amsterdam Troy Project, the site is regarded as a dynamic assemblage which is continuously changing due to the agents of scientific research (Lucas 2012). The current geography of the site of Troy is determined at least as much by archaeological activities as by ancient habitation (Van Wijngaarden et al. 2024). To study this process, for each of the major excavation campaigns, the ATP investigates issues of formal and informal research strategies, methods of documentation and the ways in which these have contributed to interpretations about the site (cf. Murray & Spriggs 2017, Van Wijngaarden et al. 2024). To this end, publications and excavation archives are studied. Moreover, we conduct excavations in re-filled trenches and excavation dumps to be able to study the ways in which research strategies were actually practiced: what was documented and collected and what not? In other words, in the ATP the archaeological process is investigated *archaeologically.* Hence the name of the research programme: Archaeology of Archaeology.

3D recording techniques play a key role in this approach. They enable the creation of a high-resolution and accurate digital surface model of the archaeological site in its current state (Figure 1). 3D modelling and visualization have a long history at Troy, where since the 1990s digital reconstructions of specific buildings in the past have been made (Brandau, Schickert & Jablonka 2004). The new model created in the framework of the ATP, however, models the site as it appears in the present. It can be used to trace the changing topography of past excavations, which contributes to an understanding of the spatial context of past archaeological activities: i.e., the definition of trenches, dumps, sections, and pathways. The 3D surface models can provide context and location to old records, plans, and photos, by comparing the model with these various excavation sources using techniques such as camera mapping and interactively analysing how the site's topography changed over time. In that way, it will become possible to reconstruct the archaeological site before and during successive excavations. The result could be a dynamic 4D information hub of the site, which may function as an access point to archived data and thus a study resource, and which will allow the interaction of different types of data and archival records.

2. CONCEPTS, QUESTIONS, AND APPLICATIONS

Since 2019, 3D recording at the site of Troy has been executed with the above goals in mind. In two campaigns, the citadel has been mapped twice and the lower city has been mapped once, both in high detail using a DJI M210 drone equipped with a DJI Zenmuse X5S camera. The collected imagery has been integrated with highly accurate dGPS measurements on the site, and subsequently postprocessed to create photogrammetrical 3D surface models of the site (Figure 1). The 2019 and 2022 3D surface models of the citadel have respectively a Ground Sample Distance (GSD, Sapirstein & Murray 2017) of 2 cm and 1.5 cm, and both an average error of 3 cm compared

