AN ATTEMPT TO ALS-DATA FILTERING IN WAVELET DOMAIN

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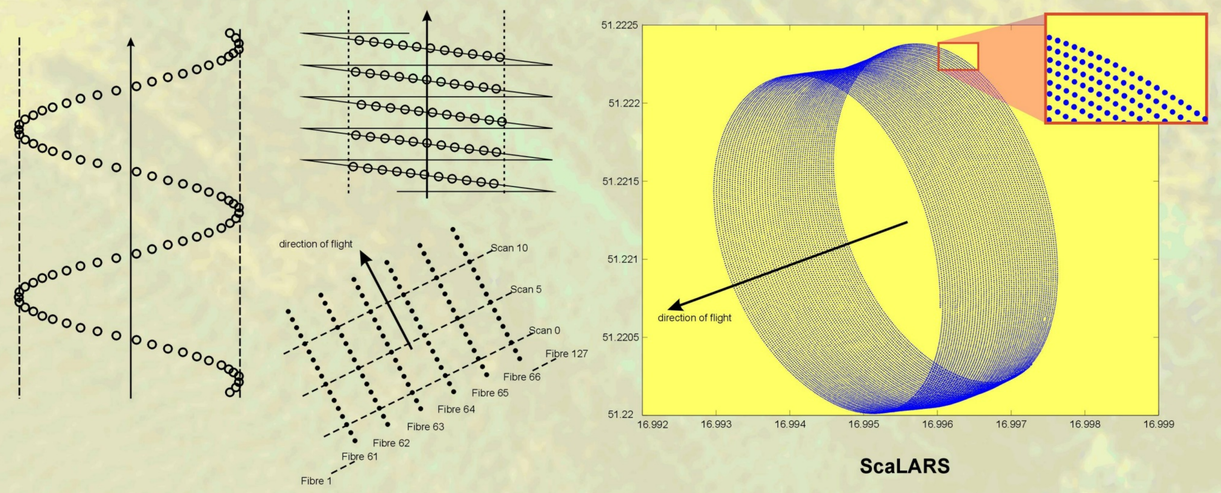
Introduction

Airborne Laser Scanning (ALS) represents the terrain as a point-set in space. Besides the desired reflections from the ground this set also contains reflections from buildings or the vegetation. If one aims at a reconstruction of the terrain (Digital Terrain Model), the undesired reflections from buildings or vegetation have to be removed from the spatial point-set.

A few filtration algorithms have been in use. The most important ones are based on linear prediction (Briese et al. 2002), cluster analysis and segmentation (Filin and Pfeifer, 2006), slope adaptive filter (Sithole, 2001) and approximation with active surfaces (Elmqvist, 2002; Borkowski, 2004). Advantages and disadvantages of the algorithms are given by (Sithole and Vosselman, 2004). Unfortunately, all algorithms fail in terrains featuring complicated structure, especially in the area of huge building complexes.

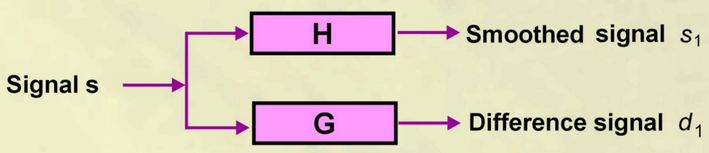
The laser-scanning system ScaLARS scans the ground along moving ellipses. Within those ellipses the data distribution is almost equidistant. Based on equidistant data property and the observation that the signal feature related to reflections from buildings typically occurs on well defined scales, a discrete wavelet technique for the detection and elimination of undesired reflections from buildings is proposed.

Typical scan patterns



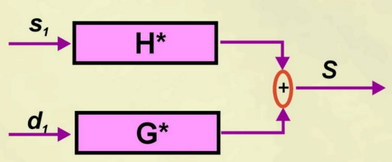
Wavelet Filter

Orthogonal wavelets generate orthogonal filter banks H, G, working in the following way:

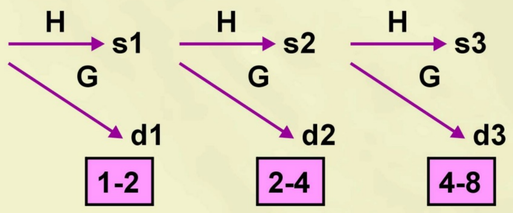


The smoothed signal contains all parts of the signal with detail sizes equal or larger two times the data sampling width and the difference sign al contains all signal parts with detail sizes smaller than two times the sampling - width.

