The Integration of ArcGIS Drone2Map with ArcGIS Pro Software to Solve the Miss Alignment in Processed Drone Data to Extract Shoreline

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المستخلص

يُعرف خط الساحل بأنه الحدود الفاصلة بين البحر واليابسة، ويؤدي استخراجه بدقة دورًا بالغ الأهمية في القيمة الاقتصادية والبيئية للمناطق الساحلية، خاصةً في ظل التأثيرات الكبيرة للاحتباس الحراري وارتفاع مستوى سطح البحر. في الآونة الأخيرة، يُستخدم الاستشعار عن بعد بالأقمار الصناعية على نطاق واسع لمراقبة البيئة.

تُظهر الصور عالية الدقة التي توفرها الطائرات المسيّرة اليا تحسّنًا كبيرًا في دقة استخراج خط الساحل وتفاصيله الدقيقة مقارنةً بالبيانات التقليدية المستمدة من الأقمار الصناعية. تعتمد الموثوقية والجودة في تقنيات الاستخراج المعتمدة على الاستشعار عن بعد على عدة عوامل مترابطة. على سبيل المثال، تُعد الصور عالية الدقة ضرورية لنوع وجودة البيانات المدخلة المطلوبة للتعرّف الدقيق على المعالم على طول خط الساحل. علاوة على ذلك، وعلى الرغم من الدقة العالية، فإن العوامل البيئية المتغيرة مثل الإضاءة أو الغطاء النباتي قد تؤدي إلى تدهور جودة صور الطائرات المسيّرة، ما يقلل من دقة تحديد خط الساحل

المعالجة الدقيقة لصور الطائرات المسيّرة أمر ضروري للحفاظ على دقتها العالية. توفر حزمة ArcGIS أدوات قوية مثل Drone2Map وArcGIS Pro لمعالجة الصور، سواء كانت مأخوذة من الطائرات المسيّرة أو الأقمار الصناعية. ومع ذلك، تم رصد انحراف ملحوظ بين البيانات المُعالجة والخريطة الأساسية عند استخدام Drone2Map في المعالجة. وقد تم استخدام أداة (Reality Mapping) ArcGIS Pro لتقليل هذا الانحراف إلى بضعة سنتيمترات، وهو ما يُعد نتيجة مقبولة لإنشاء النموذج الرقمي للسطح (DSM) من صور الطائرات المسيّرة .

Abstract

Shoreline is defined as the boundary between sea and land, and its accurate extraction plays a crucial role in both the economic and ecological value of coastal areas during the significant impacts of global warming and sea-level rise. Recently, satellite remote sensing is widely used for environmental monitoring.

High-resolution imagery provided by drones shows great improvement in accuracy and subtle variation of details of shoreline extraction compared to traditional satellite data. Reliability and quality under different remote sensing-based extraction techniques rely on several interrelated factors. For example, High-resolution photography will be necessary for the kind and caliber of input data needed for precise feature recognition along the shoreline. Furthermore, despite the increased resolution, shifting environmental factors like lighting or vegetation cover may cause drone-UAV picture quality to deteriorate, decreasing the precision of coastline delineation.

An accurate processing for drone imagery is critical to maintaining the high-resolution drone imagery. ArcGIS package offers a powerful tool, such as Drone2Map and ArcGIS Pro, to process image whether it delivered from drone or satellite. Unfortunately, the significant shift between processed data and basemap has been observed when Drone2Map has been used in the processing. The reality mapping tool in ArcGIS Pro has been used to decrease the shift to a few centimeters which is acceptable result to create the Digital Surface Model (DSM) from the drone Imagery.

Keywords: Drone, GCPs, High-Resolution, ArcGIS, Drone2Map.

