International Journal of Geospatial and Environmental Research

Volume 10 | Number 1 Article 2

July 2023

Comparing Drone2Map versus Pix4Dmapper when Creating Orthophoto Mosaics over Homogeneous Land Features

Victoria Williams
Stephen F. Austin State University, williamsv5@jacks.sfasu.edu

Daniel R. Unger
Stephen F. Austin State University, unger@sfasu.edu

David Kulhavy
Stephen F. Austin State University, dkulhavy@sfasu.edu

I-Kuai Hung
Stephen F. Austin State University, hungi@sfasu.edu

Yanli Zhang
Stephen F. Austin State University, zhangy2@sfasu.edu

Comparing Drone2Map versus Pix4Dmapper when Creating Orthophoto Mosaics over Homogeneous Land Features

Abstract

This study evaluated two popular software packages currently used within the natural resources profession to create orthophoto mosaics: Drone2Map and Pix4Dmapper. Of particular concern was how effective these two software packages would perform in creating orthophoto mosaics over a city park in East Texas consisting of forest, open grass, and urban concrete surrounding a lake. Two drone flights over the city park were conducted. One flight was at 76 meters (250 feet) above ground with a single pass configuration. The other flight was at 122 meters (400 feet) above ground with a double pass configuration. Upon the completion of each drone flight, two orthophoto mosaics were created for each flight using all images acquired per flight with Drone2Map and Pix4Dmapper software. For the single pass configuration Drone2Map failed to complete a basic orthophoto mosaic. For the double pass configuration Drone2Map did improve within the forest, grass and urban concrete areas surrounding the lake, but it was not able to identify tie points within the homogeneous lake surface resulting in void areas in the center of the lake. Pix4Dmapper was an improvement over Drone2Map for the single pass configuration, and performed better than Drone2Map in the forest, grass and urban concrete areas, but it also failed to identify tie points within the homogeneous lake. Pix4Dmapper for the double pass configuration was able to produce a complete orthophoto mosaic for all land features within the study area including the homogeneous lake. These results indicate that when a drone is flown in a double grid pattern Pix4Dmapper will produce a complete orthophoto mosaic, even over homogenous areas like a small lake, when compared to Drone2Map.

Keywords

Orthophoto mosaic, UAS, drone, Drone2Map, Pix4Dmapper

Acknowledgements

This work was supported by a McIntire-Stennis grant and a Center for Applied Research and Rural Innovation grant administered by the Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, Nacogdoches, Texas, USA.

1 INTRODUCTION

Creating orthophoto mosaics from Unmanned Aerial Systems (UAS), also known as drones, is becoming common place within the geospatial science community. Drones, which can be launched locally for site specific information, can be controlled locally and flown to acquire digital aerial imagery under control of the local user. The drone user by collecting their own imagery controls the spatial, spectral, radiometric, and temporal resolution of any derived map layer, a revolutionary change in remote sensing (Yao et al. 2019). To maintain data collection continuity, drone acquired imagery typically follows the data processing methodology that originated with the advent of aerial photography and follows the endlap and sidelap percentages that have been operating historically but with more variable percent options.

One of the most basic uses of operating a drone with natural resources applications is to generate an orthophoto mosaic of a study area (Hung et al. 2019). An orthophoto mosaic is a highly accurate georeferenced map in digital form of a study area created by mosaicking multiple individual digital images together to generate a digital composite. An orthophoto mosaic product provides a user a composite digital image useful for visual interpretation, manual digitization and cadastral mapping (Badea and Badea 2020). By obtaining imagery along predetermined parallel flight paths, and along perpendicular predetermined parallel flight paths in a grid pattern, the subsequent digital images can be stitched together with highly specialized computer software to produce a continuous image of the study area which is called an orthophoto mosaic.

