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ACCURACY ASSESSMENT OF A THREE-DIMENSIONAL MODEL OBTAINED USING THE LiDAR SENSOR OF THE iPHONE 13 PRO MAX

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Abstract. Scanning of an educational classroom was performed using the LiDAR sensor of the iPhone 13 Pro Max. Comparison was conducted between the lengths of lines and coordinates determined from the model scanned by the LiDAR sensor with precise data measured using the Leica TCR 405 ultra electronic total station and determined from the model created photogrammetrically from images captured with the Sony Cyber-shot DSC-RX100 camera. The Root Mean Square Error (RMSE) of distance and spatial positioning was calculated for the LiDAR-scanned model.

Keywords: LiDAR, iPhone 13 Pro Max, accuracy assessment, distance, coordinates, three-dimensional model.

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1. Introduction

LiDAR scanning technology is relatively new but actively finding applications in various spheres of life. Laser scanning is based on the same principle as laser distance measurement: a laser signal sent is reflected off an object and returns to the receiver. The time it takes for the optical signal to travel is used to calculate the distance from the laser to the object.

The abbreviation LiDAR was first used by Middleton and Spilhaus in their work (Middleton & Spilhaus, 1953), long before the invention of lasers. In the early lidars, light sources were pulsed or ordinary lamps with high-speed shutters forming short pulses. However, in modern geodetic lidars, laser rangefinders are used. Undergoing significant development since the 1990s, LiDAR systems have reduced in size while enhancing accuracy, making them attractive for use in various fields. Nowadays they are used in robotics, unmanned vehicles, drones, augmented reality headsets, geodetic instruments, and more. Lidars have recently been incorporated into smartphone manufacturing, with Apple being one of the pioneers by introducing LiDAR sensors in its iPhone 12 Pro, 12 Pro Max, and iPad Pro devices in 2020 (Apple, n.d.).

Apple was not the first company to think about what a LiDAR sensor is and how it can be used with smartphones. Historically, Android smartphones integrated depth sensors and augmented reality applications. The Lenovo Phab 2 Pro, released in 2016, was the first consumer device equipped with a time-of-flight depth camera; subsequently, other devices such as the ASUS Zenfone AR in 2017, Oppo RX17 Pro, Honor View 20 in 2018, and more followed suit.

The primary advantages of LiDAR scanning technology in smartphones include improved accuracy and camera focusing speed, especially in low-light conditions, faster operation of virtual and augmented reality applications, and capturing more details when working with them. Professional LiDAR scanners allow the creation of highly accurate 3D models of buildings, structures, and landscapes, applicable in construction, geodesy, and architecture. Given that smartphones are a relatively cost-effective technical solution compared to professional lidars and geodetic tools, researching the accuracy of LiDAR sensor scanning remains a relevant task.

2. Analysis of research

With the introduction of the LiDAR sensor in smartphones, publications have emerged investigating the scanning accuracy depending on various factors.

In the article (Chase et al., 2022), an accuracy assessment using an iPhone 13 Pro was performed to test for its relative and absolute accuracies using Modelar's scanning application. Additionaly, a TLS (Trimble TX5) survey was included to compare the two devices. To test and analyze Modelar's application, a surveying lab at the University of New Brunswick's Head Hall was chosen, containing a control network of sub-millimetre geometric accuracy. Results showed that with Modelar's laser scanner application, absolute accuracies of ±3 cm horizontally and ±7 mm vertically is achieved, while also achieving a relative accuracy of ±3 cm.

Authors of the research (Zaczek-Peplinska & Kowalska, 2022) used a smartphone iPhone 13 Pro with the 3D Scanner App (Laan Labs, New York, USA), and its acquired data to evaluate the accuracy of the LiDAR technologies embedded in the device in comparison with a Z+F Imager 5006h precise terrestrial laser scanner. A typical office room and a fragment of the cloisters of the main auditorium of the Warsaw University of Technology were used as test objects. The results were analyzed and compared using CloudCompare software tools. In the case of research, measurement time and scanning distance were a problem and a kind of disadvantage in relation to typical terrestrial laser scanners. The obtained accuracy could be considered reliable in the range of 1–2 cm, which is mainly due to the effect of the iPhone 13 Pro rounding some edges in the point cloud model. Additionally, the authors point out that the care in taking the measurement itself is crucial, i.e. the stability of the iPhone during measurement (it is suggested to perform the work using a photographic tripod) and the speed of turning or moving the device.