1- Introduction

More than 50% of the world's population lives along coasts and rivers mouths, relying extremely on natural resources and the environment for their life (Quang et al., 2021). Coastal regions are important for multiple fields such as coastal management, environmental monitoring, and economic development, including transportation and tourism (Tegar & Saut Gurning, 2018). However, the coastline's dynamic spatial and temporal variation is a significant concern due to erosion and accretion threats (Tercan & Dereli, 2021). Coastal zone management is a critical task in sustainable development and environmental protection. Due to global warming, coastal zone monitoring, and extraction of shorelines is an essential mission. The shoreline is defined as a line of contact between land and water body (Kafrawy et al., 2017).

Drones can capture very high-resolution imagery up to a centimeter or millimeter by flying close to an area of interest and capturing highly detailed images. In addition, drones are more available and versatile because they can fly under cloud cover and sometimes can also be deployed quickly compared to satellite systems. Furthermore, the advances in Unmanned Aerial Vehicles (UAVs) provide high-quality images and real-time data processing, which enhance how accurately shorelines are extracted compared with satellite imagery (Phiri et al., 2020).

Manual digitization is a shoreline extraction technique in which human interpretation plays a crucial role in geographic data analysis. The manual digitization approach will recognize shorelines from very high-resolution images provided by UAV systems among other sources for vector outputs to ensure the accuracy of shoreline or land-water boundary delineation. While remote-sensing methods enable efficient data handling, the complexity of local geography often needs human involvement to apply automatic processes, therefore, traditional methods are still very relevant in coastal studies (Colak et al., 2019). UAV technology has revolutionized remote sensing, particularly in coastal research. Drones provide high-resolution imagery and sensors, enabling quick and cost-effective acquisition of large aerial datasets. This is crucial for observing shoreline and vegetation changes. Technology allows researchers to create detailed Digital Surface Models (DSMs) and RGB orthophotos, enhancing the analysis of coastal geomorphic features. For instance, UAV surveys have made it possible to quantify exposed sandy regions and plant cover, which has revealed solutions for ecosystem health and the efficacy of the restoration methods involved (Kemarau et al., 2024). Second, coastline extraction is improved for greater accuracy and dependability in coastal regions by combining conventional manual digitization with automatic picture categorization in GIS. As this technique has developed, the UAV has become an essential component of the most recent advanced remote sensing as shown in Table 1.

Table 6. Advantages of Drone Imagery in Shoreline Extraction.

Advantage	Description	Source	Year
Higher Resolution	Drone images capture detailed features of the shoreline, enhancing the clarity and accuracy of shoreline mapping.	National Oceanic and Atmospheric Administration (NOAA)	2022
Cost-Effectiveness	Deploying drones can be more cost-effective than traditional aerial surveys, allowing for more frequent data collection.	U.S. Geological Survey (USGS)	2023
Flexibility and Accessibility	Drones can reach places that conventional surveying techniques would find hazardous or challenging, such as rocky or unstable shorelines.	International Society for Photogrammetry and Remote Sensing (ISPRS)	2023
Real-Time Data Collection	Drones present real-time visual data, allowing for immediate analysis and making decisions in shoreline management.	Environmental Protection Agency (EPA)	2022
Environmental Monitoring	Drones help observe changes in coastal environments over time, providing crucial data for conservation efforts.	National Geographic Society	2023

Drone in remote sensing relies on the basic set of practices concerning data quality, ethics, and collaboration. Researchers should adhere to the legal framework concerning licensing, airspace, permissions, and privacy (Kutynska & Dei, 2023). Privacy concerns should be addressed by nonidentification and data security. Sensor and software limitations should be critically reviewed/evaluated to avoid "black box" solutions that are not duly validated (Lucieer et al., 2013). Standardized protocols for data acquisition, using checklists and flight planning, ensure the quality and repeatability of data (Nex & Remondino, 2014).

ArcGIS Drone2Map plays a crucial role in drone data processing, and it is essential to create DSM for the interested area then, using that surface to extract accurate shoreline.

