Generating 3-D Models of Artifact Density in Excavation Units: A Case Study at Site 41WT69, the McAdoo Plantation Home

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ABSTRACT

This paper introduces a new 3-D modeling visualization technique, termed 3-D Choropleth Models, which facilitates the exploratory spatial analysis and display of the material culture and architecture at an excavation by combining the simple yet descriptive nature of choropleth maps with 3-D modeling. This technique generates models that display the density of artifacts in each excavation unit, in each level, thus detailing the spatial relationship of the cultural material, architectural features, structures, and site layout. This technique was applied to site 41WT69, which local lore suggests is the former McAdoo Plantation Home.

Introduction

GIS continues to be a fundamental tool used by archaeologists to study past human activities by identifying, mapping, visualizing, and analyzing the spatial distribution of artifacts (Rahtz and Reilly 1992; Wheatley and Gillings 2003; Ebert 2004; Conolly and Lake 2006; McCoy and Ladefoged 2009; Sylaiou et al. 2013). There are, however, recent advances in GIS that have yet to be fully utilized in archaeology. For example, 3-D modeling is becoming a popular tool in archaeological investigations, but its capabilities have not yet been fully explored (De Roo et al. 2013a). This interest in 3-D modeling makes sense, as archaeologists generally record data in three dimensions. These models allow archaeologists to properly interpret and visualize spatial data regarding the features of a site (Lock and Stančič 1995; Conolly and Lake 2006).

Currently, 3-D modeling is used mainly as a visualization technique, to create virtual reality models of a structure at a site (Simoneau 1994; Brutto and Meli 2012; De Roo et al. 2013a, 2013b; Demesticha et al. 2014; De Reu et al. 2014; Forte 2014; Quartermaine et al. 2014). However, 3-D modeling can also be used to analyze and visualize the stratigraphy, excavation units, and cultural material at a site (Llobera 2011; Rua and Alvito 2011), thus allowing for further exploration (Rahtz and Reilly 1992).

Losier et al. (2007) and Katsianis and Tsipidis (2008) created models that concentrate on the stratigraphy of a site. Katsianis and Tsipidis (2008) focused on using 3-D modeling to digitize the excavation process. These models focused on capturing the stratigraphy of the site, documenting intricate representations of the site, and creating a clearer view of the excavation process. Losier et al. (2007) took a similar approach with 3-D modeling, where the models focus specifically on the excavation units and relationships between the units. Like Katsianis and Tsipidis (2008), Losier et al. (2007) emphasize the ability of 3-D modeling to recreate the actual excavation.

Recreating the excavation units is useful in understanding a site. However, the cultural material that comes from those excavation units is also a key component of site analysis. The 3-D models created by Losier et al. (2007) and Katsianis and Tsipidis (2008) do not include any depiction or analysis of cultural material. GIS, using 3-D modeling technology, is now at a point where we can include more elements of the archaeological investigation such as cultural material.

This paper highlights a 3-D modeling visualization technique that expands on Losier et al. (2007) and Katsianis and Tsipidis (2008), and incorporates the visualization of cultural material in the models. Specifically, this visualization technique, termed 3-D Choropleth Models, combines choropleth style visualization with 3-D modeling. This allows for exploratory analysis of the spatial distribution and density of artifacts in each level and unit and throughout the site. Choropleth maps are thematic maps commonly used in exploratory spatial data analysis; these maps show areas in distinctive colors, or shades, to represent distinctive properties and, in the case of this study, the number of a particular kind of artifact in a particular level in an excavation unit.

This technique was used to examine the extant remains of site 41WT69, the presumed McAdoo Plantation

Home. Local lore states that John David McAdoo, a civil war general, famously occupied a two-story home and ran a plantation at site 41WT69, located in Washington County, Texas. His plantation home was once described as a "Grand Texas Frontier Home" because of its size and architecture (Jordan 1978). The home is believed to have had a large central breezeway, two stories, large windows, two chimneys, and large porches (Jordan 1978). The McAdoo Plantation Home was reportedly demolished in the 1960s (Jordan 1978). Some historical data do exist, but most of the known history of the site comes from hearsay and local stories. GIS and 3-D modeling provided an opportunity to define the extant remains of the structure at 41WT69 given the absence of standing structures and the muddled nature of the historical data.