In the article (Teo & Yang, 2023) the scanning accuracy of the iPad Pro 3D Scanner and RTAB-Map Apps were utilized for indoor scanning and modeling. The static acquisition experiment revealed that while scanning a flat surface with a distance of less than 1.5 m, about 90% of the points contained a distance lower than 1 mm to their best-fitting plane. However, when the distance increased to 4 m, the ratio decreased to about 50%, and when the scanning distance was longer than the maximum scanning distance of 5 m, only about 10% of the points achieved the 1 mm threshold. The target's color did not have a noticeable impact on the scanning accuracy. In the dynamic acquisition experiment, an iPad Pro was employed as a handheld moving scanner. In this case less than 20% of the points fulfilled the 1 mm threshold, adjusting the threshold to 1 cm resulted in about 80% of the points meeting the 1 cm requirement. The experiment indicated that the relative accuracy of dynamic acquisition was lower than that of static acquisition. The standard deviation of the C2C difference between the point clouds obtained by the iPad Pro and GeoSLAM was 5.5 cm.

In the work (Constantino et al., 2022) a comparison is provided between point clouds obtained using Android devices (Huawei P30 Pro) and iOS devices (iPhone 12 Pro and iPad 2021 Pro). The smartphones were tested in several case studies involving the scanning of several objects: 10 building material samples, a statue, an interior room environment and the remains of a Doric column in a major archaeological site. The accuracy of the performed scanning was assessed at the level of 1–3 cm.

As for scanning more extensive objects, it is worth noting the study (Luetzenburg et al., 2021). In this work, the scanning of a coastal cliff and beach in Roneklint (Denmark, length: 130 m, width: 15 m, height: 10 m) is described using the 3D Scanner App with iPhone 12 Pro and iPad Pro 2020. The model's accuracy was evaluated using the Multi-Scale Model-to-Model Cloud Comparison (M3C2) method between LiDAR point clouds, Structure from Motion Multi-View Stereo (SfM MVS) point clouds, and EveryPoint point clouds. M3C2 indicates that for 80% of all points, the maximum distance between SfM MVS and iPhone point cloud is less than 15 cm, and for 92%, it is less than 30 cm. Horizontal sections on the beach show smaller differences between the point clouds than inclined surfaces.

Additionally, rock scanning with a size of 26 meters was performed in the study (Riquelme et al., 2021). A comparison was made between three point clouds obtained using Terrestrial Laser Scanning (TLS), Structure from Motion technique, and the iPhone 12 device. The results show a promising match compared to TLS or SfM.

3. Research methods

The objective of this study is to investigate the accuracy of the LiDAR sensor in the iPhone 13 Pro Max smartphone.

For this investigation, a scan of an educational classroom measuring 6 by 13 meters was conducted. This space had been previously used for similar research (Yanchuk et al., 2021), and, therefore, 24 markers with known coordinates determined by geodetic methods were attached to its walls. However, due to recent renovation work, only 12 of these markers are currently preserved. The decision was made not to attach additional new markers to have the opportunity to compare the accuracy of the LiDAR model with the previous model created photogrammetrically from photo images. The coordinates of the markers were determined using the Leica TCR 405 ultra electronic total station and were taken as reference in further research. Their appearance is illustrated in Figure 1. Three of them are evenly distributed along the wall to the left of the entrance, five on the wall to the right of the entrance (Figure 1), two markers are placed on the wall opposite the entrance to the classroom, and two more are on the wall near the entrance.

The scanning with the smartphone was performed using the Scaniverse app (Scaniverse, n.d.) with parameters recommended for indoor scanning (Figure 2).