Material, Study Area, and Methodology

This study focuses on a coastal area of Coronation Park located north of Lake Ontario in Canada. Two datasets were collected: high-resolution images captured by P1 camera on a small UAV on 22 October 2022. The projection used is Universal Transverse Mercator (UTM) zone 17N, with

EGM96 as the geoid for elevation, and the World Geodetic System (WGS) 1984 as the ellipsoid and datum, as shown in Figure 1.

Figure 1. Area of Interest. Credit: Google Pro.

Drone data was collected as raw data of 504 images that need to be processed to use in shoreline extraction. Processing has been done using Drone2Map software to produce the DSM as shown in Figure 2.

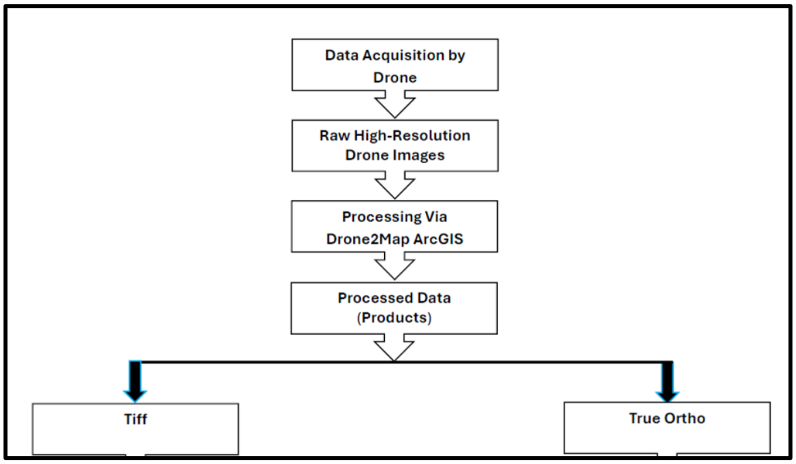

Figure 2. The Theoretical Concept of Drone Image Processing.

Combination of Tide and Seiches Effect on Lake Ontario

The Great Lakes are a chain of five connected freshwater lakes located in the North American region. These lakes include Lake Ontario which is the study area in this paper. The nature of the lakes is extremely large and is considered a major part of the entire region. However, in contrast to their size and sea-like area, the Great Lakes do not have tidal shifts as compared to other oceanic coasts. Although the Great Lakes do not have normal, so-called classic tides, there is a good deal that is close to tides in what are called seiches. It is probably more usefully viewed as the height of the water column displaced due to the combined effects of all seiche and tidal modes. When this height is multiplied by some appropriate area it gives the total volume of water involved. The logarithmic meaning value of this measure is approximately 10 cm for Lake Ontario which is not considered a significant value to shift shoreline horizontally (Trebitz, 2006).

2- Software Packages

Multiple tools have been employed in this research, including the ArcGIS packages that are provided by Esri company, such as ArcGIS Drone2Map, Arc Map, and the advanced ArcGIS Pro full package.

2.1 The ArcGIS Drone2Map

ArcGIS Drone2Map is an application that converts raw data imagery from drones into worthy information products in ArcGIS software. It has become more accessible and convenient for generating 2D and 3D products with features and areas that may be hard to access. In addition to monitoring changes in the environment, the impact of natural disasters is also monitored. ArcGIS and ArcGIS Drone2Map possess other capabilities that assist users in revealing hidden insights into drone imagery. ArcGIS Drone2Map advantages include the following:

a- Dealing with big data with time reduction.
b- Building information images that assist decisions rapidly.
c- Independence of third parties for mission-critical data gathering.
d- Reducing costs that acquired expensive aerial image processing services.
e- Enabling a pilot to quickly check his data for the first time.
f- Applying the correct defaults based on its detection for sensors.
g- Being considered an all-in-one application for image capturing, processing, and analysis.
h- Rapidly figuring out the correct settings and adjusting them.
i- Including automatic defaults that assist the user in quickly building essential information products for the project(Esri ArcGIS Co., 2024).

