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Taking a Technical Leap: 3D Imaging of New Guinea Bisj Poles

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Abstract

In 2021, the Michael C. Rockefeller Wing (MCRW) in the Metropolitan Museum of Art, which focuses on the regions of Asia, Africa, and the Oceana, began the process of deinstalling its collection to start renovations on their galleries. The Imaging Department coordinated closely with the curatorial, collections and conservation teams to develop a comprehensive 2 and 3D imaging campaign. This paper centers around the unique challenges our team faced when asked to record, completely and accurately, four monumental New Guinea Ancestor (Bisj) Poles, carved out of the wood of mangrove trees by the Asmat people, on an extremely tight timeline. The decision to employ 3D digitization is always a difficult one because technology is constantly evolving and there are few standards for image quality metrics. This paper documents our team's approach to solving technical challenges.

Background

During the early planning and testing for the MCRW imaging campaign, we found that the Artec Leo scanner worked well for digitizing oversized collection assets. Our team compared 3D renders with traditional Hasselblad 100 Megapixel digital captures to explore every potential use-case. Assets ranged from carved wooden House Posts (10 ft / 310cm) to Slit Gong Finials (5 ft /160cm). The portability and rapid capture capabilities of the Artec Leo seemed like a perfect fit for the larger in situ gallery objects, but we struggled with a particular feature of the Bisj Poles from New Guinea. The monumental 15 to 20 ft tall (4.5 to 6.6 m) carvings incorporated finely detailed rope elements (4 in / 9.1 cm) with tassels that were not resolving in the processed Leo scans and simply did not yield adequate results. We set out to test using photogrammetry with a DJI Osmo Pocket camera and a Canon DSLR to create separate models of the tassels that could eventually be aligned with the Artec Leo scan. The photogrammetry test was successful and captured not only the details of the tassels, but also revealed dramatic detail improvements of the surrounding elements of the artwork. (Figure 6) We were faced with a difficult decision: image the artworks using the Artec Leo at the expense of detail, merge the two data sets at the expense of accuracy, or attempt to capture the four sculptures using photogrammetry.

For the original tassel test dataset, our team decided to use the DJI Osmo Pocket camera because its compact size and gimbal head would help with accessing small difficult to reach elements. We used a battery powered ring light on a simple bracket for illumination. (Figure 1) With 56 photographs in the dataset, the test results of the Osmo were remarkable. Not only did we achieve more resolved tassels, but much of the area around them was rendered as well. While discussing the findings with the team, we realized that if the Osmo could net us that level of resolution, imagine the detail we could reach by using a Canon DSLR with a much larger sensor. The idea of capturing all four artworks using photogrammetry in addition to the Leo captures was initially rejected due to time constraints, the breadth of the 2D/3D imaging survey currently in progress, and the gallery's construction schedule. After reviewing the results and assuring the studio manager that our team could photograph datasets of four Bisj Poles, ranging in heights from 15 to 20 ft. (4.5 to 6.6 m) tall in four days, and before the floors of the gallery were removed, we finally received approval from our department, the conservation team, and curators to start the project. The museum staff involved concluded that while the effort ran counter to our original digitization plan, this was a once in a generation opportunity to capture these objects.

Approach

The decision to move forward with photogrammetry hinged on quickly developing a solution to safely capture thousands of images, maintain accurate color and density while constrained to, and operating on, an 8x4 ft (1.2 x 2.4 m) platform scissor lift. This would be the first time our department had approached modeling sculptures of this size using photogrammetry. Everyone in our department contributed their expertise from maneuvering a rig between the Bisj poles which, in situ, were 6 ft (2 m) apart, to color management and rendering. Our team's initial focus centered around safely, and quickly, capturing the photographs because we had only four days to complete photography before the de-install and could not go back for more captures.

The team approached photographing the Bisj poles in a similar manner to a walkaround capture of objects that are too big for a studio turntable. Some of the obstacles we encountered, and needed to resolve, included the Bisj Poles being installed next to a wall of windows, which backlit the objects. Additionally, three out of the four poles were mounted beneath the floor. (Figure 2) Using an 8 x 4 ft (1.2 x 2.4 m) platform scissor lift, that extends up to 20 ft (6 m) high, we configured 2 strobe lights with stands, umbrellas and a Broncolor strobe pack on the lift. The team placed one light stand on the far left and the other stand as far on the right as possible. (Figure 3) Due to the size of the platform rig and distance between each Bisj Pole, we needed to ensure the umbrellas did not extend over the edge of the lift and potentially damage the carvings.

