Digital Historical and Cultural Preservation

Natalie Heacock, Mark Schwartz, Ph. D.

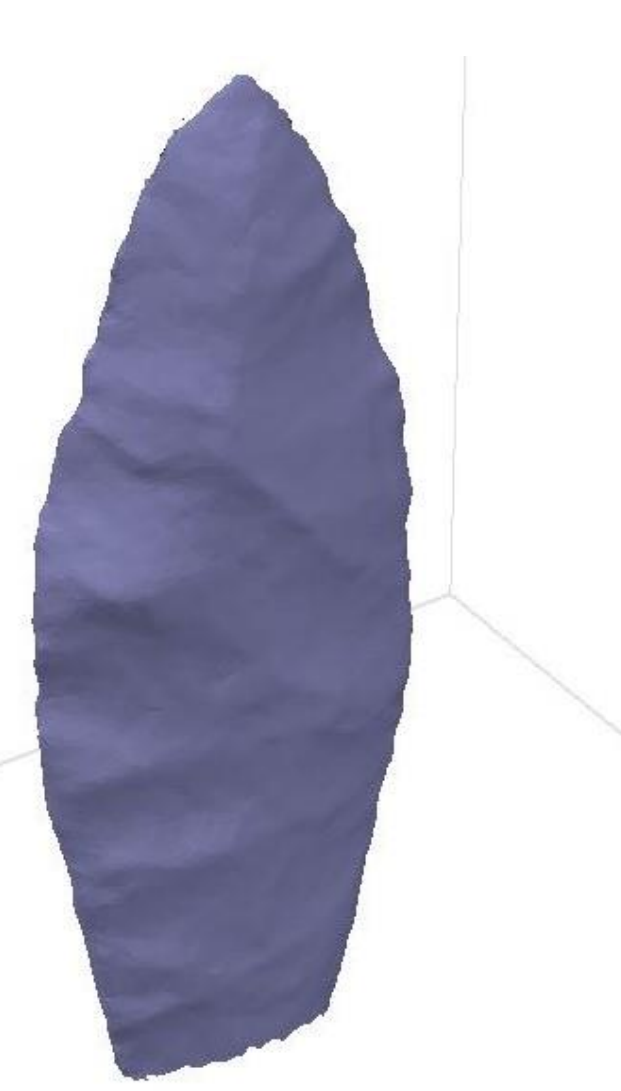**Grand Valley State University**

Introduction

It is now possible to digitally preserve and share artifacts and historical sites through the internet with the use of digital preservation techniques (Vincent et al 2017). Archaeologists and researchers can more easily collect, analyze, and disseminate information with the use of photogrammetry software and 3D scanning (Porter, Roussel, & Soressi 2016). With the availability of this newer technology and the creation of 3D models, the public's cultural heritage has become more assessable (McCarthy & Benjamin, J. 2014). The techniques discussed in this research provide an opportunity to go beyond photographic recording and create virtual replicas that can be used for accurate measuring (Richardson et al. 2012) and even printing for education purposes (Pollalis et al. 2018). This exciting newer technology opens many doors for archaeologists and cultural preservationists.

Abstract

The intent of this research is to test the effectiveness of different 3D model-making methods for digital historical and cultural preservation. The case studies presented are of two historic pots, a lithic, a bitumen sample, a shipwreck, and an historic windmill. The 3D models were created with the photogrammetry software Agisoft Metashape and the 3D mapping Structure Sensor Mark II. Equipment used in this research included a DSLR camera, tripod, photo box, lazy Susan, a scale for the small objects, and a drone for the windmill project. Digital cultural and historical preservation is important for keeping an archive of artifacts and heritage sites, not only for the sake of analysis, education, and public availability, but in case of damage or loss to the sites in the future. Each study shown provides an example of how photogrammetry software can further efforts in preservation, as well as research in the archaeological field.

Photogrammetry Application on Lithic

Photo of lithic on scale / 3D Model of Lithic / 3D print of lithic made from model

This 3D model is of an Agate Basin Projectile point excavated by the Grand Valley State University Archaeological Field School. Agate Basin points date to roughly 8500 to 7400 BC (Justice, 1995). An accurate scan of this Agate Basin projectile point was made using many photos taken every 10 degrees of the spear point. This was a particularly difficult scan due to the size and shape of the lithic, and the challenge still lies in trying to combine scans of the top and bottom, which were photographed separately. This application can be used to identify and analyze flaking and grinding marks on the lithic (Richardson et al. 2012) as well as allow others to access the artifact without having to come to the GVSU collections.

