Chapter 2
3D Recording in the Field: Style Without Substance?

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Introduction

Three-dimensional field recording is one of the fastest-growing applications in archaeology today. Increasing numbers of archaeological field projects are applying 3D methods, including laser scanning and image-based modeling. 3D recording's proponents have cited its precision and accuracy for making measurements, its efficiency in the field, and its cost-effectiveness for some applications (De Reu et al. 2014; Doneus et al. 2011: 84; Forte 2014: 13; Jorayev et al. 2016; Lambers et al. 2007; Magnani and Schroder 2015; Quartermaine et al. 2014; Reshetyuk and Mårtensson 2016; Roosevelt 2014; Sapirstein 2016; Verhoeven 2011). Criticisms or cautions aimed at the "3D revolution" have warned that certain applications of these methods may prioritize their aesthetics over their usefulness to legitimate research inquiry (Forte 2014: 2). Uncritical application of developing technology is not a phenomenon new to archaeology—similar criticisms have been leveled at GIS (Church, Brandon, and Burgett 2000; Fletcher and Winter 2008: 2; Kvamme 1999: 174; McCoy and Ladefoged 2009: 282). Yet the intervening decades have shown GIS to be a powerful tool, allowing for methodological advances and new types of analysis to be performed. The utility of 3D recording techniques to archaeology has not been similarly resolved yet, despite recognition of the importance of this issue (Olson and Placchetti 2015; Opitz 2015).

Ultimately, widespread adoption of three-dimensional approaches will depend on whether or not these methods have the potential to aid in answering archaeological research questions. The usefulness of any technology to archaeologists can be understood in three ways, ranging from most useful to least: first, that the technique will be applicable to understanding the social and ideological structures of the past, ancient lifeways, and culture change. The investigation of these concepts is the basis

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of much current archaeological research, and as such, any emergent technology's usefulness in shedding light on these aspects of the past must be considered in its adoption by archaeologists. A secondary form of utility for the technique could be found in the realm of a purely methodological advance. An approach that cannot directly shed light on the past might still prove useful to archaeologists by allowing for an improvement in already applied methods, such as an increase in the precision and/or accuracy of spatial recording. A third scenario for the usefulness of 3D technology is the bleakest for its future: that these techniques are not applicable to relevant archaeological research questions and that they do not represent a methodological improvement. In such a case, we would expect reports of a "3D revolution" in archaeology to be greatly exaggerated. Three-dimensional field recording might then be relegated to party-trick status, applied only to impress onlookers, donors, or students with 3D models. We can thus expect the future of 3D modeling to resemble one of these scenarios: that it is useful for examining ancient culture and society, useful in the day-to-day practice of archaeological excavation or investigation, or, lastly, that it is ultimately not worth bothering with. These options, running the gamut from critical tool to flash in the pan, define the best- and worst-case scenarios for the utility of 3D archaeology. A discussion of to what extent 3D field recording can put meat on the bones of the archaeological record and provide insight into relevant research questions is important to have, especially at a time when many archaeologists are considering its use.

Background

Two main 3D field recording technologies are most often applied in archaeology: laser scanning and image-based modeling (henceforth IBM). To be clear, these are not the only three-dimensional technologies applied to archaeology, nor do they account for the rapidly expanding category of 3D–based lab analysis of artifacts (e.g., Bretzke and Conard 2012; Karasik and Smilansky 2008). However, this discussion will focus on 3D recording in the field, which is primarily done through laser scanning and IBM. These two methods have emerged, hand in hand, in recent years as the most widely applied techniques of three-dimensional field recording. Each of these techniques has different advantages and disadvantages, justifying a short introduction.

