SHORT TERM SCIENTIFIC MISSION (STSM) – SCIENTIFIC REPORT

The STSM applicant submits this report for approval to the STSM coordinator

Action number: ES1402
STSM title: Improving spatial accuracy of DSM with LIDAR point cloud introduction
STSM start and end date: 06/10/2018 to 14/10/2018
Grantee name: Tamara Ivelja

PURPOSE OF THE STSM

One of the goals of the STSM is to find the best approach to achieve improved spatial accuracy (especially vertical) via introducing LIDAR point cloud to the digital surface models.

The second goal is all about finding the new approach of assessing the relative sea level. This approach will be developed on DSMs with introduces LIDAR point clouds in local coordinate system and datum with improved vertical accuracy and spatial resolution.

Improving spatial accuracy if of high importance for assessing the relative sea level. It will be done on high-resolution mapping products of the structures dimensions and elevations above mean sea level (MSL) by producing airborne images carried out by drone, terrestrial measurements by terrestrial Light Detection and Ranging system (t-LiDAR) and Differential Global Positioning Systems (DGPS).

Up today, photogrammetry products were compared/competed LiDAR products. This is mainly due to cost to effectiveness ratio and the fact that both techniques provide similar services (3D point clouds) with different resolution and accuracy (mainly absolute accuracy). The user could simply choose the most beneficial product to fulfill the needs. In the current study, these techniques no longer compete each other, but complement, as t-LiDAR is known for its high millimetric accuracy and photogrammetry is known for its visualization and relatively large survey areas, the data are integrated in the photogrammetric workflow producing high resolution (bellow 1cm) and fine-scale surface/bathymetric model for measuring and mapping underwater structures/objects.

This study suggests a new technique for above and under shallow water surface/bathymetry reconstruction integrating drone RGB data transformed from 2D images into 3D cartometric models using t-LiDAR point cloud (millions of physical/ground points) as sets of tie or corresponding points (normally features that can be clearly identified in two or more images) in the photogrammetric workflow.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

Main work that was carried out during STMS was methodology development for improving the vertical accuracy of UAV DSM with LIDAR point cloud introduction as it follows:

- Preprocessing

LIDAR data was inspected for outliers in order to assure the quality of the data. On another hand, UAV imagery went under the quality inspection of radiometric performance

- Processing

Since it was important for this task to determine how different amount of LIDAR data and its configuration is affecting the result, several combinations of point clouds were co-registered. For that purpose, 4 different co-restarted point clouds with different LIDAR configurations were produced applying a cloud-to-cloud registration procedure.

UAV imagery was processed using automated processing procedure based on Structure from Motion (SfM) algorithms. The processing of novel approach started with gaining Sparse Point Cloud in initial processing procedure. After the first stage was done, earlier produced LIDAR datasets were introduced in order to increase the density of the Sparse Point Clouds. Also, GCPs were introduced to the model in order to provide the LIDAR scanning positions. Additional processing of UAV imagery was done in order to provide data for the assessment of model heights with and without introduced LIDAR point clouds. It was done by applying automatic 3-stage processing procedure while the same configuration of GCPs was introduced.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

1. Comparison of validation points/objects coordinates collected with DGPS on the field and coordinates gained from 4 different models showed that vertical accuracy is improving with the number of introduced LIDAR point clouds as shown in the table below (Table 1):

