COMPARISON OF COMPUER-VISION-BASED PHOTOGRAMMETRIC SOFTWARE FOR RECONSTURCTING VIRTUAL INDIGENOUS TRIBE

Yu-Qi Lin (1), Sendo Wang (1)

[1]Dept. of Geography, N.T.N.U., 162 HePing E. Rd. Sec. 1, Taipei 10610, Taiwan, R.O.C.

Email: kiki850729@gmail.com; sendo@ntnu.edu.tw

KEY WORDS: Photogrammetry, Computer Vision, Virtual Indigenous Tribe

ABSTRACT: To help the young generation of urban indigenous peoples who is far from their home tribes to learn their traditional environmental knowledge, we proposed a novel concept called "Virtual Indigenous Tribe". It is reconstructed by aerial images taken by an unmanned aerial vehicle (UAV) and panoramic images taken by a 360° dual-fish-eye camera. Benefit from the rapid development of computer vision algorithms and technologies, the ortho-rectified mosaic image and the 3D mesh model of an indigenous tribe can be comparably easier derived from aerial images. However, the precision of these computer-vision-based photogrammetric software are always challenged and their results will also differ widely by locations. Thus, we expect to compare the difference between these computer-vision-based photogrammetric software when reconstructing a virtual indigenous tribe. Pix4Dmapper and Agisoft Metashape Professional are the two computer-vision-based photogrammetric software chosen to compare with. We will first survey and compare the specifications of each software, such as hardware requirements, the difference between different versions, input data requirements and so on. Then, we generate 3D models using these software that all parameters are set to the same. We compare each software with the operating time, simplicity of operation, and the precision and accuracy of the results. Result shows that Pix4Dmapper is more effective and has higher degree of automation than Agisoft Metashape Professional. Therefore, we recommend Pix4Dmapper for teachers and people in tribes to reconstruct their Virtual Indigenous Tribes.

1. INTRODUCTION

1.1 Virtual Indigenous Tribe

To help the young generation of urban indigenous peoples far from their home tribes to learn their traditional environmental knowledge, we proposed a novel concept called "Virtual Indigenous Tribe". There have been some researches on applying virtual reality on the inheritance of indigenous traditional knowledge. Digital Songlines, developed by ACID (Australasian CRC for Interaction Design), connected the spirit and culture of the indigenous people to their land. They built a virtual landscape with oral history and mythological stories (Wyeld et al., 2007). As for Taiwan, Lejen (2015) developed a Truku (one of Taiwanese sixteen indigenous peoples) traditional hunting game. Through 3D virtual reality simulation of hunting scenes and activities, he aroused the curiosity and interest of indigenous students in traditional ecological knowledge. Both of them built 3D properties, landscape, and characters

by 3D animation software, such as Autodesk 3ds Max. However, we will try to reconstruct the tribal landscape by aerial images taken by an unmanned aerial vehicle (UAV) in this study. This method can not only give the 3D model absolute coordinates but also make the "Virtual Indigenous Tribe" more realistic because of the image texture.

1.2 Computer-vision-based Photogrammetric Software

Benefit from the rapid development of computer vision algorithms and technologies, the ortho-rectified mosaic image and the 3D mesh model of an indigenous tribe can be comparably easier derived from aerial images. Computer-vision-based photogrammetry or so called Structure-from-Motion (SfM) photogrammetry is a low-cost, user-friendly and effective method relative to traditional digital photogrammetry (Westoby et al.). There are some commercial computer-vision-based photogrammetry software such as Pix4Dmapper, Agisoft Metashape, Bentley ContextCapture, Altizure and so on. Some of them provide limited time free trail for users. Due to the low-cost, user-friendly and effective characteristic, we apply computer-vision-based photogrammetric software to reconstruct virtual indigenous tribes so that teachers and people in the indigenous tribes are able to teach and preserve traditional environmental knowledge through the concept of "Virtual Indigenous Tribes". According to the above, the objective of this study is to compare the difference between computer-vision-based photogrammetric software for the purpose of reconstructing Virtual Indigenous Tribes.

