Jurnal Mantik
Volume 4, Number 3, Nov 2020, pp. 1616-1621 E-ISSN 2685-4236
https://iocscience.org/ejournal/index.php/mantik

Digital Preservation of Real World Objects Using Photogrametry from Digital Image

Moch Fachri[1], Nur Hikmah[2]

1,2Informatics,Faculty of Engineering,Universitas Krisnadwipayana, Jl. Raya Jatiwaringin, Jawa Barat 13077, Indonesia

E-mail: [1]moch.fachri@unkris.ac.id, [2]nurhikmah@unkris.ac.id,

ARTICLE INFO

Article history:
Received: 12/07/2020
Revised: 22/08/2020
Accepted: 30/09/2020

Keywords:
photogrametry , *3D reconstruction*, *digital preservation* .

ABSTRACT

One form of objects preservation is by converting real world objects into digital form. This allows historical information from these relics to be preserved even if due to some reason, the physical objects have disappeared. This research develops a digital image processing technology called photogrammetry to create three-dimensional models of real world objects. The use of photogrammetry is intended for digital preservation of real world objects which is formed in a 3D Reality Capture. The results we show that the digital information of real world objects can be presented in a virtual world and the data can be stored for preservation and future use.

1. Introduction

Preservation of an object into digital data gain interesting attention. This digital preservation is the use of digital technology in preserving historical heritage, which can be in the form of manuscripts or digital text, or in the form of multimedia[2]. This digital preservation is a new challenge in the current era for those that are responsible for preserving historical heritage[4]. One of the most recent uses is the largest temple object in Indonesia, namely the Borobudur temple [9]. In this study, the authors made use of multi-resolution photogrammetry to reconstruct the Borobudur temple in the form of digital three-dimensional objects. Information from the photogrammetric data is preserved for the purposes of restoring the temple in the event of a disaster which results in damage to the structure of the Borobudur temple.

Other recent example of usage in landscape model[10], with photogrametry the 3D topography and model of cultural landscapes can be preserved in digital form. With the help of technology, especially in the field of digital image processing, preservation of historical objects in the form of three-dimensional digital modeling can be done using commercial cameras[2]. This is made possible by using photogrammetry, so that digital modeling of historical objects can be carried out at relatively low cost.

The devices used in photogrammetry vary from smartphone cameras [11] to laser scans [12]. The use of UAV (Unmanned Aerial Vehicle) can also assist in retrieving data objects by aerial method[13]. This research focuses on the photogrametry of digital images taken from mirrorless cameras. The data from the real world objects will be processed into digital information. The digital information obtained will be used in the process of reconstructing the object into a 3D model.

2. Method

The use or utilization of photography in acquiring distance, depth metric measurement data is part of photogrammetric engineering [5]. Data acquisition in photogrammetry deals with the acquisition of the shape and properties of the photographic object. The information obtained from the photogrammetric data includes geometric information. This information is related to spatial data and the shape of the object photographed. This information is the most important information in photogrammetry. Physical information refers to electromagnetic properties, radiant energy, wavelength, and polarization. Semantic information which is about the meaning of the captured image is obtained from the interpretation of the data obtained. Temporal information is about changes in objects over time. Data comes from various images captured at different time stages.

Accredited "Rank 4"(Sinta 4), DIKTI, No. 36/E/KPT/2019, December 13th 2019.

In a photogrammetric workflow generally begins with the search and matching of tie points based on features in the digital image. This is followed by strict detection and elimination of outlier points, and beam alignment to calculate the position and orientation of each camera [7]. An important part of a photogrammetric workflow is external orientation or aerial triangulation, which aims to determine the relationship between the image system and the object system. This relationship is described by the position and orientation of the camera projection center in the object coordinate system [1].