Merging Scans

This scan was made from an example of a Hopewellian Quadrilobate Pot from Newyago County donated to the W. L. Coffinberry Chapter of the Michigan Archaeological Society by H. Bouwknegt. Hopewell culture predominated in the Midwest from 100 BC to 500 AD, (Fagan 2005). The top and bottom were scanned separately. With the use of markers, the photogrammetry software was able to combine the two scans almost seamlessly to create one solid object.

3D model of pot in the photogrammetry software

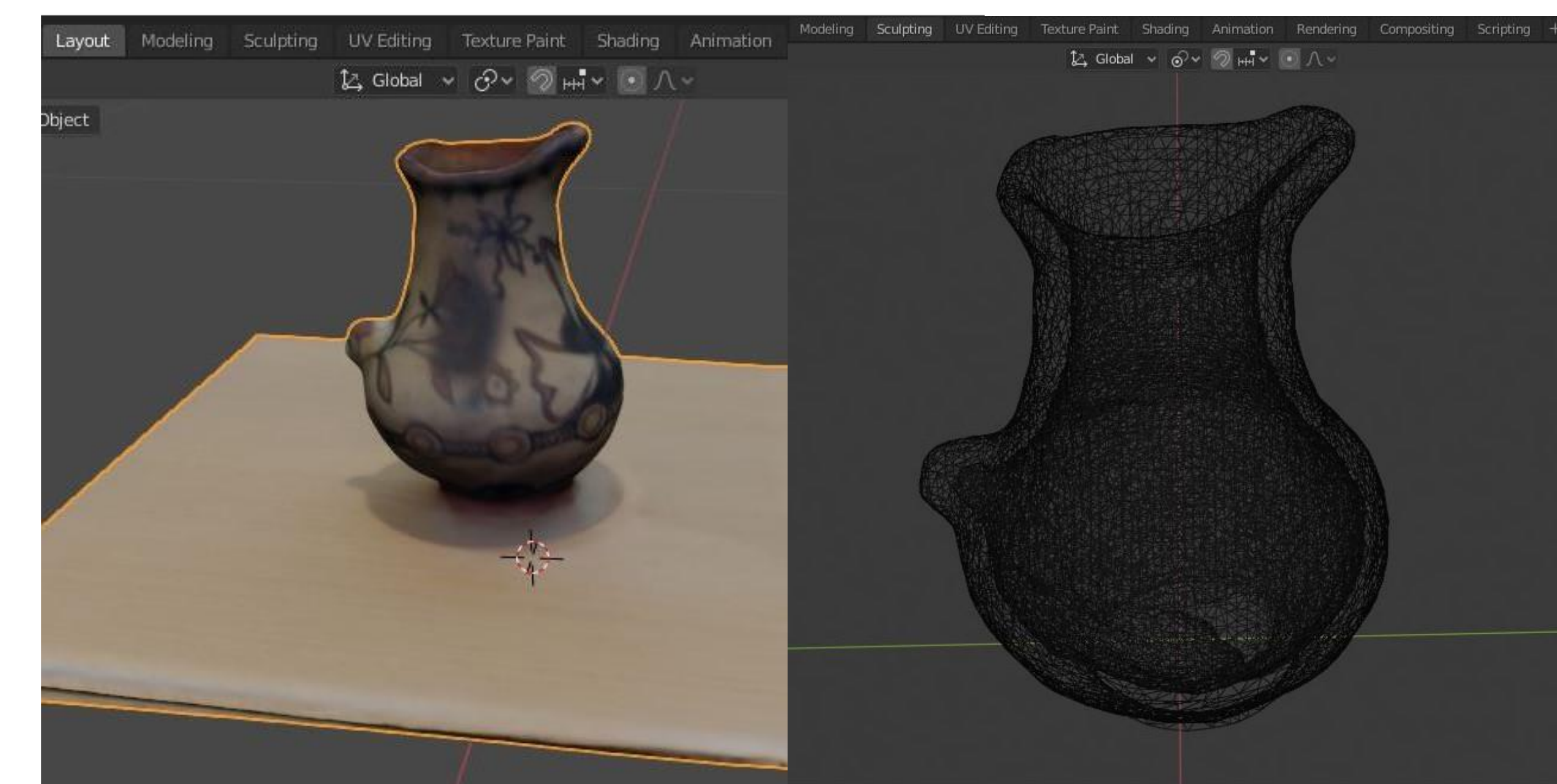The data acquisition process involves taking many photos