When it came time to plan the lighting setup, the team wanted to soften the strobe flash as much as possible by bouncing the light off umbrellas. We also set up a white bounce card on the opposite side of each Bisj Pole to help manage the light falloff. On the scissor lift, there was only about 2 x 4 ft (0.6 x 1.2 m) of space between the lights and open umbrellas. The team decided that hand-holding the camera would be best instead of using a tri/monopod because movement on the lift was extremely limited. The physical stress of that decision on the body added up by the fourth day of shooting but there was not a better, or safer, option for capture. The camera we used to photograph the datasets was a Canon EOS RP. The exposure was F11 at 1/125, ISO 100. We used a one-third overlap dataset capture with an EF 11-24mm lens fixed at an 18mm focal length.

About one week after the original captures, the Bisj Poles were deinstalled and wrapped for storage by the conservation team and placed horizontally on wheeled racks. The conservators left the bases that were once beneath the floors unwrapped for photography. For this dataset capture, we used a similar set up to the platform scissor lift, with two strobe lights, umbrellas, and the Canon EOS RP. The art handlers were able to raise the bottom of the three Bisj Poles by placing protective mounts under the weakest points of the wood carvings until we could safely photograph the base and capture enough detail from this new dataset to align with the in situ dataset.

After our team completed photographing all four Bisj Poles, including the bases that were hidden, the number of photographs in these datasets ranged from 1600, on the smallest Bisj pole, to 2000 on the largest. (Figure 4) The raw DNG images were processed in Lightroom using an ISO19264 scene-referred preset that was calibrated and verified using a DCSG color chart, photographed under umbrellas and strobes. Because of the limitations of fixed lighting from the lift, a percentage of images required adjustment to shadows & highlights for consistency. To maintain objective color accuracy, we used a linear grayscale with holes punched and a spectrophotometer to measure L*a*b* values from the actual objects. While photogrammetry software tools incorporate lightness balancing functions, we have learned that accurate scene-referred source images will always result in higher fidelity models.

After exporting the photographs from Lightroom, the datasets were processed in 3DFlow Zephyr and two of the datasets came together seamlessly. Our team is constantly exploring new tools and techniques as 3D imaging is rapidly evolving. At the time of this project, we had just started exploring Reality Capture (RC) and we were already trained in Metashape and 3D Flow Zephyr (3DF). We decided to try modeling the datasets, 1979.206.1611 (Bisj Pole 01) and 1978.412.1254 (Bisj Pole 04) that were not aligning in 3DF into RC. Reality Capture was quick and efficient when it came to aligning the photographs, but unfortunately, we were still having a hard time aligning the bases with the in situ captures. The alignment issues were primarily due to conservation's support elements obstructing the bottom captures, which could not be removed for safety reasons, and thus hiding potential alignment points with the in situ captures of that same area. To complete these two models, we used the top (in situ) STLs from RC and imported them into 3DF where we had already modeled the base (conservation racks). By looking for visual artifacts that matched on both meshes, we manually attached the mesh of the top to the base mesh by adding control points to the matching artifacts and then merging the meshes. The mesh of 1979.206.1611 (Bisj Pole 01) merged perfectly with no defects on the base. The models from 1978.412.1254 (Bisj Pole 04) did not merge seamlessly, creating a line in the mesh between the joints where the top and bottom datasets attached, which we would need to repair.

Our team faced an entirely different set of challenges refining the models and preparing them to be viewed for online and possible book publishing. Specifically, we would need to repair the 1978.412.1254 (Bisj Pole 04) mesh and texture from the misalignment and refine the mesh of the tassel and rope elements for a more accurate curvature. Geomagic Wrap, a mesh editing software, was used to cut the problematic areas out of the mesh and refill the holes to smooth out the geometry of the triangles. To match the fine detail of the tassels, we used photogrammetry images as a visual reference for our edits. We used Substance Painter, the 3D painting software, to fix the texture on the base and tassels. Within Substance Painter, the color selection tool was used to accurately match the color of the tassels from the diffuse map. The opacity and shape of the brush used to paint color onto the model was also important in blending the edits seamlessly. (Figure 5)

Results

Our team's workflow often incorporates editing a version of the mesh and texture to resolve issues, conservation buildouts, or model comparison. We make sure to archive every step of the process while also having a final edit that is ready for printing or publishing. Upon successful completion of the Bisj Pole model, our next challenge was figuring out how to get 1979.206.1611's (Bisj Pole 01) very detailed, high-poly render into a presentable format.

There are currently no objective methods to compare the quality of 3D models. One approach is to render the 3D model as a Tiff file and compare this to a traditional 2D image of the same object. While this is still a visual comparison method with variables and limitations, observers are able to quickly assess quality. Many rendering programs exist, but the software our team used for rendering the Bisj Poles was Keyshot by Luxion. Keyshot is a ray tracing and global illumination software program that allows a user to view how lighting affects the 3D model or scene. Depending on the material of the 3D model, a shiny surface versus a matte surface will change the impact of the lighting effect. One limitation of photogrammetry (outside of a light stage) is that not all necessary material properties are generated when texturing. Adjusting the material properties of the file such as gloss level and generating ambient occlusion maps will help achieve the desired effect on the piece, but this work is highly subjective, and skill based. Creating HDRI maps can help with general illumination, but creating an HDRI for the in situ Bisj Poles would not be possible.