Figure 1. Fragment of the classroom wall with control markers

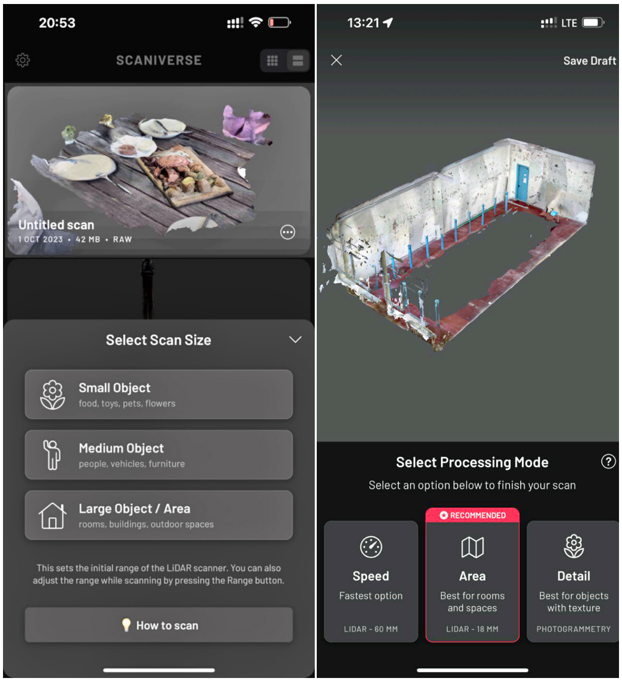

Figure 2. Scanning parameters for the model in the Scaniverse app

Laboratory work with the obtained point cloud was conducted using the CloudCompare software (CloudCompare, n.d.). To assess accuracy, distances between markers were measured in all possible combinations based on the obtained point cloud. Subsequently, their deviations from distances determined by geodetic measurements were calculated (the Equation (1) was utilized for distance computation). Based on the values of the deviations, the root mean square error of distance determination was calculated according to Equation (2) (Voitenko, 2003).

$$S = \sqrt{\Delta X^2 + \Delta Y^2 + \Delta Z^2}; \quad (1)$$

$$m = \sqrt{\frac{[V_i V_i]}{n-1}}, \quad (2)$$

where ΔX, ΔY, ΔZ – coordinate increments between markers for which the distance S is calculated; V_i – the difference between the distances determined by the model and those taken as reference; n – the number of control points.

An assessment of the accuracy in determining the coordinates of the markers based on the LiDAR-generated point cloud was also conducted. For this, it is necessary to align the cloud scanned in the conventional coordinate system with the accepted coordinate system of geodetic measurements. The aligning was performed using 10 characteristic points of the room contours (Figure 3). Consequently, it became possible to determine the coordinates of control markers using the referenced model and compare them with the reference markers.

Based on the obtained deviations, the root mean square errors of coordinate increments along the m_X, m_Y, and m_Z axes were calculated using Equation (2). The root mean square error of spatial positioning, m_{npocm}, was computed using Equation (3).

Figure 3. Example of characteristic points of room contours used for aligning the scanned point cloud

$$m_{npocm} = \sqrt{m_X^2 + m_Y^2 + m_Z^2}, \quad (3)$$

where m_X, m_Y, m_Z – root mean square errors in determining coordinates along the X, Y, and Z axes, respectively.

For additional accuracy assessment, a point cloud (Figure 4) created photogrammetrically from images taken with the Sony Cyber-shot DSC-RX100 camera was utilized (Yanchuk et al., 2021). It was created for the same classroom, using 8 markers for aligning. Another 16 markers were used to evaluate the accuracy of the created model. As a result, it was determined that the RMSE of the spatial positioning coordinates of control markers, based on this point cloud, is 0.008 m. Therefore, considering the high accuracy of the model created photogrammetrically, it was also used to assess the accuracy of the model scanned by the LiDAR sensor.