2. METHODOLOGY

2.1 Software

We choose two computer-vision-based photogrammetric software to compare with, which is Pix4Dmapper and Agisoft Metashape Professional. The specifications from official webs and manuals of Pix4Dmapper and Agisoft Metashape are shown below:

2.1.1 Computer Requirements: Table 1 shows the recommended system requirements of Pix4Dmapper and Agisoft Metashape. Both of them require similar hardware, while Pix4Dmapper requires slightly high specification on the operating system. Besides, Agisoft Metashape support the Mac OS X and Debian/Ubuntu operating system but Pix4Dmapper don't.

Table 1. Recommended Computer Requirements

Hardware	Pix4Dmapper	Agisoft Metashape
Operating system	Windows 8, 10, 64 bits	Windows 7 SP 1 or later (64 bit), Mac OS X Mountain Lion or later, Debian/Ubuntu with GLIBC 2.13+ (64 bit)
CPU	quad-core or hexa-core Intel i7/Intel i9/Threadripper/Xeon/	Intel Core i7 or AMD Ryzen 7 processor
GPU	GeForce GTX GPU compatible with	Discrete NVIDIA or AMD GPU

	OpenGL 3.2 and 2 GB RAM	
Hard Disk	SSD	Not mentioned
RAM	32 GB RAM (over 500 images)	32 GB

2.1.2 Inputs: The inputs to Pix4Dmapper are mainly images, video files can be imported instead of still images as well. Pix4Dmapper can process images taken with any camera, as long as it is either JPEG or TIFF files, video files that can be imported into Pix4Dmapper are .avi, .mp4, .wmv and .mov (Pix4D, 2019). The supported image formats that can be imported into Agisoft Metashape are JPG, TIFF, PNG, BMP, OpenEXR, JPEG 2000, TARGA, DNG, Portable Bit Map (PGM, PPM), Multi-Picture Object (MPO), Norpix Sequence (SEQ) and AscTec Thermal Images (ARA) (Agisoft, 2019). In short, only JPEG and TIFF images can be imported into Pix4Dmapper, and video files can't be imported into Agisoft Metashape.

2.1.3 Features and Outputs: Outputs that Pix4Dmapper generates are shown in Table 2.   Comparison of features between standard edition and professional edition of Agisoft Metashape are shown in Table 3.

Table 2. Outputs of Pix4Dmapper (Pix4D, 2019)

Outputs	Output formats
Color point cloud	.las, .laz, .ply, .xyz
Classified point cloud	.las, .laz
Orthomosaic	GeoTiff (.tif), .kml
Digital surface model (DSM)	GeoTiff (.tif), .xyz, .las, .laz
Digital terrain model (DTM) Digital elevation model (DEM)	GeoTiff (.tif)
3D textured mesh	.ply, .fbx, .dxf, .obj, .pdf
Contour lines	.shp, .dxf, .pdf
Facade digital surface model	GeoTiff (.tif)
Facade orthomosaic	GeoTiff (.tif)
Reflectance maps	GeoTiff (.tif), .shp
Index maps	GeoTiff (.tif), .shp
Thermal maps	GeoTiff (.tif)
Video animation	.mp4, .mkv, .avi
3D digitized objects	.shp, .dxf, .kml, .dgn

Table 3. Comparison of features between different editions of Agisoft Metashape (Agisoft, 2019)

Features	Professional Edition	Standard Edition
Photogrammetric triangulation	✓	✓
Dense point cloud: generation and editing	✓	✓
3D model: generation and texturing	✓	✓

Spherical panorama stitching	✓	✓
Fisheye camera support	✓	✓
Spherical and cylindrical camera support	✓	✗
Dense point cloud: classification	✓	✗
DEM: georeferenced DSM / DTM export	✓	✗
Georeferenced orthomosaic export	✓	✗
Orthomosaic seamline editing	✓	✗
Ground control points support	✓	✗
Coded / non-coded targets auto detection	✓	✗
Multispectral imagery processing	✓	✗
NDVI and other vegetation indices calculation	✓	✗
Hierarchical tiled model generation	✓	✗
4D modeling for dynamic scenes	✓	✗
Network processing	✓	✗