The resolution of the rendered tiff was set to approximately 5K in order to ensure that the fine details of the piece could be seen. To achieve photographic quality and match the 2D Hasselblad images taken during the imaging campaign of the MCRW galleries, the render was adjusted in Photoshop to match the colors of the 2D Hasselblad photographs. By masking affected areas, making the masks into layers, and adjusting the layers in Photoshop, we were able to enhance the saturation, density, and color temperature of 1979.206.1611 (Bisj Pole 01) and 1978.412.1254 (Bisj Pole 04) to varying degrees. The gray background of this render was created with the gradient tool. We made a shadow by using the shape of the Bisj Pole, the skew tool and a fill layer, to help the render look more believable. Attempts to render a shadow in Keyshot proved to be difficult because there was no studio lighting precedent for these objects standing on their own without support, only photographs with the poles installed beneath the floor. (Figure 2)

Working on 1979.206.1611 (Bisj Pole 01) and 1978.412.1254 (Bisj Pole 04) has undoubtedly impacted how we render moving forward. The surface quality of the model, the method of lighting, and the render settings used all contribute greatly to the resulting image. A challenge with rendering in Keyshot is that the output did not keep the color of the original Bisj Pole. The method of lighting for photogrammetry is one that emphasizes flat lighting to eliminate shadows. The process of lighting in any 3D software entails doing the opposite.

For example, in Keyshot, lights are placed along an XYZ axis to mimic a real-life lighting scenario and the diffuse map provides the color of the object. Editing the diffuse map with the roughness, ambient occlusion, normal map, and metallic map, in a process called shading, is what helps the object react to the lighting because those maps provide the information about the object's surface quality. The combination of lighting and shading is what creates a photorealistic render. This is one of the reasons why so much post-production was needed on the render. Our team learned that if material adjustments are not made within Keyshot, you will have to make these adjustments in another program. Fidelity is our team's focus in cultural heritage imaging and we found it is best to improve the quality of the render than spend time fixing the result in Photoshop.

For public use, we decimated the models and used a software program called InstaLod to optimize and bake low poly 2K and 4K texture delivery files. (Table 1) These OBJ files were converted to USDZ using Reality Converter and GLB using Adobe Stager. The Bisj Pole models have also been used to create 2D and 3D printed mock-ups for the newly renovated galleries and to help create mounts for shipping and gallery installation. Currently, one of the Bisj pole renders (1979.206.1611) can be seen on the Metropolitan Museum of Art's object page.

Table 1

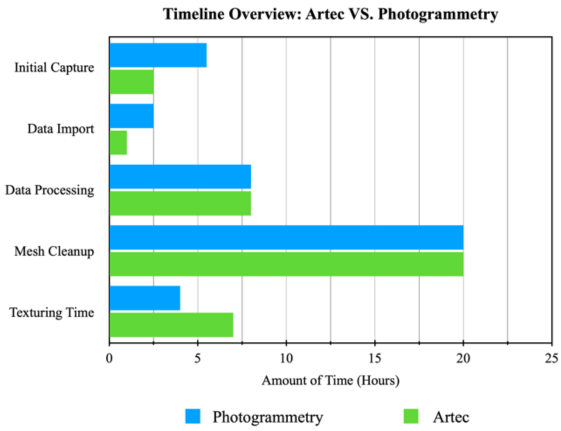
1	2	3
RAW SCAN DATA REALITY CAPTURE	FULL RES PROCESSED	INSTALOD
4.19 GB	1.2 GB	1.2 MB
Triangles: 37,999,998	Triangles: 9,512,918	Triangles: 7,820
Texture: 16K	Texture: 16K	Texture: 4K

Bisj Pole 1 OBJ File Specs

Conclusions

What ultimately led to the utilization of photogrammetry over TOF Hybrid scanning (Artec Leo) was a combination of the resulting mesh and texture quality on large scale objects. Before the endeavor of imaging the Bisj Poles, we scanned a multitude of objects for MCRW that were constructed primarily of wood and other natural fibers. The Artec Leo scanner was able to thoroughly capture the pieces in a short amount of time due to its portability. However, processing time following the collection of scan data, as well as the quality of those results in comparison to photogrammetry, influenced how we proceeded following the scanning of the Bisj Poles. (Table 2) When processing a large-scale file in Artec Studio, multiple rounds of filtering had to be done manually to ensure the quality of the model. To eliminate errors, scan passes had to be separated out of the overall group until the rate of error shown by the scan passes was low. After that, a global registration was performed. It was only after all of these steps that a mesh could be created and textured. When the total time for the end-to-end process was taken into consideration, the photogrammetry process was at least as efficient while delivering a higher quality result. (Figure 6) It is important to note that the photogrammetry processing times can vary greatly, and in the case of the four Bisj Poles, 3D Flow Zephyr and Reality Capture both had problems with one or more data sets. Photogrammetry and all forms of 3D scanning are full of variables, extremely proprietary and few standards exist to share objective benchmarks.