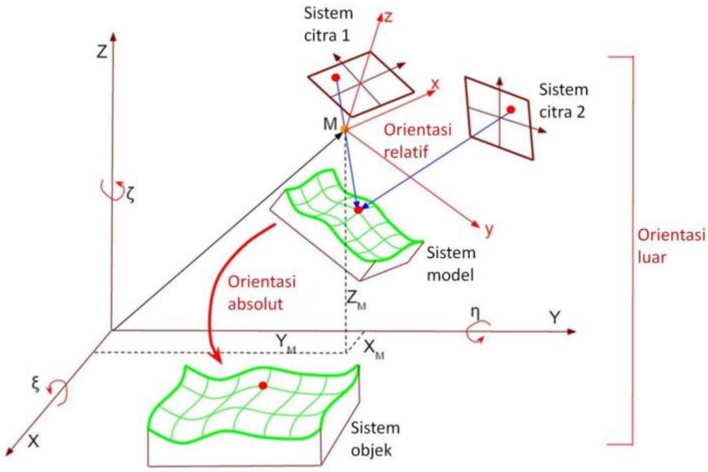

Fig 1. Outer object orientation[8]

There are a number of approaches that can be taken to solve the outer orientation problem as depicted in Figure 1, namely the linearity equation which is a mathematical relation where this relation connects a point in the object system, to the projection of a digital image, and the center of the projection into the same line [8] In most photogrammetric projects, a point will be projected onto two or more images. For two overlapping images, the two beams that come out of the same object point towards the projection in each image form a coplanar plane. The mathematical formulation of this condition is contained in the equilibrium equation [8].

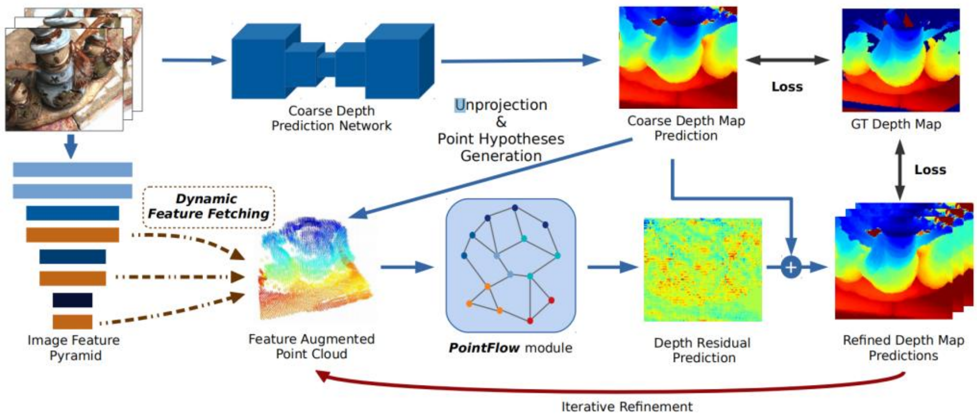

Fig 2. Ilustration of depth calculation and mapping from point cloud[14]

Once the object orientation and depth info are obtained, point cloud data can be acquired [14]. These point clouds are the feature points of an object and become a reference in the mesh generation process. This process performs sequential construction in 3D point space on each components paired by extracted points. Once the construction is done, it uses the point information to colour the vertices. Furthermore, angle position from the camera used to calculate the map of the images for mesh construction[14].

