# Few images based 3D Reconstruction of Korean Wooden Architecture Bracketing System(Gongfo)

Jong Gook Ko, Seung Jae Lee
Content Research Division,
ETRI (Eletronics Telecommunications Research Instutue)
Daejeon, Korea
jgko@etri.re.kr, seungjlee@etri.re.kr

***Abstract*—Three-dimensional (3D) reconstruction from 2D input images is a fundamental task in computer vision and has numerous applications in fields such as robotics, augmented reality, and cultural heritage preservation. This paper presents a technique for performing 3D reconstruction of Korean Wooden Architecture Bracketing using Structure-from-Motion(SfM) and Multi-View_Stereo(MVS) technology. SfM leverages the geometric relationships between multiple images to estimate camera poses and reconstruct the underlying 3D scene. the MVS algorithm is used to complete the dense reconstruction of objects. We show that few iages based 3D reconstrution results for korean wooden architecture bracketing system named by Gongfo in korean.**

**Keywords— 3D reconstruction, SfM, MVS**

## I. INTRODUCTION

Three-dimensional (3D) reconstruction from 2D input images is a fundamental task in computer vision that aims to reconstruct the underlying 3D structure of a scene or object. It has gained significant attention in recent years due to its wide range of applications in various fields, including robotics, augmented reality, virtual reality, cultural heritage preservation, and urban planning. The ability to extract accurate 3D models from 2D images enables the creation of immersive experiences, accurate measurements, and enhanced understanding of real-world environments. Structure-from-Motion (SfM) technology is a powerful technique that addresses the challenge of 3D reconstruction from 2D images. It leverages the geometric relationships between multiple images captured from different viewpoints to estimate the camera poses and reconstruct the 3D scene. By extracting and matching features across images, SfM algorithms can recover the camera trajectories and generate dense 3D point clouds that represent the shape and structure of the scene.

The 3D reconstruction of buildings holds immense importance in understanding the structure of traditional Korean wooden buildings. Here are several reasons why 3D reconstruction is crucial in comprehending these architectural structures:

- Cultural Heritage Research and Education: 3D reconstruction enhances research and educational endeavors focused on traditional Korean wooden buildings. The detailed virtual models allow for immersive exploration, virtual tours, and interactive experiences that engage researchers, students, and the general public. It facilitates the study of architectural history, cultural practices, and the evolution of traditional Korean architecture, contributing to a deeper understanding and appreciation of this cultural heritage.
- Reconstruction and Visualization: In cases where traditional Korean wooden buildings have been lost or severely damaged, 3D reconstruction offers a means of visualizing and reconstructing these structures. By utilizing historical records, photographs, and other available data, accurate 3D models can be created, aiding in the reconstruction process. These models serve as references for rebuilding efforts, ensuring that the reconstructed buildings retain their cultural authenticity and historical significance.

In summary, 3D reconstruction plays a pivotal role in understanding the structure of traditional Korean wooden buildings. It enables architectural analysis, preservation documentation, analysis of construction techniques and materials, assessment of structural stability, cultural heritage research, and reconstruction visualization. By leveraging 3D reconstruction technology, researchers and experts can gain valuable insights into the design, construction, and significance of traditional Korean wooden buildings, fostering their preservation and ensuring their legacy for future generations. In the management of Korean traditional wooden buildings, the investigation of the Gongfo part and its detailed components is one of the most important parts.

This paper deals with the 3D reconstruction of the bracketing of a korean wooden building. The SfM method was used to extract point clouds, which are three-dimensional data, from the 2D images taken. SfM is an algorithm that uses the motion information of two-dimensional images to backtrack the camera position and orientation of the captured images, and then structures the relationship between the images and the cameras. MVS is used to create a dense point cloud. MVS captures more scene viewpoints to improve robustness and reduce the impact of image noise and surface texture

## II. RELATED WORKS

The field of 3D reconstruction from 2D images has been extensively studied, and numerous techniques have been developed to address the challenges involved. In this section, we provide an overview of the related work, including various approaches to 3D reconstruction and the specific focus on Structure-from-Motion (SfM) and Multi-View Sereo(MVS) methods technology.