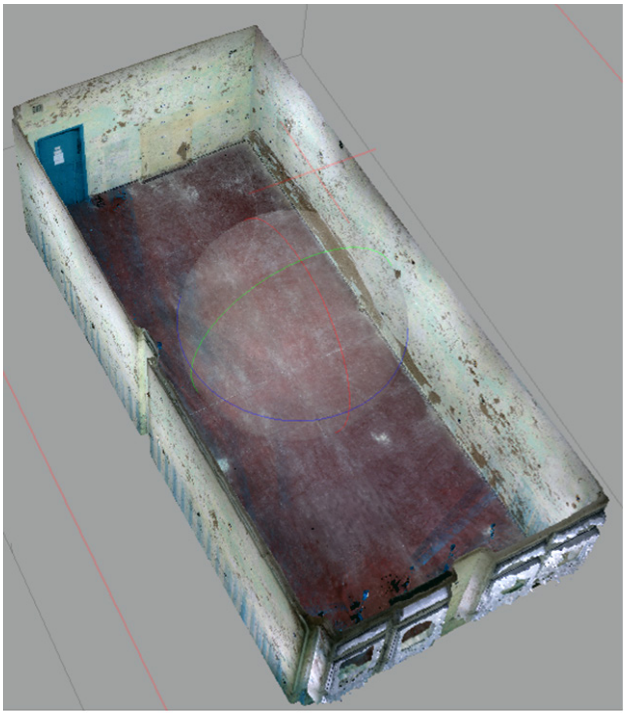

Figure 4. Overview of the model created photogrammetrically during photographing with the Sony Cyber-shot DSC-RX100 camera (Yanchuk et al., 2021)

4. The results of the research

Therefore, using the iPhone 13 Pro Max, the classroom was scanned using LiDAR. The scanning was performed handheld, going around the classroom so that the distance to the walls was 2–4 meters. In other words, no additional devices for aligning the smartphone in space (tripod, stabilizer) were utilized. The scanned model is presented in Figure 5. The point cloud contains a total of 833492 points.

Overall, the quality of the model can be considered satisfactory. The vast majority of elements have a clear geometry. Some fragments contain distortions or gaps in elements and incorrectly displayed glass in windows. Additionally, the floor and ceiling are absent in this model, and the columns for instrument placement are only partially represented, as capturing these elements was not our goal. The depiction of control markers on the model is clear and allows for the unambiguous determination of their coordinates. Therefore, we consider the obtained model suitable for further research.

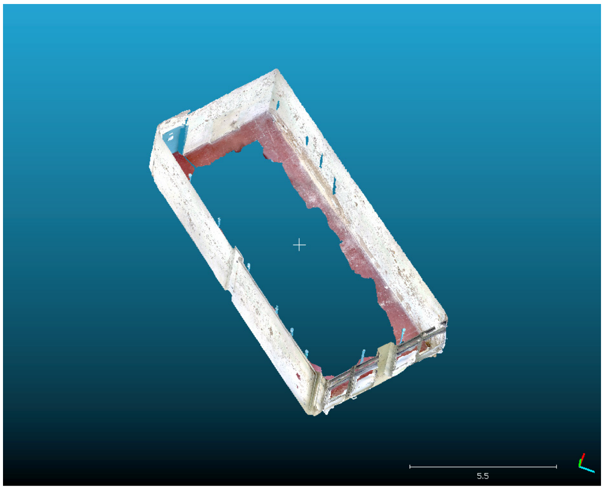

Figure 5. Overview of the model scanned using LiDAR on iPhone 13 Pro Max

To assess the accuracy of the LiDAR model in the CloudCompare software, measurements of distances between 12 control markers were taken in all possible combinations. In total, 66 lines were measured. Subsequently, their deviations from distances calculated based on coordinates determined by the electronic total station were computed, and the RMSE was determined using Equations (1) and (2). The results are summarized in Table 1. Thus, the RMSE of distance measurements for the unregistered LiDAR model is 0.042 m.

To assess the accuracy of coordinates, it is necessary to align the model with an accepted coordinate system. This was done using 10 points on the contours of the classroom for which coordinates were determined by the total station. As a result, it is possible to compare the coordinates of control markers for the aligned LiDAR model with the coordinates determined by the total station and additionally with the coordinates determined by the photogrammetrically created model (Figure 4). The coordinates for 12 control markers and their deviations from reference coordinates are provided in Table 2. In addition, based on the coordinates determined by three methods, distances between markers were calculated in all combinations (66 lines), and the RMSE of distance determination was computed (Table 3). Thus, the RMSE of deviations along individual axes ranges from 0.021 to 0.029 m. The RMSE of spatial position in both cases (deviations from coordinates measured by the total station and determined by the photogrammetric model) is 0.045 m. For distances, the RMSE is 0.042 m for deviations from total station measurements and 0.043 m for deviations from values measured by the photogrammetrically created model.

Thus, as evident from tables 1 and 3, the RMSE of distance determination calculated using the unaligned model created by LiDAR scanning is similar to the RMSE of distance determination calculated using the aligned model.