In recent years, Drone2Map became almost the most common drone image processing software due to its superior performance compared with other commercial software such as Agisoft Photoscan and Pix4D. Many studies revealed the capability of photogrammetry and computer vision in UAVs to recognize the products that construct 3D geometry. The evaluation of the output products was conducted using different visual and statistical metrics. While comparing in terms of visual data, a vertical profile was generated over other features in which Done2Map was able to create a more accurate DSM over the tree canopy while the Agisoft Photoscan and Pix4D software at the same time had failed, which can be cleared to be considered as the drawback in point cloud generation. Even on the elevated road, Drone2Map was able to generate the proper elevation profile (Tyagi et al., 2022).

3- Drone Data Processing

Drone images have been processed using Drone2Map by uploading the captured high-resolution drone images. The project was created, and pre-processing adjustments such as camera calibration, georeferencing, and checking the parameters of final products were made. Once the adjustment is applied, it is saved in the project option and ready to be used during the processing, as shown in Figure 3. Running the Drone2map tool to process the high-resolution images delivered by the P1 camera on the drone will take longer processing time depending on the machine performance used, such as CPU or GPU, in addition to the quality required to generate the desired products, for example, DSM or True Ortho products.

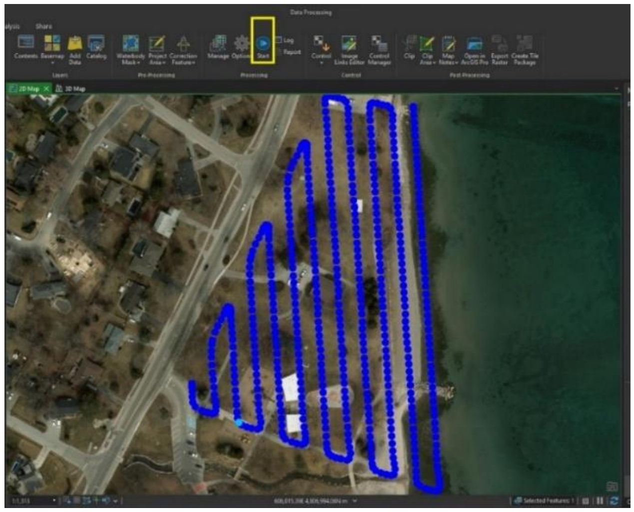

Figure 3. Data Adjustment Before Processing Using Drone2Map.

3.1 Data Processing Report

Drone2Map reconstructs drone imagery into desired products. The processing report offers essential information about the project, including details on quality and accuracy, as well as a summary of the defined processing options. The processing took more than 14 hours, indicating 6 mm as a resolution of the captured data and the number of images that have been processed, as shown in Table 2.

Table 7. The Processing Summary.

Project Summary	
Project Name	FINAL DATA PROCESSING MELIGY57
Processed On	12/5/23, 06:58 AM
Camera Model	DJI ZENMUSEP1
Images	504 out of 504 images calibrated
Project Area	0.056 km2 / 5.644 ha / 0.022 sq. mi. / 13.947 acres
Ground Resolution	0.006 (m)
Processing Time	14h:32m:23s

Table (2) also shows essential information about the project, such as the project name, date, and camera model. All the project images were processed and calibrated successfully, and no problems occurred due to the project configuration. If images are not calibrated, the interesting images should be double-checked and investigated for the causes of the problem.

Drone2Map utilizes photogrammetry to process the project's imagery. The software identifies neighboring images that share overlapping features and creates tie points between them. This process is repeated thousands of times throughout the project, establishing a network of connections (solution points) that Drone2Map uses to align the images accurately. The project reconstruction is proper when there are more tie points and solution points.

3.2 Images Positions Uncertainty

The adjustment of image positions graphic shows the visualization of shifts that occurred to the center point of the adjusted images. The blue points reveal the imagery locations of the initial position, and the green points show where they were reprojected. A significant shift between the points indicates a poor positioning system in data collection.