Orthophoto mosaics are created by merging individual images collected along predetermined parallel flight paths, or with individual images collected along predetermined parallel flight paths combined with images collected with subsequent perpendicular predetermined parallel flight paths (Unger et al. 2016). Through geographic positioning within specialized computerized software, edge matching, and photogrammetry, this orthorectify process generates a highly accurate and useful digital image used as a base map in many geospatial science products (Zhang et al. 2023).

Drone2Map (ver. 2022.1.1) and Pix4Dmapper (ver. 4.8.2) are specialized computer software designed to mosaic individual digital images acquired from the air into an orthophoto mosaic. During this process, other products can be created such as an elevation point cloud, digital elevation model, digital surface model, and 3D mesh (Badea and Badea, 2020; Kulhavy et al. 2021). Drone2Map is an Environmental Systems Research Institute, Inc. (ESRI) product while Pix4Dmapper is a Pix4D Inc. product. Both software products are very popular among drone users.

Digital images utilized by both software packages are not software dependent meaning both software products can use digital imagery acquired from the same flight. In addition, both Drone2Map and Pix4Dmapper can create orthophoto mosaics using digital imagery created via a single pass flight (images collected along parallel flight lines) or a double pass flight (images collected along parallel and perpendicular flight lines) (Unger et al. 2019). For flight planning, Jakubek and Tran (2020) in a previous study migrated from Drone2Map to Pix4Dmapper orthophoto mosaic creation software based on availability and reliability of Pix4Dmapper when flying a double grid mission, with the camera set to 80 degrees with a minimum of 80 percent sidelap and 80 percent endlap.

Although Drone2Map and Pix4Dmapper allow a geospatial scientist to create an orthophoto mosaic, the ability of each unique software package to create an orthophoto mosaic needs to be evaluated for their ability to create a complete and accurate orthophoto mosaic based on the initial drone flight settings. The purpose of this study was designed to evaluate and compare Drone2Map versus Pix4Dmapper when creating orthophoto mosaics over homogeneous land features for natural resource applications. In particular, over a city park in East Texas encompassing forest, open grass, and urban concrete surrounding a lake. Drone2Map and Pix4Dmapper were chosen for their ease of implementation and popularity within the geospatial science community while the city park was chosen to compare the derived orthophoto mosaics across variable land features. It is important for both the academic and geospatial science user community to understand the effectiveness of Drone2Map and Pix4Dmapper when creating homogeneous orthophoto mosaics across a variable landscape.

2 METHODS

2.1 Study Site

This study evaluated the ability of Drone2Map versus Pix4Dmapper in creating complete orthophoto mosaics over homogeneous land features in Ellen Trout Memorial Park in East Texas encompassing approximately 56.4 hectares (139.4 acres). Ellen Trout Memorial Park is a city park located in the northwest portion of Lufkin, Texas. In the center of the park is Ellen Trout Memorial Lake which is surrounded by forest, open grass, and urban concrete (Figure 1).

Figure 1. Ellen Trout Memorial Park in northwest Lufkin, Texas.

Drone2Map and Pix4Dmapper were evaluated for their ability to create complete orthophoto mosaics using digital imagery from 2 different drone flights. The first drone flight collected digital imagery from a single pass flight with the image data collected along parallel flight lines. The second drone flight collected digital imagery from a double pass flight with the image data collected along parallel and perpendicular flight lines. Study site methodology is visualized in the schematic diagram in Figure 2.

