

# A Study of 3D Model Construction Method with Photogrammetry and Laser Scanning

Masaru Furukawa  
Iwate University

Enkhbayar Altantsetseg  
National University of Mongolia

Katsutsugu Matsuyama  
Iwate University

Kouichi Konno  
Iwate University

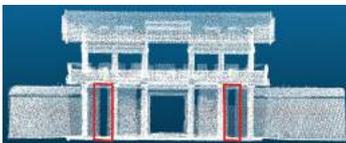
## 1 Introduction

The information to express object surfaces is provided as a three-dimensional coordinate point cloud by laser scanning or photogrammetry. Single laser scanning can directly acquire a large-scale point cloud of an object surface in the three-dimensional coordinate. However, measurement of multiple view points takes time and may cause some troubles. Otherwise, photogrammetry can obtain surfaces of small sections such as gaps or the back side of pillars, and measurement itself is handy since what is required is just taking pictures. Generally, laser scanning takes longer time than photogrammetry.

Fig.1(a) shows the south gate of Shiwa castle ancient park in Morioka-shi in Iwate prefecture, Japan, which is measured in this study. Fig.1(b) is the point cloud obtained by laser scanning, and lacking parts enclosed in the red frames are observed. In this study, we propose a new method to introduce the point cloud data obtained by photogrammetry for interpolating the lacking parts, so as to build the perfect surface information.



(a) Appearance



(b) Point cloud

Fig.1 South gate of *Shiwa* castle ancient park

## 2 Our method

In our method, point cloud obtained by laser scanning is combined with point cloud obtained by photogrammetry.

### 2.1 Point cloud acquisition by photogrammetry

A technique has been suggested to reconstruct three-dimensional shapes using photo images. A three-dimensional model is restored by analyzing overlapping parts of photo images taken from several different positions. This technique is called "SfM (Structure from Motion)" [1]. At first, camera position and direction (parameter) are obtained by SfM. Next, MVS (Multi View Studio)[1] estimates the dense point cloud with the camera parameters obtained by SfM. These operations obtain high-density point cloud data.

### 2.2 Technique for combining point clouds of laser scanning

First, the points on the boundary (boundary points) of lacking parts in the point cloud by laser scanning are obtained. Next, the density of the obtained points is calculated, and, the lacking parts are combined with considering the density of both point clouds.

#### 2.2.1 Acquisition of boundary points for the lacking parts

We randomly select a point among point cloud as a start point. Then, all the points including a sphere defined by the representative point and radius  $R_1$  are extracted. In addition, the number of points in radius  $R_2$  about the extracted point are obtained. The density of points around the boundary of the lacking parts is low, and the point that has the smallest number of points will be the candidate of the next representative point as shown in Fig.2.

#### 2.2.2 Extraction of the sampling domain around the lacking parts

A sampling domain is decided to put scales of the point cloud obtained by photogrammetry together. A sampling domain regarded as a sphere osculating the boundary point. Fig.3(a) shows the green sphere in-

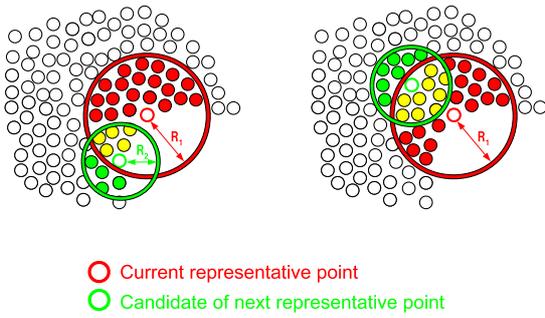


Fig.2 Method of selecting boundary points

cludes boundary points and the green sphere in Fig.3(b) does not contain boundary points. In this study, a sampling domain like the green sphere in Fig.3(b) is extracted at plural locations around the lacking parts.