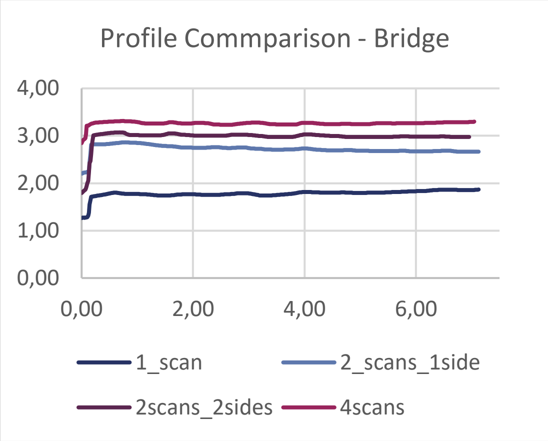
1 scan introduced		2 scans intorduced - 1		2 scans intorduced - 2		4 scans introduced		No scans - No GCPs	
Elevation	delta	Elevation	delta	Elevation	delta	Elevation	delta	Elevation	delta
0,652994	0,20899	-0,19324	-0,63724	0,125799	-0,31820	0,260544	-0,18346	-13,0828	-13,52682
0,146767	-0,26923	-0,72174	-1,13774	-0,22618	-0,64218	0,024467	-0,39153	-13,362	-13,77801
0,309408	-1,02759	0,58138	-0,75562	1,028952	-0,30805	1,298557	-0,03844	-12,1576	-13,49458
-1,16683	-3,35683	0,857151	-1,33285	1,330941	-0,85906	1,869938	-0,32006	-11,7748	-13,96479
-2,16928	-2,71328	-2,2328	-2,77680	-0,89889	-1,44289	0,101668	-0,44233	-13,5313	-14,07535
0,233959	-1,63204	1,166082	-0,69992	1,471487	-0,39451	1,611500	-0,25450	-11,8435	-13,70955
1,448925	1,10693	0,293642	-0,04836	-0,03127	-0,37327	-0,362352	-0,70435	-13,5176	-13,85960
Mean	-1,09758	Mean	-1,05550	Mean	-0,61974	Mean	-0,33353	Mean	-13,77267

Table 1 Validation point vertical accuracy comparison

Comparison of models spatial resolution showed high dependency upon the configuration of introduced LIDAR point clouds. The best spatial resolution (0,01296m) was achieved when introduced LIDAR data had 2 co-registered point clouds facing each other. The lowest spatial accuracy (0,01339m) was achieved when the model was processed with no GCPS and introduced point clouds.

The spatial resolution of the model with introduced LIDAR dataset with co-registered 4 point clouds dropped, achieving slightly better spatial result than the model with lowest spatial accuracy (0,01328m). This leads us to the conclusion that we should be aware of the tradeoff between spatial resolution and vertical accuracy when introducing LIDAR dataset with higher number of co-register point clouds.

2. Comparison of the heights within models with introduced different LIDAR point clouds on structures on land and in shallow water. For this purpose, profiles of 2 objects were selected and its values are shown below (Figure 1):



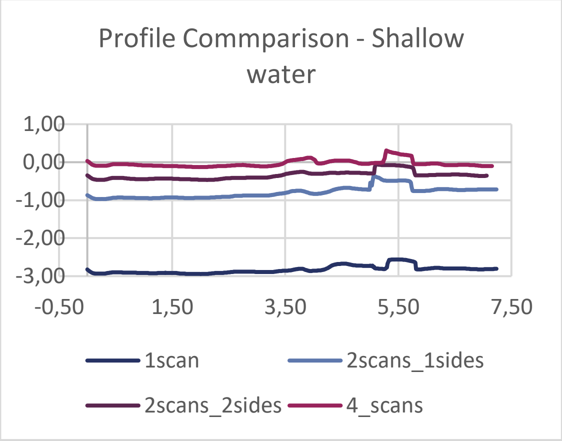


Figure 1 Different models profile comparison. Left - Profile comparison of bridge object sampled on 4 different digital surface models. Right Profile comparison of shallow underwater surface sampled on 4 different digital surface models.

From the analysis of different model profile values, we came to the conclusion that heights are becoming more realistic with the number of introduced point clouds.

3. Assessment how model its self is affected by introducing LIDAR data set was done by calculating DoD for the model with provided GCPs and model with the same GCPs and introduced LIDAR point cloud. Results showed that DoDs of models with higher number introduced LIDAR point clouds of have higher values. This is of great importance for areas under shallow water which are used for assessing the relative sea level.

FUTURE COLLABORATIONS (if applicable)

Future work will include publishing a joint paper, presenting the proposed method and achieved results. Also, the developed method will be applied to several other data sets collected in central Dalmatia, Croatia in order to assess the new relative sea level proxy.