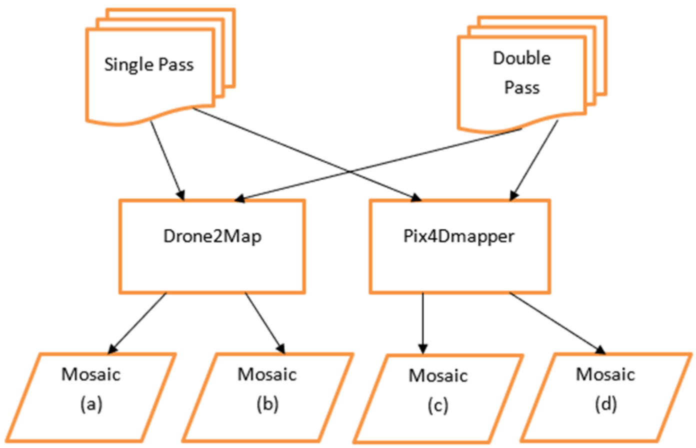

Figure 2. Hierarchical diagram of drone imagery acquisition and orthophoto generation: (a) single pass with Drone2Map, (b) double pass with Drone2Map, (c) single pass with Pix4Dmapper and (d) double pass with Pix4DMapper.

2.2 Drone Flight 1

The first drone flight was flown at noon on January 19, 2023 using a DJI Phantom 4 Pro Version 2 drone. In the field, the Pix4Dcapture app on an iPad mini (6th generation iPadOS ver. 16.5) synched to the drone was utilized to design a single pass flight at an altitude of 76 meters (250 feet) above ground that resulted in a spatial resolution of 2.08 centimeters (0.82 inches) per pixel. Flight path dimensions were 774 x 511 meters (2539 x 1676 feet) and projected to be completed in 34 minutes and 40 seconds (Figure 3, Table 1). Endlap percentage along the single pass image collection flight was set to 70 percent and sidelap of 60 percent with a nadir view of 90 degrees (Figure 4).

Table 1. Single and double drone flight path configurations designed in Pix4Dcapture.

	Drone Flight 1 (single pass configuration)	Drone Flight 2 (double pass configuration)
Date	January 19, 2023	February 10, 2023
Number of Images	432	504
Flight Time	34 Minutes 40 Seconds	41 Minutes 16 Seconds
Flying Height (meters)	76	122
Endlap (percent)	70	80
Sidelap (percent)	60	60
Flight Path Dimensions (meters)	774 × 511	752 × 490

Figure 3. Single pass drone flight configuration designed in Pix4Dcapture.

After completing flight 1 the drone flight image data were downloaded onto the server in the Arthur Temple College of Forestry and Agriculture (ATCOFA) GIS research lab. The data were then imported into both Drone2Map and Pix4Dmapper software to create orthophoto mosaics of Ellen Trout Memorial Park using the single pass drone flight data.

In order to calculate the percentage of completeness per drone flight, each orthophoto mosaic product was used to create a map of completeness using the remote sensing software package ERDAS Imagine 2022 (Hexagon, Inc. ver. 16.7.0). Within ERDAS Imagine software each orthophoto mosaic was classified into a map depicting two specific areas; an area of coverage labelled completeness and an area of no coverage or no completeness.

