PRACTICAL RECORDING ISSUES AT SMALL AND LARGE SCALES IN MAYA ARCHAEOLOGY IN BELIZE

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Abstract: Field archaeology presents challenges for accurate recording. Over the past three years the Center for Heritage Conservation at Texas A&M and the Maya Research Program (MRP) have partnered together to explore how, and if, digital recording technology provides advantages for their ongoing work in the Blue Creek region of Belize. The current standard for recording of sites and artifacts for the MRP is 2D stippled line drawings for artifacts and 2D CAD or hand drawings for sites. Since many of the sites explored are in danger speed and accuracy are important, but so too is product. This paper explores challenges to digital recording techniques presented by various MRP endeavors covering large scale sites, burials, chultuns, and small scale artifacts. Technologies discussed are terrestrial LIDAR, structured light scanning, and photogrammetry.

1. INTRODUCTION

The RecorDIM initiative of ICOMOS, CIPA, and the Getty Conservation Institute was an effort to overcome the gap that exists between information providers (service providers) and information users. (1) This initiative predicted the current condition of many "information users" with respect to digital 3D data resulting from tools such as laser scanners and photogrammetry. With an ever increasing availability of 3D digital services, users are faced with questions about how best to utilize these proven technologies for their particular needs. The Center for Heritage Conservation (CHC) at Texas A&M University works with many end-users exploring how they might best utilize digital 3D data. These users are typically small offices or agencies of Architects, Engineers, and Archaeologists that do not have resources to hire or manipulate scan data on a regular basis.

The Maya Research Program (MRP) is a non-profit organization that explores Maya Civilization and Culture in the Blue Creek region in Belize. They have a 20 year work history in Belize having discovered dozens of buildings and sites. Each summer session yields large expanses of architecture, special finds, skeletal remains, and hundreds of pottery sherds. All of these objects are meticulously cleaned and catalogued for further study. The architecture is surveyed, usually by hand and drawings are produced with basic measurements as a record of its form and size. Since many of these sites are vulnerable when exposed the work is often completed in a single summer; sites are exposed, documented, and preserved through reburial.

Documentation of the work is always important, but when the architectural evidence is covered and the artifacts removed, documentation becomes the public object. For the past 20 years the Maya Research Program has relied on 2D products as the public record of their work. The CHC has been working with MRP to explore alternatives for that 2D public record. This paper will cover the status of collaborative efforts between the CHC and the MRP at understanding the value of digital documentation at various scales. To this end we will explore the use of LIDAR, Photogrammetry, and Structure Light Scanners for use at varying levels of detail and scale and utilization of 3D products.

2. TERRESTRIAL LASER SCANNING

Archaeological fieldwork presents challenges for documentation. Project locations can create adverse conditions for careful documentation through dangerous or difficult contexts, the need for speed, or complex conditions that require multiple approaches. Archaeologists understand well all these challenges and also understand how to deal with them through conventional means. One of the embedded advantages of 2D products like drawings and photographs is that they require strategic analysis of site conditions in order to produce the drawings and photographs required to adequately describe and interpret the site. Tools that produce point clouds don't require the same kind of strategic thinking but they are not completely void of planning. (2) Still, the promise of ubiquitous coverage with point clouds can reinforce attitudes of false confidence in a tool's ability to correct what the operator might neglect.

In our work for MRP laser scanning hasn't come easily, though it is now more common in archaeology in general.(3) Sites often occur in deep jungle contexts requiring transport of a large amount of equipment. Though new scanners are emerging that are one-quarter the weight and size of our Riegl 390 we don't yet have the resources for them. Since we generally have one chance at recording a site and the schedule is negotiated with the archaeologists in charge, we must be certain that we have come away with proper data. Data registration between scan positions is extremely important so we spend a good deal of time in preparation for the actual scan. Target locations and scan positions are mapped according to object information. Negotiations between our team and the archaeologists concerning the hierarchy of information usually occurs before our visit to the site and continues while on location.

