THE COMPARISON OF DIFFERENT LIDAR ACQUISITION SOFTWARE ON IPAD PRO M1 2021

G. A. J. Kartini[a,d,*], I. Gumilar[b], H. Z. Abidin[b], L. Yondri[c]

[a]Department of Geodesy and Geomatics, Faculty of Earth Sciences and Technology, Institut Teknologi Bandung, Bandung, Indonesia – ayujessy@itenas.ac.id
[b]Geodesy Research Group, Faculty of Earth Sciences and Technology, Institut Teknologi Bandung, Bandung, Indonesia
[c]Center for Prehistoric Research and Historical Archaeology, National Research and Innovation Agency, South Jakarta, Indonesia
[d]Departement of Geodetics Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Nasional Bandung, Bandung, Indonesia

Commission II

KEY WORDS: iPad Pro M1 2021, point cloud, cave, M3C2

ABSTRACT:

The application of Apple LiDAR is now being researched in a variety of fields. Several research projects have been conducted to provide an answer, including those focused on heritage documentation, forest inventory, and geoscience applications. In cave, it is common practice to photograph with a digital camera equipped with photogrammetric techniques and a terrestrial laser scanner. The focus of this study is on how the iPad Pro M1 2021 can generate a point cloud that describes the graffiti on the cave walls. This investigation was carried out in Barong Cave, West Java, Indonesia. Scanning with iPad Pro M1 2021 was completed using three applications: 3D Scanner App, EveryPoint, and SiteScape. Point cloud of each application is analyzed using M3C2 plugin in CloudCompare. Based on this research, SiteScape is the best application to use. It can be concluded that the LiDAR iPad is suitable for use in caves and can capture detailed information about cave walls.

1. INTRODUCTION

It is common practice to photograph caves with a digital camera equipped with photogrammetric techniques and a terrestrial laser scanner (TLS) (Fritz et al., 2016; Rustan et al., 2019; Strasser et al., 2018). TLS can obtain a three-dimensional image with just one scan of the tool in the form of a point cloud, whereas photogrammetric requires several photos, which are then combined to form a 3D image. Digital cameras are easier to transport during the acquisition process than TLS, though TLS and HS forms have become more compact and lighter in recent years, making them more adaptable for use in caves. The presence of Apple LiDAR perhaps can help the data acquisition process be more effective because of its shape, which is easier to carry and use in extreme environmental conditions such as caves. The focus of this study is on how the LiDAR iPad can generate a point cloud that describes the graffiti on the cave walls.

The application of LiDAR integrated into Apple devices is now being researched in a variety of fields. The development of LiDAR is intended to enhance augmented reality on Apple devices, but it also begs the question of whether LiDAR can be used for scientific research. Several research projects have been conducted to provide an answer, including those focused on heritage documentation (Murtiyoso et al., 2021), forest inventory (Gollob et al., 2021), and geoscience applications (Luetzenburg et al., 2021). One of the interesting things to investigate is the variety of LiDAR applications developed for Apple devices.

This investigation was carried out in Barong Cave, located in West Java. Barong Cave is one of the caves in West Java's Pawon Cave cultural heritage area. It should be noted that prehistoric human skeletons were discovered a folded buried at the Pawon Cave. In terms of discovery, Barong Cave is one of the caves studied by archaeologists due to its suitability for human habitation. The cave was excavated, and artifacts such as pottery and obsidian flakes were discovered (Yondri, 2019). To get to the entrance of Barong Cave, we must first climb the cave wall until reach Barong Cave. One of the reasons why there are not many visitors to Barong Cave is the difficulty of getting there. With these conditions, the vandalism on the walls of Barong Cave was never cleaned up, and we can still see graffiti that dates back to the 1950s. Since this cave is one of the paths for rainwater to flow, most of the caves are dark and quite slippery when it rains.