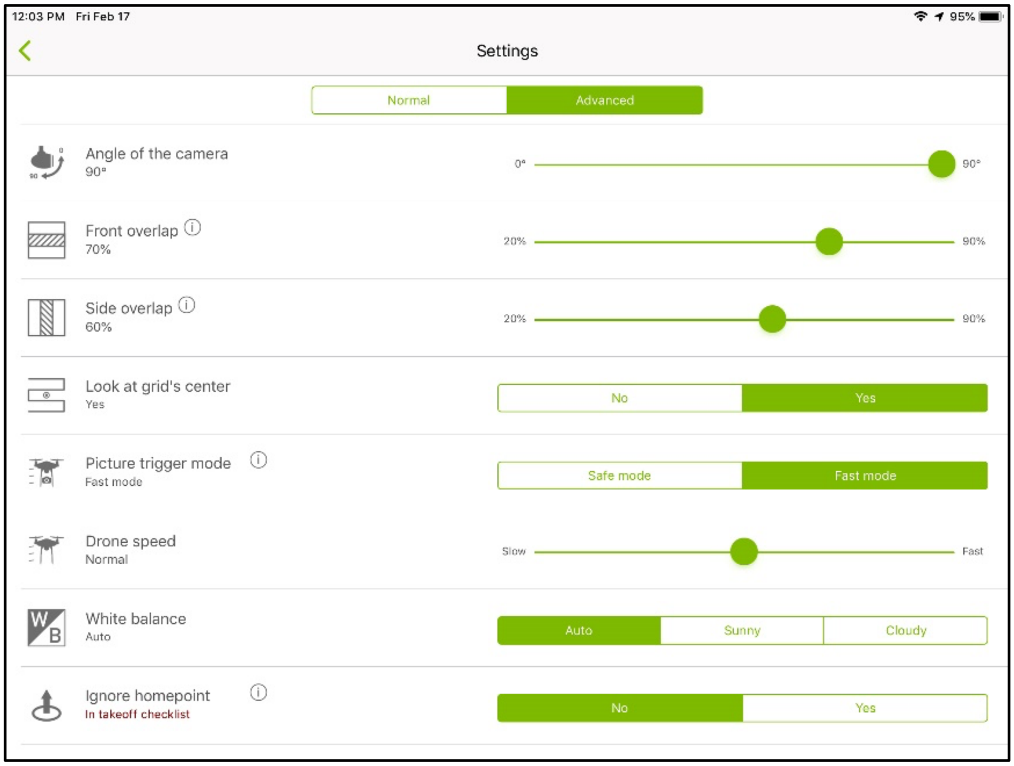

Figure 4. Single pass drone flight camera specifications designed in Pix4Dcapture.

2.3 Drone Flight 2

The second drone flight was flown at noon on February 10, 2023 using the same DJI Phantom 4 Pro Version 2 drone while maintaining similar weather conditions. In the field, the Pix4Dcapture app on an iPad mini synched to the drone was utilized to design a double pass flight at an altitude of 122 meters (400 feet) above ground that resulted in a spatial resolution of 3.38 centimeters (1.33 inches) per pixel. Flight path dimensions were 752 $\times$ 490 meters (2467 $\times$ 1607 feet) and projected to be completed in 41 minutes and 16 seconds (Figure 5, Table 1). Endlap percentage along the parallel flight lines was set to 80 percent, sidelap percentage along the perpendicular flight lines was set to 60 percent, with a nadir view of 80 degrees (Figure 6).

Figure 5. Double pass drone flight configuration designed in Pix4Dcapture.

Figure 6. Double pass drone flight camera specifications designed in Pix4Dcapture.

After completing flight 2 the drone flight image data were downloaded onto the server in the ATCOFA GIS research lab. The data were then imported into both Drone2Map and Pix4Dmapper software in the ATCOFA GIS research lab to create orthophoto mosaics of Ellen Trout Memorial Park using the double pass drone flight data.

In order to calculate the percentage of completeness per drone flight, each orthophoto mosaic product was used to create a map of completeness using the remote sensing software package ERDAS Imagine. Within ERDAS Imagine software each orthophoto mosaic was classified into a map depicting two specific areas; an area of coverage labelled completeness and an area of no coverage or no completeness.

For both drone flights Drone2Map and Pix4Dmapper apply similar algorithms of image matching in producing an orthomosaic. They both take the geographic coordinates embedded in each aerial image, along with the internal camera parameters, to determine the spatial orientation of individual images. In this process, ground control points (GCP) can be introduced to increase the positional accuracy of a derived orthophoto mosaic. It this study, it was solely based on the camera coordinates without GCPs nor manual tie points, as positional accuracy was not our concern but rather the completeness of the derived orthophoto mosaics. Before the matching process, camera parameters are optimized to compensate for the varying temperature, time, altitude, and terrain for each image taken. A bundle block adjustment is applied to determine the position and orientation of each image through triangulation. At the end, the number of key points per image and number of overlapping images per pixel are determined. In our study, the input image coordinate system was GCS WGS 84, whereas the output orthomosaic was UTM zone 15N WGS 84.