Historical data include an interview with Ed Lathan and a painting and photographs of what is thought to be the 41WT69 structure. Mr. Lathan is believed to have lived in the home as a child, and he is also a member of the Breedlove family, who owned the property in the 1900s. The interview with Mr. Lathan captured descriptions of the layout of the home as well as its architecture. Mr. Lathan described his former childhood home as a large two-story structure with a large central hallway, two chimneys, and a kitchen attached to the home by the porch (Ed Lathan 1993, pers. comm.). Mr. Lathan noted that the home was demolished in the 1960s. In the mid-20th century Earnest Youens, an architecture student from the University of Texas, took photographs and painted a watercolor. The structure depicted in the photograph in Figure 1 corresponds to the structure that Ed Lathan described in his interview.

Data Collection and Creation of 3-D Models

In order to create 3-D models, spatial data must be carefully collected in the field. The horizontal coordinates and

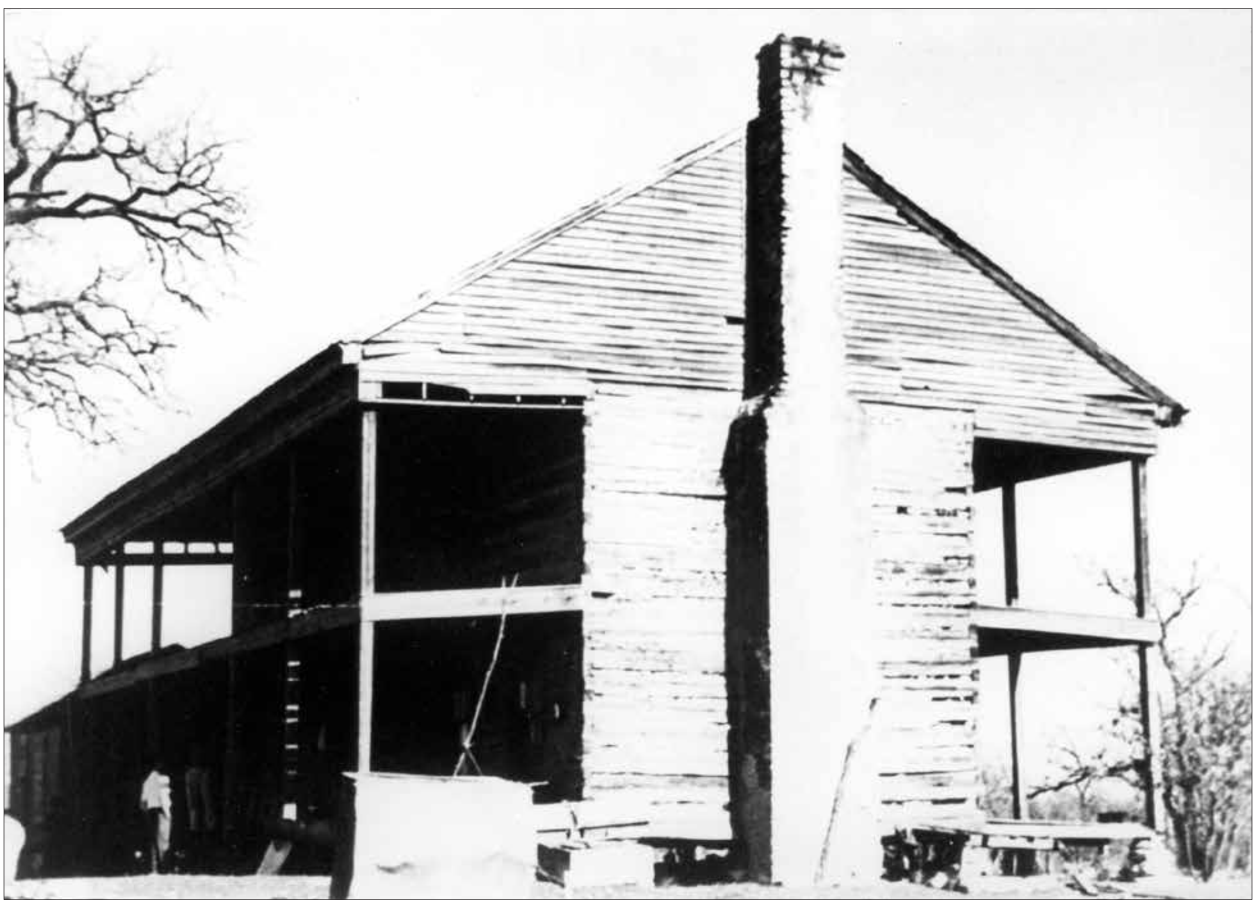

Figure 1. Photograph of the presumed McAdoo Plantation Home (41WT69). (Courtesy of the Log Cabin Registry, University of North Texas.)