2.1 Chum Balam Nal

Figure 1. Chum Balam Nal Site Blue Creek, Belize

The Chum Balam Nal (CBN) site is a residential group, measuring approximately 60m by 30m, that has been excavated over two seasons (Figure 1). Because of the dense jungle location and multiple level changes it provides good reasons for adopting laser scanning for documentation while also offering practical challenges for it. The most important challenge is the location of targets and scan positions to ensure the capture of critical object information and also provide excellent registration of project scans. To accomplish this prescan arrangement requires detailed understanding of the exposed architecture, but it also requires knowledge of important context information such as relationships of buildings, location of artifact discovery zones, burials, and possible burials. Even with excellent preparation, plans can change depending on time, weather, and site conditions. Knowledge of critical information requirements helps frame scan resolutions at each position and decisions to create new scan positions in the project.

Given no malfunctions of operator or equipment the documentation in the form of point clouds of this site was accomplished in 4 to 6 hours. What has actually been accomplished at this point is the capture of many individual scans with the promise of being able to register them well. Though we try to create plenty of overlap with our targets we always back up this system by locating targets with a total station. With manual registration as an option this gives us three possible means of registration to use independently or in combination.

It is misleading to think that this six hour field session constitutes documentation, but it already has created some benefit. The organic qualities of the architecture coupled with large variations in elevation make hand measuring quite difficult. Plans and sections that include relationships between buildings and site features would require either a great deal of time or an abdication of certain forms of information. Still, there is something of value with hand measuring and drawing. The engagement with the site required in hand measuring and drawing provides the benefits of reflection and study. The team performing this work will certainly become experts on site relationships and specific construction details, an expertise that may not be gained even by the managing archaeologist.

With a digital point cloud, unless the archaeologist is comfortable with this data type, she must rely on others to create the final product. Is this really a problem? Archaeology is a multidisciplinary activity with many specialists contributing their expertise to the research. Yet, at this point, familiarization with digital scan information is still very limited. Even if there were capabilities to handle translation of point cloud data into knowledge products communicating research with others is difficult. Thus we have suggested that products we produce for them should be 2D and easy to manipulate through CAD or hand drafting. This is not to say that we think they should rest at this point accepting our data and interpretive products. So we also engage in educational experiences to foster comfort with new digital tools that would allow exploration of 3D models and point clouds. But before they reach that point we provide them with 2D orthographic images (Figures 2 and 3) of the scan at a common scale that they can use in printed form or digitally manipulate in graphics and CAD packages.

Figure 2. Chum Balam Nal Point Cloud

Figure 3. Chum Balam Nal Point Cloud Section

3. PHOTOGRAMMETRY

Laser scanners are expensive to own and operate and require experienced personnel connected with the project to manipulate point cloud data and mine information. The high prices of scanners ($30,000 - $150,000) will keep experienced users in an elite group preventing the creation of the casual user class. Photography was in this same situation 150 years ago, close-range photogrammetry just some 30 years ago (4), and digital photography had the same experience just ten years ago. However, as prices have fallen and technical prowess has accelerated, digital photography has created a large class of casual photographers. Though the point-and-shoot class may not speak the same language as highly experienced amateurs or professionals they nonetheless know how to manipulate their cameras and the resulting digital images. At a fraction of the $50,000 and up for a laser scanner, digital cameras are available for between hundreds and a few thousand dollars. With some training in composing images and software such as Photomodeler equipment costs are reduced, field time is short and the result is a 3D surface model or point cloud.

3.1 Burials

Burials in the Blue Creek settlements are often discovered beneath plaster floors reveling themselves as faint indentions near doorways. These discoveries often bring with them the stress of increased documentation requirements at the latter part of a dig season when time is short. Because they often contain multiple layers burials are documented multiple times. Each layer is photographed and measured before work continues with the removal of remains and artifacts. Traditional documentation methods can delay progress through the burial layers as they require direct access to each layer. If, however, field time consists of taking a few photographs, work can continue immediately after the photographs are obtained. With Photomodeler Scan and a calibrated camera we were able to reduce field time to a few minutes and provide them with orthographic images they needed to trace their drawings. The only field requirements are positioning of camera shots that lie within tolerances of stereo pairs, i.e. ratio of distance between shots to distance of object is on the order of ¼ to 1. Multiple pairs of stereo shots are combined with shots at various angles so that camera orientations may be calculated to high tolerance. If one is pressed greatly for time, a single stereo pair can give very good results. Figure 4 is a photograph used to aid in processing but not one of the stereo pairs used to create the point cloud in Figure 5. The brighter areas of Figure 5 represent areas of higher resolution processing (2mm point spacing). The burial at Bedrock is an example of shots taken as backups for total station documentation but were processed into a model two years later. Processing time was less than one hour.