3 RESULTS

Upon the completion of each drone flight, two orthophoto mosaics were created for each flight using all images acquired per flight within Drone2Map and Pix4Dmapper software, respectively. This resulted in four orthophoto mosaics; two per drone flight (one for each computer software package utilized).

Results demonstrate that Drone2Map failed to produce a reliable and complete orthophoto mosaic. For the single pass configuration Drone2Map failed to complete a basic orthophoto mosaic (Figure 7a). For the double pass configuration Drone2Map did improve within the forest, grass and urban concrete surrounding the lake, but it was not able to identify tie points within the homogeneous lake surface resulting in void areas in the center of the lake (Figure 7b). Although Drone2Map did improve with a double pass configuration, the homogeneity nature of the forest and grass features without discrete identifying differences contributed to the lack of a complete orthophoto mosaic.

Pix4Dmapper was an improvement over Drone2Map for the single pass configuration, and performed better than Drone2Map in the forest, grass and urban concrete areas, but it also failed to identify tie points within the homogeneous lake area (Figure 7c). Pix4Dmapper for the double pass configuration was able to produce a complete orthophoto mosaic for all land features within the study area including the homogeneous lake surface (Figure 7d). This was an extremely significant result which indicates that even over a homogeneous surface feature such as a lake Pix4Dmapper was able to identify tie points to create an orthophoto mosaic when Drone2Map failed.