A multi view image of an object is used for object 3D reconstruction. After extracting and matching features from the images, camera parameters and object structure are calculated[1]. The above process is to restore the structure from motion (SfM). Motion refers to the motion trajectory of the camera, that is, the camera parameters, and structure refers to the 3D points of the object, that is, the sparse model of the object. With the success of the structure from motion (SfM) algorithm [4][5], multi-view 3D reconstruction technology has developed rapidly. With the improvement in camera imaging quality and computing power, the multi-view 3D reconstruction method has a good guarantee of efficiency and reconstruction accuracy [6]. The general struct from motion method can be divided into incremental and global according to the order of using images. The incremental method first selects the initial image pair, then registers the images in turn, and calculates the camera parameters and object structure[4]. The global method calculates all camera parameters and the object structure according to the global constraint relationship of the camera [2]. After the object's spars are reconstructed, camera parameters, spars 3D points, and corresponding image 2D points are obtained, but this information cannot fully represent the object and must be converted to a dense representation of the object. There are many methods to represent the dense model of the scene, mainly including voxels, depth maps and dense point clouds [3]. High-density reconstruction of a scene is also known as MVS. MVS captures more scene points to improve robustness and reduce the impact of image noise and surface texture. In general, it is divided into voxel-based algorithms, point cloud diffusion algorithms, and depth map fusion algorithms according to the representation of the scene.[7].

## III. Few images based 3D Reconstruction of Korean Wooden Architecture Bracketing system

In this work, we adopt SfM and openMVS as the 3D reconstruction of korean wooden architecture bracketing system. The SfM method was used to extract point clouds, which are three-dimensional data, from the 2D images. MVS is used to create a dense point cloud. MVS captures more scene viewpoints to improve robustness and reduce the impact of image noise and surface texture. SfM stands for Structure From Motion, and it is an algorithm that uses the motion information of a two-dimensional image to backtrack the camera position and orientation of the captured image, and then structures the relationship between the image and the camera. The camera model is used to model the conversion relationship between 2D pixel coordinates and 3D coordinates as shown in the figure below.

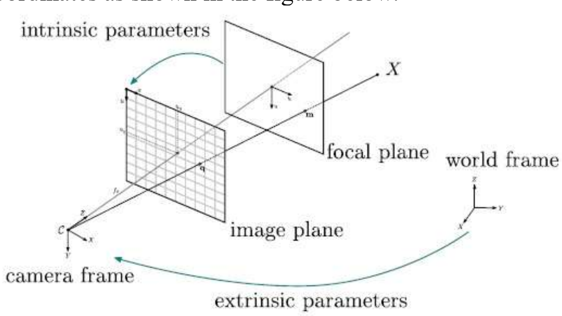


**Fig. 1. camera model [8]**

Using SfM, the camera's position can be obtained by obtaining a unique feature point for each captured image and matching and calculating the relationship between the feature points for each captured scene.

In this paper, we used OpenMVG, which allows you to create programs and revise algorithms directly at the API (Application Program Interface) level. For reference, the development environment was Ubuntu 18.04. Using 12 photographed images as input, the camera position was generated using SfM, and a point cloud was generated by calculating the three-dimensional position of the feature points. The result is saved as a PLY file. The calculated feature points and camera information are saved together. The PLY file generated by CloudCompare and MeshLab is shown in Figure 2. You can see the result generated as a sparse point cloud. To create a dense point cloud reconstruction, OpenMVS was used.

The figure below shows the sparse point cloud result for the input image of the guipo of Daewoongjeon Hall in Sudoksa Temple.