Table 2



Our goal was to share the magnificence of the Bisj Poles in their entirety via high-detail renditions and to make them accessible for everyone. (Figure 7) Throughout the Met's journey into 3D modeling, we have had the honor of working closely with engineers at many software companies such as Adobe, Apple, Nvidia, 3DFlow Zephyr, Faro Technologies, and Luxion (Keyshot). Facing this specific challenge, our team collaborated with software developers to help improve the capabilities of photogrammetry applications, resulting in more knowledge and has influenced the way we approach projects. For example, we sent datasets to Zephyr months before working on the Bisj poles so the engineers could see some of the problems we were experiencing when aligning art objects in the software. The Zephyr engineers helped us through the problem and in their next software update addressed those issues. When we were working on aligning the Bisj Poles the technical improvements incorporated into the software from our feedback played a key role in our ability to combine the base to the model in a way that was not working in other modeling software. The Bisj Pole models became a quality bar reference and a topic for public education workshops, helping illustrate how our team solves problems and learns through process. Even though we are primarily modeling large objects regularly through Reality Capture, we still find it necessary to run datasets through multiple photogrammetry tools to resolve problems. Our team continues to meet with engineers, software developers, peer museums, and companies integral to the advancement of imaging on a regular basis. The Metropolitan Museum of Art will always support the unique needs of the cultural heritage community and advocate for the standards necessary to support seamless global delivery and interchange.

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***Figure 1**. Tassel test with DJI Osmo Pocket Camera and ring light*

***Figure 2**. In situ view of base from 1978.412.1254 (Bisj Pole 04)*

***Figure 3**. Capturing images for photogrammetry*

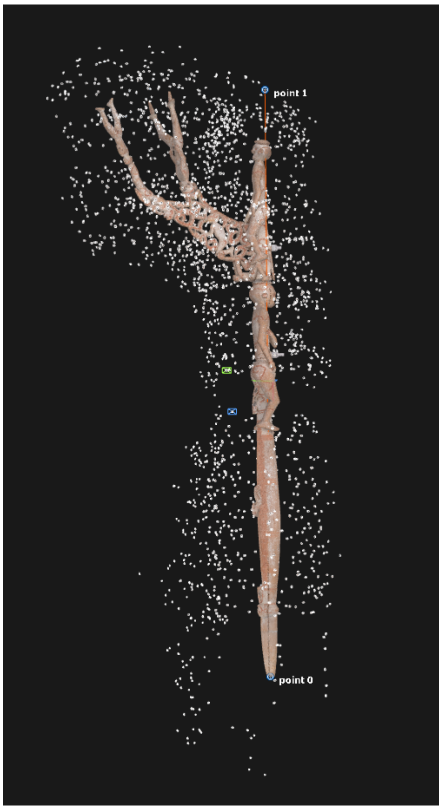

***Figure 4**. Camera positions in 3DFlow Zephyr*

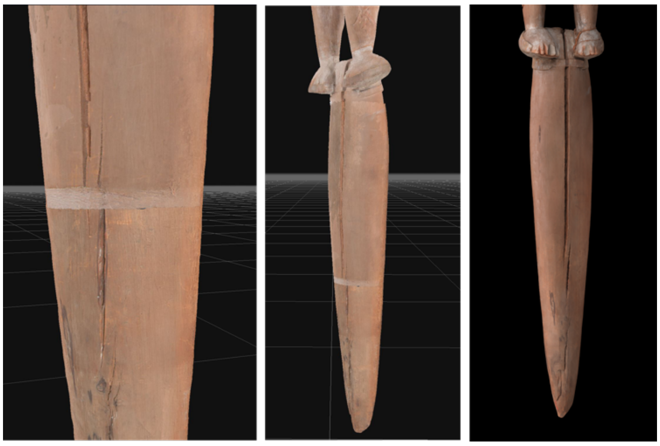

Figure 5. *Render comparison of original photogrammetry model in 3DF (left: close up of misalignment in texture; middle: wide angle of misalignment; right: edited version)*

Figure 6. *Render comparison of Artec model (left) and photogrammetry model (right)*

Figure 7. *Digital render of 3D models (left: 1979.206.1611 [Bisj Pole 01], right: 1978.412.1254 [Bisj Pole 04])*

Author Biography

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