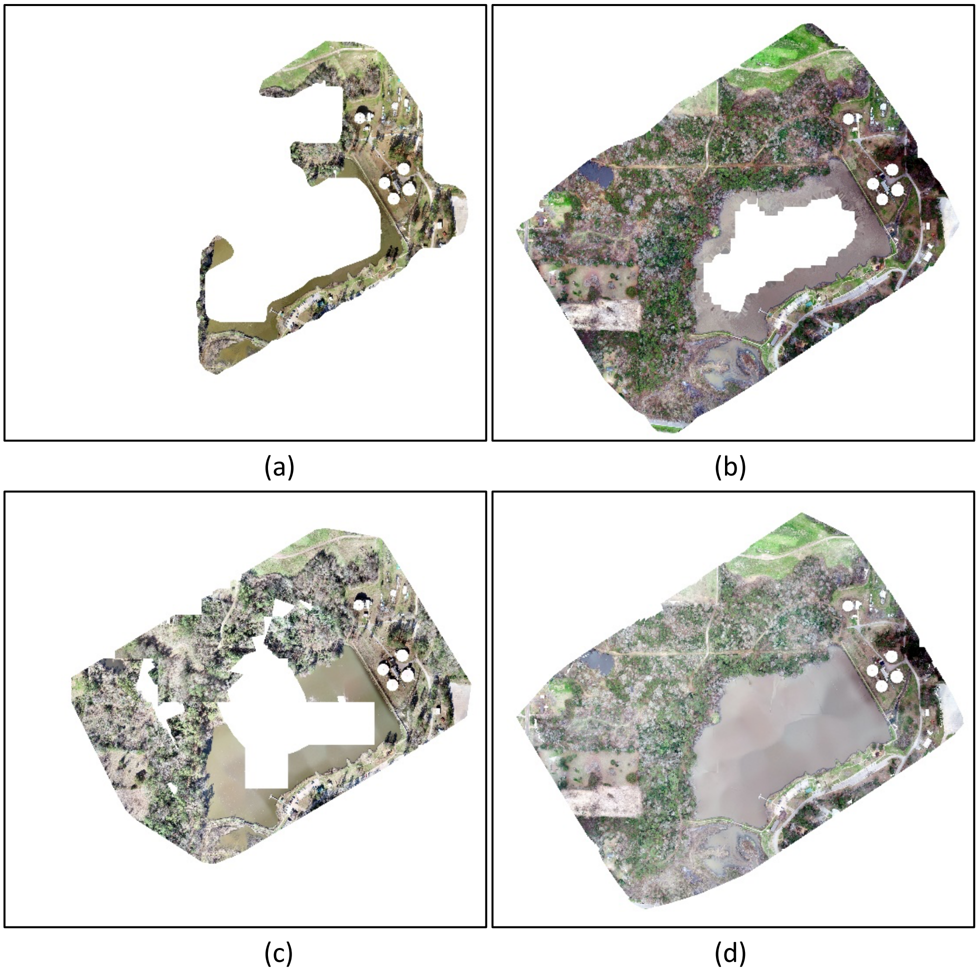

Figure 7. Orthophoto mosaics created for a single pass flight with Drone2Map (a), a double pass flight with Drone2Map (b), a single pass flight with Pix4Dmapper (c), and a double pass flight with Pix4Dmapper (d).

Results from the ERDAS Imagine analysis of completeness indicate that Drone2Map failed to produce a reliable and complete orthophoto mosaic. For the single pass configuration Drone2Map failed to complete a basic orthophoto mosaic and only retained 27.9 percent of the original drone coverage area (Figure 8a, Table 2). For the double pass configuration Drone2Map did improve within the forest, grass and urban concrete surrounding the lake, but it was not able to produce a complete orthophoto mosaic and only retained 92.3 percent of the original drone coverage area (Figure 8b).

Pix4Dmapper was an improvement over Drone2Map for the single pass configuration, and performed better than Drone2Map in the forest, grass and urban concrete areas, but it also failed to produce a complete orthophoto mosaic and retained only 67.3 percent of the original drone coverage area (Figure 8c).