2. DATA CAPTURING AND PROCESSING

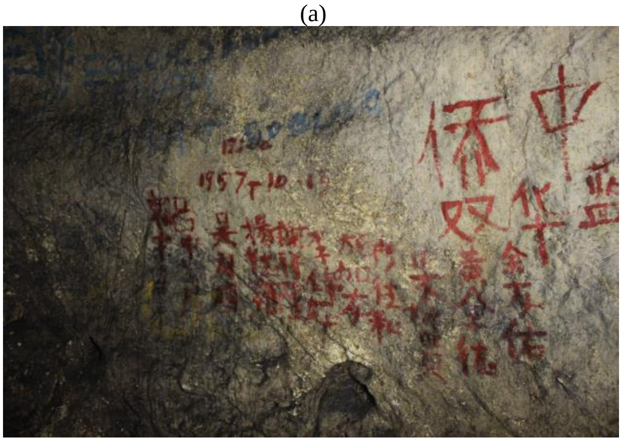
Data was collected in Barong Cave, Pawon Cave Cultural Conservation Area. The Pawon Cave complex consists of six caves, including Barong Cave. Barong Cave is close to the entrance of Pawon Cave, but the path to the entrance of Barong Cave is difficult. On March 15, 2022, scanning with iPad Pro M1 2021 was completed using three applications: 3D Scanner App (https://3dscannerapp.com/ accessed 7 September 2022), Every Point (https://everypoint.io/ accessed 7 September 2022), and SiteScape (https://www.sitescape.ai/ accessed 7 September 2022). Table 1 shows the data retrieval parameters used in the three applications.

Because almost the entire Barong Cave area receives no direct sunlight, artificial light is required to illuminate the scanned area. A Coretech ring light with a diameter of 26 cm and an LED white light color with an illumination of 1440-5440 LM is used as an additional light. The experiment was conducted in three different locations, as shown in Figure 1.

Name	Parameters
3D Scanner App	Max depth 5 m; resolution 5 mm; high confidence; masking disabled
EveryPoint	EveryPoint LiDAR Fusion; 3D voxel size 0.5 cm; max scanning depth 5 m
SiteScape	Scan mode maximum detail; high point density; medium point size

Table 1. Parameters used in the LiDAR iPad application.

(a)



(b)

(c)

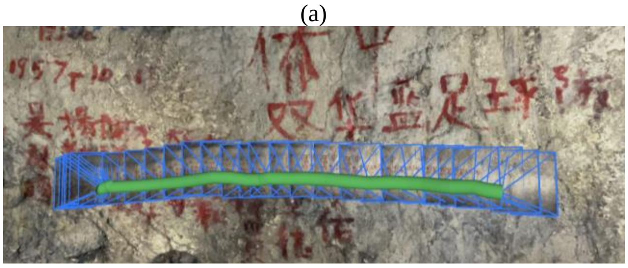
Figure 1. Grafitti from the three locations (a) case 1, (b) case 2, and (c) case 3, which were used in this study.

The results of all iPad Pro M1 2021 scans will be compared to the Leica BLK360 TLS point cloud, which was measured on September 2, 2021. With a measuring distance of 0.6 - up to 60 m, the Leica BLK360 can record 360° horizontally and 300° vertically. The Leica BLK360 has an 830 nm wavelength and a measurement accuracy of 4 mm @ 10 m.

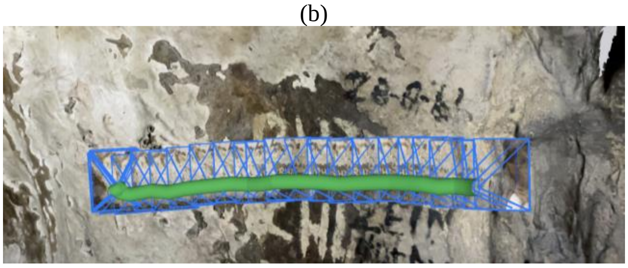
The data acquisition process using iPad Pro M1 2021 is simple and can be completed in a short period of time. SiteScape recommends keeping the iPad Pro M1 2021 distance from the object between 1 and 4 meters during the data acquisition process. To avoid blurry images, the 3D Scanner App recommends moving slowly; rapid movement will affect scan quality.

