Coastal Remote Sensing Techniques

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1. Intoduction

Terrestrial Laser Scanner (TLS) or terrestrial Lidar is a remote sensing technique developed for surveying in primarily industrial and mine applications. Nowadays the TLS use expands in several environmental sciences offering new capabilities. The TLS can record three-dimensional spatial data from targets within a specified line of sight; its opto-mechanical design produces rapid changes in the vertical angle of the emitted laser pulses and combined with a gradual rotation of the TLS unit in the horizontal plane, allows a view of all targets surrounding the TLS.

In order to investigate the use of green wavelength TLS in coastal engineering applications, an experiment is carried out to survey the nearshore bathymetry (both foreshore and inshore) and to possibly detect water surface. In the present work a Leica ScanStation2 is used having a pulsed laser at 532-nm wavelength. The distance range of the instruments is up to 300m, with a scan rate of up to 50,000 points/sec and a nominal accuracy of 6mm in position (for distances of 0~50m) and of 4mm in distance.

2. Data and Methedology

2.1 Study Site and Field work

The selected study area is a small pocket beach located in Artemida ("Loutsa") of Attica in Greece (Figure 1a). The beach is sandy with its front covered by sea wracks. The experiment has been conducted in spring 2014 under clear/sunny atmospheric and calm wave conditions.

Figure 1. a) The study site b) The deployment of the TLS (Terrestrial Laser Scanner), the TS (Total Station) and one of the spherical targets in the field site c) Measuring bathymetry by classical surveying techniques. Orthophoto of the beach field site with over-imposed bathymetric contours derived from Total station bathymetric survey and with the TLS position and scanned area.

Initially, a topographic network was established and georeferenced with the RTK method. In addition, the network stations, the position of two spherical TLS targets and of two fixed points were measured by a Leica TS (Total Station) model TS02 (Figure 1b). The TLS was mounted 2.65m above the sea surface, with a panoramic view of the beach. Upon the scanning completion, a topographic survey was also conducted in order to obtain the bathymetry (Figure 1c) and the elevation of the sea surface.

2.2 Data Processing

Initially the established topographic network is solved and geo-referenced to the Hellenic Geodetic Reference System (H.G.R.S.87), followed by the calculation of tachymetric points. A bathymetric surface is produced (Figure 1d) in AutoCAD Civil 3D software and finally, with the help of an alignment, a bathymetry profile is created. The TLS point-clouds are then geo-referenced in Leica Cyclone software by using two spherical TLS targets and two fixed points (Figure 1c). A TLS bathymetric surface is also produced and a profile is then created at the same alignment and same position with the tachymetric survey (Figure 2b).

Figure 3a presents an intensity plot of all the TLS data collected at the field site; intensity values of the TLS data are particularly useful for detecting shorelines since colour variations may depict related variations in elevation/depth. Figure 3a clearly shows that TLS point density reduces dramatically with distance away from the instrument, with most data captured within 25 m away from the scanner location.

