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Comparison of open-source and commercial software for 3 modeling with terrestrial photogrammetry

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Abstract

Thanks to advancing computer technologies, computer programs are used in many fields instead of classical methods. Photogrammetry has become a technique accessible to many users, especially with the introduction of open-source software as well as commercial software. Thus, the use of photogrammetry in different fields is becoming widespread. In this study, a miniature statuette and calibration cube made of wood is modeled in 3D with Meshlab and Visual SFM, which are Open-Source software. On the other hand, the same small object is modeled in 3D using the commercial software Agisoft Photoscan and 3DF Zephyr. Accuracy analysis was carried out with the measured lengths on the models. RMSE was calculated as ± 0.7 mm for Agisoft Photoscan, ± 5.3 mm for MeshLab and ± 1.5 mm for 3DF Zephyr.

1. Introduction

As computer vision algorithms and photogrammetric technologies are combined, procedures that automate the image-based 3D modeling process become more common. Photogrammetry's main goal is to create a three-dimensional model from terrestrial or aerial pictures (Duran and Atik, 2021). The open-source software and software enhanced over the last 25 years is one of the most essential factors that fasten this cycle. Today, Information is accessible at any time. Producing an application with the open-source software using this information, processes such as product and result analysis can be commonly improved and shared. Open-source software attracts attention in many areas thanks to the freedom of use it provides, the freedom to interfere with the source code, and the freedom to use and distribute it free of charge. (Weber, 2004).

In this study, a miniature figurine and calibration cube made of wood is modeled in 3D with Meshlab and Visual SFM, which are Open-Source software. On the other hand, the same small object is modeled in 3D using the commercial software Agisoft Photoscan and 3DF Zephyr. RMSE (Root Mean Square Error) and MAE (Mean Absolute Error) values were compared between the points determined on these 3D models obtained with Agisoft Photoscan, 3DF Zephyr, and Visual SFM + Meshlab. Finally, this software is compared with each other in terms of performance, ease of operation, processing time, and accuracy.

2. Method

2.1. Data used

In this study, historical artifact figurine and wooden cube were modeled. A mobile phone camera (Samsung Galaxy J7) was used to obtain the images. The camera has a 3.7 mm focal length and 13 megapixels resolution. A total of 36 pictures were taken from around the object (Fig. 1).

2.2. Software Used

The VisualSFM program that was developed by Chang chang Wu, is a graphical user interface (GUI) application that provides 3D modeling with images using the SFM technique (Wu, 2011).

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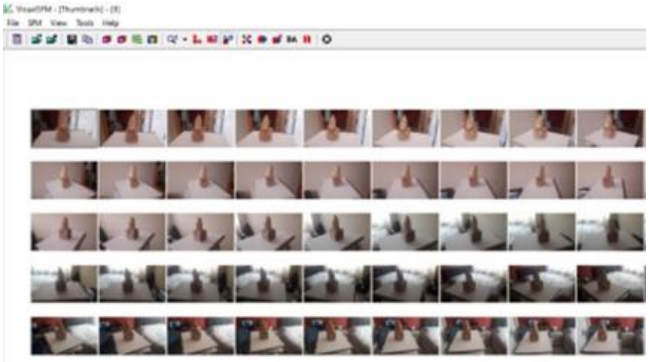


Figure 1. Captured photos.

MeshLab is a 3D mesh processing software system aimed at organizing and processing huge unstructured meshes, with capabilities for editing, cleaning, healing, inspecting, rendering, and converting them. (Cignoni *et al.*, 2008).

Agisfot photoscan is commercial software based on SFM for point clouds, mesh models, DSMs / DTMs and orthophotos from images. (Agisoft, 2014).

3DF Zephyr is commercial photogrammetry and 3D modeling software. It's a software suite that includes various post-processing tools for post-processing, measuring, 3D modeling, and content production. It enables for 3D reconstruction from photographs or movies by automatically removing frames and selecting the ones that are most suited for calculation.

2.3. Camera Calibration

The calculation of the camera's internal orientation parameters using the 3D coordinates of a point in space and the related picture coordinates is known as camera calibration (Song *et al*., 2013). Agisoft Lens software used as the first camera for the calibration. Photos taken chessboards to add chunk and add photos were installed by performing the steps respectively. Then the camera Calibration tool was opened and the calibration file was loaded, evaluated in Agisoft Lens software and saved in xml format (Table 1). This way, the camera type used was introduced to the program and calibrated. For calibration, 13 images were taken from different angles of the software's chessboard (Fig. 2).