Table 1. Distances determined by the unaligned LiDAR model and measured by the total station, along with their differences

Line	Distance according to the LiDAR model, m	Distance based on coordinates determined by the total station, m	Differences in distances LiDAR/total station, m
V2-V3	2.832	2.888	–0.055
V2-V4	5.510	5.585	–0.075
V2-V7	8.432	8.470	–0.037
V2-V8	5.865	5.862	0.003
V2-M04	9.603	9.675	–0.072
V2-M05	9.368	9.451	–0.082
V2-M06	10.218	10.261	–0.044
V2-M07	10.357	10.404	–0.048
V2-M09	6.139	6.198	–0.059
V2-M10	6.458	6.479	–0.021
V2-M11	6.258	6.214	0.044
V3-V4	2.678	2.698	–0.020
V3-V7	6.567	6.535	0.032
V3-V8	7.733	7.706	0.027
V3-M04	7.046	7.055	–0.009
V3-M05	6.703	6.724	–0.021
V3-M06	7.992	7.968	0.023
V3-M07	8.206	8.186	0.020
V3-M09	5.356	5.341	0.016
V3-M10	5.737	5.693	0.045
V3-M11	8.045	7.993	0.052
V4-V7	5.639	5.567	0.072
V4-V8	9.945	9.907	0.038
V4-M04	4.908	4.882	0.026
V4-M05	4.401	4.385	0.016
V4-M06	6.378	6.313	0.065
V4-M07	6.671	6.610	0.061
V4-M09	5.942	5.890	0.051
V4-M10	6.284	6.218	0.066
V4-M11	10.186	10.134	0.052
V7-V8	9.439	9.367	0.073
V7-M04	4.389	4.376	0.014
V7-M05	3.884	3.865	0.020
V7-M06	2.216	2.211	0.005
V7-M07	3.002	3.007	–0.005
V7-M09	3.357	3.319	0.038
V7-M10	3.967	3.927	0.040
V7-M11	9.680	9.608	0.072
V8-M04	12.412	12.387	0.025
V8-M05	12.267	12.226	0.042
V8-M06	11.653	11.576	0.077
V8-M07	11.747	11.701	0.046
V8-M09	6.084	6.049	0.034
V8-M10	6.397	6.366	0.031
V8-M11	2.064	2.079	–0.015
M04-M05	2.108	2.098	0.010
M04-M06	3.608	3.589	0.020
M04-M07	2.860	2.834	0.026
M04-M09	6.866	6.852	0.014
M04-M10	6.509	6.498	0.011
M04-M11	12.246	12.217	0.029
M05-M06	2.916	2.885	0.031
M05-M07	3.581	3.549	0.032
M05-M09	6.546	6.521	0.026
M05-M10	6.864	6.837	0.028
M05-M11	12.454	12.410	0.044
M06-M07	2.175	2.176	0.000
M06-M09	5.570	5.527	0.043
M06-M10	5.984	5.946	0.038
M06-M11	11.860	11.787	0.073
M07-M09	5.899	5.881	0.018
M07-M10	5.500	5.487	0.013
M07-M11	11.571	11.524	0.047
M09-M10	2.146	2.135	0.011
M09-M11	6.466	6.434	0.032
M10-M11	6.071	6.037	0.034
		RMSE	0.042

Table 2. Coordinates determined by the aligned LiDAR model, photogrammetrically created model, and measured by the total station, along with their differences

Marker number	Coordinates, m									Coordinate differences, m					
	Using the LiDAR model			Using the photogrammetric model			Measured with the total station			LiDAR/ photogrammetry			LiDAR/total station		
	X, m	*Y*, m	*Z*, m	*X*, m	*Y*, m	*Z*, m	*X*, m	*Y*, m	*Z*, m	Δ*X*, m	Δ*Y*, m	Δ*Z*, m	Δ*X*, m	Δ*Y*, m	Δ*Z*, m
V2	505.260	498.914	102.477	505.296	498.978	102.446	505.295	498.975	102.446	–0.036	–0.064	0.031	–0.035	–0.061	0.031
V3	505.291	496.082	102.518	505.281	496.090	102.503	505.285	496.088	102.502	0.010	–0.008	0.015	0.006	–0.006	0.016
V4	505.352	493.405	102.503	505.302	493.392	102.507	505.307	493.390	102.506	0.050	0.013	–0.004	0.045	0.015	–0.003
V7	499.787	492.500	102.585	499.812	492.519	102.555	499.808	492.524	102.551	–0.025	–0.019	0.030	–0.021	–0.024	0.034
V8	500.229	501.928	102.478	500.207	501.884	102.507	500.205	501.882	102.504	0.022	0.044	–0.029	0.024	0.046	–0.026
M04	502.598	489.919	100.416	502.597	489.918	100.418	502.594	489.908	100.420	0.001	0.001	–0.002	0.004	0.011	–0.004

