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3D modeling of Mersin Akyar Cliffs with wearable mobile LIDAR

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Abstract

LiDAR (Light Detection and Ranging) is a remote sensing technology that measures distance a laser light on objects and catching the light reflected back. The rapid change in navigation systems and technology, the introduction of sensors into our lives have brought new systems that map the environment in the cartography profession. The lidar scans the area and measures the time it takes the light to reach various objects and return. Wearable Mobile Lidar designed for indoors and outdoors, complex sites, underground mines, multi-floor buildings, forests, urban areas, stockpile volumes. In this study, a 3D model was produced by scanning the Akyar cliffs in Silifke district of Mersin with Wearable Mobile LIDAR (GML). It has been experienced from our previous studies that LIDAR pulses make different reflections and affect the measurement when they hit the water. In the study, it was seen that the effect of the measurements made at the seaside on the SLAM algorithm was reduced by using the Ground Control Point (GCP).

Introduction

Mersin is an important tourism city in Turkey. Akyar cliffs are located in Silifke district of Mersin province. Domestic and foreign tourists coming to the region come here to see these natural wonders. In this study, cliffs were modeled in 3D and using GML at the seaside and its effect on LIDAR data and using Ground Control Point GCP were examined.

There is limestone from carbonate rocks in the cliffs, and there is more than 50% $CaCO_3$ in carbonate rocks [1].

Material and Method

The WML Gexcel Heron we used in this study is a Wearable 3D Mobile Mapping System. The system started to be used in 2015. The system, which uses the SLAM algorithm, is designed to be used in places where a person can walk. The system is used to measure all kinds of natural and artificial objects such as tunnels, mines, cultural heritage. The system can capture 3D point cloud and 5K panoramic images.

Gexcel Heron WML emits infrared laser beams with a wavelength of 903 nm. A 16-channel Velodyne Puck LITE laser scanner provides 300,000 points per second in single rotation mode from 360-degree horizontal vision and 30-degree vertical vision. It has a range of 100 meters. The laser scanner sensor is combined with an XSens MTI, IMU, whose data is used in system trajectory prediction. While measuring, the scan head is mounted on a telescopic carbon fiber pole, connected to a battery and a control unit. The LIDAR scanner head is used by mounting on a pole. Range rod is carried upright by hand or by placing it in a pocket attached to the belt [2-3].

Gexcel Heron is a wearable or handheld mobile laser scanner. It uses SLAM Algorithm. It can be used in all kinds of walkable areas. It can be used in places such as indoor and outdoor, underground mines, geospatial applications, structures, tunnels, cultural heritage sites, forensic events, forests, urban areas. Captures 3D point clouds and 5K panoramic images to collect both geometry and color information together.

The portable Mobile laser scanner tested in this study is the Heron wearable Lidar device manufactured by Gexcel. It is a 16-channel Velodyne Puck LITE laser scanner that emits infrared laser beams at a wavelength of 903 nm and provides 300,000 points per second in single rotation mode from 360 degrees horizontal vision and 30 degrees vertical vision. Range measurements are performed on the time-of-flight principle with a maximum measurable distance of 100 m. The laser scanner sensor is combined with an XSens MTI, IMU, whose data is used in system trajectory prediction. While surveying, the scan head is mounted on a telescopic carbon fiber pole, connected to a battery and a control unit. According to the manufacturer's specifications, the system provides a local accuracy of 3 cm and a final global accuracy of 5 cm. By the presence of system loops and closures, as well as the characteristics of the scanned environment, the SLAM algorithm may be affected and the accuracy may drop to 20-50 cm [2-3].

Today, there have been significant developments in measurement technologies. Unmanned aerial vehicles, 3D laser scanners and lidar technology, and photogrammetric methods have made significant contributions to measurement technology [4-20].

Scanning was performed by creating open and closed routes using and without Ground Control Point for cliff measurement.

Working methods in the field

Akyar cliffs are located in Narlıkuyu town of Silifke district of Mersin. In the study, 5 ground control points were placed on the land. Two of the ground control points were measured with GNSS and the other points were measured with a total station (Figure 1).

Figure 1. Images from fieldworks in Akyar cliffs

3D modeling of cliffs using ground control points (GCP)

A route passing through all control points was followed in the fieldwork. The route was followed as a closed route and the starting point was reached again. The route was completed in about 5 minutes. As a result of the transformation and adjustment, the largest RMS value was 3 cm and the average was 2 cm (Figure 2).

