Bathymetric LiDAR waveform data analysis

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Bathymetric LiDAR data is commonly used to map the elevation of the seabed and to extract features derived from these elevation maps (such as slope, aspect, coarseness etc.). More information can be obtained, however, when considering the full return waveform of the LiDAR pulse. The waveform contains components describing the water surface, water column and the benthic cover. In order to extract information on the benthic cover, the return waveform should be corrected for various condition variables such as in-water optical axis path, seabed slope, gain etc. Here we introduce an algorithm for decomposing the bathymetric LiDAR waveform, extracting a set of features from the bottom return pulse, reducing the effect of the condition variables, and clustering the bottom return waveforms using the Self Organizing Map (SOM). The work has been presented in more detail in [1].

The flow chart of the algorithm is presented in the Fig.1. The LiDAR return waveform is modelled as a sum of three components: 1) Gaussian-shaped water surface return pulse, 2) backscatter waveform modelled as the convolution between the LiDAR shot pulse and the exponential water column effect, and 3) Gaussian-shaped bottom return pulse. The bottom return pulse is extracted and further modelled as a sum of two Gaussian functions to allow feature extraction in poor signal to noise conditions. Several features are extracted from the modelled bottom return pulse including maximum amplitude, pulse widths, rise and fall times. Regression analysis is then used to compensate for known condition variables and SOM is used to map the data into prototype cells based on the corrected features. The neighborhood distance matrix method is used for grouping the prototype cells into final clusters.

The algorithm was tested on a data set obtained with the Hawk Eye II bathymetric LiDAR system from the Olkiluoto area. The cluster mapping was compared to a reference map composed based on the data from geological surveys and photic zones in the region. The results were found to be promising, i.e., the delineation of clusters followed the geological features reasonably well. It should be noted, however, that the developed algorithm performs unsupervised clustering rather than classification into predefined classes. The interpretation of the clustering result depends on the specific area.

References

[1] T. Kumpumäki, P. Ruusuvuori, V. Kangasniemi, and T. Lipping, "Data-Driven Approach to Benthic Cover Type Classification Using Bathymetric LiDAR Waveform Analysis," *Remote Sens.*, vol. 7, no. 10, pp. 13390–13409, 2015.

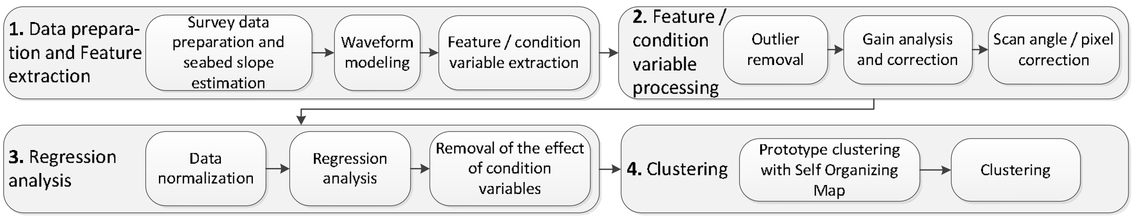

Figure 1) Flow chart of the data processing chain.