2.1.4 Prices: Pix4Dmapper provides a 15 days free trail while Agisoft Metashape provides a 30 days free trail for users. Both software provide educational special prices for educational institutions. Prices of Pix4Dmapper are much more expensive than those of Agisoft Metashape (Table 4). Moreover, Pix4Dmapper provides floating-license on the official website, but you should purchase the floating-license of Agisoft Meatshape only from resellers of your country.

Table 4. Prices of Pix4Dmapper and Agisoft Metashape

Products	License	Price (USD)
Pix4Dmapper Perpetual	Floating-license (1 device)	$4990
Pix4Dmapper Subscription Yearly	Floating-license (2 devices)	$292/month
Pix4Dmapper Subscription Monthly	Floating-license (2 devices)	$350/month
Pix4Dmapper Education Perpetual Professor	Floating-license (2 devices)	$1990
Pix4Dmapper Education Perpetual Classroom	Floating-license (25 devices)	$6700
Agisoft Metashape Professional Edition	Node-locked license(1 device)	$3499
Agisoft Metashape Standard Edition	Node-locked license(1 device)	$179
Agisoft Metashape Professional Educational	Node-locked license(1 device)	$549
Agisoft Metashape Standard Educational	Node-locked license(1 device)	$59

2.2 Comparison

Michael Schwind and Michael Starek (2017) compared three different types of Structure-from-Motion software, including two commercial software, Pix4D and Agisoft PhotoScan, and an open-source software called OpenDroneMap. They compared the data processing and the output quality through point cloud density and standard deviations of these software. For the purpose of Virtual Indigenous Tribe, we will compare the mesh built by

Pix4Dmapper (version 4.4.12) and Agisoft Metashape Professional (version 1.5.3.8469). Also, we will compare the workflow and the operating time building mesh of the two software to see which one is more effective.

3. EXPERIMENT

3.1 Study Area

Da-Tung Junior High School is located in Yilan County, Taiwan. Most students are from Atayal tribes near the school so there are a plenty of indigenous constructions in school, such as barn, firewood house, hunting building, traditional house and observatory. Therefore, this is a suitable place to be our study area for reconstructing Virtual Indigenous Tribes.

3.2 Data

We use Parrot Anafi to take aerial images of Da-Tung Junior High School. Parrot Anafi is a UAV manufactured by Parrot, a French company. 1313 JPG format images were imported. The shooting date was April 8, 2019. The focal length is 4mm obtained from EXIF and the resolution is 5344*4016. The flight height was 30 meters above the ground. We didn't add control point into the process because survey is a professional subject that teachers and people in tribes may unlikely familiar with.

4. RESULTS AND DISCUSSION

4.1 Operating procedures and Time for Reconstructing Virtual Indigenous Tribes

The operating procedures of Pix4Dmapper are quite simple. First of all, we should set up a new project. Secondly, add UAV images of indigenous tribes (JPEG or TIFF). After adding images, Pix4Dmapper will read the exterior orientation parameters from EXIF. Then, we should set the coordinate system you want to export and choose the mode to generate. Finishing the steps above, Pix4Dmapper will automatically run the project, all we can do is waiting until it finished. There are three phases in 3D Maps mode, Initialization Processing, Point Cloud and 3D Textured Mesh Generation, and DEM, Orthomosaic and Index. The operating procedures of Agisoft Metashape Professional are relatively less automatically but are really similar to Pix4Dmapper. The first step is to add photos. The next step is to align photos. We can choose the accuracy and tie point limit in this step. After aligning photos, we can choose to build dense cloud, mesh, texture, DEM or orthomosaic. We only generate mesh in this article. The last step is to export model. Different from Pix4Dmapper, the export coordinate system is chosen in this step. The operating time of Pix4Dmapper and Agisoft Metashape Professional are shown in Table 5. Compare with Pix4Dmapper, it took twice time generating mesh in Agisoft Metashape Professional.