Figure 4. Bedrock Burial Blue Creek, Belize

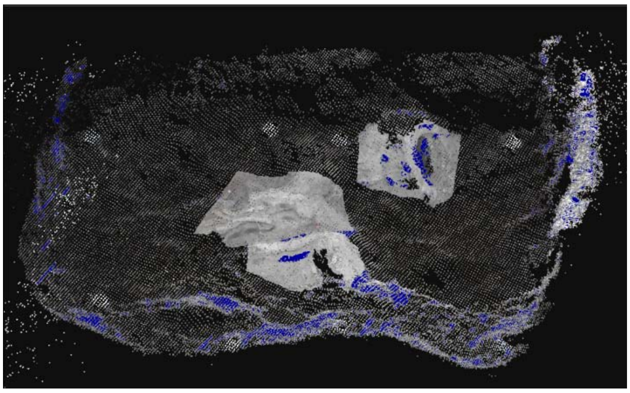

Figure 5. Bedrock Burial Blue Creek, Belize

3.2 Special Finds Disk

Large scale objects can be modeled with surfaces and textures but they can require a great amount of time and computing resources depending on the resolution requirements of the model. Small objects lend themselves to modeling but are challenging because the resolution of their information is quite high. Another test of Photomodeler was the measuring and modeling of a carved disk which had inlay regions for stones and markings scratched on its surface. The disk in Figure 6 is 60mm in diameter which allows for easy access for photography. Though many options exist for measuring and modeling the disk our interest is whether photogrammetry, with a relatively inexpensive package is up to the task in terms of accuracy and resolution, but we also want to know if the process is simple enough to be accessible to those with little photogrammetry background. Ideally one would aim for a completed model of front and back faces complete with edge detail. We only tested the front face with its inlay notches. Using a Nikon D200 with an 18-70 mm lens we created a single stereo pair. After a few minutes of processing we reached the result in Figure 7. Creating a textured model that represents an abstracted model is quick and simple, but one look at the shaded model shows it to be a false representation. Without careful attention to point and mesh quality one might take the automatic processing to be successful. This doesn't discount the quality of the photographs or even the initial point cloud processing. Creating final accurate 3D models requires time.

Figure 6. Disk With Inlays

Figure 7. Disk Model

Traditionally the documentation of this disk would be a stippled drawing created through tracing a print of a rectified photograph. Artifacts of this caliber are sent for safe keeping to the Institute of Archaeology, stored out of sight from public view. Do 2D drawings and photographs hold enough information to understand this artifact? In many ways they do, but they necessarily exclude information that might be useful. It seems useful to try and obtain a quality textured 3D model. Like most choices, this goal is achievable at a small initial cost in time but modeling time can be quite extensive. To achieve an accurate finished model is not automatic for the average user, but it is possible.

4. Structured Light Scanning

Another promising technology for modeling small complex objects is structured light scanning. A number of inexpensive (a few thousand dollars) products exist that give good results. We chose a product from 3D3 Solutions to test the ease of use on artifact models. Though this particular model is a bit cumbersome compared to other mid priced or higher priced products it is easily transported and setup for work. Structured light scanners operate by projecting a known grid onto the object and calculating coordinates from a stereo pair of images of the deformed grid as it is draped over the object. Figure 8 shows a small 4cm bone sculpture with the resulting grid. One advantage of these tools is very high sub millimeter resolution in there point clouds making them ideal for very small complex artifacts. A drawback is the need for their projected grid to be seen and photographed thus rendering their use difficult or impossible in bright light conditions.

This bone sculpture was modeled from 12 scans from various angles (Figure 9). Like terrestrial laser scanning the individual scans were registered together to form a single point cloud. Instead of using the point cloud directly to create orthographic images for producing 2D drawings, we explored advantages of a triangulated mesh, realizing of course the difficulties faced with creating an accurate model. We chose to utilize 3D developments in Adobe PDF to produce a 3D PDF of the model. Users do not need to have the extended version of Acrobat to read and manipulate the model giving them great leverage in creating the products they need to enhance their research. Figure 10 is an example of a section cut of a 3D PDF. Season Field reports will remain 2D when printed, but as digital documents, artifacts can be viewed, manipulated, and analyzed in 3D.