End of Table 2

Marker number	Coordinates, m									Coordinate differences, m					
	Using the LiDAR model			Using the photogrammetric model			Measured with the total station			LiDAR/ photogrammetry			LiDAR/total station		
	X, m	*Y*, m	*Z*, m	*X*, m	*Y*, m	*Z*, m	*X*, m	*Y*, m	*Z*, m	Δ*X*, m	Δ*Y*, m	Δ*Z*, m	Δ*X*, m	Δ*Y*, m	Δ*Z*, m
M05	502.678	489.908	102.522	502.649	489.908	102.513	502.648	489.903	102.517	0.029	0.000	0.009	0.030	0.005	0.005
M06	499.791	490.284	102.655	499.799	490.316	102.631	499.795	490.314	102.629	–0.008	–0.032	0.024	–0.004	–0.030	0.026
M07	499.771	490.360	100.482	499.802	490.370	100.454	499.798	490.369	100.454	–0.031	–0.010	0.028	–0.027	–0.009	0.028
M09	499.940	495.853	102.627	499.955	495.840	102.612	499.951	495.839	102.609	–0.015	0.013	0.015	–0.011	0.014	0.018
M10	499.932	495.857	100.481	499.971	495.853	100.471	499.971	495.853	100.474	–0.039	0.004	0.010	–0.039	0.004	0.007
M11	500.178	501.923	100.414	500.190	501.889	100.423	500.190	501.886	100.425	–0.012	0.034	–0.009	–0.012	0.037	–0.011
									RMSE	0.028	0.029	0.021	0.027	0.029	0.021

Table 3. Distances determined by the aligned LiDAR model, photogrammetric model, and measured by the total station, along with their differences

Line	Distances, m			Distance differences, m	
	Using the LiDAR model	Using the photogrammetric model	Measured with the total station	LiDAR/ photogrammetry	LiDAR/ total station
V2-V3	2.832	2.889	2.888	–0.056	–0.055
V2-V4	5.510	5.586	5.585	–0.077	–0.076
V2-V7	8.432	8.474	8.470	–0.041	–0.037
V2-V8	5.865	5.861	5.862	0.004	0.003
V2-M04	9.604	9.669	9.675	–0.064	–0.071
V2-M05	9.369	9.449	9.451	–0.080	–0.082
V2-M06	10.219	10.261	10.261	–0.042	–0.043
V2-M07	10.358	10.404	10.404	–0.047	–0.047
V2-M09	6.140	6.197	6.198	–0.057	–0.059
V2-M10	6.459	6.482	6.479	–0.024	–0.020
V2-M11	6.256	6.216	6.214	0.040	0.041
V3-V4	2.678	2.698	2.698	–0.020	–0.020
V3-V7	6.567	6.532	6.535	0.035	0.033
V3-V8	7.733	7.702	7.706	0.031	0.027
V3-M04	7.047	7.046	7.055	0.001	–0.008
V3-M05	6.704	6.719	6.724	–0.015	–0.020
V3-M06	7.993	7.963	7.968	0.030	0.024
V3-M07	8.207	8.181	8.186	0.026	0.021
V3-M09	5.357	5.333	5.341	0.024	0.016
V3-M10	5.737	5.690	5.693	0.047	0.045
V3-M11	8.043	7.992	7.993	0.051	0.050
V4-V7	5.639	5.559	5.567	0.080	0.072
V4-V8	9.944	9.903	9.907	0.041	0.037
V4-M04	4.908	4.873	4.882	0.035	0.026
V4-M05	4.402	4.379	4.385	0.023	0.017
V4-M06	6.379	6.306	6.313	0.073	0.065
V4-M07	6.671	6.603	6.610	0.068	0.062
V4-M09	5.941	5.882	5.890	0.060	0.051
V4-M10	6.283	6.215	6.218	0.068	0.065
V4-M11	10.183	10.133	10.134	0.050	0.049
V7-V8	9.439	9.373	9.367	0.066	0.072
V7-M04	4.390	4.369	4.376	0.021	0.014
V7-M05	3.883	3.856	3.865	0.027	0.019