The 3D Scanner App can provide a lot of information. This app even offers raw data in the form of photos, point clouds in a variety of data formats, and scanned videos. Figure 2 depicts the data retrieval path at all locations as seen from the 3D Scanner App results.

(a)



(b)



(c)

Figure 2. Scan path illustrations for all applications obtained from the 3D Scanner App.

Following data collection, the point cloud of each application is downloaded and analyzed using CloudCompare. The TLS reference point cloud data is used to register all data. Point Pairs Picking and ICP are the registration methods used. Because the point cloud generated by the LiDAR iPad lacks a normal, normals and curvature must be estimated. This is done so that the M3C2 distance analysis can be performed.

3. RESULTS AND DISCUSSION

Case (1) involves a curved cave wall that is approximately 2 meters above the cave floor. Because it is at the entrance to the Barong cave, this wall receives direct sunlight. Additional light is used to scan the cave walls to ensure that all objects are well lit. This wall clearly displays the inscription 'EKI MULKIASIH EDR,' which is extremely useful during the registration process. In the first case, the registration procedure employs an Iterative

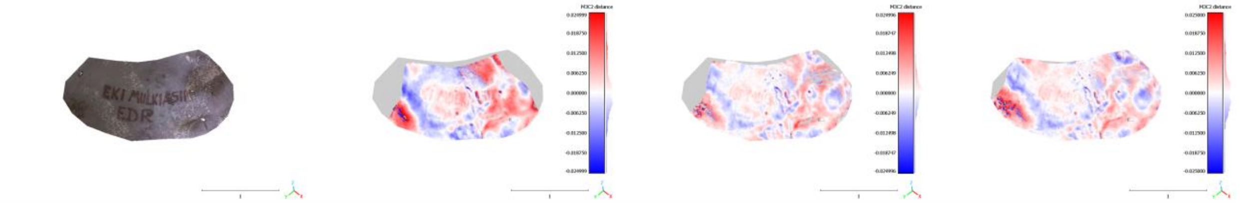


Figure 5. The comparison in case (1) is between TLS and iPad LiDAR using M3C2 analysis in Cloud Compare. The gray area represents an outlier.

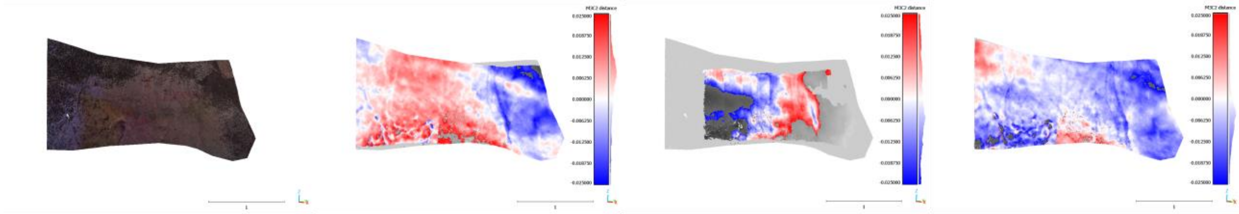


Figure 4. The comparison in case (2) is between TLS and iPad LiDAR using M3C2 analysis in Cloud Compare. The gray area represents an outlier.