Laser scanning, broadly, refers to the collection of tens of thousands to millions of data points through shooting lasers onto an object and recording its position in 3D space (relative to the scanner). Points from laser scanning, in addition to spatial coordinates, also can contain limited color values, originating from a camera often included in the laser scanner. Laser scanning is performed through one of three main measurement techniques: the time-of-flight method, the phase comparison method, and the triangulation method. In time-of-flight scanning, the most popular variety for application at archaeological excavations, a laser pulse is emitted from the scanner and reflected from the target object back to the scanner, at which point the amount of time the reflection took and the angle of the initial pulse are used as the basis to calculate the location of the reflecting object (Boehler and Marbs 2002; Lerma et al. 2010: 501). The phase comparison method works similarly to the time-of-flight method, though the scanner also records the difference in between the wavelength of the emitted beam and the reflected light. This can result in more accurate point detection, though the range of the scanner and the number of successfully recorded points may suffer (Boehler and Marbs 2002). Lastly, the triangulation method separates the laser emitter from the camera, which identifies the position of the laser on the object. This final approach can be more useful for short-range scanning (Boehler and Marbs 2002; Lerma et al. 2010: 501). Our discussion of laser scanning will be limited to time-of-flight methods, as these are most common in field archaeology. This approach can be applied with a terrestrial scanner or a scanner mounted on a plane, referred to as aerial laser scanning (ALS) or LiDAR (**Li**ght **D**etection **A**nd **R**anging; an excellent overview of LiDAR as a technology is available in White 2013). In general, laser scanning has been praised for its ability to record highly precise and accurate point data, with millimeter or submillimeter precision possible depending on the specific equipment (Yastikli 2007: 424). As such, the technique is the gold standard of precision and accuracy in 3D field recording of archaeological excavation (Boehler and Marbs 2004: 297). However, laser scanners also rely on line-of-sight recording, meaning that occlusions in recorded datasets can be common, especially at topographically complex archaeological sites. Resolving this issue requires the taking of multiple scans and the co-registration of these separate point cloud datasets (Al-Kheder et al. 2009: 540–2). This can be a potentially lengthy and difficult process, depending on how many scans are required (Lerma et al. 2010: 501; Levy et al. 2010: 140). A laser scanner is also an unwieldy piece of equipment, the price of which can run well beyond the reach of smaller archaeological projects at tens or hundreds of thousands of dollars (Boehler and Marbs 2004: 292).

Image-based modeling is a second option for three-dimensional archaeological field recording. IBM refers to the creation of 3D models from photography taken of a target object from multiple directions, a process of digital photogrammetry. The method of data capture for IBM must necessarily be adapted to the size and shape of the object of interest in each case, but the basic principles are similar regardless of exact approach. IBM requires that many (ranging from tens to thousands) photos be taken of the target and that each image share a considerable overlap with adjacent images (the user's manual for Agisoft Photoscan, one IBM program, suggests >60% overlap between images [Agisoft 2017]). This is due to the fact that reconstruction of the object occurs through identification of the same point in multiple images. As such, any part of the object or area of interest must be present in at least two images in order to be reconstructed (Agisoft 2017). Quality reconstructions of objects or areas of interest depend on the acquisition of detailed images with comprehensive coverage of the target; however, expensive equipment is not required for generating viable 3D models. Best practices for data capture would include a DSLR camera with a fixed focal length lens shooting in RAW format, but results are also achievable with setups as simple as a cell phone camera or inexpensive point-and-shoot.

Whatever the camera arrangement, acquiring comprehensive overlapping coverage is the most important factor in generating a complete and detailed model.

Once the photos are taken, processing IBM models typically consists of three or more main steps. First, an algorithm identifies identical points across multiple images, triangulating their location as well as that of the camera when the photograph was taken in arbitrary space. This process results in the creation of a sparse point cloud. A dense point cloud, consisting of substantially more points, may be developed as a subsequent stage. In the second main step of IBM processing, the point cloud is used as the basis to form a mesh, a continuous 3D model constructed of polygons. In the last stage of model development, the images used to create the model are mosaicked or averaged onto the mesh to create a more-or-less photorealistic 3D model. IBM software packages contain one or all of these processing capabilities, with some programs also offering additional features such as the ability to edit models between stages or georeference the 3D model. IBM's advocates have highlighted the technology's cost-effectiveness, given that its application requires only a basic digital camera and software, and its efficiency in field recording (Olson et al. 2013; Lerma et al. 2010: 500). The simplicity of IBM's workflow (depending on the software used to implement it) has also been praised by its users (Kjellman 2012: 23). The technology, though not usually as precise or accurate as laser scanning, can rival laser scanning in these regards when precisely and carefully used (Doneus et al. 2011: 84–5). IBM—like laser scanning—can be applied terrestrially or aerially.