the elevation of each unit and feature must be recorded. The spatial arrangement of artifacts must also be recorded carefully. At site 41WT69 the corner coordinates of each 2 × 2-m unit were taken with a total station, in addition to the top and bottom elevation of each corner. Coordinates for material culture, such as artifact clusters, diagnostic items, and features, were derived from the digitization of hand drawn field maps.

Esri's ArcScene was used to create the 3-D models. Although other 3-D modeling software exists (e.g., Surfer and AutoCAD), they do not have the capability to combine the specific visualization styles in order to develop the 3-D Choropleth Models. The visualization technique created 3-D Choropleth Models showing a gradient of colors to depict density of a particular kind of artifact in a particular unit and level.

3-D choropleth modeling involves creating separate layers for each level at the site. Since excavations at 41WT69 used arbitrary levels, all the units could be added to the model in a single layer. Sites with more complex stratigraphy may need to add each level of each unit individually. Figure 2 shows a workflow for developing these 3-D representations. Artifact counts are stored in attribute tables in the level layers. An artifact type can be chosen for display, to make a choropleth model, but the artifact counts must be classified. Manual distribution was used to uniformly classify these data across levels and units.

Examining a Site with 3-D Choropleth Models

This 3-D modeling technique provides a clear view of a structure layout and the cultural material found within