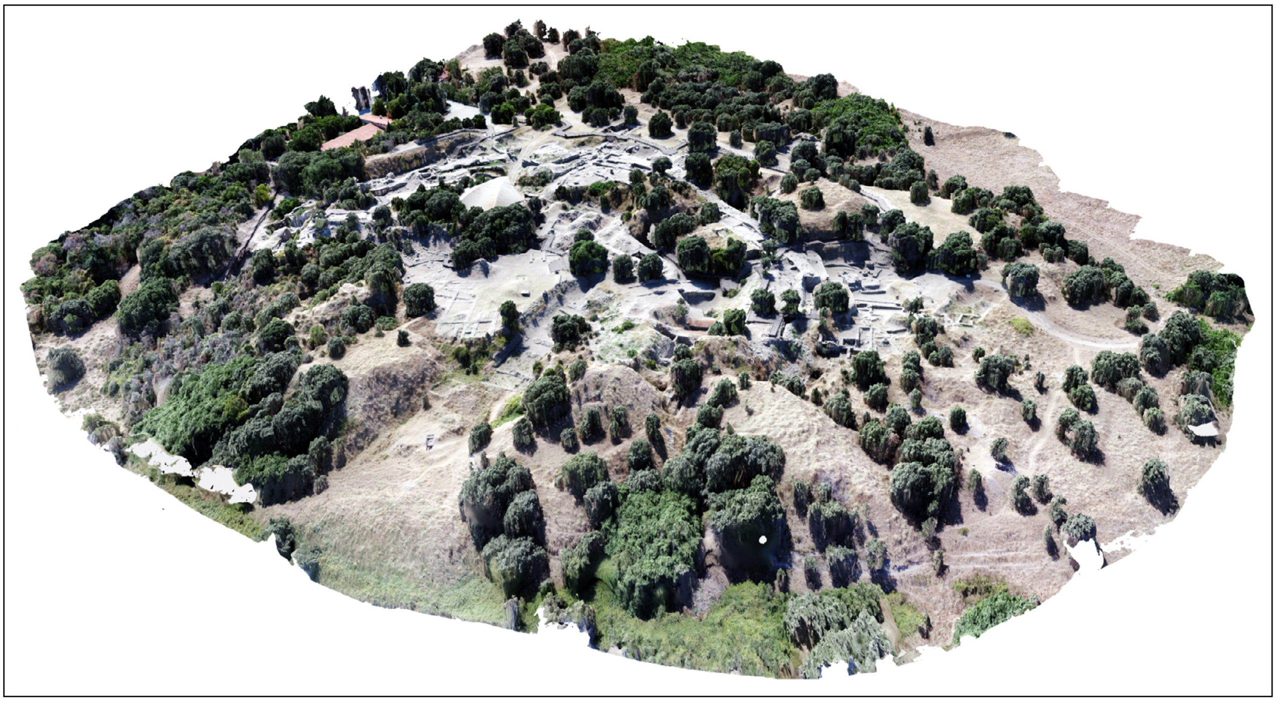

Figure 1 Image of the photogrammetric 3D model of Troy as recorded in 2019 (Turkey).

to <1 cm accurate dGPS control measurements. For the average error the effect of wind on the canopy of the quite overgrown site must be taken into account, and the average geometrical error of the architecture will be markedly less. The 3D surface model of the lower city, an area of ca. 90 ha, features a GSD of 4.7 cm and an average error of 7.6 cm, for which again canopy movement must be weighed in, although this will be less influential as the lower city consists of agricultural fields alternated by bits of woodland/trees lining roads or field demarcations.

In order to further conceptualize and systematically integrate the 3D data in the archaeology of archaeology approach, a round table session was organized by Jitte Waagen and Gert Jan van Wijngaarden at the Computer Applications and Quantitative Methods in Archaeology annual international conference in Amsterdam in 2023. In this round table, called Understanding Archaeological Site Topography: 3D Archaeology of Archaeology, the discussion aimed at the potential of combining 3D recording and 3D information systems with geographical and archival information of archaeological activities at a site.

The following participants presented their projects at the session:

- Walsh, J. Orbons and R. Haemers: Rijckholt (The Netherlands) in 3D: The role of close-range photogrammetry within the archaeological trajectory of Limburg's Flint Mines
- R. A. Brunchi, C. Brașoveanu, A. Asăndulesei and F. Adrian Tencariu, 3D Documentation and Public Archaeology at the Eponymous site of Cucuteni Culture (Romania)
- T. Zoldoske, The HS2 railway line in the UK
- P. Wolff and B. Ullrich, Interpreting geophysical survey data with the help of old site photography – a case study from ancient Napata in northern Sudan.
- N. Lercari and D. Tanasi, Archaeology of Archaeology at Heloros: Re-interpreting the Urban Layout of a Complex Greek Settlement in Sicily using Proximal Sensing and Data Fusion

From the discussions during the session, it is possible to extract three main fields in which 3D recording can contribute to the aims of the Archaeology of Archaeology approach. Here, they will first be elaborated upon regarding the Amsterdam Troy Project, and then the comments on these topics by the various participants of the session at Amsterdam will be summarized.

2.1 CURRENT AND FUTURE SITE TOPOGRAPHY

Through the 3D recording of the site, it is possible to accurately document the spatial configuration of the most recent phase of archaeological research at the site. This means that the current archaeological excavation activities, as well as trenches from earlier campaigns, pathways, dumps etc. are recorded and their surface geometry and colour at the time of data capture digitally preserved. This could be regarded as a sort of baseline measurement. As such, future archaeological activities can be related to the current documented phase, as can natural and human processes of weathering/degradation. Troy as a whole has now been documented by drone twice, in different resolutions and, hence, in different levels of detail. If this would be a recurrent process, it would be possible to accurately monitor processes of change on the site, and always be able to look back at an older phase of the research. The availability of the current models also enables us to better assess the important questions of what levels of detail are actually desirable for what purposes, in the context of flexibility and accessibility of the model.