Review

Before considering the usefulness of these 3D technologies for addressing broader questions in archaeology, we must turn to how they are applied in the field today. Our discussion will begin with laser scanning, which had been more widely applied by archaeologists until very recently. Laser scanning, as mentioned, allows for both terrestrial and aerial approaches. Archaeological applications of terrestrial laser scanning have most frequently related to the recording, documentation, and preservation of monuments and ancient art (see De Reu et al. 2013 for examples). These uses often border on the related fields of cultural heritage and/or cultural resource management. Laser scanning has been less often applied to actively excavated archaeological sites, though these uses still occur (Doneus and Neubauer 2005; Forte 2014; Levy et al. 2010: 138–42; Neubauer 2004: 162–3; Schreiber et al. 2012). The length of time per laser scan (upwards of 1.5 h, according to Levy et al. [2010: 140]), the necessity of multiple scans for complete coverage (which then necessitates co-registration of point clouds), and the cost of laser scanners (potentially tens of thousands of dollars or more, prohibitively expensive for many projects) may explain why terrestrial laser scanning has not seen widespread adoption on active excavations, despite its widely touted accuracy.

Aerial laser scanning (or LiDAR), on the other hand, has become increasingly popular with archaeologists in recent years. LiDAR has been used primarily for two purposes: for the collection of high-resolution elevation data at an inter-site/inter-regional scale for background data or mapping and for investigative survey of heavily vegetated areas. Archaeologists have made use of LiDAR's resolution to identify and map archaeological features across the landscape through their identification in elevation differential as seen in the point cloud or a derived DEM (Fisher and Leisz 2013; Harmon et al. 2006; Štular et al. 2012). Archaeologists have also applied LiDAR in heavily vegetated areas in order to get a view of the ground below the canopy. By applying certain filters to the point cloud data acquired from aerial scans, archaeologists have been able to filter out points recorded on the vegetation, leaving only a subset of the points consisting of laser strikes on the ground (Devereux et al. 2005; Sithole and Vosselman 2004). The remaining points from this process enable the creation of a digital terrain model (DTM) consisting of only elevation data from ground level, as opposed to a digital surface model, which consists of the highest recorded elevation, i.e., including vegetation (Doneus et al. 2008; White 2013: 183–4). This application of LiDAR has become especially popular in regions where sites and the archaeological landscape are often obscured by dense vegetation, allowing researchers to identify features and sites under the canopy (e.g., Chase et al. 2013; Evans 2016; Fernandez-Diaz et al. 2014; Hare et al. 2014).

Image-based modeling—though sometimes applied in concert with laser scanning—is often used differently than its laser-based counterpart. Terrestrial applications of IBM often relate to the modeling of excavation units or specific contexts at archaeological sites (De Reu et al. 2013; De Reu et al. 2014) or to the lab-based recording of artifacts, which is beyond the scope of this chapter. Archaeologists have applied IBM for recording of excavation units because of the temporal efficiency of this approach and its benefits for accurate recording of archaeological features (Verhoeven et al. 2012; Olson et al. 2013). Scholars have applied the technique for the generation of orthophotographs for the purpose of digitization of features (Quartermaine et al. 2014: 115–7), updating the method of field recording by drawing directly on vertical imagery in GIS (Levy and Smith 2007: 53). These vertical images can also be captured by aerial photography platforms (such as UAVs or balloons), and archaeologists have applied these airborne systems to record excavation units as well (Howland et al. 2014; Quartermaine et al. 2014). However, aerial applications of IBM are more often performed at a sitewide scale, where researchers have used the technique to collect GIS-compatible datasets such as orthophotos and digital elevation models (DEMs) for site mapping (Howland et al. 2014; Verhoeven et al. 2012). Aerial IBM is gaining popularity as an archaeological field recording technique as the use of UAVs/drones becomes increasingly popular and effective (Remondino et al. 2011; Verhoeven et al. 2012). IBM does suffer from limitations related to lighting conditions, including an inability to function at night or in poor lighting conditions (Lercari 2016: 8). In general, however, IBM has seen widespread adoption over the past several years due to the cost-effectiveness and temporal efficiency of the technique in the field.