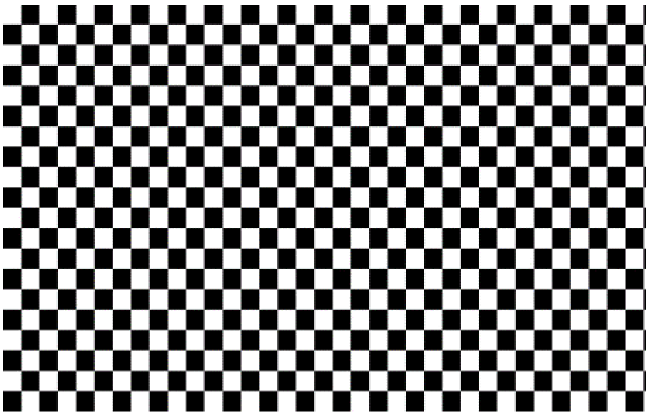


Figure 2. Agisof Lens Calibration Cheesboard

Table 1. Camera interior orientation parameters.

Parameter	Value
f	3.78 mm
c_x	0.074 mm
c_y	-0.003 mm
k_1	0.362182
k_2	-1.96877
k_3	3.84656
k_4	-2.18084
b_1	-1.36718
b_2	3.77981
p_1	-0.00019
p_2	-0.00166

2.4. Structure from Motion (SFM)

The software based on the Structure-from-Motion (SfM) method, which uses photogrammetric principles to derive the 3D coordinates of an object by measuring the corresponding points between two overlapping photos. Contrary to traditional photogrammetry, SFM creates object geometry by autonomously resolving camera locations and orientation without the need of a target network with specified 3D coordinates. Camera pose and scene geometry are reconstructed in real time by automatically matching points in several photos, and camera positions and object coordinates are calculated using these points' coordinates (*Duran et al.*, 2021). Initial values are iteratively improved by applying linear least-squares adjustment (Westoby *et al.*, 2012).

2.5. Experiment

After calibration, 36 images were transferred to softwares for photogrammetric model generation. Images were matched to each other using automatically generated key points. The camera's resolution was used as full capacity and 60.000 was selected as the key point limit. Then, tie points were determined among the key points for matching, and thus, all images were aligned. The tie point limit is set to 10,000. The lengths on the cube were used to scale the model. The lengths were measured with caliper and defined on the software. Thus, it was ensured that the generated point cloud was formed on a real-world scale. Dense point cloud was produced by using the resulting sparse point cloud. In order to pass from the point cloud to the mesh model, the surface is passed through the points with interpolation. The model was produced literally by adding the texture produced from the images. All processes for Photoscan and 3D Zephyr have been completed via software. On the other hand, scaling and point cloud generation were performed in VisualSFM, then the model was produced by transferring the point cloud to MeshLab. The visual of the produced model is shown in Fig. 3.

3. Results

Mesh model generation and scaling have been completed in three software. The visuals of the produced models are shown in Fig. 4.

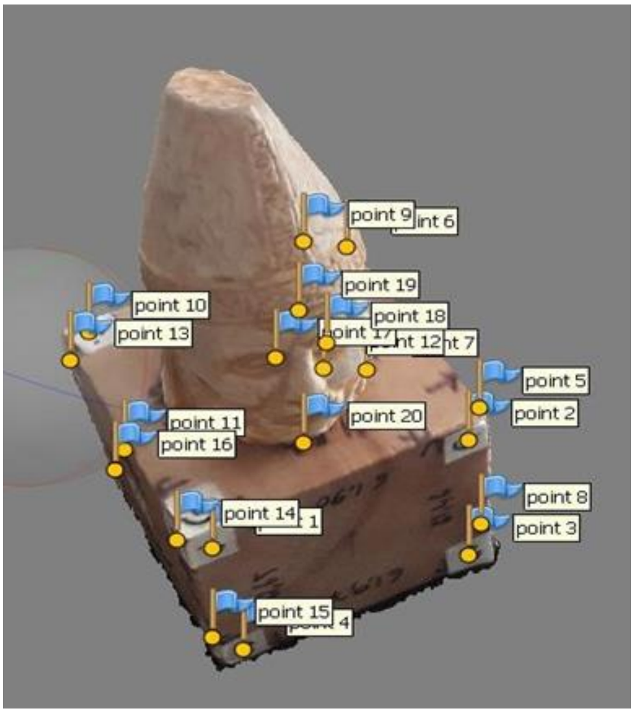
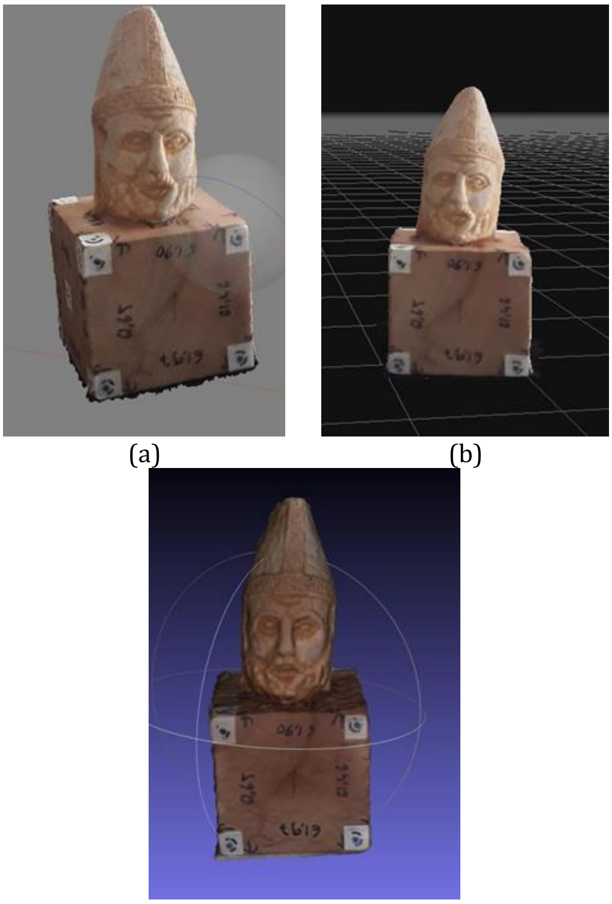