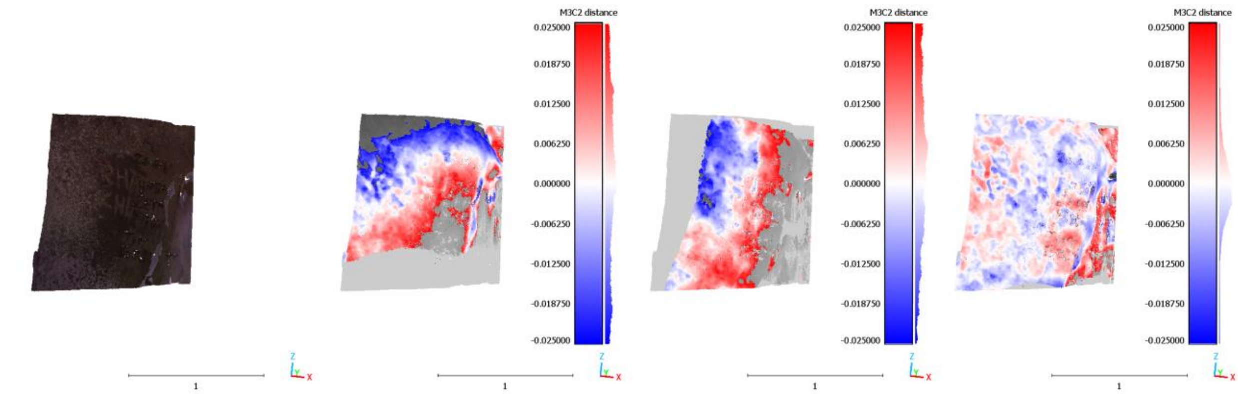


Figure 3. The comparison in case (3) is between TLS and iPad LiDAR using M3C2 analysis in Cloud Compare. The gray area represents an outlier.

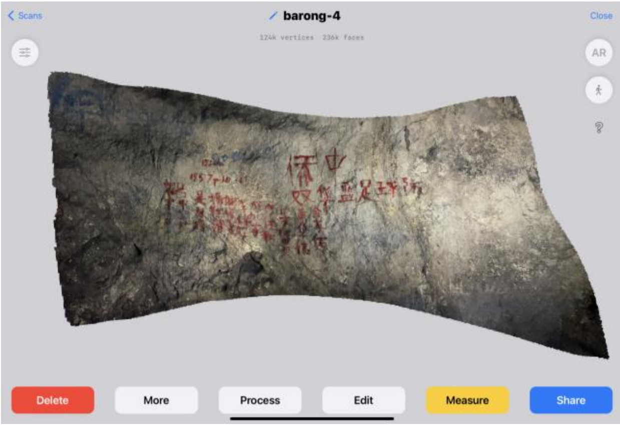
Closest Point (ICP). Figure 5 depicts a comparison of the iPad Pro M1 2021 results in Case (1) using TLS as a reference.

The results of the case (1) show that SiteScape produces a model with a standard deviation of 0.7 cm that is close to the reference. Systematic errors appear in the results of the 3D Scanner App and EveryPoint, which may be influenced by ICP registration. Aside from systematic errors, both applications have significant outliers ranging from 46% to 54%. The point density of the two applications can also have an effect on this.

In the case (2) (Figure 4), the cave wall is in an area that is not exposed to sunlight. The cave walls are long and relatively flat. On this wall are written letters in Chinese that have not yet been translated. Even though it has been there since 1957, the writing is still legible. In this case, the ICP technique was used for registration. The Leica BLK360 TLS data acquisition was done without the use of additional light, so the resulting RGB color was dark. This has an impact on the registration process for iPad Pro M1 2021 data and TLS. The fact that all applications contain the same errors demonstrates how difficult the registration process is.

In the case (3) (Figure 3), the registration process is carried out using Point Pairs Picking, which is the process of selecting the same points on the TLS object and LiDAR iPad that are used as registration references. EveryPoint has the least clear point cloud results of the three applications, indicating that the registration process is quite challenging, as evidenced by the systematic error of 0.3 cm. Outlier values for EveryPoint and 3D Scanner App remain in the 40%-50% range, as in the first case. Meanwhile, SiteScape's results are fairly consistent from case (1) to case (3), with outlier values of less than 15%. In Figure 5, Figure 4, and Figure 3, $\bar{x}$ denotes mean and σ denotes standard deviation. While the gray area is the outlier.

Figure 6 depicts the point cloud generated by each application. The point cloud of the 3D Scanner App has been textured in these images, so the results are close to the conditions in the field. The EveryPoint app's point cloud appears sparse and cannot clearly show streaks. The SiteScape application can generate a point cloud that is accurate to field conditions.



(a)

(b)

(c)

Figure 6. (a) The result of the 3D Scanner App that has gone through the texture process. (b) EveryPoint results, and (c) SiteScape results, both in the form of a point cloud.