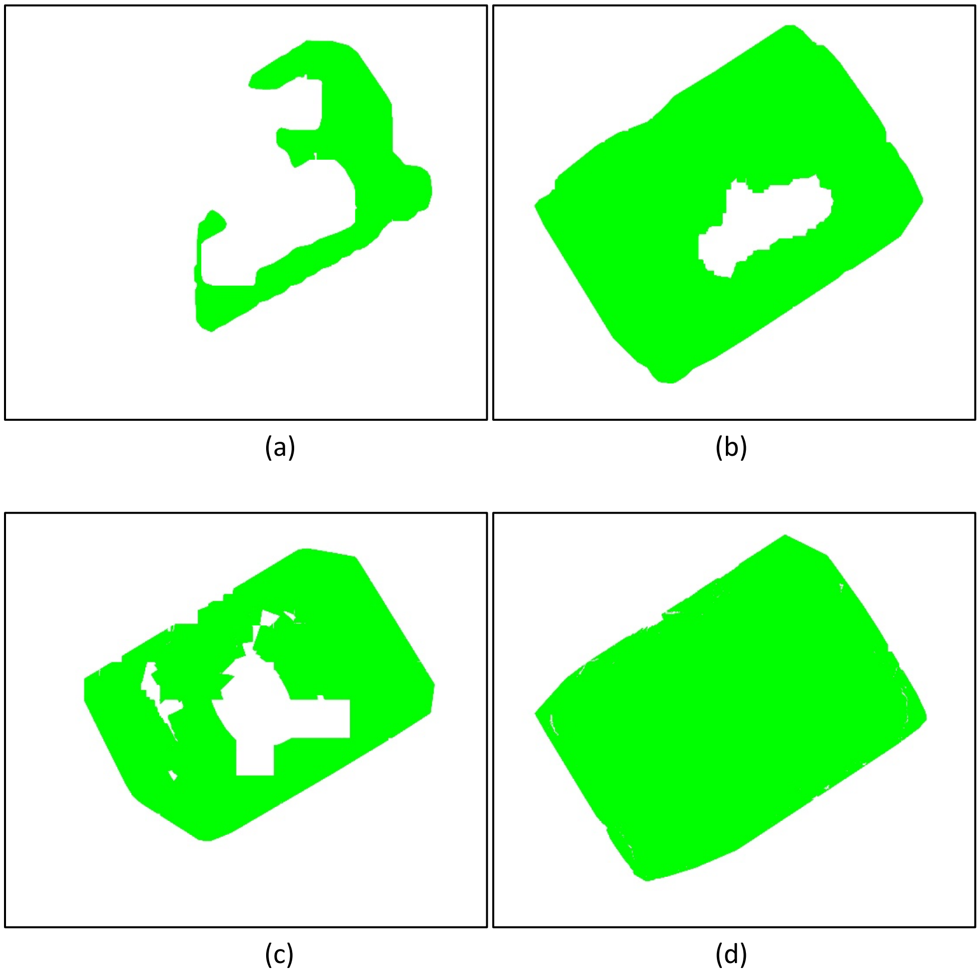

Figure 8. Maps of completeness created for a single pass flight with Drone2Map (a), a double pass flight with Drone2Map (b), a single pass flight with Pix4Dmapper (c), and a double pass flight with Pix4Dmapper (d).

Pix4Dmapper for the double pass configuration was able to produce a complete orthophoto mosaic for all land features within the study area including the homogeneous lake while retaining 99.8 percent of the original coverage area (Figure 8d). The 0.2 percent not included in the coverage area were the outlying areas at the extreme edges of the flight paths outside the study area with minimal to no tie points available.

The image retained ratios ranged from 27.9 to 99.8 percent for the four combinations of flight pass and processing software (Table 2). It translates to an error ranging from 0.2 to 72.1 percent where pixels are missing on the orthophoto mosaic. A root mean square error (RMSE) of 39.8% was observed for the four combinations tested in this study.

Table 2. Orthophoto completeness percentages per mosaic created.

Flight Number	Software	Study Area (Hectares)	Mosaic Area (Hectares)	Background (Hectares)	Image Retained (Percent)
1 (single pass)	Drone2Map	56.4	15.7	40.7	27.9
1 (single pass)	Pix4Dmapper	56.4	38.0	18.5	67.3
2 (double pass)	Drone2Map	56.4	52.1	4.3	92.3
2 (double pass)	Pix4Dmapper	56.4	56.3	0.1	99.8

4 CONCLUSIONS

These results indicate that when a drone is flown in a double pass pattern Pix4Dmapper will produce a complete orthophoto mosaic, even over homogenous areas like a small lake, when compared to Drone2Map when using an 80 percent endlap and a 60 percent sidelap configuration. Although a double pass flight will take more time to complete than a single pass flight, the additional flight time in the field and additional computer processing time will produce better results (Williams et al. 2023).

Although the single pass and double pass flights in this study were flown at different altitudes of 76 meters (250 feet) and 122 meters (400 feet) respectfully, further research should be undertaken to validate the robustness of our results. However, the data show that to ensure the most complete orthophoto mosaic created with Pix4Dmapper that a double pass flight with a combination of parallel and perpendicular flight lines should be employed when designing each drone flight. As was the case with Williams et al. (2023) who found that the best results were obtained with an 80 percent endlap and an 80 percent sidelap. Jakubek and Tran (2020) made the same observations when assessing the ability of Pix4Dmapper to create complete and accurate orthophoto mosaics, but they did not test alternative endlap and sidelap percentages for processing the drone acquired imagery in either Drone2Map or Pix4Dmapper. Drones are useful for image data collection of limited area due to the precision of the drone and the increasing camera resolution (Budiharto et al. 2021). These results support evaluation of drones to use high end technology to solve an environmental question in natural resource management of use of mapping techniques (Bullard et al. 2014).

The results from our study indicate that Pix4Dmapper is recommended for creating the most complete orthophoto mosaic when compared to Drone2Map. For natural resource applications, in particular when homogeneous land cover features such as forest, open grass and lake features are concerned, Pix4Dmapper outperformed Drone2Map in creating a more complete orthophoto mosaic. The main advantages of using Drone2Map are detecting enabling rapid processing with ArcGIS integrating into orthomosaic construction (Badea and Badea 2020).