Figure 4. visualizes the shifts between blue and green points, which is the shift between the initial and reprojected positioned images. The accuracy of the positioning system will be checked compared to the ground truth of this mission.

Figure 4. Image Positions Adjustment.

3.3 Postprocessing Results

Although geodetic control points (GCPs) were used in collecting the datasets, they were not applied in the processing. However, by the end of processing, the processed data was validated by extracting coordinates of the GCPs positions from the processed data and comparing them to the original GCPs to check the matching and accuracy between the base map and the processed data. The difference in the horizontal component demonstrates a significant shift of more than one meter, as demonstrated in Table 3. This significant uncertainty requires some editing and adjustment.

Table 8. The Shift Between Original and Processed GCPs.

GCPs	Original True GPCs		Processed Data GCPs
pt3	605948.38	4807222.24	605,948.57 E 4,807,223.19 N
pt4	605934.91	4807159.49	605,934.76 E 4,807,160.1 N
pt5	605890.27	4807098.74	605,889.91 E 4,807,098.68 N
pt6	605932.1	4807020.63	605,932.07 E 4,807,020.13 N

To visualize the mismatching, Figure 5. displays the shift between the base map and the processed images without applying the original GCPs.

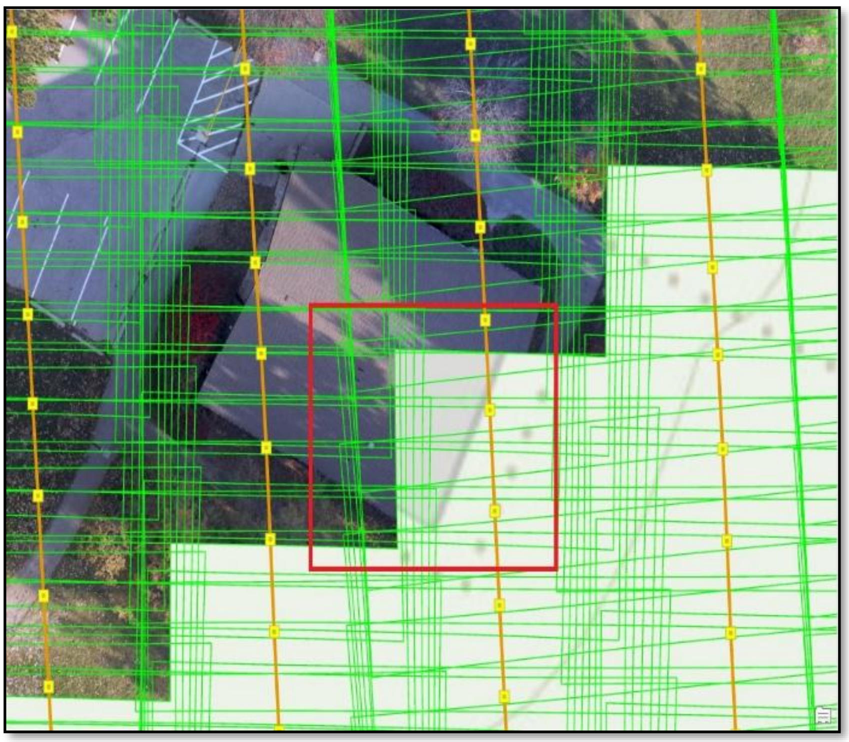

Figure 5. The Mismatching Between the ESRI Base Map and Processed Images.

Hence, the solution should exist in Drone2Map because its back end was built on the PIX4D in the past, and nowadays, its back end has been built on the German software nFrames. However, an alternative solution has been found to correct the mismatching and complete the processing phase through the ArcGIS Pro with a Reality Mapping extension. This extension is the same as Drone2Map, but the ArcGIS Pro can deal with big data, as indicated in Figure 6.