Figure 3. Produced 3D model and marked points.



(a) (b)

(c)

Figure 4. Produced 3D models. (a) Photoscan; (b) 3DF Zephyr; (c) VisualSFM+MeshLab

A total of 26 length were measured on the model. Absolute error was calculated as the actual values were measured with a caliper. RMSE was calculated as ± 0.7 mm for Agisoft Photoscan, ± 5.3 mm for MeshLab and ± 1.5 mm for 3DF Zephyr (Table 2).

Table 2. Comparison of reference lengths and accuracy analysis.

	Absolute Error		
Length	Photoscan (mm)	VisualSFM (mm)	3DF Zephyr (mm)
1	-1	-1.1	0.3
2	0.4	0.5	0.2
3	1.7	2.2	2.6
4	-1.2	-2.9	-1.4
5	-1.1	-0.7	-0.3
6	-0.5	-1.5	0.5
7	-1	-1.1	-1.8
8	-0.5	-0.3	0.5
9	-0.3	-0.4	1
10	-1.2	-2.1	-1.1
11	-0.2	0.3	0.2
12	0.2	1.4	0.4
13	-0.7	5.6	0.9
14	-0.2	3.2	-0.4
15	-0.3	4	1.5
16	-1.3	1.9	-3.4
17	0.1	2.1	0.7
18	-0.5	0.9	-0.4
19	-0.8	1.1	-2.2
20	-0.4	3.2	0.2
21	-0.8	2.2	-0.3
22	-0.5	4.2	-0.2
23	-0.6	1.2	0.2
24	-0.7	0.3	0.9
25	0.2	-0.9	-0.2
26	-1.5	-1.8	-0.7
RMSE	± 0.7 mm	± 5.3 mm	± 1.5 mm

4. Discussion

In the studies carried out in the commercial software of Agisoft Photoscan, it is seen that the photos with regular cover rates give good results in the software and the 3D models formed are true to reality. Furthermore, as the number of photos used for the 3D model in Agisoft software is increased, it is seen that the model accuracy increases in direct proportion to the Tie Points and Key Points limit, but the processing time is extended and the unnecessary points occur.

Although increasing the number of images increases the visual completeness and accuracy of the models, it prolongs the processing time. For this reason, an optimum balance must be achieved between the image capture parameters and the processing time.

When Meshlab software, Agisoft Photoscan and 3DF Zephyr software were compared in terms of obtaining Texture Clothed Model and their performance, it was observed that Agisoft and Zephyr commercial software performed the processes faster. In contrast, in the Meshlab Open-Source Software, the processes were slower as they were done in steps and manually.

Although the Dense cloud created in Visual SFM contains a lot of unnecessary points and as a result, the defects occurring in the modeling made in Meshlab software are tried to be eliminated by filtering and cleaning processes

5. Conclusion

In this study, the performance of Open-Source Software is evaluated as an alternative to commercial software used in modeling small objects. The accuracy, convenience and processing times between 3D models produced with open-source software and 3D models obtained with commercial software are evaluated. In this study, Zeus miniature statuette and a calibration cube made of wood of a specific size are used as small objects. The photographs of the objects were taken from different angles and saved for 3D modeling. Photos are used to produce 3D models in Agisoft Photoscan, Visual SFM + Meshlab and 3DF Zephyr software.

Even if Agisoft Photoscan and 3DF Zephyr are better than MeshLab and Visual SFM, which are Open-Source software in terms of ease of processing, shorter processing time and accuracy, Open-Source software can be used as an alternative to Commercial software as it is used and developed by many users. As more information is shared among users and the number of people using for photogrammetric purposes, the processing times of these software will be shortened, and their accuracy will increase.

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