Table 5. Operating Time of Generating 3D Mesh

	Pix4Dmapper	Agisoft Metashape Professional

Initial Processing	11h 43min 16s	
3D Textured Mesh Generation	44min 25s	
Matching Time		1h 5min
Alignment Time		53min 48s
Depth Maps Generation		9h 58min
Reconstruction		15h 16min
Total Processing Time	12h 27min 41s	27h 12min 48s

4.2 Average Camera Location Error

The average camera location error of Pix4Dmapper and Agisoft Metashape Professional are shown in Table 6. Where Z coordinates produced the largest error compare with X and Y coordinates and between two software. It shows that the horizontal variability was less than the vertical variability.

Table 6. Average Camera Location Error (meters)

	X (meters)	Y (meters)	Z (meters)
Pix4Dmapper	1.279165	1.589240	2.538159
Agisoft Metashape Professional	1.29164	1.58543	2.86336

4.3 Mesh

The whole mesh are shown in Figure 1 and 2. The region of Pix4Dmapper is bigger than that of Agisoft Metashape Professional. The mesh of Agisoft Metashape Professional cuts the sports field, but trees near the edge of the mesh are more complete compared with Pix4Dmapper. Besides, colors of both mesh are similar.

Figure 1. 3D Textured Mesh of Da-Tung Junior High School (Pix4Dmapper)

Orthographic

faces: 1,051,808 vertices: 526,970

Figure 2. 3D Textured Mesh of Da-Tung Junior High School (Agisoft Metashape Professional)

4.3.1 Semi-Indoor Basketball Field: The texture of the roof generated by Pix4Dmapper is more detailed, we can see clearly Atayal totem on the roof (Figure 3). However, the edge of the roof is relatively smooth in Agisoft Metashape Professional (Figure 4).

Figure 3. Semi-Indoor Basketball Field (Pix4Dmapper)

Figure 4. Semi-Indoor Basketball Field (Agisoft Metashape Professional)

4.3.2 Farm and Vegetation: Trees and leaves are considered homogeneous textures, they are relatively hard to match to the right point. Therefore, trees and farm are more blurred than the buildings in both software (Figure 5 and 6).

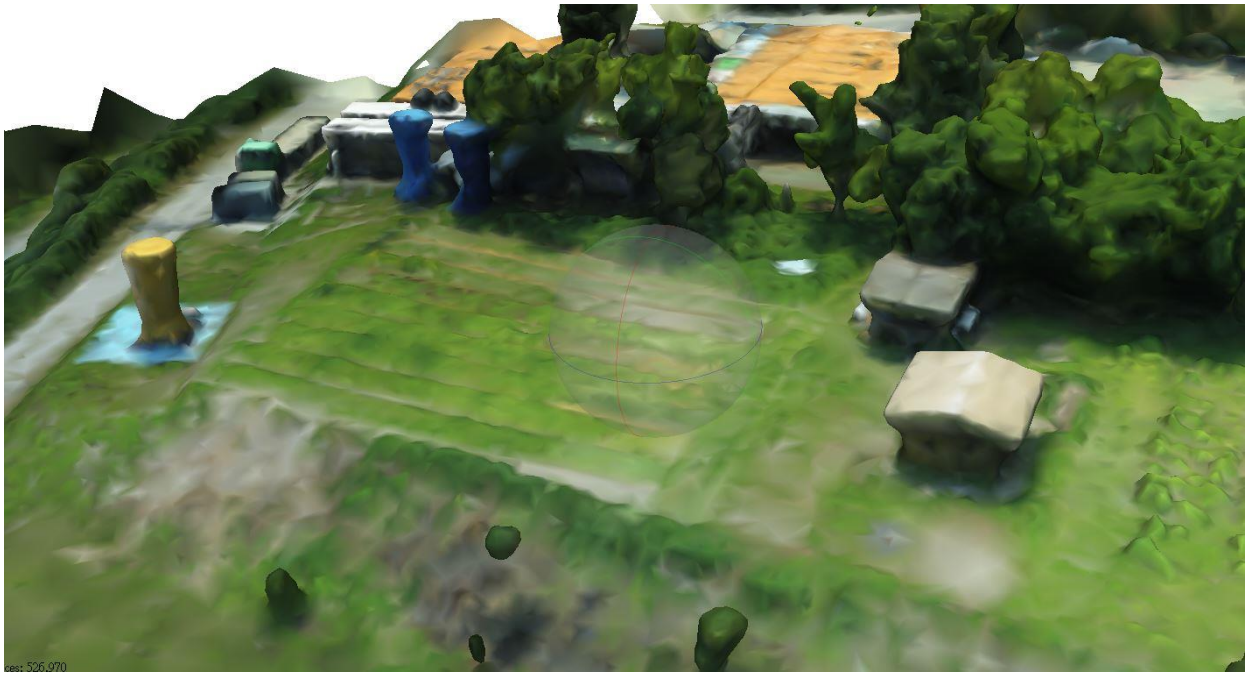Figure 5. Farm and Vegetation (Pix4Dmapper)