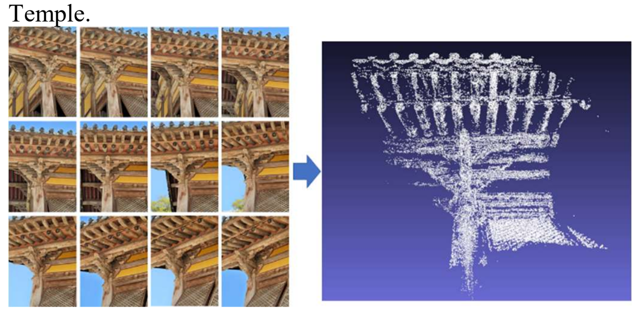

**Fig. 2. the sparse point cloud result**

The result of restoring a dense point cloud-based texture and colour is shown in Figure 3. In 3D reconstruction, 3D reconstruction is generated for all input pixels to generate 3D reconstruction results for unwanted parts. In this paper, the meshlap programme was used for 3D reconstruction only for the specific scare part of the building and the unnecessary parts were deleted.

**Fig. 3. The results of 3D restoring a dense point cloud-based texture and colour**

## IV. Experiments

In this section, we show experimental results of our proposed method for 3D reconstruction of Korean Wooden Architecture Bracketing System. We used 18 images taken as input for for 3D Reconstruction. For Gongfo 3D reconstruction, we used images taken from left to right.

Gongfo parts of traditional Korean wooden buildings were photographed and used to create 3D models. Figure 4 shows the results of creating 3D models of the Gongfo parts of Buseoksa Muryangsujeon, Bongjeongsa Geukrakjeon, and Gyeongju Hyanggyo Building. It was possible to rotate the actual gongfo parts left and right for a closer look. It can be seen that it is possible to examine the detailed components of the Gonfg in more detail through 3D reconstruction than through photographs alone. The Muryangsujeon and Geukrakjeon are well reconstructed based on the input images, but the Gyeongju Hyanggyo has a hole in the wall to the right of the gongfo. This can be expected as a result of the failure to extract point cloud features due to the simple surface.

## V. CONCLUSION

We propose a technique for performing 3D reconstruction of Korean Wooden Architecture Bracketing system using Structure-from-Motion and Multi-View_Stereo technology. In this study, a 3D model of the gongfo section of a traditional Korean wooden building was created from 2D images to provide an easy way to examine the gonfo section in more detail. Although there are limitations in viewing the complex shape of the gonfo with 2D images, it was shown that it can be examined in more detail through the 3D model.

We are planning to reconstruct 3D model not only Gongfo, but the entire wooden building from 2D images in next time.


## ACKNOWLEDGMENT

This work was supported by 2023 Cultural Heritage Smart Preservation & Utilization R&D Program of Cultural Heritage Administration, National Research Institute of Cultural Heritage (Project Name: Development of AI based CAD conversion technology for traditional architecture drawing images, Project Number: 2023A02P03-001, Contribution Rate: 100%).


## REFERENCES


[1] Cefalu, A.; Haala, N.; Fritsch, D. Hierarchical structure from motion combining global image orientation and structureless bundle adjustment. Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. 2017, 42, 535–542.

[2] Wang, R.; Lin, J.; Li, L.; Xiao, Z.; Hui, Y.; Xin, Y. A revised orientation-based correction method for SfM-MVS point clouds of outcrops using ground control planes with marks. J. Struct. Geol. 2021, 143, 104266.

[3] Dugan, U.; Sangsoo, L. Microscopic structure from motion (SfM) for microscale 3D surface reconstruction. Sensors 2020

[4] Lei Gao, Yingbao Zhao, Jingchang Han and Huixian Liu ¨ Research on Multi-View 3D Reconstruction Technology Based on SFM. https://doi.org/10.3390/s22124366, 2022

[5] DeTone, D.; Malisiewicz, T.; Rabinovich, A. Superpoint: Self-supervised interest point detection and description. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition Workshops, Salt Lake City, UT, USA, 18–23 June 2018; pp. 224–236.