Evaluation

Techniques of 3D recording in archaeology have spread far and fast in recent years in what some have called a "3D revolution" (Guery and Hautefort 2014). The question of whether or not the contributions of these techniques will remain relevant after their novelty fades remains, however. Whether or not these approaches can contribute to outstanding archaeological research questions is also an outstanding issue. Each of the four techniques detailed above has been applied by archaeologists in differing ways, so it is important to continue to separate them when evaluating their effectiveness in contributing to grand narratives in archaeology.

Terrestrial laser scanning, providing the most precise and accurate data of any 3D field recording method applied to archaeology, is probably the least likely to achieve widespread adoption. The prohibitive cost of laser scanners as well as the time required to properly scan and process data from archaeological terrain means that laser scanners are unlikely to be applied regularly for the recording of active excavations in the near future. Thus, their effectiveness in answering archaeological research questions is necessarily limited. However, the recording of more static archaeological features is still a possibility, and laser scanning sees wide use in the related fields of cultural heritage and archaeological conservation, given that the technology's precision allows for the monitoring of monuments or structures for degradation over time or structural defects (Al-Kheder et al. 2009; Armesto-González et al. 2010; Fanti et al. 2013). This type of application of the technique is effective, as data acquired through terrestrial laser scanning is extremely precise and avoids much of the human error inherent to field measurements. In fact, the majority of uses of terrestrial laser scanning relate primarily to documentation for the sake of preserving the present form of a structure or site or guiding conservation efforts. Even proponents of TLS have highlighted its particular usefulness for "large-scale data capture of buildings and heritage sites" (Lercari 2016: 27). Despite the usefulness of terrestrial laser scanning for documenting static contexts, however, archaeologists do not often make use of the approach for the generation of new archaeological knowledge, thus missing the potential of terrestrial laser scanning for explaining or understanding the behavior of ancient people. In a few cases, archaeologists have found useful applications for terrestrial laser scanning in these ways, allowing them to conduct measurement-based analyses on archaeological features in the landscape. For example, recent investigations into construction techniques and uses of "desert kites" in the Negev using terrestrial laser scanning serve as an example of one particularly useful application of the technology, providing an insight into past labor, subsistence, and lifeways (Arav et al. 2014; Nadel et al. 2013). Yet this example is a rare case of archaeological fieldwork applying terrestrial laser scanning to gain a greater understanding of how and why a particular feature was used. It does, however, show the potential of the approach for understanding how and why ancient people modified and constructed their environments in the ways that they did. Thus, while terrestrial laser scanning clearly possesses the potential for facilitating complex archaeological analysis and interpretation, it is seldom used in such a way. The jury will remain out on the long-term viability for terrestrial laser scanning to significantly contribute to grander questions for many archaeological projects and depend on dedicated users of the technology to apply it to appropriate research questions. The restrictions of price and time of use will likely remain limitations on the approach going forward, however. As such, it seems that—for the time being, at least—terrestrial laser scanning is not an essential part of the toolkit of the archaeologist looking to investigate culture change or other grand questions in archaeology.

