Modelling of water surface topography on the Digital Elevation Models using LiDAR data

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Abstract

This paper presents a method to extract and model water surface topography on Digital Elevation Models based on Light Detection and Ranging data. Analyses were carried out on two test sites. The first area of research presents terrain with artificial reservoirs, the second – floodplain terrace with a meandering river. Extraction of the water body extent were achieved using available functions, based on Delaunay triangulation in the GIS software. Water surface topography was achieved using reduction to equal water level (in standing water bodies) and Inverse Distance Weighting interpolation (in flowing water). Results were evaluated visually on a basis of profiles across and along the water surfaces.

Keywords: LiDAR, DEM, TIN, IDW, water surface topography.

1   Introduction

Light Detection and Ranging (LiDAR) from Airborne Laser Scanning (ALS) is one of the high accuracy techniques for measuring the height above sea level. By using this technology it is possible to detect ground and other objects like vegetation or buildings. The detection of points in water areas is difficult, because a laser scanner does not have reflectance of the water, particularly when they are standing waters. Nevertheless, some reflectance of the water is possible when there are some waves or some objects above the water surface.

Detection of the water body extent on the LiDAR data and modelling water surface topography into Digital Elevation Model (DEM) is an important research area in fields connected with hydrology modelling. Most of the research has been done in extracting the coastal line [1, 2, 3, 4, 8], but detection and modelling of other water areas such as lakes, reservoirs and rivers still need some research to be done. An approach consisting in detection and classification of LiDAR points into water can be found in [5, 6].

This paper presents an approach to extraction of standing and flowing water bodies and their further modelling to surface topography for DEM generation.

2   Study area and data

In this research paper two test sites were taken to conduct the analysis. Both of them are situated in average slope terrain. The first test site presents a group of artificial reservoirs with standing water bodies in Podlesie village. The second test site presents meandering Wisła river with wing dams.

The data used for analysis were collected in June 2010 with minimum 3 points/m² density. Other scanning parameters ware as follows: average ground level (AGL) 1110 m, field-of-view (FOV) was 60° and MODE parameter was set to 5 (300 kHZ).

3   Methods

One of the most important things while performing analysis on huge volume of LiDAR data is to maintain the accuracy and correctness of data processing, especially when the aim is to point cloud data classification, extraction of some objects and changing (fixing) the data elevation.

The analysis presented in this work was conducted by means of Terrasolid (TerraScan), ArcGIS and Global Mapper softwares.

The first step was to delineate the water bodies extent. It was performed on the assumption that the scanner beam does not have reflectance from water areas. This information was used to indentify gaps in data. The gaps were calculated using the 'Draw polygon' tool (TerraScan) [7]. This tool draw 3D shapes around groups of points, the elevation of the vertices is defined by the laser points [7]. To define the polygons is necessary to specify several parameters: source class(es), maximum distance in gaps and also minimum and maximum size of a polygon [7]. As an input data were selected all point cloud data classes.

The second step was to visualise the evaluation of water body extent accuracy based on additional references files (orthophotomaps) and manual intervention in places where the applied function fails; for example in shaded areas where laser beam does not have reflectance and also in water body extent with high vegetation.

Further analysis consisted of classification into water class points within polygons and these which touch the boundary of the water body extent polygons. Then, the points from test site 1 were reduced to one water level, which was selected as average of 15 percent of the lowest available water points. The 15 percent was chosen as the best result from several

tests; smaller interval caused results disorder by 'low points'; higher interval caused disorder by 'low vegetation points'.

In test site 2 it was not possible to use the same method, because water within the river does not have the same level, therefore analyses were performed in a different way. Firstly, points were classified to eliminate outlier points with higher and lower value than neighbouring points. It was achieved using 'Classify ground' tool (TerraScan), which classifies points by iteratively building a triangulated surface model [7]. Maximum altitude distance difference into triangle was chosen as 0.5 m. This difference allowed to obtain relatively smooth surface without big differences between neighbouring points. Then the points were selected from classified data every 100 m distance and interpolated using the Inverse Distance Weighting (IDW) method. To achieve more smoother surface 2 power option and 100 number of points in search radius settings were used. The generated surface was used to calculate the height of water points.

4 Results

The results achieved were presented as surfaces, using Triangular Irregular Network (TIN) data structure (fig. 3, 4). Smoothed water surfaces were compared with input data (non smoothed water, fig. 1, 2) visually and also using transects across and along the water surfaces (fig. 1, 2, 3, 4). As is shown in fig. 1 and fig. 2 the water surface topography generated from raw point cloud is not smooth. Through the use of reduction to one water level in standing water bodies and IDW interpolation in flowing water bodies was possible to achieve smooth water surface topography (fig. 3, 4).