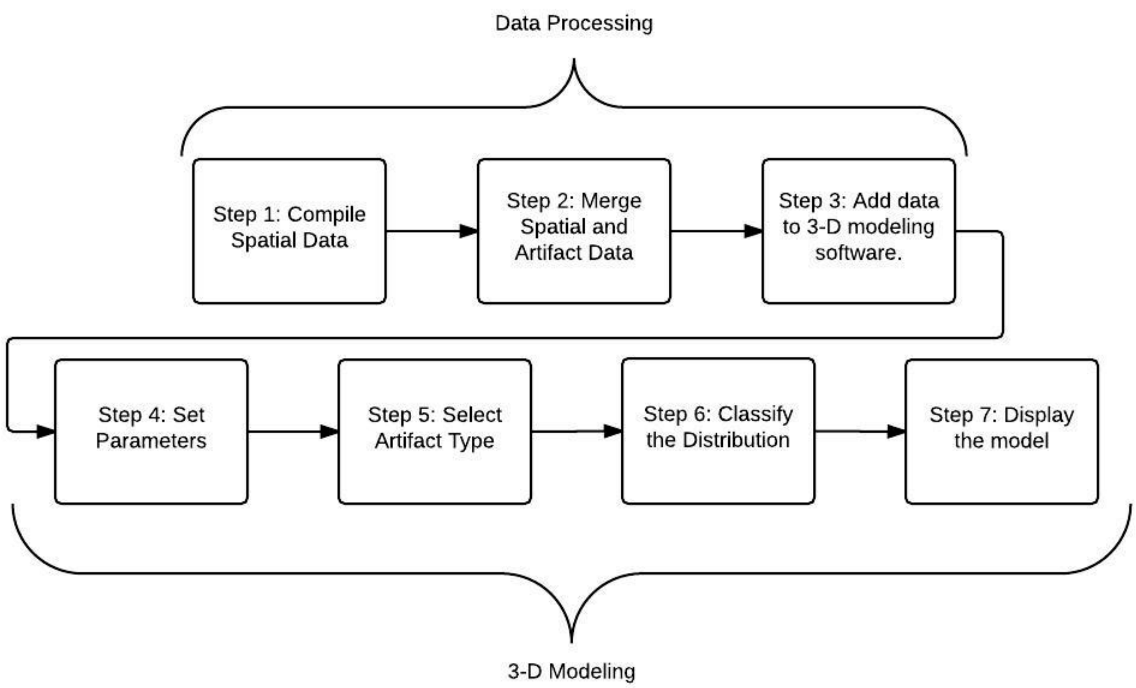

Figure 2. Workflow of 3-D Choropleth Models. Step 1: compile geographic coordinates of the excavation units and elevation of levels (which must be negative to make the model appear underground). Step 2: merge artifact counts in each unit and level (table can be made for each unit or each level). Step 3: create layers by adding data to Esri's ArcScene. Step 4: set parameters in the software; note that levels may need to be extruded if they are small. Step 5: select artifact type to display; the same artifact type will need to be selected for each layer. Step 6: classify the distribution, which creates a graduated color choropleth model of the artifact count; note that the classification must be uniform to accurately analyze the artifact distribution, thus a manual distribution may be the best option (must be done for each layer). Step 7: display the model; if the model will be displayed in 2-D choose an orientation that will best allow the entire site to be seen, if an animated visualization is possible a fly through can be made of the model. (Graphic by author, 2015.)

the structure. At 41WT69, 3-D modeling revealed the layout of the home—the spatial arrangement of architectural features such as the kitchen and windows. These models helped determine an era of occupation for the structure. This study focuses on two types of artifacts that were found at 41WT69: window glass and kitchen related items. Window glass served as a reliable proxy for dating the site, and provided a sense of where the building was situated. Kitchen related items, such as utensils and cut faunal bones, helped locate a kitchen area of the structure.

Window glass at the site was abundant. Although the home was torn down and no windows were intact, the broken remains of those windows were evident in the ground. Recordings of clusters of window glass in each unit and level allowed for the spatial arrangement of the glass to be analyzed, and the layout of the structure to be seen. Figure 3 is a 3-D model of the site showing the distribution of window glass in each level of each unit. The 3-D model reveals that Level 3 of each unit contains the most window glass. This model also shows that the window glass in Level 3 is distributed throughout the entire footprint of the home. The units with high window glass concentrations correspond to window placement in the home in the visual history (see Figure 1). According to the thickness of the glass, the structure dates to approximately 1894 (Jurney and Moir 1987). Since the glass is prominent in Level 3 of the site, this stratigraphic level can be dated no earlier than the late 1800s.

The architectural data, coupled with the GIS and artifact data, allow us to draw some conclusions about the placement of outbuildings and other structures at the site. If this structure is indeed the McAdoo Plantation Home it must have had a kitchen attached to it. In Figure 1 a structure can be seen in the background of the photo; the description of the kitchen placement in the oral history matches the placement of the structure in the photo. Plantation home kitchens were often situated away from the main structure due to the danger of fire (Carlson 1995).

According to Mr. Lathan's 1993 interview, the kitchen was attached to the home depicted in Figure 1 by a porch and was located on the east side of the home between the house and the cistern. There is both archaeological and GIS evidence that the kitchen of the site 41WT69 house structure was also situated between the home and the cistern. The kitchen area was determined through explor-