In contrast to the application visualization, the point cloud view of each application in the Cloud Compare reveals that SiteScape has the highest point density when compared to the other two applications. It is assumed that the SiteScape point density level has a resolution of less than 5 mm, so a higher point density may result. Figure 7 depicts the graph of the density of points at a radius of 1 cm.

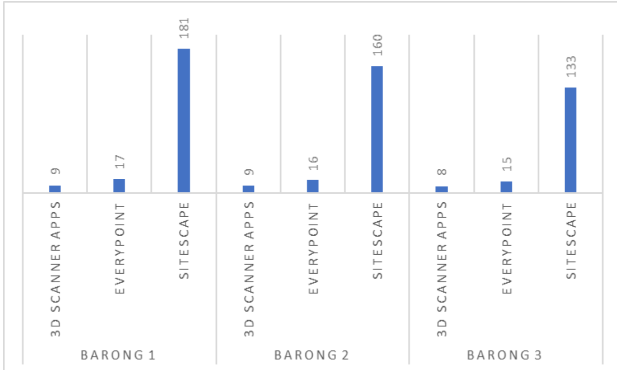


Figure 7. Point density graph with a value of r = 1 cm using the nearest neighbor calculation.

4. CONCLUSION

In Barong Cave, data acquisition using a LiDAR iPad has been successfully completed, though it should be noted that more light is required for accurate data recording. SiteScape is the best application to use based on the results of the three applications. The total point density of SiteScape is nearly ten times that of the 3D Scanner App and EveryPoint. In all three experimental cases, the systematic error and resulting outlier values from SiteScape are consistently better than the other two applications. Point cloud data from SiteScape results can be researched and used for other purposes. Based on these findings, it can be concluded that the LiDAR iPad is suitable for use in caves and can capture detailed information about cave walls.

REFERENCES

Fritz, C., Willis, M. D., & Tosello, G. (2016). Reconstructing Paleolithic cave art: The example of Marsoulas Cave (France). *Journal of Archaeological Science: Reports*, *10*, 910–916. https://doi.org/10.1016/J.JASREP.2016.05.012

Gollob, C., Ritter, T., Kraßnitzer, R., Tockner, A., & Nothdurft, A. (2021). Measurement of Forest Inventory Parameters with Apple iPad Pro and Integrated LiDAR Technology. *Remote Sensing 2021*, *Vol. 13*, *Page 3129*, *13*(16), 3129. https://doi.org/10.3390/RS13163129

Luetzenburg, G., Kroon, A., & Bjørk, A. A. (2021). Evaluation of the Apple iPhone 12 Pro LiDAR for an Application in Geosciences. *Scientific Reports 2021 11:1*, *11*(1), 1–9. https://doi.org/10.1038/s41598-021-01763-9

Murtiyoso, A., Grussenmeyer, P., Landes, T., Macher, H., & Group, G. (2021). *FIRST ASSESSMENTS INTO THE USE OF COMMERCIAL-GRADE SOLID STATE LIDAR FOR LOW COST HERITAGE DOCUMENTATION*. *XLIII*, 599–604.

Rustan, R., Duli, A., & Nur, M. (2019). MENGUKUR LAJU KEROSAKAN GAMBAR GUA PRASEJARAH STUDI KASUS DI GUA-GUA PRASEJARAH KAWASAN KARST MAROS-PANGKEP PROVINSI SULAWESI SELATAN, INDONESIA. *Asian Journal of Environment, History and Heritage*, *3*(2), 183–194. https://spaj.ukm.my/ajehh/index.php/ajehh/article/view/137

Strasser, T. F., Murray, S. C., van der Geer, A., Kolb, C., & Ruprecht, L. A. (2018). Palaeolithic cave art from Crete, Greece. *Journal of Archaeological Science: Reports*, *18*, 100–108. https://doi.org/10.1016/J.JASREP.2017.12.041

Yondri, L. (2019). *Manusia dan Budaya Prasejarah di Gunung Pawon*. Balai Arkeologi Jawa Barat.