Aerial laser scanning, on the other hand, has already demonstrated substantial utility for archaeologists in a number of ways. This approach retains the characteristic accuracy and precision of terrestrial scanning while also remaining a cost-intensive technique. However, aerial laser scanning possesses an additional advantage over its competitors in remote sensing. Of primary importance is the ability of LiDAR to cut through foliage and allow archaeologists to see the ground level beneath vegetation. This is perhaps the most significant contribution of the technique (Opitz 2016). This capacity of the technology has allowed archaeologists to discover previously unknown sites in heavily forested areas, which may be too densely vegetated for traditional survey approaches (Chase et al. 2013; Fernandez-Diaz et al. 2014; Hare et al. 2014). LiDAR, in these cases, represents not only a methodological advance in terms of aerial survey but also a substantial step forward in our ability to discover sites and understand the spatial patterning of ancient societies. The use of LiDAR for regional data collection, while not as much of a revolutionary advance for the field, also improves archaeologists' ability to collect and use site-scale (e.g., Harmon et al. 2006) or landscape-scale (e.g., Werbrouck et al. 2011) spatial data. These types of data collection initiatives can supply archaeologists with high-resolution elevation data (DEMs on the order of a few meters spatial resolution), much higher than the (ca. 15–30 m) resolution typically available from satellite sources. This type of elevation data can allow for the identification and location of landscape features that may be difficult or impossible to see from the ground, at scales and resolution not achievable through other methods (Bewley et al. 2005; Štular et al. 2012). As such, LiDAR can be a very effective tool for landscape-level feature identification and mapping in both forested and nonforested areas. Given aerial laser scanning's effectiveness for survey across varying biomes, the approach clearly has the potential to be a powerful tool for archaeologists moving forward. The cost of applying this technique may be prohibitive in many cases, but this cost can often be justified, especially where the approach achieves results not possible through other methods, as is the case with survey through heavy vegetation. LiDAR can clearly be seen as a methodological advance for archaeologists interested in acquiring regional elevation and survey data. More important is the question of whether or not the technique can help archaeologists to address grander questions in archaeology, however. From the studies presented above and others, the answer would seem to be yes. As noted already, LiDAR can provide high-resolution dataset elevation in both forested and nonvegetated areas, which can result in the discovery of new sites or archaeological features at known sites. By enabling the expansion of knowledge of the settlement patterns of ancient people at a site or landscape level, aerial laser scanning can contribute new knowledge about the ways in which people lived in the past. Thus, despite the limitations of cost, LiDAR has great potential to substantially contribute to archaeological knowledge in many situations and will likely continue to remain of great use in the future.

Terrestrial IBM, as previously mentioned, has been primarily used for the documentation and recording of excavation units. The main characteristics of this approach that recommend its use are its time and cost efficiency, as well as the simplicity of its application. These characteristics make IBM very easy for archaeological projects to adopt and implement into their workflow. However, the usefulness of photographic-based 3D recording for archaeological research, rather than its ease of use, is the factor that will ultimately determine whether or not it achieves widespread adoption. As noted above, scholars have primarily applied terrestrial IBM for the purposes of documentation and recording of excavation units. Documentation of the process of investigation of a site on a regular basis (e.g., Olson et al. 2013: 252–5) can allow for the creation of photorealistic 3D models at every stage of excavation, made feasible by the temporal efficiency of IBM. Having a complete 3D record of a site as it is excavated facilitates the efforts of future researchers desiring to view loci in their original contexts or even make field measurements (De Reu et al. 2014: 260–1). IBM also has a second purpose for archaeologists in recording and digitization of features, as we have seen. IBM recording allows for the production of orthophotographs, which are an accurate basis for the GIS-based digitization of archaeological features. These images allow for an improvement in accuracy and precision of GIS-based digitization over other methods (De Reu et al. 2014: 260–1; Olson et al. 2013: 254–5). Taking these two aspects of terrestrial IBM recording in concert, we must attempt to determine the extent that their advantages translate to an improved ability to investigate larger issues in archaeology, such as social change and grand narratives in the field. What does seem clear is that terrestrial IBM provides some clear benefits in the documentation of sites, and would seem to greatly facilitate the work of researchers working on data from recorded sites after they are excavated. Bringing the standard of archaeological documentation closer to the high standard of cultural heritage projects must be seen as a significant step forward for archaeology in general. However, this benefit, in and of itself, does not directly contribute to archaeologists' ability to connect the dots of ancient material evidence into a line of broader issues. Similarly, an improvement in the specific accuracy of field recording could be advantageous to archaeologists desiring to attain the highest degree of accuracy possible, but would not necessarily provide any additional aid to archaeologists asking the big questions. Thus, while terrestrial IBM may very well be a useful tool for archaeologists—and one that is increasingly applied for these reasons—it remains a tool and not an approach for answering questions at scales beyond the minutiae of daily excavation.