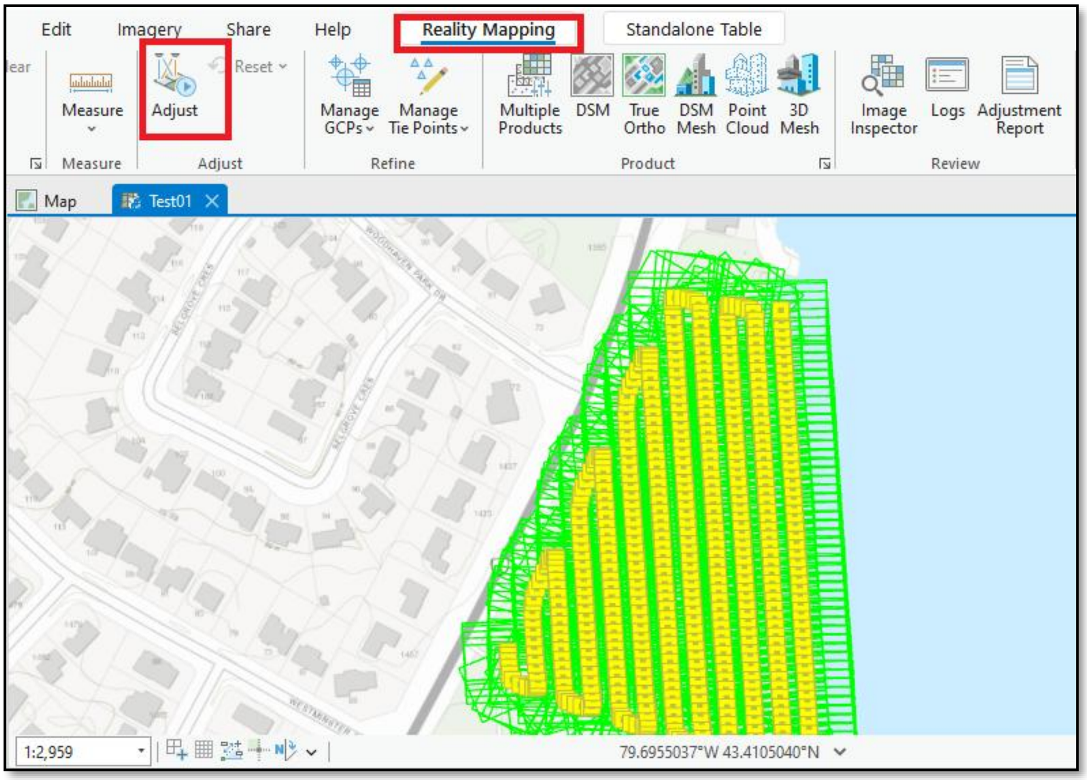

Figure 6. Reality Mapping Extension.

To correct this shift, two methods were found as follows:

a- To align the processed images with the base map, attempt to adjust their positions to correct any shifts. However, this method is effective only when GCPs consistently shift at each location. Unfortunately, this approach is not suitable for the current situation.

b- The second option is to utilize Reality Mapping to correct mismatches. This process begins with the (Adjust) function aligning the photos, defining their boundaries, computing tie points, and extracting the coordinates from the images themselves. However, the adjustment was made without using the GCPs, and manual management was made to correct the mismatches of each GCP.

The second option was applied to complete the adjustment phase, and reality mapping products were activated to create the True Ortho product and verify its accuracy and consistency.

The GCPs have not been used to assist in the adjustment because the primary purpose of the GCPs is to validate the processing results. Also, the DSM product was generated after correcting the mismatches, as reported in Figure 7.