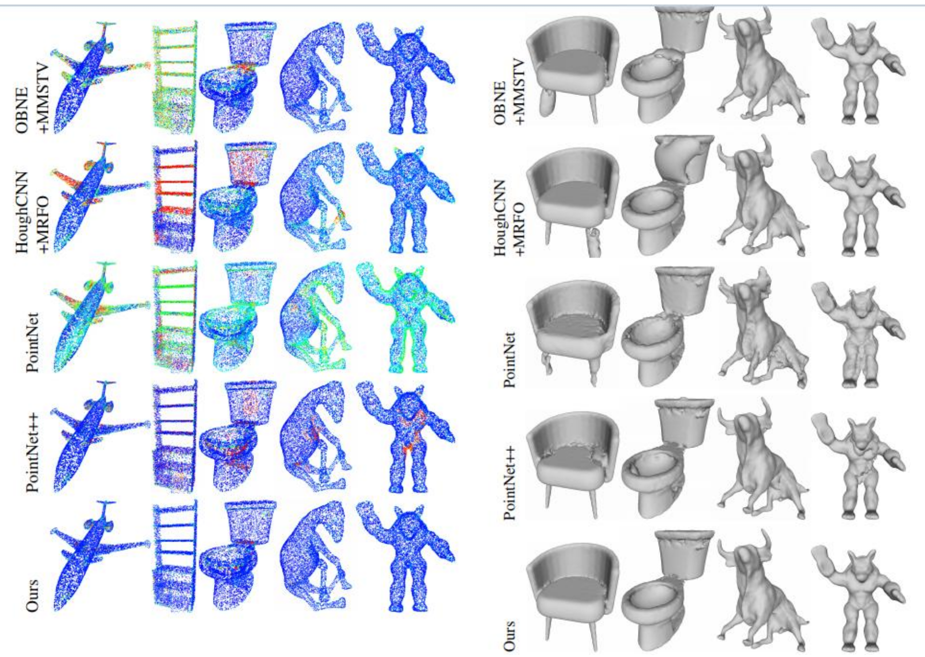

Fig 3. Mesh construction from point cloud[15]

The point cloud only contain information of the approximating shape of the real world object[16]. Information such as the area of the surface and clearer appearance are not provided. Therefore, in order to rebuild the model in the virtual space, the reconstruction of 3D mesh process is required. The mesh is composed of connecting triangles. Each triangle is a unit to construct any polygon[16]. in mesh construction, normal vector of each point representing the object surface need to be estimated. From this normal vector, the 3D mesh will be generated. If the normals of the point cloud can be estimated with high accuracy, we can make use of that information and obtain the 3D mesh of the object close to the ground truth[15]. The estimation of the normal vectors mainly consists of the the alignment to correct all the unoriented vectors so that these normals are consistent[15].

3. Result and Discussion

In our testing, there are two objects used. The object is a jar and vase. Image data of each object is taken by using the camera from various angles. This data can be seen in Figure 4 for the jar object and figure 5 for the vase object. Each object has image data of 100 images. Figure 4 shows the image data for the object taken from the jar and figure 5 is the data from the image taking of the vase object. The captured image has a resolution of 4608x3456 pixels. The image data is processed with the help of the Autodesk Recap Photo application. With the help of this application, automatically the depth of each object image along with the orientation of the original object will be obtained to be processed into a point cloud, which is then processed by Autodesk Recap Photo in its cloud service to be reconstructed into a 3D model.

Accredited "Rank 4"(Sinta 4), DIKTI, No. 36/E/KPT/2019, December 13th 2019.