Landmark Preservation

Photo of the historic De Zwaan windmill and the 3D model

The historic De Zwaan Windmill, located on Windmill Island Park, was photographed using drone photography. Since its purchase from the Netherlands by the city of Holland, Michigan, it has become a local, much loved historical landmark (Goodell 2015). The photogrammetry software had problems identifying the beams and blades, but the overall shape, color and texture turned out well. This case study is an example of how photogrammetry can be used to preserve historic sites like this one and to create models of archaeological sites.

Further Research into Artifacts
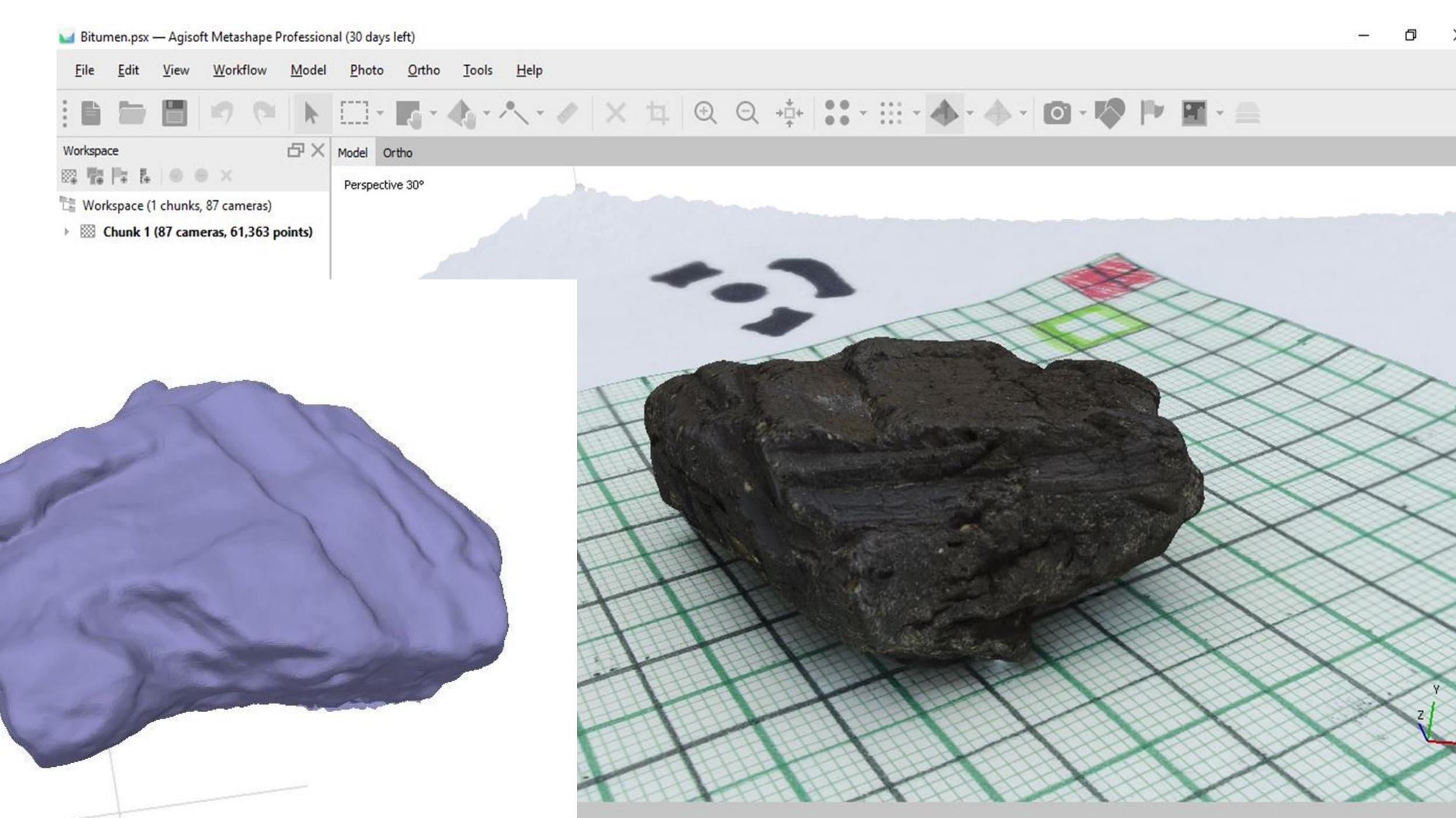
Screenshots taken of the bitumen 3D model in Agisoft Metashape