During the session the participants presented additional reasons to record the site topography. For example, R. Brunchi and his colleagues mapped the topography of the site of Cucuteni-Cetăţuie in NE Romania. Via an online platform, they created the possibility to present this rather remote site to a broad audience. In addition, there was also the goal to monitor site destruction, as they now have a publicly available baseline of its current site topography. A. Walsh and J. Orbons discussed the Prehistoric flint mines at Rijkholt in the Netherlands, which are situated in deep shafts near Valkenburg (Orbons n.d.). These mines are difficult to access and visits cause damage to the current topography. The photogrammetric recordings and resulting model may facilitate public virtual access to the site and possibly contribute to the conservation of the site. Also, the photogrammetric recording of the site topography is probably for the near future the only document that represents the site in its current state and allows for contextualizing previous research. An interesting observation they made was that they were now able to detect toolmarks more easily and in greater detail. In other words, they documented archaeological traces that they did not envision beforehand. On a larger scale, T. Zoldoske presented a case where an archaeological landscape is no longer preserved in situ, because of the HS2 railway link in the UK. However, the 3D recording done prior to the railway construction enables the reconstruction of the archaeological landscape. So, the recording of current site topography for these projects assisted in monitoring change, permitting the identification of new evidence, and allowing the creation digital models of soon-to-disappear historical landscapes. A shared agreement here is that the detailed recording of site data demands specific goal-oriented data collection strategies, each with their own requirements for accuracy, precision, and spatial detail.

2.2 PAST SITE TOPOGRAPHY AND THE ARCHAEOLOGY OF ARCHAEOLOGY

The assemblage of an archaeological site can be understood as a continuously changing set of relations between material remains and people (archaeologists) interacting with them (Jervis 2018: 62–68; Lucas 2012). At Troy, the first form of such a set of relations are the successive phases of habitation in Antiquity, which are defined by archaeologists. In each of these layers, older traces are erased or integrated into a new layout of the site. A second set of relations are the effects of the successive excavations, during which younger layers are removed and older features are exposed. For example, the phase Troy I remains at the bottom of the so-called Schliemann trench are among the most notable features at the site. A third set of relations are the dumps created by 150 years of excavation activities, which have their own stratigraphy. Together, these sets of relations within the dynamic assemblage of the site constitute a dynamic conglomerate of past activities, where the high accuracy and the high level of detail of a 3D model have added value. The 3D surface model can be meticulously related to information about the older states of the site, such as aerial photographs, excavation photos, drawings, etchings etc. We expect that it is possible to unravel the various sets of relations and to study which effects archaeological activities have had on the definition of specific phases and features. Important questions here are how to develop a systematic methodology for that and to what degree this can lead to new insights about choices and strategies of past excavators.

At the conference session, P. Wolf and B. Ulrich showed how photographs from older excavations helped to identify features that had become visible through GPR at the site of Napata in northern Sudan. Moreover, new photogrammetric surface models from overview photographs helped to georeference and topographically situate archaeological features from older research. So, clearly, the integration of old and new (3D) data from archaeological research led to a more complete and detailed understanding of the site topography. Along similar lines, in their integrative approach of new and old site data at the site of Heloros on Sicily, Nicola Lercari and his colleagues were able to identify archaeological features in older excavations that had not been mentioned in their respective reports. Again, the integration of data of archaeological research from different epochs created added value due to the increased resolution, accuracy and scale of the modern 3D recording and modelling approaches. The example of toolmark identification was already mentioned above, but the larger effort at the Rijkholt mines is that Walsh and Orbons are reinterpreting excavations that took place in 1880 and during the 1960s. From the presented and discussed examples, it can be concluded that 3D recording of site topography can be decidedly useful: not only does it shed light on the methods of older excavations, but it can also contribute to the reinterpretation of older research results.