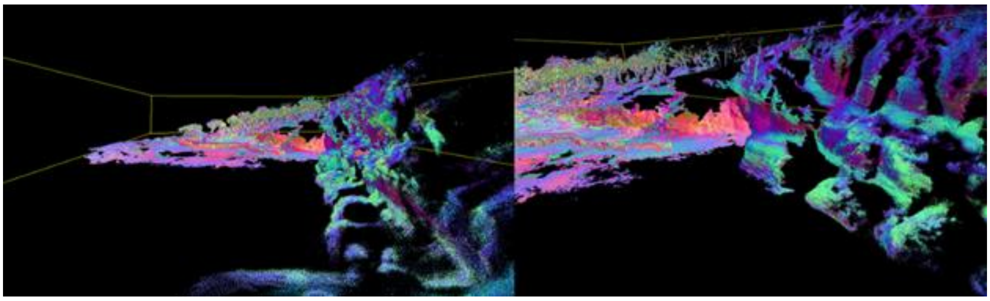

Figure 2. 3D model of Akyar cliffs

Open route 3D modeling of cliffs with GCP

The route was completed in about 3 minutes. As a result of the transformation and adjustment, the largest RMSD value was 6.5 cm and the average was 3 cm (Figure 3).

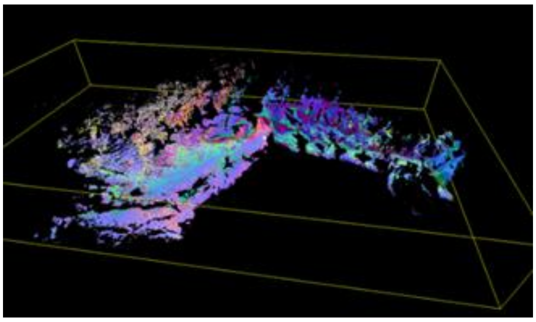

Figure 3. Akyar cliffs 3D model

It was observed that RMS values and bond errors increased in the open route between working as a closed route and working as an open route in the same study area.

3D Modeling of Akyar Cliffs with Closed Route without GCP

The route measurement was completed in approximately 5 minutes (Figure 4).

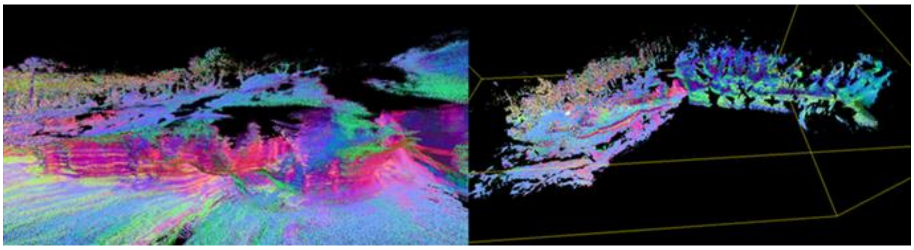

Figure 4. The 3D model produced without the closed route GCP

All ligaments together have an average of 3.5 cm adjusted RMS square root error between 5 cm and 2 cm.

Results

To interpret the results of the methods used, the orthophotos produced in each method were compared in Figure 5 (Table 1).

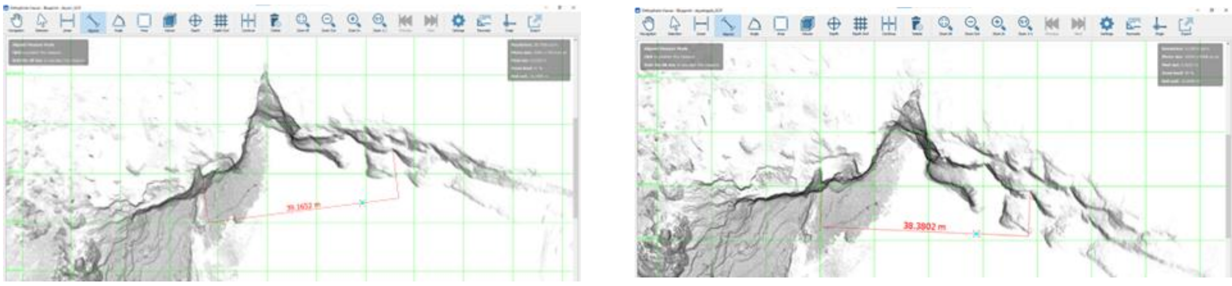

Figure 5. Orthophotos from left to right 1. With GCP 2. Without GCP, taken with closed route

Table 1. Base lengths found by different methods

Survey type	With GCP open	With GCP closed	Without GCP closed
Base lenght	39,18m	39,17 m	38,38m

While there is a 1 cm difference between the measurement methods used at GCP points, there is a difference of approximately 80 cm on the route without GCP.

Discussion

GML scans using a GCP point show little to no difference. However, when GCP is not used in the measurement, the difference exceeds the given error rate of GML. There was no difference between the open and closed routes made by taking GCP. In studies without GCP, the baseline length was found to be incorrect. It exceeds the error rate expected from GML. The fact that the deviation is too much is due to the reflections from the sea surface disrupting the SLAM algorithm.

Conclusion

As a result, using GML without using GCP does not give reliable results since the water surface breaks the SLAM algorithm at the water's edge. In the future, it is necessary to carry out studies to determine the cliff deformations on the 3D model.

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