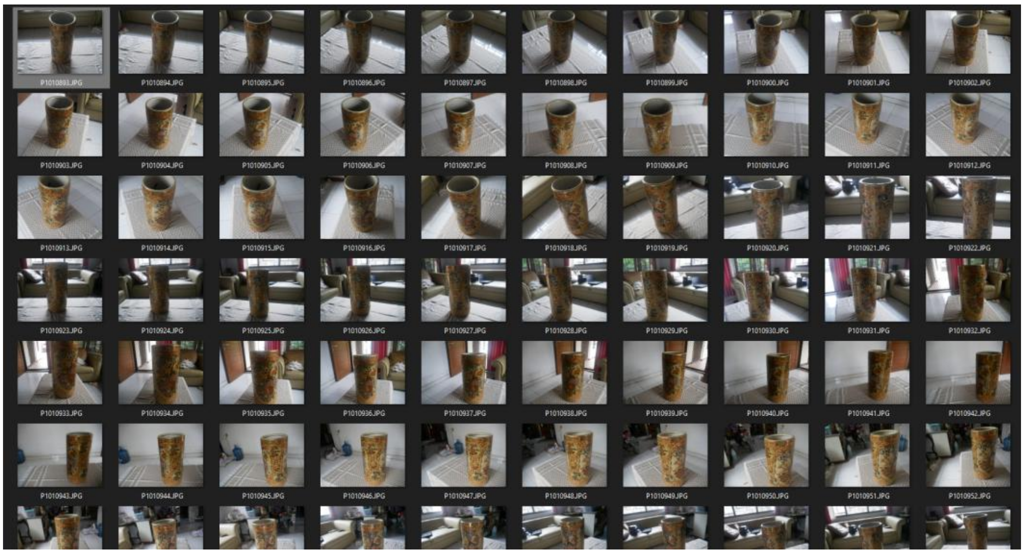

Fig 4. Digital image data of the jar object.

Image data that is processed still leaves environmental information around the main object that the image is taken from. As can be seen in Figures 4 and 5, besides the image of the object to be reconstructed, the environmental background is also taken which results in the background object being reconstructed. So that the results obtained are still noise from the constructed background object. Denoising is done by cropping the main object against its background.

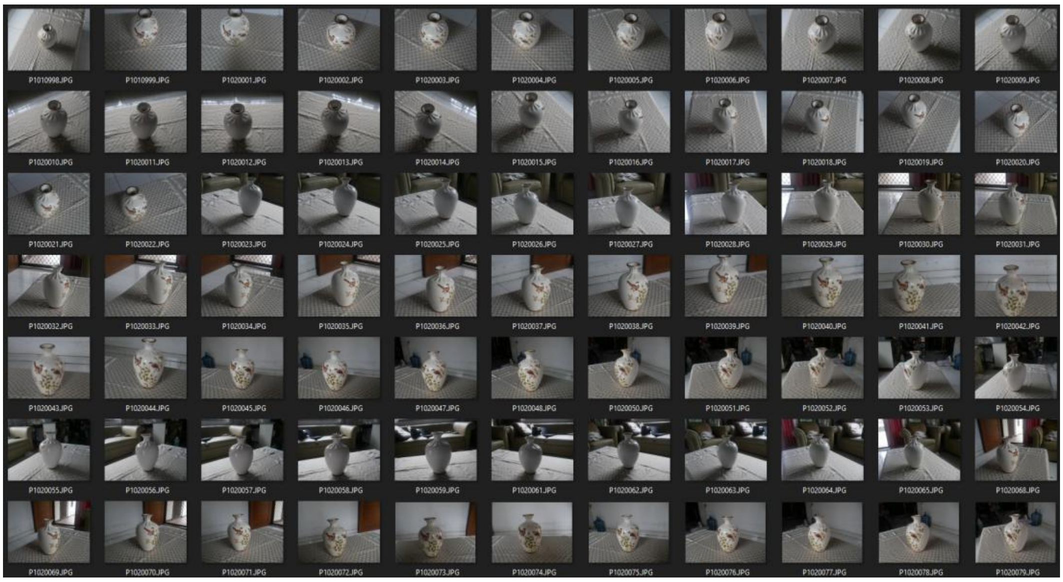

Fig 5. Digital image data of the vase object.

Fig 6. Scanned 3D model without texture.

The results of the reconstruction of the 3D model without texture can be seen in Figure 6. In this figure, you can see a mesh of the reconstructed vase and jar objects. As shown in the figure, the vertices that make up the mesh model can represent the shape of objects from the real world to the virtual world. The object of the jar has an area in the real world of 3518.58 cm^2. The object of the jar is reconstructed with the number of vertices as many as 225,411 vertices. The vase object has an area in the real world of 1282.41 cm2. The vase object was reconstructed with 116,725 vertices. Figure 7 shows the reconstruction results with textures taken from real-world object image data.

Fig 7. Scanned 3D model with texture.

4. Conclusion

In this study we demonstrate the use of photogrammetry to extract information on the shape of real-world objects to be represented in the virtual world. This information can be preserved as digital data containing geometric information from real world objects. Our experimental results show that the real-world objects we take pictures of can be photogrammetically processed into digital 3D models. The jar object with area of 3518.58 cm^2. successfully reconstructed with 225,411 vertices. While the vase object with area of 1282.41 cm^2 was reconstructed with 116.725 vertices.

