Digital Recordation, Analysis, Distribution, and Replication of Archaeological Artifacts

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Abstract

In order to protect archaeological collections, access to artifacts is commonly restricted to researchers with specific purposes. Even so, traveling to collection facilities to make in-person studies of artifact attributes can be time consuming and costly; moreover, manual measures of artifact morphology are relatively slow and realistically limited to a narrow range of potential dimensions. For studies based on the morphometric aspects of artifacts, three dimensional scans offer a viable alternative to museum visits or collection loans.

Here, we describe the application of 3D laser scanning to create digital replicas of artifacts, the use of these digital replicas for quantitative analyses, and their dissemination. We also describe the use of new, relatively low cost 3D printing techniques to create physical artifact replicas and their potential applications.

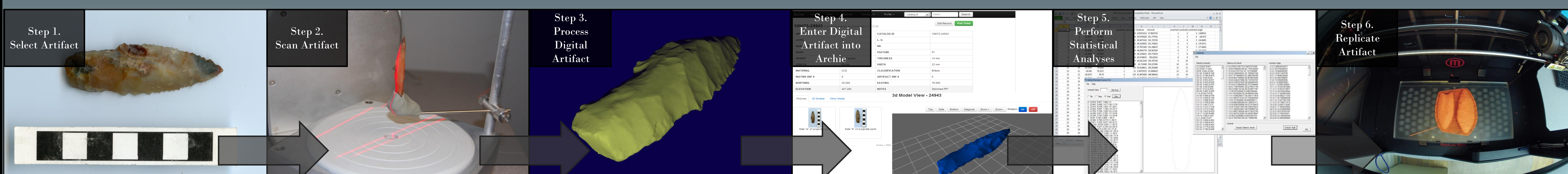
3D Laser Scanning

3D Laser scanning is a relatively low cost, non-destructive method of creating digital representations of physical artifacts. We used a Nextengine™ 3d scanner to achieve a 3-dimensional point cloud density that averages between 4,650 to 7,750 per cm^2 (30,000-50,000 per in ^2), with individual models containing between a few hundred thousand to several million data points depending on artifact dimensions. Artifacts are scanned from multiple angles and individual scans are stitched together, generating a watertight model that can be exported to various cad formats, used in digital analyses, or exported to 3d rendering applications to create complex animations for instructive purposes.

Analyses

Recent growth in computing capabilities, information accessibility, data processing, and 3d scanning hardware is poised to have a profound effect in morphometric analyses. Traditional methods of measuring artifacts can be bolstered by digital models in that measurement locations can be digitally recorded and audited by external reviewers. Three-dimensional scanning technologies generate large datasets however, with each model containing hundreds of thousands or millions of data points. Recording basic morphometrics (such as length, width, and thickness of a projectile point) using 3d data is fairly trivial, but does not fully leverage the possibilities of these large datasets. More extensive landmark based morphometric approaches can benefit greatly from modern 3d scanning technologies (Kuzminsky and Gardiner, 2012), however also require large amounts of time and extensive training to accurately perform.

Here, the authors propose using a combination of three-dimensional scanning, statistical morphometric analyses, and machine learning tools such as BigML (Leavitt, 2013) to facilitate high-precision measurements in a reproducible, accessible, and low-cost format.



Data Distribution

Many institutions have digital museums allowing for viewing of 3D models. However, most do not allow the download of the source data files and either restrict or do not have access to associated data such as provenance information or field notes. Access to source data is important in that it allows for analysis using digital statistical morphometrics, replication by CNC systems or 3d printing technologies, as well as being able to frame artifacts in broader archaeological contexts.

Because of this frustration, we adapted Archie (http://archiedb.com), a freely available, open source, web based archaeological inventory system to handle 3d data sets (Nyers and Vollmer, 2012). This system allows access to field notes, artifact provenance data and photographs, and has an integrated viewer /downloader for 3d data.

From the Digital to the Physical

The field of additive manufacturing has exploded in the past several years, with varying types of devices at a multitude of price points. We opted to use an extrusion based 3D printer known as the Makerbot Replicator 2 ™ to create physical replicas of digital models. This device has low up-front, operating, and maintenance costs, creates physically robust objects that can be used in classroom environments, and supports resolutions approaching 100 microns (Makerbot, 2012).

Using software, models can be adjusted in scale, allowing for the resizing of physically small models (such as a microcore) or the scaling down of large models (such as a lidar scan of a landscape.) Digital models of artifacts can also be digitally "repaired" and then printed, allowing for reconstruction of fragmentary artifacts (Flaherty, 2012).

References

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