Title:
Documentation of Temple Sculptures Using 3D Gaussian Splatting

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Introduction:
The presentation of heritage requires an integrated effort of conservation and reconstruction technology. This research aims to connect AI and reconstruction technology in a seamless way using imagery data taken 17 years ago. This project was implemented in Gongfan Temple (Fig. 1), Mailiao Yunlin, Taiwan. This reconstruction has changed the traditional working environment and has adopted a different approach from the traditional 3D model process. With the assistance of AI, it is expected to open up diversified environments to connect game engine (i.e., Unreal Engine® or UE®) and multimedia software (i.e., After Effects® or AE®).

This study uses Postshot® and KIRI Engine® to document the sculptures in a temple, in addition to a general-purpose photogrammetry tool of Zephyr®. Upon the 3D reconstruction of historical artifacts, the building envelope 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 embedded story characters, should be applied as an efficient conservation method.

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

Related studies:
Temple-related arts should be represented in the form of a digital twin. The 3D reconstruction of art 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, including Neural Radiance Fields (NeRF) and Gaussian Splatting (GS) [4], which are integrated together for the 3DSG model. NeRF applies an 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] is that this approach is less dependent on defining 3D geometries first. It seems this new AI method for obtaining 3D models is better than general photogrammetry in filling in gaps more intelligently.

Materials and Methods:

About 1000 old images were reused from a project conducted 17 years ago. This approach provides a renewed survey result of the old sculptures in the field (Fig. 2). The process presents an exploration of a solution that is enhanced by AI. The images include the number of all available working photos taken in radial direction to document the 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 failure, presented a ratio of reuse.

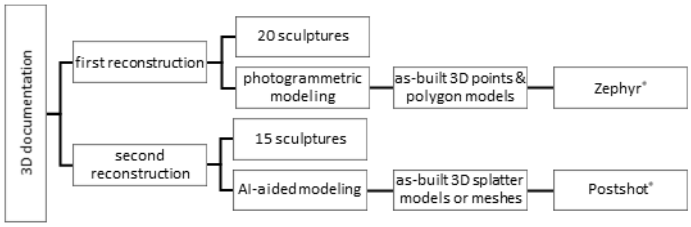

Fig. 2: Research flowchart.

The original restrictions on taking pictures affected the subsequent software types in application: Postshot® (more than 10 photos), RODIN® (1-4 photos), KIRI Engine® (more than 20 photos), and Zephyr® (more than 10 photos). Certain arrangement of shooting rules applies. Space configuration was tested by linear, parallel, and centered filming or image-taking, for both traditional photogrammetry tools using Zephyr® and the new AI tool. In linear filming, the moving path and shooting angle were parallel to the surface wall before or after turning around at the end.

Centered image-taking was made to a single object (Fig. 3, left). A test was applied to a flower setting without any interference using 360-degree images. This setup tried to retrieve as many 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 detail. Linear filming was made in a corridor and a wall using Postshot® (Fig. 3, right). 3D models have become an important measure to convey creative intention in an enclosed space.

Fig. 3: Result generated by Postshot® of a flower setting (left) and a corridor (right).

Results:

Field 3D documentation

Stone sculptures are deployed on exterior walls and documented using both photogrammetry (Zephyr®) and Postshot® (Fig. 4). 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 detailed visual details (textures) and structural details for off-site inspections.

Fig. 4: 3D model of a stone sculpture panel using Zephyr® (left) and Postshot® (right).

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

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

The 3D mesh model is an affirmative physical representation of the final data (Fig. 5). 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.

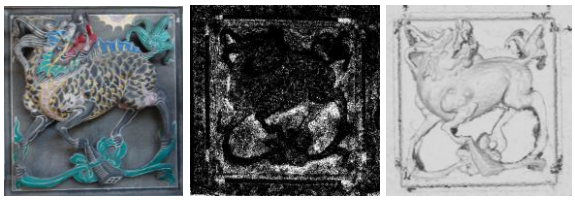

Fig. 5: 3DGS in splatters (left), points (middle), and mesh (right).

Old images have to be arranged to create a series of connected sequential locations of camera for both Postshot® and Zephyr® (Fig. 6, left & middle). 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 (Fig. 6, 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® (Fig. 6, right), 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.

Fig. 6: Stone lion model by Postshot® (left), Zephyr® (middle-left), RODIN® (middle-right), KIRI Engine® (right).

Conclusions:

The AI-assisted approach 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 though the 3D output satisfactory rate was about 75%, it is still of great help to raise the sustainability of old digital data.

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

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