5. References

[1] E. M. Mikhail, J Bethel, C Mcglone. “Introduction to Modern Photogrammetry”. Wiley, 2012.

[2] Banoriya D., Purohit R., Dwivedi R.K. (2015). Modern Trends in Rapid Prototyping for Biomedical Applications. Materials Today: Proceedings, 2(4-5): 3409-3418.

[3] E.G. Burcaw.”Introduction to Museum Work 3rd edition”.American Association for State and Local History,1992,ISBN-10: 0761989269

[4] S.Kjetil, and R. Parry.”Museums in a Digital Age”.London & New York: Routledge. 2010.

[5] T. Schenk.”Introduction to Photogrammetry”.Coimbra:University of Coimbra.2005.

[6] N.O. Sadiku, Matthew & Shadare, Adebowale & M. Musa, Sarhan.”Digital Preservation”. International Journal of Advanced Research in Computer Science and Software Engineering. 7. 5-6. 10.23956/ijarcsse/V7I4/01408.2017

[7] Remondino, F., Del Pizzo, S., Kersten, T.P., Troisi, S. “Low-cost and open-source solutions for automated image orientation–a critical overview”. Progress in Cultural Heritage Preservation 7616 LNCS, 2012.

[8] Luhmann, T., Robson, S., Kyle, S., Boehm, J.“Close-Range Photogrammetry and 3D Imaging, 2nd ed”. De Gruyter.2014.

[9] Suwardhi, D., Menna, F., Remondino, F., Hanke, K., Akmalia, R.”Digital 3D Borobudur - Integration of 3D Surveying and Modeling Techniques”. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. 2015. XL-5/W7, 417–423.

[10] G. Büyüksalih, T. Kan, G. E. Özkan, M. Meriç, L. Isın, and T. P. Kersten, “Preserving the Knowledge of the Past Through Virtual Visits: From 3D Laser Scanning to Virtual Reality Visualisation at the Istanbul Çatalca İnceğiz Caves,” PFG, vol. 88, no. 2, pp. 133–146, Apr. 2020, doi: 10.1007/s41064-020-00091-3.

[11] V. Munir, E. Dempster, and D. A. Lyons, “Innovative Strategies for 3D Visualisation Using Photogrammetry and 3D Scanning for Mobile Phones,” presented at the Proceedings of EVA London 2019, Jul. 2019, doi: 10.14236/ewic/EVA2019.43.

[12] A. T. Hassan and D. Fritsch, “Integration of Laser Scanning and Photogrammetry in 3D/4D Cultural Heritage Preservation – A Review,” vol. 9, no. 4, p. 16, 2019.

[13] M. Chen, A. Feng, K. McCullough, P. B. Prasad, R. McAlinden, and L. Soibelman, “3D Photogrammetry Point Cloud Segmentation Using a Model Ensembling Framework,” J. Comput. Civ. Eng., vol. 34, no. 6, p. 04020048, Nov. 2020, doi: 10.1061/(ASCE)CP.1943-5487.0000929.

[14] R. Chen, S. Han, J. Xu, and H. Su, “Point-Based Multi-View Stereo Network,” in 2019 IEEE/CVF International Conference on Computer Vision (ICCV), Seoul, Korea (South), Oct. 2019, pp. 1538–1547, doi: 10.1109/ICCV.2019.00162.

[15] T. Hashimoto and M. Saito, “Normal Estimation for Accurate 3D Mesh Reconstruction with Point Cloud Model Incorporating Spatial Structure,” Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) Workshops, 2019, pp. 54-63

[16] N. Wongwaen, C. Sinthanayothin, and S. Tiendee, “Method of 3D Mesh Reconstruction from Point Cloud Using Elementary Vector and Geometry Analysis,” 2012 8th International Conference on Information Science and Digital Content Technology (ICIDT2012), Jeju, 2012, pp. 156-159.