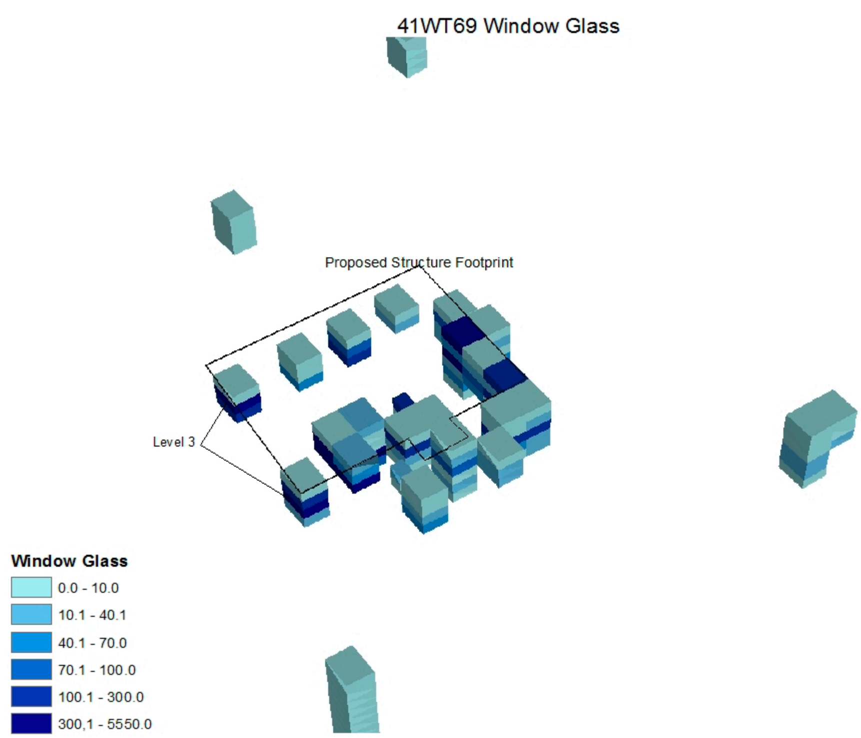

Figure 3. Distribution of window glass; each level is 5 cm deep, the maximum number of levels is nine. (Graphic by author, 2013.)

atory analysis of 3-D models and comparisons between the archaeological record and historical data. An abundance of kitchen related items such as utensils and cut faunal bones were found in the excavation units located at the east side of the structure (Figure 4). Many of the kitchen items were found at Level 3, which corresponds to the level at which the window glass was found.

This 3-D visualization technique does not have the spatial analysis abilities of other tools such as Esri's Spatial Analyst, but it provides an informative means of performing exploratory data analysis on spatial archaeological data. Additionally, while tools such as Esri's Spatial Analyst allow you to analyze artifact clusters and distributions, they do not allow you to visualize these phenomena across both vertical and horizontal scales. This 3-D Choropleth Model allowed each level and excavation unit to be visualized in the same map. Table 1 demonstrates the effectiveness of this visualization technique in the examination of site 41WT69 by comparing the information gained through the exploratory analysis of 3-D models to 2-D maps as well as analysis of the historical and archaeological data.

Conclusion

In the case of site 41WT69 the uncertainty found in the historical data suggested that an alternate means to seek information about the site might be a useful approach. GIS and 3-D modeling became indispensable tools for defining and examining the site. This visualization technique highlighted some of the major features of the home, including the kitchen and the windows. The window glass revealed the footprint of the home, and the kitchen materials revealed the kitchen area. The 3-D models showed that Level 3 (10–15 cm deep) reflected the most intense period of occupation of the structure. Upon analysis of the window glass, it was determined that this level must date later than ca. 1890.

These models have advantages and disadvantages (Table 2). 3-D models allow archaeologists to display each level of an excavation unit at the same time. Sometimes, however, each level and unit cannot be displayed together for a finished map product, although the obstructed units do not affect the overall message of the maps or the analysis. Another potential disadvantage of 3-D models is the

