




## Documentation of Temple Sculptures Using 3D Gaussian Splatting

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**Abstract.** This study aims to use AI-assisted applications to reconstruct sculptures in a temple. The temple structure around envelop usually creates a context decorated by stone or wood sculptures. After preliminary tests with images and videos, both visual and structural details were reconstructed in AI. This active and efficient conservation method documented 20 artifacts with about 75% satisfactory rate in applying original working photos taken around sculptures and scan locations.

**Keywords:** heritage conservation, 3D Gaussian Splatting (3DGS), photogrammetry, AI.

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### 1 INTRODUCTION

The presentation of heritage requires an integrated effort of conservation and reconstruction technology. AI has been involved as part of the reality engineering nowadays. How does it connect to the past, or it's just another paradigm shift in totally different technology? This research aims to connect AI and reconstruction technology in a seamless way using imagery data took 17 years ago.

This application was implemented to Gongfan Temple (Figure 1), in Mailiao, Yunlin of Taiwan. This reconstruction has changed traditional working environment and conducted a different approach from traditional 3D model process. With the assistance of AI, it is expected to connect game engine (i.e. Unreal Engine<sup>®</sup> or UE<sup>®</sup>) and multimedia software (i.e. After Effects<sup>®</sup> or AE<sup>®</sup>) and open up diversified modeling environments.

This study uses Postshot<sup>®</sup> and KIRI Engine<sup>®</sup> to document the sculptures of a temple, in addition to general-purposed photogrammetry tool of Zephyr<sup>®</sup>. Upon the 3D reconstruction of historical artifacts, the building envelop of a temple usually creates a context decorated by stone or wood sculptures as the second skin, and the original construction design as the first skin. Those sculptures deliver multi-disciplinary stories of history. A reconstructive tool, which is considered to be an active approach to document the imbed story characters, should be applied as an efficient conservation method.



Figure 1: Former field 3D scans and imagery documentation.

## 2 RELATED STUDIES

Temple-related arts should be represented under a form of digital twin. The 3D reconstruction of arts used to be achieved through structure from motion (SfM) photogrammetry [1-3]. With the solutions provided by existing tools and platforms, field application should allow a fast and intuitive documentation from an image-based generative approach in AI. Postshot® beta (v. 0.5.48) uses modern AI techniques include Neural Radiance Fields (NeRF) and Gaussian Splatting (GS) [4], which are integrated together for 3DSG model. NeRF applies AI-trained process on the radiosity of a subject to generate views from different angles. Gaussian Splatting is a different technique to generate solid models. The major difference from the existing approaches of 3D photogrammetric modeling and 3D scanning [5-7] is that this approach is less dependent on defining 3D geometries first. It seems this new AI method for obtaining 3D models better than general photogrammetry in filling in modeling gaps more intelligently.

## 3 MATERIALS AND METHODS

About 1000 old images were reused from a 3D scan project conducted 17 years ago. This approach provides a renewed survey result of the old sculptures in the field (Figure 2). The process presents an exploration of solution that is enhanced by AI. The images include the number of all available working photos taken in radial direction to document peripheral environment around scan locations, or taken in centripetal direction to document sculptures. Photogrammetry usually produces 3D results, but the results are not always clear or acceptable. The number of photos for 3D reconstruction, success or fail, presented a ratio of reuse.

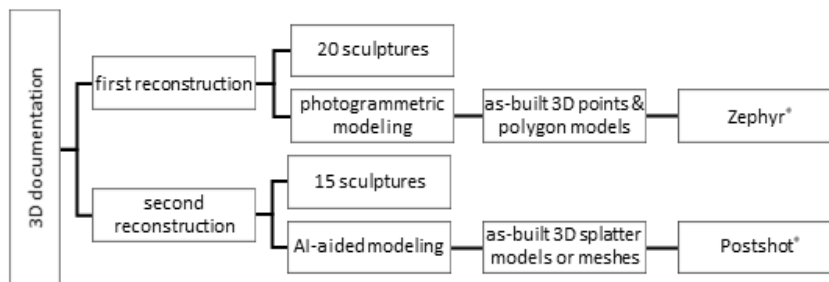


Figure 2: Research flowchart.

### 3.1 Preliminary Test in Centered Image-Taking

Centered image-taking was made to document a single object (Figure 3). A test was applied to a flower setting using 360-degree images. This setup tried to retrieve as much details as possible, i.e. the separated twigs. The final exported 3D model in ply format only included limited point

numbers in Postshot®, although the inspection presented a much better sense of details. The photogrammetric model only presented a clustered and merged polygons in Zephyr®.



**Figure 3:** Result generated by Postshot®.

## 4 RESULTS

### 4.1 Linear Filming Test

Linear filming was made to a corridor and a wall using Postshot® (Figure 4). The result was connected to other 3D program, such as CloudCompare® (3D point cloud process) and Meshlab® (general 3D display). 3D models have become an important resource to convey creative intention in an enclosed space, particularly on the walls near riverfront. The perspectives facilitated inspection when rotating and scaling were applied.