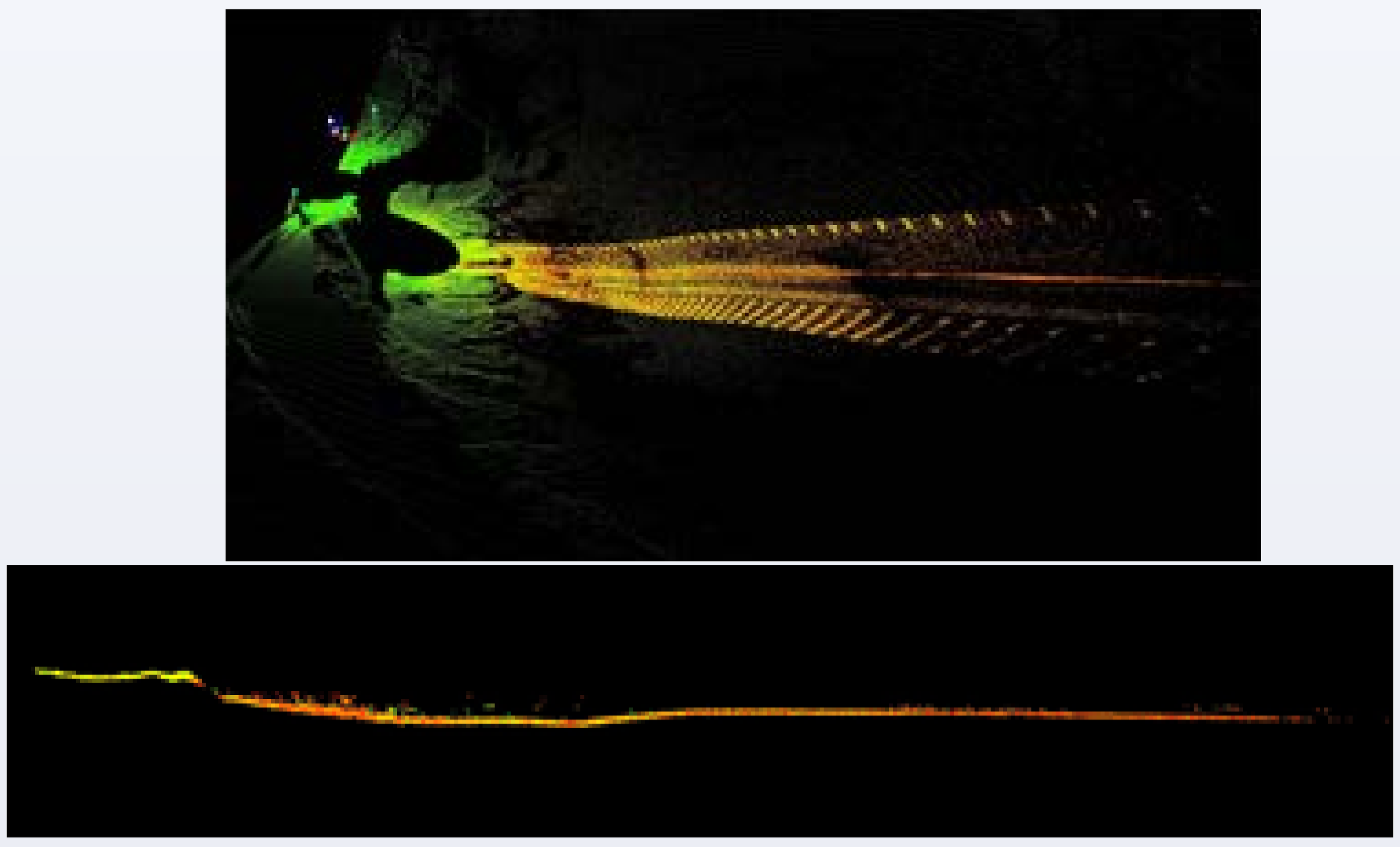

***Figure 2**. a) Intensity plot of all the TLS data collected at the field site b) Profile derived from TLS (Scan No.3)*

Nevertheless, some TLS points from the sea surface are mixed with seabed reflections, thus making the data interpretation more difficult (Figure 2b). The scan angle may also severely affect TLS data density, which rapidly reduces as the scan angle approaches the horizontal.

***Figure 3**. High resolution (1mm x 1mm) TLS Scan No.3 revealing the micro-bathymetry of bed ripples under clear shallow water conditions.*

Scan taken at high resolution (1mm x 1mm) and being less noisy in the range of 7~20m from the TLS location managed to survey micro-scale seabed sand ripples.

3. Results

Figure 4 shows the comparison of a bathymetric profile derived from conventional Total Station survey (TS profile) and from TLS measurements. The TS profile is considered as the "real" seabed topography. Within the first 10m from the shore the vertical differences between the two profiles are up to 10cm, increasing to 30cm at 10-20m distances, and finally reaching 40cm at 26m from the shore; after 26m distance the TLS becomes unable to survey the bathymetry, due to the incline angle becoming too obtuse.

The TLS bathymetry points when evaluated against the TS measurements (used as a reference) result into a Root Mean Square Error calculated for N=50 points by Equation 1:

$$RMSE_z = \sqrt{\frac{\sum (Z_{TS} - Z_{TLS})^2}{N}} = 0.1981 \sim 20\%$$

4. Conclusions

The results are encouraging, since the TLS manages to detect seabed topography, especially within the foreshore. The overall TLS accuracy can be further improved by performing refraction correction models; in addition by implementing several scanning positions and mounting the instrument at higher elevation may improve the survey coverage, thus providing new potential to validate morphodynamic models within the swash zone. Further researcher can be carried out taking into account the scanning range and geometry, such as suitable incidence angles, intensity values and filtering techniques. Finally, the TLS technology can be combined with video cameras, developing a 24-hour hybrid observation system for coastal monitoring.

5. References

Panagou Th. and E.K. Oikonomou. 2014. Applications of terrestrial laser scanning in coastal engineering. Accepted oral presentation at 1st International GEOMAPPLICA Conference 2014, Skiathos Island, Greece, September 8-11, 2014.

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