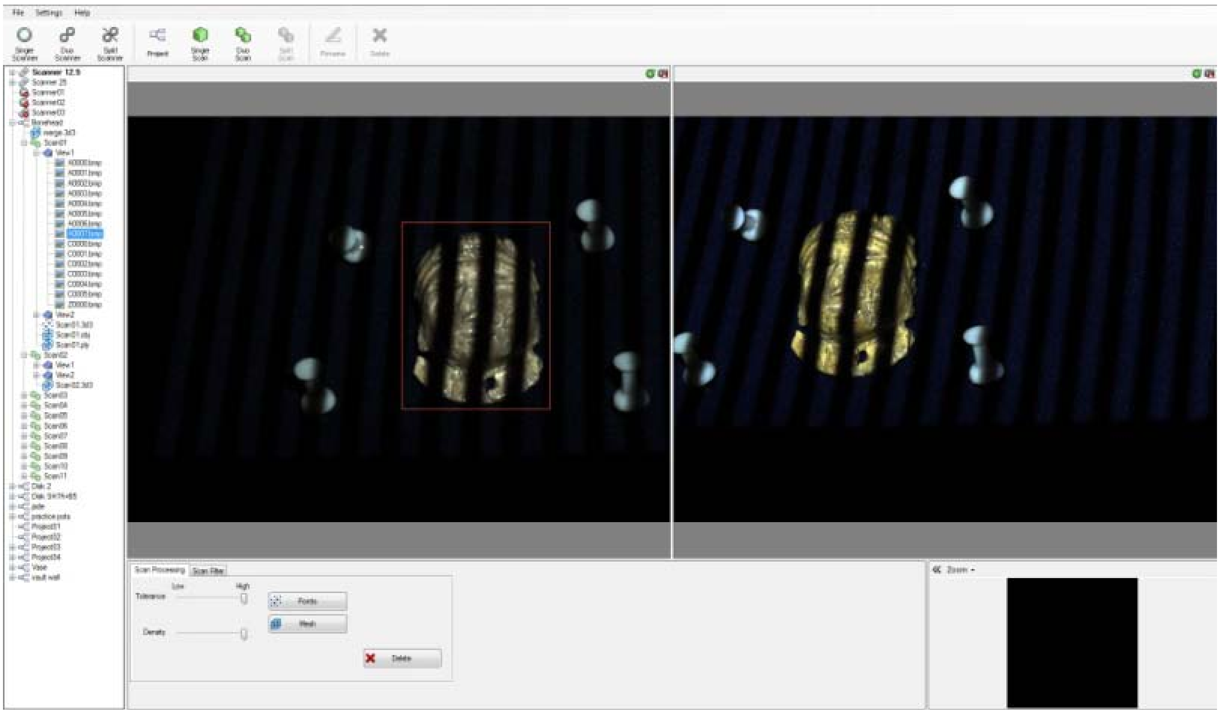

Figure 8. Bone Sculpture With Light Grid

Figure 9. Disk With Inlays

Figure 10. Disk Section 3D PDF

5. CONCLUSIONS

Technologies used in all of these case studies are not now revolutionary. Scanning and photogrammetry have been around for decades in various forms, but are typically reserved for disciplines with deeper pockets than archaeology. In each of these cases, higher end equipment (or newest versions in the case of terrestrial scanning) might offer better results more rapidly. But it should be noted that there is no magic to gaining high quality 3D results. Errors in procedure, equipment, and software create errors in models that to the casual observer seem correct. There are no tools whose casual use, automatically result in high quality 3D products. Drawing requires expert abstraction of 3D information into 2D planes. 3D products require different expertise for their creation but at least equal or greater amounts as their 2D counterparts to ensure quality. Archaeology has been making the move towards this creative expertise for some time, now it must begin to make strides in manipulating and reading 3D products. As new ubiquitous software solutions such as 3D PDF and web based point cloud review become commonplace the power of 3D will incentivize its acceptance as the new data form.

6. REFERENCES

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