**Figure 4:** Postshot® generated scenes of a corridor (top) and a graffiti wall (bottom).

### 4.2 Field 3D Documentation

Stone sculptures are deployed on exterior walls and documented using both photogrammetry (Zephyr®) and Postshot® (Figure 5). Three-dimensional models enable a thorough description of spatial structure, which is connected to the deployment of a complete decorative set. All creations can be inspected on walls, across walls, and on the ceiling. In total, multiple sculptures of nearly 20 were created from different parts of the front gate. The models have displayed visual details (textures) and structural details for off-site inspections. Deep recessed void spaces still caused difficulty. Comparing to the larger size of traditional 3D scanner, the size of a smartphone was more suitable to take images from different angles.



**Figure 5:** 3D model of a stone sculpture panel using Zephyr® (left) and Postshot® (middle), comparing to former 3D scanned result (right).

### 4.3 Visual and Structural Details

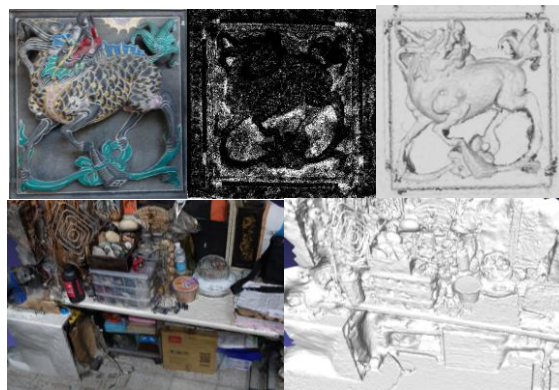
The visual details were more acceptable in Postshot® than the one made in Zephyr®. The least setting of NVidia RTX2060 and 8 MB RAM made it a perfect first attempt to reconstruct 3D field scene. When centered image-taking was conducted in Zephyr®, some structural details were not satisfied. The visual detail was also worse than the one made by NeRF and Gaussian Splatting, in which the same small pedals indicated in Figure 3 were grouped into larger polygons in less structural details.

## 5 DISCUSSION

There have been advances in mobile operation of smartphone-based images and 3D reconstruction of environment. With the combination of AI, the use of 3D Gaussian Splatting (or 3DGS) data has substantially improved the level of reality and generation efficiency. Compared with the traditional and perhaps more reliable photogrammetry method, the output of 3D spatial and shape data can be created by new alternative documentation method now.

### 5.1 Three-dimensional Meshes

The 3D mesh model is an affirmative physical representation of the final data (Figure 6). The top model was created using the images taken years ago. To verify details, however, the final point cloud needed to be wrapped into mesh. For a smaller object on the bottom, a mesh model can be created from 3D Gaussian Splatting. The visual and structural details were sufficiently self-explanatory to identify the composition of the reconstruction generated by KIRI Engine®.



**Figure 6:** 3DGS in splatters or points (top) and mesh (bottom).

## 5.2 Alternative Reconstruction of Details

Old images have to be arranged to create a series of connected and sequential locations of camera for both Postshot® and Zephyr® (Figure 7, left). The scan markers, which were part of the scene, were eliminated on the lion. A novel approach of RODIN® also created 3D mesh model in one image (Figure 7, right). Although this model has less resemblance to real one, it is interesting how the number of pictures and details were referred.

The 3DGS can be transferred into mesh format in KIRI Engine® (Figure 8), which traditional 3D working platform can also be benefit from the new 3D documentation approach, in addition to Unreal Engine® and After Effects®. Moreover, openwork carving of stones and woods can be better reconstructed along with components in black, semi-transparent, reflective surface, using AI-assisted apps or software.



Figure 7: Stone lion model by Postshot® (left), Zephyr® (middle), RODIN® (right).



Figure 8: 3D mesh model of a sculpture panel using KIRI Engine® (left) and Zephyr® (right).

## 6 CONCLUSION

AI-assisted application becomes an efficient documentation tool. Operational restrictions still apply from the number of photos, the way photos were taken, and the quality of the photos. Even the 3D output satisfactory rate was about 75%, it is still of great help to raise the sustainability of old digital data.

Do we use powerful AI tools just to create general purposed 3D scenes for gaming engine, by skipping the polygon model? The fly-through like animation no longer needs model-creation process, so is the platform to elaborate the 3D effect what a presentation can provide. Let alone the details and realistic scenes are far better than those used to be.

The photogrammetry-to-AI method has proved to be an efficient modeling process, especially when the same ubiquitous device of smartphone was used to take pictures of a real object or environment. The featured sources of image constituted the reconstruction of the sculptures. In comparison to the existing photogrammetric approach, AI-assisted modeling was preferably but still needed to connect to general 3D programs effectively in polygons occasionally.

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