Line	Distances, m			Distance differences, m	
	Using the LiDAR model	Using the photogrammetric model	Measured with the total station	LiDAR/ photogrammetry	LiDAR/ total station
V7-M06	2.217	2.204	2.211	0.013	0.006
V7-M07	3.000	3.005	3.007	–0.005	–0.007
V7-M09	3.357	3.325	3.319	0.032	0.038
V7-M10	3.965	3.935	3.927	0.030	0.037
V7-M11	9.678	9.617	9.608	0.061	0.070
V8-M04	12.413	12.380	12.387	0.033	0.026
V8-M05	12.267	12.222	12.226	0.045	0.041
V8-M06	11.654	11.576	11.576	0.078	0.078
V8-M07	11.748	11.703	11.701	0.045	0.047
V8-M09	6.084	6.050	6.049	0.034	0.034
V8-M10	6.398	6.370	6.366	0.028	0.032
V8-M11	2.065	2.084	2.079	–0.019	–0.014
M04-M05	2.108	2.096	2.098	0.012	0.010
M04-M06	3.609	3.590	3.589	0.020	0.020
M04-M07	2.862	2.832	2.834	0.030	0.028
M04-M09	6.868	6.846	6.852	0.022	0.015
M04-M10	6.509	6.490	6.498	0.019	0.011
M04-M11	12.246	12.211	12.217	0.035	0.029
M05-M06	2.914	2.881	2.885	0.033	0.030
M05-M07	3.580	3.544	3.549	0.036	0.031
M05-M09	6.546	6.516	6.521	0.030	0.025
M05-M10	6.863	6.833	6.837	0.030	0.026
M05-M11	12.452	12.408	12.410	0.044	0.042
M06-M07	2.174	2.178	2.176	–0.003	–0.001
M06-M09	5.571	5.526	5.527	0.045	0.044
M06-M10	5.984	5.946	5.946	0.038	0.038
M06-M11	11.859	11.788	11.787	0.071	0.072
M07-M09	5.899	5.882	5.881	0.017	0.018
M07-M10	5.499	5.486	5.487	0.014	0.013
M07-M11	11.570	11.526	11.524	0.045	0.047
M09-M10	2.146	2.141	2.135	0.005	0.011
M09-M11	6.465	6.437	6.434	0.028	0.031
M10-M11	6.071	6.040	6.037	0.031	0.034
			RMSE	0.043	0.042

5. Conclusions

The accuracy of the model obtained by scanning with the LiDAR sensor of the iPhone 13 Pro Max without using additional stabilizing devices was assessed. The study involved scanning an educational classroom measuring 6 by 13 meters. To assess accuracy, 12 control markers were used, whose coordinates were determined by geodetic methods using the Leica TCR 405 ultra electronic total station. The RMSE of distance determination between these markers was computed (a total of 66 lines), resulting in 0.042 meters for both unaligned and aligned models. Additionally, for the aligned model, the RMSE of spatial positioning was calculated, measuring 0.042 meters (deviations from the coordinates determined by the total station) and 0.043 meters (deviations from the model created photogrammetrically).

Therefore, in all considered cases, the accuracy of the LiDAR model was achieved at the level of 4–5 cm. The accuracy depends on the size of the scanned object and the distance to it, which will be the focus of further research. The obtained accuracy at this stage does not allow the use of the LiDAR sensor of the smartphone for high-precision scanning work. However, such technology can be utilized for approximate assessments of object size or volume and for making preliminary decisions before conducting professional engineering work.

The accuracy of the model is independent of model alignment. Thus, measurements can be conducted using both aligned and unaligned models. However, in the case of the unaligned model, it is recommended to use a reference measure for controlling the obtained results.

The accuracy of the model created using LiDAR is inferior to the accuracy of the model created photogrammetrically from photographic images. However, in the case of LiDAR, the main advantage lies in the speed and simplicity of obtaining a point cloud.

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