[6] Zhu, S.; Shen, T.; Zhou, L.; Zhang, R.; Wang, J.; Fang, T.; Quan, L. Parallel structure from motion from local increment to g1obal averaging. arXiv 2017, arXiv:1702.08601.

[7] Khalil, M.; Ismanto, I.; Fu'ad, M.N. 3D reconstruction using structure from motion (SFM) algorithm and multi view stereo (MVS) based on computer vision. IOP Conf. Ser. Mater. Sci. Eng. 2021

[8] https://openmvg.readthedocs.io/_/downloads/en/stable/pdf/


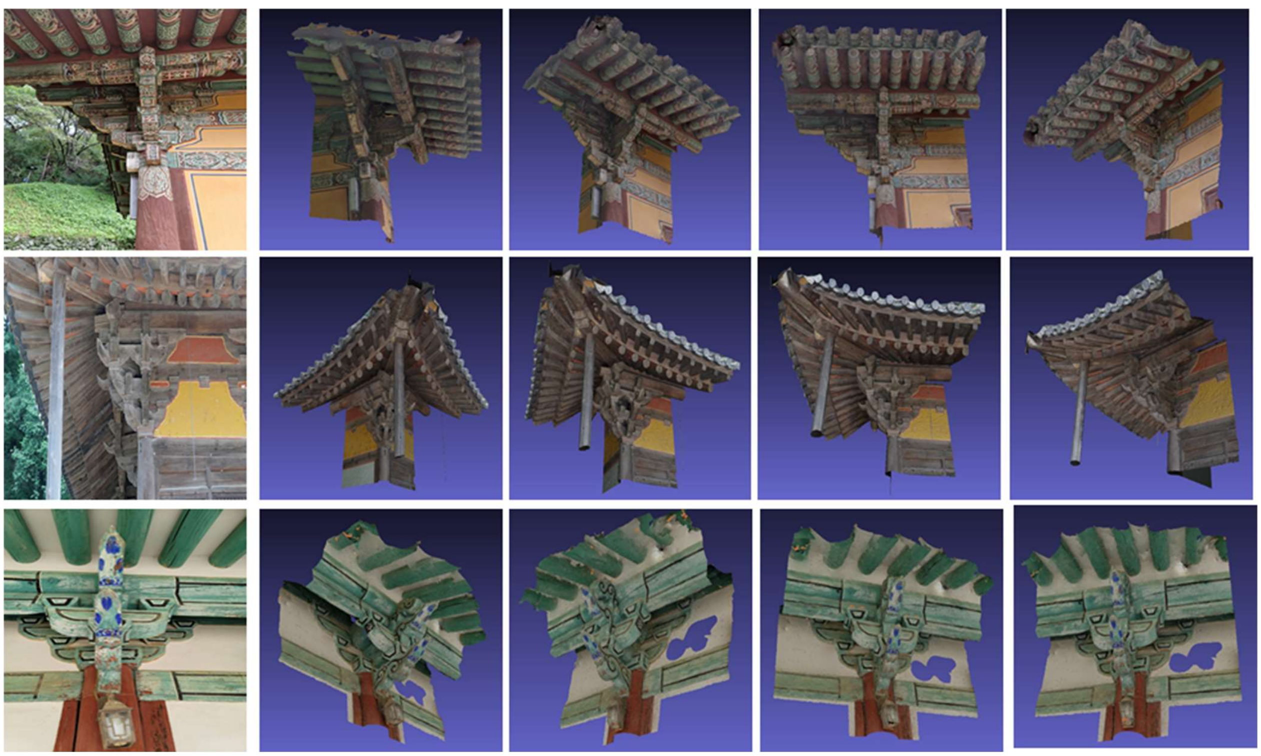

**Fig. 4. The results of 3D reconstruction for Gongfo from 2D images**