Figure 6. Farm and Vegetation (Agisoft Metashape Professional)

5. CONCLUSION

Both Pix4Dmapper and Agisoft Metashape Professional provide a whole set of generating 3D textured mesh from images taken via UAV, which is used to reconstruct Virtual Indigenous Tribes. However, they provide different procedures and parameters setting. According to the results, the operating time of Pix4Dmapper is extremely less than that of Agisoft Metashape Professional. The average camera location errors were close in X and Y coordinates to each other, while errors of Z coordinates were smaller in Pix4Dmapper. Region of the 3D textured mesh are more complete in Pix4Dmapper, but the building edges are more complete and smoother in Agisoft Metashape Professional. The workflow of Pix4Dmapper is more effective and has higher degree of automation than Agisoft Metashape Professional. In conclusion, we recommend Pix4Dmapper for teachers and people in tribes to reconstruct their Virtual Indigenous Tribes due to the simplicity of operation compare with Agisoft Metashape Professional.

6. REFERENCE

References from Journals:

Lejen, K., 2015. Pisaw's Hunting School: Digital Game-based Learning for the Eudcation of Truku's Traditional Hunting Culture. Master, National Taiwan Normal University.

Westoby, M.J., Brasington, J., Glasser, N.F., Hambrey, M.J. & Reynolds, J.M., 2012. 'Structure-from-Motion' photogrammetry: A low-cost, effective tool for geoscience applications. Geomorphology, 179, pp. 300-314.

Wyeld, T. G., Carroll, J., Gibbons, C., Ledwich, B., Leavy, B., Hills, J. & Docherty, M. J., 2007. Doing Cultural Heritage Using the Torque Game Engine: Supporting Indigenous Storytelling in a 3D Virtual Environment. International Journal of Architectural Computing, 5(2), pp. 418-435.

References from Other Literature:

Agisoft LLC, 2019. Agisoft Metashape User Manual: Standard Edition, Version 1.5.

Pix4D, 2019. Pix4Dmapper 4.1 User Manual.

References from websites:

Agisoft LLC, 2019. Features, Retrieved August 18, 2019, from https://www.agisoft.com/features/compare/.

Pix4D, 2019. Inputs and Ouputs, Retrieved August 18, 2019, from https://support.pix4d.com/hc/en-us/articles/115002439503-Inputs-and-outputs.

Schwind, M. & Starek, M., 2017. Producing High-quality 3D Point Clouds from Structure-fron-Motion Photogrammetry, Retrieved August 20, 2019, from https://www.gim-international.com/content/article/structure-from-motion-photogrammetry.