Since Drone2Map and Pix4Dmapper are comparable in cost, roughly $1,500 per year and $3,000 per year for Drone2Map and Pix4Dmapper respectfully, we did not feel the need to discuss and analyze a cost comparison for our study. We felt with the cost of both software packages relatively close it was more important to focus on the effectiveness of each software package.

Our study focused on comparing the ability of Drone2Map and Pix4Dmapper, which were chosen for their ease of implementation and popularity, to derive complete orthophoto mosaics. Future research should address and compare the robustness of not only Drone2Map and Pix4Dmapper within other cover types and locations but relative to the orthophoto mosaics derived using DroneDeploy, OpenDroneMap, ReCap and PhotoScan.

REFERENCES

Badea, A.C., and Badea, G. (2020) An overview of geoprocessing and export options for creating 3D GIS models using Drone2Map. *RevCAD Journal of Geodesy and Cadastre*, 28, 7-14.

Budihaeto, W., Irwansyah, E., Suroso, J.S., Chowanda, A., and Ngarianto, H. (2021) Mapping and 3D modelling using quadrotor drone and GIS software. *Journal of Big Data*, 8, 48. https://doi.org/10.1186/s40537-021-00436-8

Bullard, S H., Stephens Williams, P., Coble, T., Coble, D.W., Darville, R., and Rogers, L. (2014) Producing "society ready" foresters: A research-based process to revise the Bachelor of Science in Forestry curriculum at Stephen F. Austin State University. *Journal of Forestry*, 112(4), 354-360. https://doi.org/10.5849/jof.13-098

ERDAS Imagine (2022) Hexagon Geospatial computer software. Hexagon, Inc. ver.16.7.0.

Hung, I., Unger, D., Kulhavy, D., and Zhang, Y. (2019) Positional precision analysis of orthomosaics derived from drone captured aerial imagery. *Drones*, 3, 46. https://doi.org/10.3390/drones3020046

Jakubek, D. and Tran, J. (2020) *Drones In Libraries: The Development Of An Interdisciplinary Research Service Using Drones And 3D Modeling Technologies At Ryerson University Library*. Association of Canadian Map Libraries and Archives, 165, Summer/Spring: 1-10.

Kulhavy, D., Hung, I., Unger, D., Viegut, R., and Zhang, Y. (2021) Measuring building height using point cloud data derived from unmanned aerial system imagery in an undergraduate geospatial science course. *Higher Education Studies*, 11(1), 105-113. https://doi.org/10.5539/hesv11n1p105

Unger, D.R., Kulhavy, D.L., Busch-Petersen, K., and Hung, I. (2016) Integrating faculty led service learning training to quantify height of natural resources from a spatial science perspective. *International Journal of Higher Education*, 5, 104-116. https://doi.org/10.5430/ijhe.v5n3p104

Unger, D.R., Kulhavy, D.L., Hung, I., Zhang, Y., and Stephens Williams, P. (2019) Integrating drones into a natural resource curriculum at Stephen F. Austin State University. *Journal of Forestry*, 117(4), 98-405. https://doi.org/10.1093/jofore/fvz031

Williams, V., Unger, D., Kulhavy, D., Hung, I., and Zhang, Y. (2023) Assessing drone mapping capabilities and increased cognition retention using interactive hands-on natural resource instruction. *Higher Education Studies*, 13(2), 28-36.

Yao, H., Qin, R., and Chen, X. (2019) Unmanned aerial vehicle for remote sensing applications—A review. *Remote Sensing*, 11, 1443. https://doi.org/10.3390/rs11121443

Zhang, Y., Kulhavy, D., Gerland, J., Hung, I., Unger, D., Wen, X., and Viegut, R. (2023) Evaluating different UAS flight methods for 3D model generation and printing of a tornado destroyed cultural heritage: Caddo House in Texas. *Drones and Autonomous Vehicles*, 1, 10003. https://doi.org/10.35534/dav.2023.10003