The photogrammetry software produced a highly accurate scan of a bitumen artifact using 87 photos taken in 20-degree increments. The artifact is a petroleum asphalt block with reed impressions that was recovered from a Mesopotamian trading colony in Syria dating to 3600 BC (Schwartz and Hollander 2016). A 3D print was made at the Grand Valley State University Tech Showcase located in the library. Further research can be done on this artifact by creating a mold of the 3D model to find out more about the reed and rope impressions on it. This artifact is only 5 cm wide, proving that the photogrammetry software is able to scan very small objects.

3D Structure Sensor Application

Editing the pot scan in the 3D rendering software Blender

In this case study of a historical pot the 3D mapping Structure Sensor Mark II was used. The scan produced moderate results, though the image that transferred was not good quality. Attempts were made to scan objects like a lithic, however, the scanner did not identify anything smaller than the size this pot which is approximately 20 cm high. The sensor attaches to an iPad and is advertised for scanning building interiors and portraits. Blender, an open source 3D editing software, was used to remove the scanned table from the pot.

Attempt in Scanning Old Shipwreck Footage
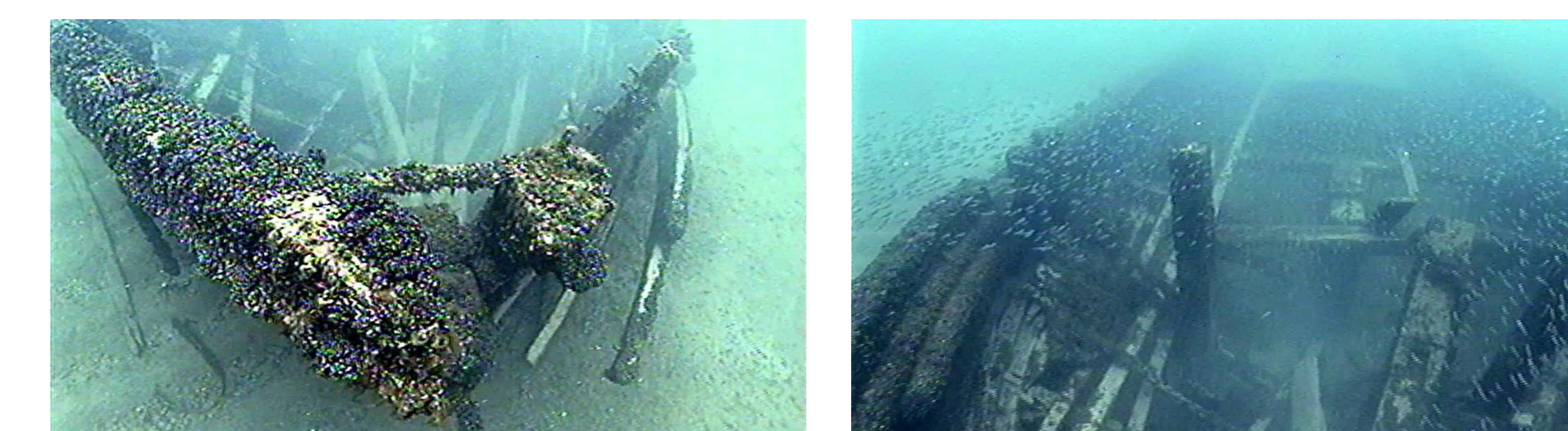
Snapshots of the Lumberman taken from old video footage

An attempt was made at taking old video footage of the shipwreck *The Lumberman* to create a 3D model in the photogrammetry software. The Lumberman was built at Blendon Landing, now part of Grand Valley State University, and sank in Lake Michigan in 1893 (Cooper and Kriesa 1992). Masking and marking techniques were able to improve the accuracy, but the scans did not turn out well because there was too much debris in the water. The many particles and fish make it difficult for the software to discern what is part of the structure.