Aerially applied IBM potentially has a broader utility to match the wider scale at which it is normally applied. Practitioners of aerial IBM have used the technique to record excavation areas, sites, and even larger areas, usually producing DEMs and/or orthophotos as GIS-compatible outputs in addition to 3D models approaching photorealism (Olson et al. 2013; Quartermaine et al. 2014; Verhoeven et al. 2012). These GIS datasets have a substantial resolution advantage over satellite data (by a factor of 10 or more in orthophotos in terms of horizontal resolution, and even more for elevation data), which often is the only readily available source of these types of datasets. IBM-based production of elevation data also provides an efficient alternative to its acquisition through traditional total station survey, which can take up valuable time in the field. These data enable archaeologists to augment their work in a few main ways. First, much like terrestrial IBM, aerial applications of this technique have the potential to improve the accuracy and precision of mapping archaeological features in comparison to the use of georeferenced vertical imagery for the same purpose. IBM recordings of entire sites can also provide a new, potentially invaluable perspective on sites. Combining site-wide scale with local levels of detail, aerial IBM potentially allows archaeologists to discover and investigate patterns at a site not immediately recognizable from the ground. Archaeologists have long recognized the potential for using aerial photography to identify certain types of features that may not be obvious from the ground but immediately stand out when seen from above, such as cropmarks (Bewley 2003). Aerial images can also be effective in identifying partially buried walls or disconnected continuations of walls when these features may be difficult to identify from a lower perspective. Aerial IBM, as a subset of aerial photography, shares these advantages and adds three-dimensional perspective that can help clarify features by viewing from different angles. The GIS datasets produced by aerial IBM also can serve as a basis for intra-site GIS analyses, which potentially require high-resolution GIS datasets not available through other means of acquisition.

The drawbacks of aerial IBM include its accuracy in recording and its applicability in certain environments. IBM, while in some cases reaching the level of accuracy attained by laser scanning, has been criticized for its failure to always do so (Boehler and Marbs 2004: 293). Because aerial IBM is practiced with a camera positioned much farther from the object of interest, pixels in the photographic datasets represent larger real-world areas. For example, while a terrestrial IBM model taken of a small excavation unit might consist of images with pixels representing 1 mm^2 or less, an aerial model of a site might contain images with pixels of 4 cm^2 or more. In other words, an image for a typical terrestrial IBM model might have a ground-sample distance (GSD) of <1 mm, while an aerial image could have a GSD of >2 cm, depending on camera resolution and elevation. In general, the sizes and distances involved in aerial IBM-oriented recording come along with a natural decrease in data resolution and a corresponding expansion in error margins. As such, aerial IBM practitioners would be well advised to take particular care in checking the accuracy of their datasets with other methods, especially if they are relying on their data for point elevations or precise location measurements. The nature of IBM as a line-of-sight technology also carries with it some potential issues. Sites obscured by vegetation may be difficult or impossible to record by aerial IBM, either because of the impracticality of flying balloons or kites among trees or because of the obscuring of features by leaves and branches. IBM also fails to accurately reconstruct scenery in motion, such as tree leaves shifting in the wind.

Aerial IBM also carries a greater risk of loss or breakage of equipment than other 3D field recording methods. Elevating camera equipment tens or hundreds of meters into the air is a risky proposition and can potentially result in its damage or destruction. These limitations and risks, while significant, have not seemed to slow the trend of enthusiastic adoption of aerial IBM approaches in archaeology, however.

Discussion

The approaches detailed above vary in cost and effectiveness, as we have seen. Cost, in particular, can be a prohibitive factor in adoption by archaeological projects. Laser scanning, aerial and terrestrial, is particularly affected by this issue, with aerial LiDAR scans running into the tens of thousands of dollars and terrestrial laser scanning units also in the five-figure range. IBM can provide archaeologists with a cheaper alternative to laser scanning, although potentially at the cost of a loss of accuracy and/or precision. However, one must account for the general downward trend in the prices of developing technology before ruling out the future use of currently expensive technologies. With time, we might expect the costs of pricier equipment, such as a terrestrial laser scanner, to fall into the range of affordability for smaller projects, though this remains to be seen.