Figure 1: 1-D profile across the DEM with non smoothed water level (test site 1).
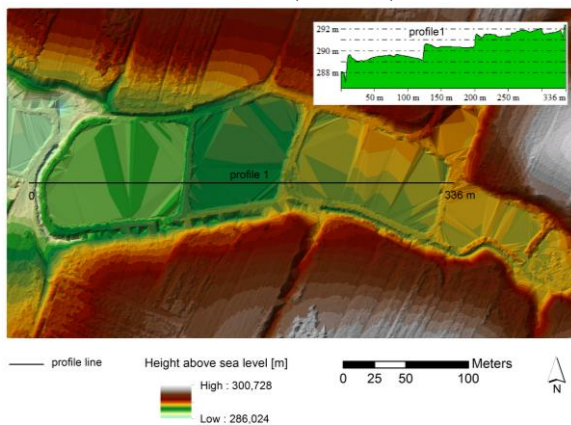
Source: Own study based on MGGP Aero data.

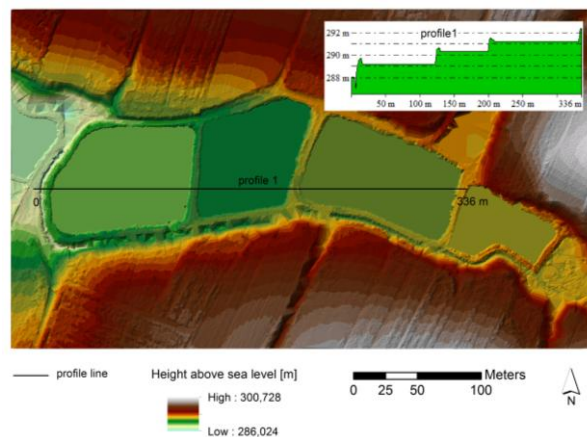Figure 2: 1-D profile across the DEM with non smoothed water level (test site 2).
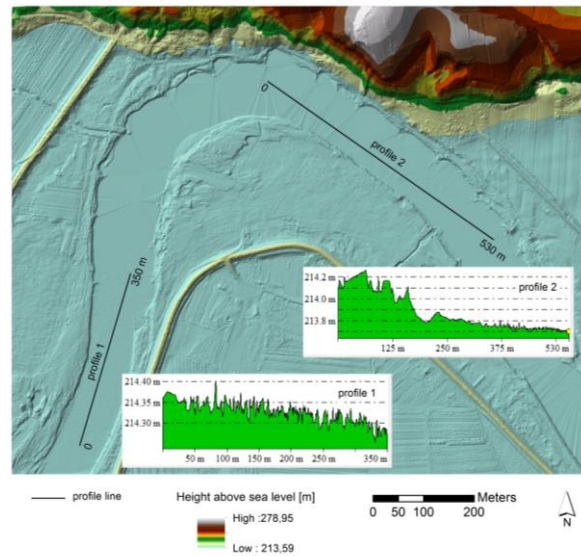
Source: Own study based on MGGP Aero data.

By analysing the generated transects it is possible to notice that the computed artificial surfaces do not have big influence on the boundary edge, the reason of which is input data density.

The IDW interpolation method, used for computation of flowing water bodies surface, achieves good results, because the elevation is computed on weighted average of the neighboured points - it has big influence, especially in one-direction-sloped areas like rivers.

Figure 3: 1-D profile across the DEM with smoothed water level (test site 1).

Source: Own study based on MGGP Aero data.

Figure 4: 1-D profile across the DEM with non smoothed water level (test site 2).
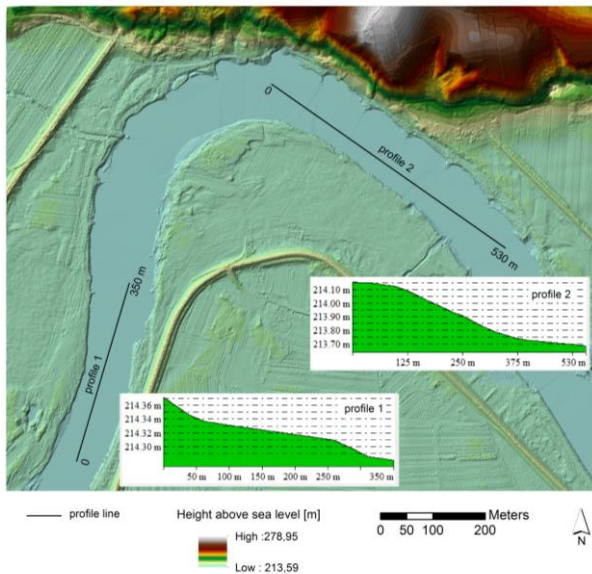
Source: Own study based on MGGP Aero data.

5   Dicussion and conclusions

In this paper a method for semi-automatic extraction of water bodies extent was presented. This work was also focused on modelling water areas for DEM generation. By reducing elevation and using the interpolation method it was possible to create smooth surfaces with the same water elevation in standing water bodies areas and smooth, not uniform sloping water in flowing water bodies.

However, the method achieved needs some research aimed at automation of the water extent extraction, especially in areas with high vegetation where very few ground points can be found and water boundary is generated according to vegetation.

6   References

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