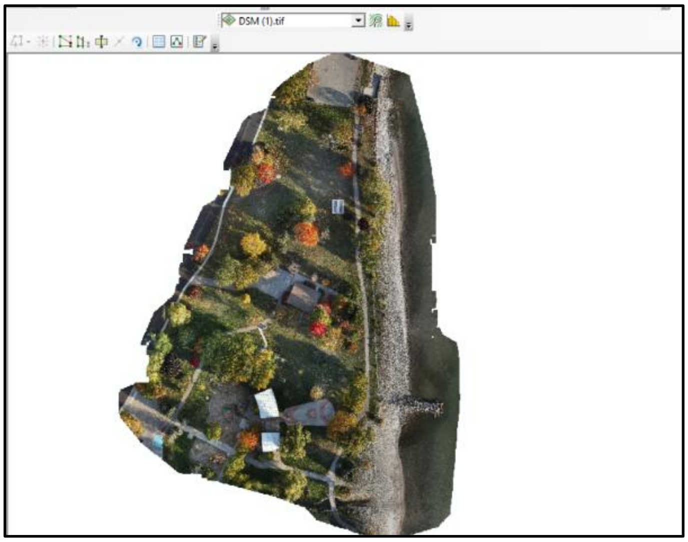

Figure 7. DSM Product from the Drone.

Additionally, an accuracy validation of the processing was employed by comparing the coordinates of the GCPs located on the DSM with the original ones. This comparison highlighted a significant improvement in accuracy. Moreover, the previous horizontal shifting has been reduced from one meter to just a few centimeters, as shown in Figure 8. and Table 4.

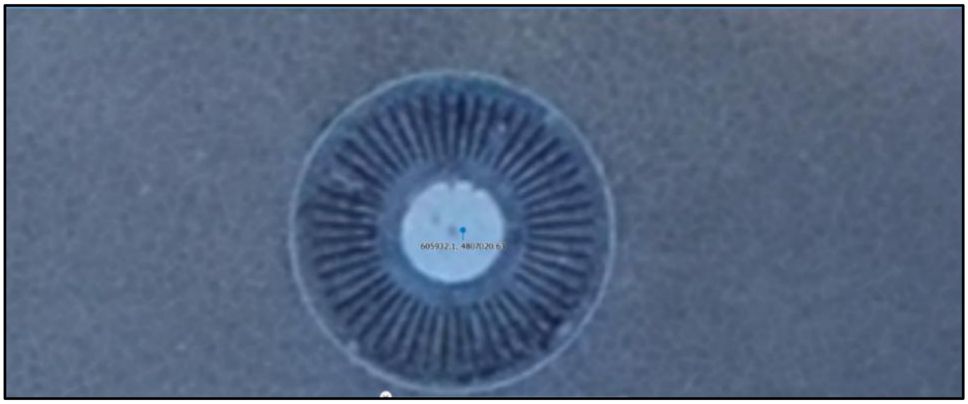
Figure 8. The Comparison Between Original and DSM GCPs.

Table 9. The Original GCPs vs. the DSM GCPs.

GCPs	Original Coordinates		GCPs	From true ortho after processing without using the original control points	
3	605948.38	4807222.24	3	605948.45	4807222.20
4	605934.91	4807159.49	4	605934.88	4807159.45
5	605890.27	4807098.74	5	605890.25	4807098.71
6	605932.1	4807020.63	6	605932.08	4807020.65

The images delivered from the P1 camera on the drone have been processed successfully and validated using the original GCPs to ensure the accuracy of high-resolution images delivered by drone. Therefore, the drone processed imagery is ready to use for shoreline extraction.

3- Conclusions

The main aim of this paper is to Solve the Miss Alignment in Processed Data from Drone in Shoreline Extraction through the integration of ArcGIS Drone2Map with ArcGIS Pro Software. First, the drone imagery has been processed using ArcGIS Drone2Map and by the end of this processing, the evaluation has been applied using the GCPs finding the shift between the processed data and the basemap. ArcGIS Pro played an essential role in figuring out this shift by reprocessing the drone data using the reality mapping tool which can decrease that shift to a few centimeters without using the GCPs in the processing as a ground truth. To conclude, validation is crucial in each phase of the processing, in addition to, the integration between several software such as ArcGIS Drone2Map and ArcGIS Pro has powerful to maintain the data accuracy.

4- Acknowledging

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