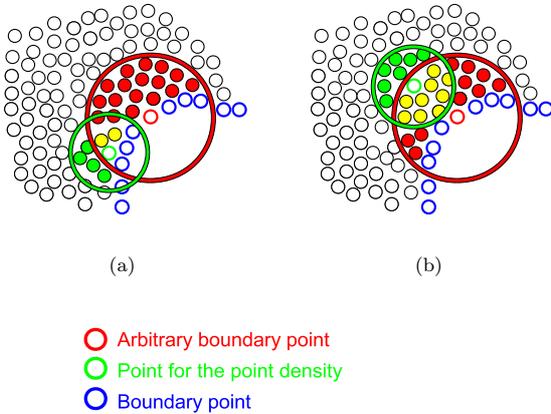


Fig.3 Method of deciding sampling domains

### 2.2.3 Interpolation of the lacking parts

Interpolation is performed with scaling of the point cloud obtained by photogrammetry and combining them by ICP algorithm[2]. The ICP algorithm is a representative technique of the point cloud matching, and a large number of derivation techniques are suggested. In this study, the ICP algorithm is used to make slight modifications, and the initial positions of both point clouds should be closed to the correct location, which is a restriction of the interpolation. Therefore, in this study, the initial positions are aligned by specifying one corresponding point in both point clouds.

$$S_n = \sum_{i=1}^n (L_i - P_i) \quad (1)$$

In equation (1),  $L_i$  is the number of points in the point cloud obtained by laser scanning in the sampling domain.  $P_i$  is the number of points in the point cloud obtained by photogrammetry in the sampling domain.  $n$  is the number of sampling domains. In this study, interpolation

is performed with scaling of the point cloud obtained by photogrammetry and combining them by ICP algorithm so that  $S_n$  approaches to zero.

## 3 Result of experiment

In Fig.4, the green points show the point cloud obtained by photogrammetry. the red points show the boundary of the lacking parts. We obtained 125 boundary points as the result. The twelve circular sections of the yellow points indicate the sampling domains. The average of the points in the twelve sections is 200.

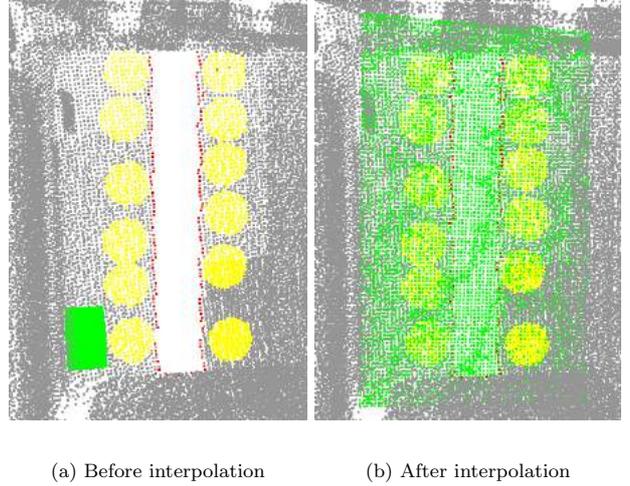


Fig.4 Result of Interpolation

Fig.4(a) shows the initial location of the processing. Fig.4(b) shows the result of the interpolation. The average of the differences of the points in both point clouds in the twelve sections is 15. This value indicates that the lacking parts are interpolated and the point density is uniform to some extent inside and outside the lacking parts.

## 4 Summary and future work

In this paper, we applied an interpolation method to the lacking parts in the laser measurement point cloud by using the photogrammetry point cloud. The proposed technique was applied to the data of the south gate of Shiwa castle ancient park and the good result was obtained. The future work is to raise the precision of the interpolation and to remove photograph point clouds outside the lacking parts.

## References

- [1] Subaru Nisitani, Tomio Echigo: "Representing a 3D Scene from Selected Optimum Textures by using a Multi-view Stereo", IPSJ SIG technical reports (CVIM), Vol. 2013-CVIM-187, No. 14, pp. 1-8, (2013)
- [2] Besl, P. J., and McKay, N. D.: "A method for registration of 3-d shapes", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 14, No. 2, pp. 239-256, (1992)