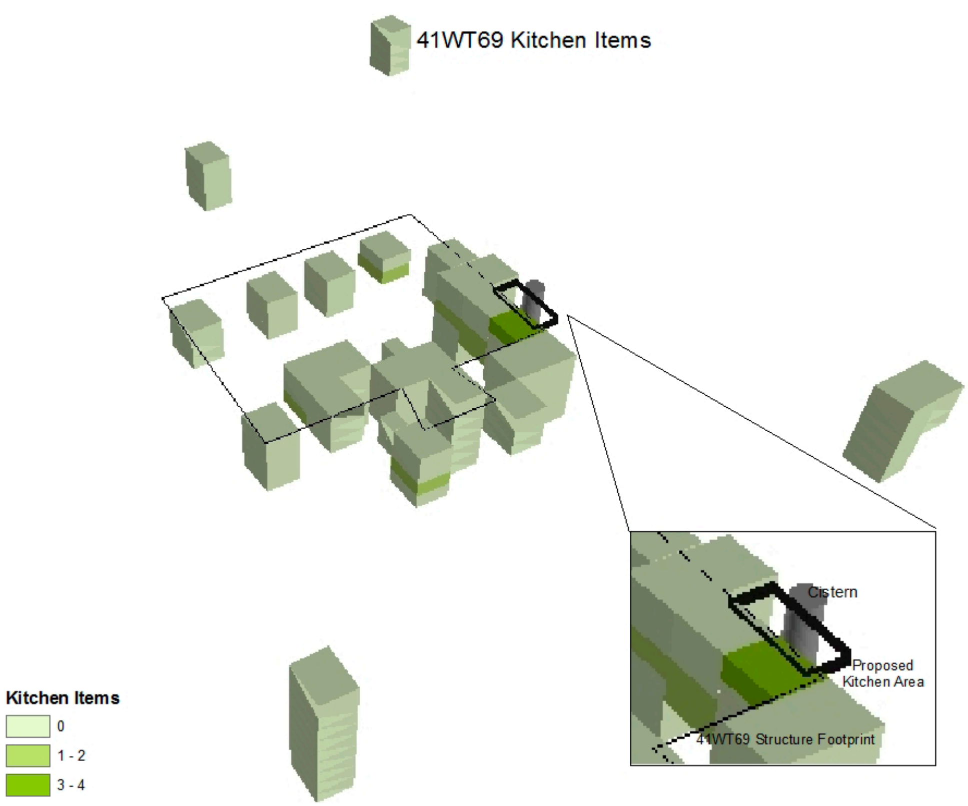

Figure 4. Distribution of kitchen items; each level is 5 cm deep, the maximum number of levels is nine. (Graphic by author, 2013.)

Table 1. Comparison of Data Types and Analysis.

			Spatial Data	
	Historical Data	**Archaeological Data**	**2-D Maps and Analysis**	**3-D Choropleth Models**
Windows	Windows were present on both stories of the home; this glass should date at least to the early 1900s to correspond to the date of the photographs and oral history.	Large amounts of window glass found that date to early 1900s.	Glass found dispersed throughout the footprint of the structure.	Higher density of glass in Level 3 of the site (Level 3 is determined to be the height of occupation at the site).
Kitchen Area	Kitchen is located between the house and cistern, connected by a porch. Photograph shows small structure adjacent to the house.	Kitchen related items found: utensils, cut bone, and ceramics.	Items concentrated in the units between the main footprint of the house and cistern.	Kitchen items found concentrated in Level 3.

Table 2. Advantages and Disadvantages of the 3-D Modeling Technique.

Advantages	**Disadvantages**
Display and analysis of each level and unit of a site.	Some excavation units or levels may be obstructed with 2-D visualization for a 3-D model.
Spatial analysis of artifacts.	Difficult to uniformly classify artifact count for each different level.
Can model the stratigraphy of a site.	The different levels may need to be exaggerated vertically for display.

scale of archaeological spatial data. Archaeological levels are often only a few centimeters deep. In order to display the data to show distinctions between levels, vertical exaggeration may be necessary, which can affect the integrity of the data. In order to combat this issue, cartographic license was exercised and arbitrary elevations were used to make the levels more distinct.

Although these models have minor disadvantages, 3-D models can be integral tools for archaeologists. By using the technique highlighted in this paper, 3-D models can be used to examine artifact distribution in each level and unit at a site at the same time. This technique can also be used to recreate the site and closely examine the stratigraphy and the architectural and structural features. In the case of site 41WT69, 3-D modeling facilitated the reconstruction of the layout and architecture of the structure and led to the discovery of new aspects of the site, such as the possible outbuildings.

This project introduced a new visualization technique, 3-D Choropleth Models, which combines two visualization styles: choropleth maps and 3-D modeling. Other visualization styles and techniques can be combined with 3-D modeling to further enhance archaeological site visualizations. Some 3-D modeling software, such as Esri's ArcScene, offer the ability to record a "fly through," which allows the model of the site to be rotated and seen at multiple angles in a video animation format. This tool may be helpful to explore sites whose layout does not lend itself to be seen from a static angle. The use of animated mapping combined with 3-D modeling also has the potential to enhance archaeological site visualizations. This particular technique was applied to vector data to create choropleth models; it can be applied to raster data to create continuous surface density maps, and may be implemented in other 3-D modeling software.

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References

Brutto, M., and Paola Meli
2012 Computer Vision Tools for 3D Modelling in Archaeology. *International Journal of Heritage in the Digital Era* 1(1):1–6.

Carlson, Shawn B.
1995 *The Anson Jones Plantation: Archaeological and Historical Investigations at 41WT5 and 41WT6, Washington County Texas.* Texas A&M University, College Station.