2.3 A 4D SITE INFORMATION HUB

Due to the complexity of a site such as Troy and the longevity of the archaeological research, the artefacts, documentation, digital databases, and publications are themselves an assemblage dispersed through space and time. To integrate the many archaeological studies about the site it would be extremely beneficial to bring together and make accessible all information and interpretation from 150 years of archaeological excavations. Considering the role of layeredness and local topography in the interpretations about the site (Korfmann 2006), this is a site for which a 3D GIS/3D information system would be exceptionally useful. Such a 3D 'hub' for anchoring all digital or yet-to-be digitized archives of fieldwork in Troy would be immensely valuable not only for archival purposes, but also to facilitate new research and to serve as a basis for visualizing new interpretations. Such a system could, for example, take the form of an online model, in which various components can be switched on and off, and can be clicked on to display the associated information and the effects on interpretations. Important questions here would be how to create a suitable interface, taking into account aspects like spatial and temporal granularity of the datasets, their accuracy, etc.

From the examples discussed at the CAA session the demands in terms of hardware and software capabilities for such models became clear. In England, T. Zoldoske has been able to combine extensive databases and imagery to a LiDAR survey of the HS2 routes. She emphasized the challenges in creating meaningful models with all this information due to the project's immense size, which necessitates decision making on content and purpose. Brunchi and his colleagues in Romania and Wolf and Ulrich in Sudan were successful in combining different types of legacy and digital data, because the starting points were in both cases new remote sensing images, indicating the potential of creating such an information hub. In addition, for Cucuteni-Cetăţuie, the platform actually aimed to represent all research done on the site. A clear takeaway from the presented examples is that the role of a 4D hub is most effective when tailored to specific research questions and datasets. However, it was also concluded that serious challenges remain; there is no ready-made software that archaeologists can use for such purposes, despite several initiatives developing at the moment. Most attention is currently focused on the potential of 3D GIS, in which a 3D documentation system could be built while profiting from all the affordances of already refined and advanced GIS software packages (see Dell'Unto & Landeschi 2022). However, these are not yet there and the various excellent examples available still use mostly custom-built solutions.

3. CONCLUSIONS

Clearly, the main conclusion of this Round Table session Understanding Archaeological Site Topography: 3D Archaeology of Archaeology is that the application of the ever advancing (drone) 3D recording of existing archaeological sites with a long history of research is an increasingly promising field. The reasons to return to such sites with new recording techniques generally fall into three groups. First of all, 3D modelling allows (online) public access to sites. This is especially helpful when they are no longer there, such as in the case of the SH2 railway line, or when they are difficult to access as in the cases of Rijkholt and Cetăţuie. Secondly, new techniques can help re-interpreting results from older excavations, especially when new techniques are combined with older data, such as site photographs. The cases of Napata in Sudan and Heloros on Sicily, are examples where new techniques led to new interpretations. Similarly, in Cetăţuie, older hypotheses were disproved by the new research. Thirdly, 3D recording is used to better understand the strategies and methods of older excavations, as is the case at Rijkholt and at ancient Troy.

The Archaeology of Archaeology approach as developed in the Amsterdam Troy Project mostly falls within the third of the groups mentioned above. With the long and often confusing history of archaeological research at sites such as Troy, it is imperative to acquire a better understanding of the methods and conditions of previous excavations in order to be able to evaluate results. The examples at the conference sessions clearly showed how beneficial it is when 3D recording techniques can be combined with other available information. In particular, the potential of old photographs was highlighted. Our experiences at Troy suggest that re-excavation of dumps and specific trenches and comparison of finds are also highly promising. In addition, considering the manifold possibilities of 3D hard- and software and the sheer quantity of the data available for a site such as Troy, several attendees to the session emphasized the necessity of a problem-oriented approach when researching and developing a platform as an access point, and when organising and presenting collected information.

3D recording of archaeological site topography is likely to develop further in the near future. As organizers of this session, we are thankful to all participants who have been willing to share their knowledge and ideas. We sincerely hope that we will be able to continue the discussions at a future occasion and to elaborate on the valuable lessons learned during this Round Table session.

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COMPETING INTERESTS

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REPRODUCIBILITY

Data sharing is not applicable to this article as no new data were created or analysed in this study.

PEER REVIEW

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