We have also discussed the usefulness of these approaches for archaeological research, although this discussion warrants a summary. For regional projects, aerial laser scanning/LiDAR is probably the most useful approach. The scale of recording allowed by aerial laser scanning vastly outpaces other 3D methods. Thus, archaeologists can record large areas with LiDAR, making the approach a legitimate technique of regional site survey. This holds true even in areas covered with heavy vegetation, where LiDAR is still able to record the ground surface after points relating to vegetation are sorted out. This function of LiDAR has already demonstrated the potential to be a game changer for archaeology. Instead of hacking through dense vegetation for days or weeks, archaeologists can conduct vast surveys from their desk chair. Thus, LiDAR can allow for a fuller picture of ancient settlement patterns, shedding light on past lifeways and helping to address grander questions in archaeology. This technology's land-based cousin seems to lack the same capacity to drastically change the way in which archaeology is done. Terrestrial laser scanning does not have the same possibility of recording at broad scales due to problems of occlusion and perspective. These issues also mean that setting up the laser scanner and taking scans multiple times could be necessary. This process of slow yet precise and accurate documentation can be ideal for static monuments, though it is not efficient for the kind of constantly changing conditions found at an archaeological site under active excavation. In any case, the high-resolution documentation of archaeological sites can provide an excellent basis for digitization of features and later reinterpretation by scholars, though it does not necessarily contribute to archaeologists' ability to contribute to theoretical debates in archaeology. The same holds true for terrestrial IBM approaches, which are also effective for digitization of features and later reinterpretation by scholars. Terrestrial IBM is better suited to regular documentation of changing conditions than terrestrial laser scanning due to its rapidity and efficiency of data collection, though it may suffer from lower precision and accuracy in some cases. Again, terrestrial IBM can potentially be an important improvement for archaeologists' methodological toolbox in the field, although it is unlikely to inspire or answer grander questions of human behavior. Aerial IBM approaches allow for the collection of data at a broader scale (though not as broad as aerial LiDAR). The perspective of an aerial dataset can be valuable in its own right for identifying features, while the collection of orthophoto and elevation data at area, site, or even wider scales can be a powerful asset in comprehensive site mapping or conducting intra-site spatial analyses, as we have seen. These more complex approaches to the archaeological record can potentially facilitate the archaeologist's ability to move beyond simple interpretations of ancient material evidence and potentially investigate social and ideological structures of the past. In general, the usefulness of 3D recording of archaeological sites is a mixed bag, as some techniques will improve recording accuracy and precision at sites, while others may provide an avenue of insight into past societies and culture change. Ultimately, as long as 3D recording technologies are applied with caution, preparation, and within a theoretical framework, they can and will be useful to archaeologists going forward.

Conclusion

At the outset of this discussion, we envisioned three possible futures for 3D recording in archaeology: that 3D is flashy but ultimately a distraction from legitimate research, that it represents a methodological advance in field recording, and, most optimistically, that it has potential for helping archaeologists to understand ancient lifeways, society, and culture change. We have seen that in many cases, 3D recording represents a clear methodological advance over traditional recording techniques, demonstrating that there is likely a future for these techniques. Furthermore, some of the excellent work of archaeologists highlighted above demonstrates that, when properly conceived and applied, certain types of 3D recording do have the potential to revolutionize archaeological fieldwork and shed light on some of the driving questions of archaeology. However, the usefulness of 3D recording techniques for archaeological purposes clearly depends on the specific technology itself, as well as the method of its application. Any critical consideration of the appropriateness or usefulness of 3D technology must take this into account and not consider 3D recording approaches to be a monolithic field. To this end, the application of 3D approaches in the field should be tailored specifically to the project in question. Particularly important are the issues of the budget of the project and the clearly defined envisioned research goals of the project. 3D documentation and recording in general is not a cure-all any more than is GIS software, a total station, or even a trowel. One must apply tools to accomplish definite objectives, without which 3D approaches can quickly become a money sink. In general, three-dimensional recording techniques vary greatly in their ability to be effectively applied to active archaeological excavations, with some more applicable than others to facilitate archaeological research and inquiry. Perhaps most encouraging is the possibility of some techniques to raise the level of archaeological analysis. These approaches can—literally and figuratively—provide a new perspective on archaeological sites. As such, it seems reasonable to conclude with a cautiously optimistic view of 3D recording for archaeology. As with many other techniques widely used by archaeologists around the world, 3D recording technologies have the capacity to substantially contribute to our understanding of ancient societies when used judiciously. The utility of these approaches ultimately depends on the way they are used. As such, archaeologists interested in applying three-dimensional technologies to their field projects would be well advised to carefully consider the pros and cons of specific technologies and application strategies with regard to their specific research goals in order to best apply 3D recording.

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