Discussion

The case studies provided in this research show strengths and weaknesses of each method. Porter et al. (2016) developed the data acquisition process used in this research for the bitumen, lithic, and the Hopewell pot. Each object was placed on a 10 x 10 cm scale on a lazy Susan. The lazy Susan was rotated in intervals of 10 to 30 degrees for each photo. The camera height was raised up three times and the object was rotated again to obtain a significant amount of overlap in the photos. The use of the scale was important so that photogrammetry software could identify where the cameras were located relative to the object and produce an accurate scan (Porter et al 2016). Challenges lie in getting sufficient data for the scans, such as acquiring enough photos of the object; they must all be taken in the same lighting and therefore a high volume of photos must be acquired in a short period of time (McCarthy & Benjamin 2014). The Hopewell pot was photographed upside down and then photographed again sitting on its base, these sets of photos were scanned separately, marked at common points, and then the scans were combined to create one solid object. The marking method did not work with the lithic and it may be necessary to combine the top and bottom models in a 3D modeling software. Masking and marking techniques are used to improve the quality of the scan by selecting what the software needs to use and not use in the images as well as find common points on the objects. The case studies proved that these techniques work on both large-scale and small-scale projects. These applications can be used to create 3D models to preserve artifacts, historic landmarks, and archaeological sites for archaeological analysis and teaching aids.

3D models can be found on Sketchfab

https://sketchfab.com/natalieheacock

References

Cooper, David and Paul Kriesa (1992). *Great Lakes Shipwrecks of Wisconsin. National Park Service, National Register of Historic Places Multiple Property Documentation Form.* Unpublished manuscript on file, Division of Historic Preservation, Wisconsin Historical Society, Madison.

Fagan, Brian M. (2005). *Ancient North America.* Thames and Hudson, London.

Goodell, A. (2015 April 15) DeZwaan Windmill celebrates golden anniversary in Holland. *The Holland Sentinel.*

Justice, N. D. (1995). *Stone age spear and arrow points of the midcontinental and eastern United States: A modern survey and reference.* Bloomington: Indiana University Press.

McCarthy, J., & Benjamin, J. (2014). Multi-image photogrammetry for underwater archaeological site recording: An accessible, diver-based approach. *Journal of Maritime Archaeology, 9*(1), 95-114.

Olivito, R., Taccola, E., & Albertini, N. (2016). Cultural Heritage and Digital Technologies Theory, Methods and Tools for the Study and Dissemination of Knowledge in the Archaeological Practice. M. Forte and S. Campana (Eds), *Measuring the face of the past and facing the measurement.* 475-494.

Pollalis, C., Minor, E., Westendorf, L., Fahnbulleh, W., Virgilio, I., Kun, A., & Shaer, O. (2018). Evaluating learning with tangible and virtual representations of archaeological artifacts. Paper presented at the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction 626-637.

Porter, S. T., Roussel, M., & Soressi, M. (2016). A simple photogrammetry rig for the reliable creation of 3D artifact models in the field: Lithic examples from the early upper paleolithic sequence of les cottés (france). *Advances in Archaeological Practice, 4*(1), 71-86.

Richardson, E., Grosman, L., Smilansky, U., & Werman, M. (2013). Extracting Scar and Ridge Features from 3D-scanned Lithic Artifacts. In Earl, G. & Onwerpers, M. (Eds), *Archaeology in the digital era: Papers from the 40th annual conference of computer applications and quantitative methods in archaeology (CAA), southampton, 26-29 march 2012,* 83-92. Amsterdam, [Netherlands]: Amsterdam University Press.

Schwartz, M., & Hollander, D. (2016). The Uruk expansion as dynamic process: A reconstruction of Middle to Late Uruk exchange patterns from bulk stable isotope analyses of bitumen artifacts. *Journal of Archaeological Science: Reports, 7,* 884–899.

Vincent, M. L., López-Menchero Bendicho, V. M., Ioannides, M., Levy, T. E., ... (2017). *Heritage and archaeology in the digital age: Acquisition, curation, and dissemination of spatial cultural heritage data* (1st 2017. ed.). Cham: Springer International Publishing.