Conolly, J., and M. Lake
2006 *Geographical Information Systems in Archaeology*. Cambridge University Press, Cambridge, UK.

Demesticha, Stella, Dimitriou Skarlatos, and Andonis Neophytou
2014 The 4th-Century BC Shipwreck at Mazotos, Cyprus: New Techniques and Methodologies in the 3D Mapping of Shipwreck Excavations. *Journal of Field Archaeology* 39(2):134–150.

DeReu, Jeroen, Philippe De Smedt, Davy Herremans, Marc Van Meirvenne, Pieter Laloo, and Wim De Clercq
2014 On Introducing an Image-Based 3D Reconstruction Method in Archaeological Excavation Practice. *Journal of Archaeological Science* 41:251–262.

De Roo, Berdien, Jean Bourgeois, and Philippe De Maeyer
2013a On the Way to a 4D Archaeological GIS: State of the Art, Future Directions and Need for Standarization. In *Proceedings of the 2013 Digital Heritage International Congress*, Alonzo C. Addison, Livio De Luca, Gabriele Guidi, and Sofia Pescarin, editors, pp. 617–620. Institute of Electrical and Electronics Engineers, New York, NY.

2013b A Survey on the Use of GIS and Data Standards in Archaeology. *International Journal of Heritage in the Digital Era* 2(4):491–508.

Ebert, David
2004 Applications of Archaeological GIS. *Canadian Journal of Archaeology / Journal Canadien d'Archéologie* 28(2):319–341.

Forte, Maurizio
2014 3D Archaeology: New Perspectives and Challenges—The Example of Çatalhöyük. *Journal of Eastern Mediterranean Archaeology and Heritage Studies* 2(1):1–29.

Jordan, T. G.
1978 *Texas Log Buildings: A Folk Architecture*. The University of Texas Press, Austin.

Jurney, David H., and Randall W. Moir (editors)
1987 *Historic Buildings, Material Culture, and People of the Prairie Margin.* Richland Creek Technical Series Volume 5. Archaeology Research Program, Institute for the Study of Earth and Man, Southern Methodist University, Dallas, TX.

Katsianis, M., and S. Tsipidis
2008 A 3D Digital Workflow for Archaeological Intra-Site Research Using GIS. *Journal of Archaeological Science* 35(3):655–667.

Llobera, Marcos
2011 Archaeological Visualization: Towards an Archaeological Information Science (AISc). *Journal of Archaeological Method & Theory* 18(3):193–223.

Lock, G., and Z. Stančič
1995 Archaeology and Geographical Information Systems: A European Perspective. *American Journal of Archaeology* 101:163.

Losier, L. M., J. Pouliot, and M. Fortin
2007 3D Geometrical Modeling of Excavation units at the Archaeological Site of Tell 'Acharneh (Syria). *Journal of Archaeological Science* 34(2):272–288.

McCoy, Mark D., and Thegn N. Ladefoged
2009 New Developments in the Use of Spatial Technology in Archaeology. *Journal of Archaeological Research* 17(3):263–295.

Quartermaine, Jamie, Brandon R. Olson, and Ann E. Killebrew
2014 Image-Based Modeling Approaches to 2D and 3D Digital Drafting in Archaeology at Tel Akko and Qasrin: Two Case Studies. *Journal of Eastern Mediterranean Archaeology and Heritage Studies* 2(2):110–127.

Rahtz, S., and P. Reilly (editors)
1992 *Archaeology and the Information Age: A Global Perspective.* Routledge, London, UK.

Rua, Helena, and Pedro Alvito
2011 Living the Past: 3D Models, Virtual Reality and Game Engines as Tools for Supporting Archaeology and the Reconstruction of Cultural Heritage—the Case-Study of the Roman Villa of Casal de Freiria. *Journal of Archaeological Science* 38(12):3296–3308.

Simoneau, Daniel
1994 3-D Models in the Service of the Past: Geomatics in Archaeology. *APT Bulletin* ART XXVI-1-94:11–14.

Sylaiou, S., S. Basiouka, P. Patias, and E. Stylianidis
2013 The Volunteered Geographic Information in Archaeology. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences* II-5/W1:301–306.

Wheatley, D., and M. Gillings
2003 *Spatial Technology and Archaeology: The Archaeological Applications of GIS*. Taylor & Francis, London, UK.

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