The original signal *s* can exactly be reconstructed from the smoothed signal and the difference signal applying the adjoin filters : *H* G**,



Cascading the decomposition and the reconstruction filters yields a decomposition of the signal into non overlapping detail spaces with varying detail sizes:

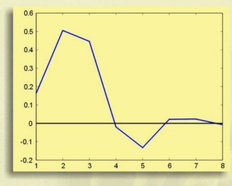


Observing, that the typical size of a house is 2^n.... 2^m times the data sampling width, the houses are found in the detail spaces d_n .... d_m of the wavelet spectrum of the ALS-data. Therefore, the elimination of reflection at buildings from ALS-data is done by the following algorithm:

1. Compute the wavelet- spectrum of the ALS-data.
2. Apart from the detail spaces *dn ...dm* set all other detail spaces to zero.
3. Reconstruct a signal $\tilde{s}$ from the modified spectrum. The reconstructed signal contains mainly a smoothed version of the houses.
4. Mask all data, which are reflections from buildings by thresholding:

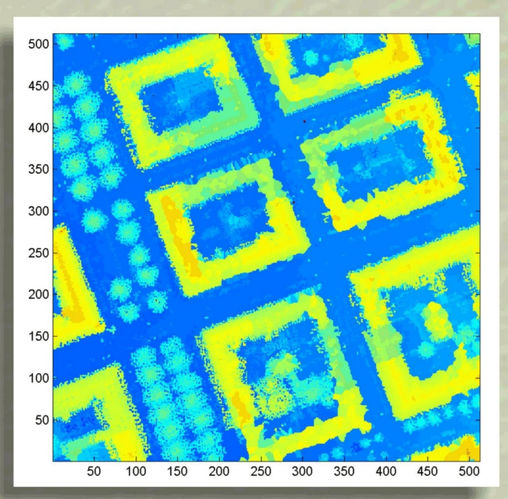
$$\bar{s} = \begin{cases} 1, |\tilde{s}| > \varepsilon \\ 0, else \end{cases}$$

5. Remove the reflections from buildings by $\hat{s} = s - \bar{s} \cdot (s - h_{avg})$, with h_{avg} being the average terrain height.
6. Final smoothing step.

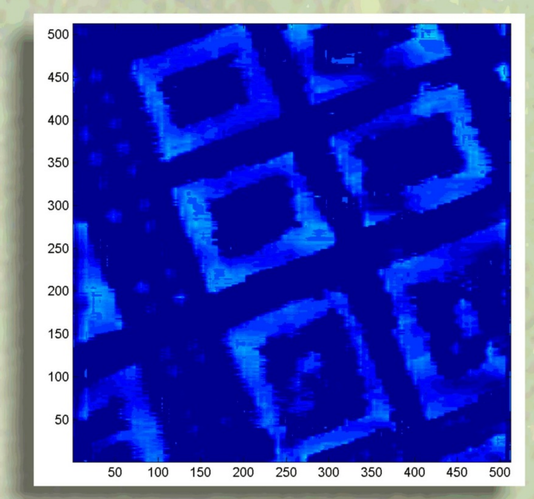


Used wavelet: Daubechies, order 4

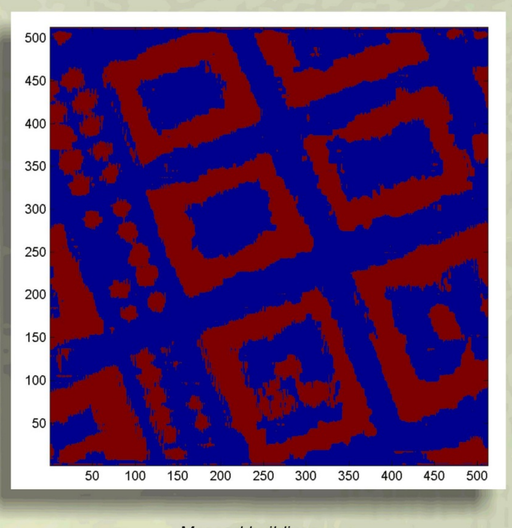
Test



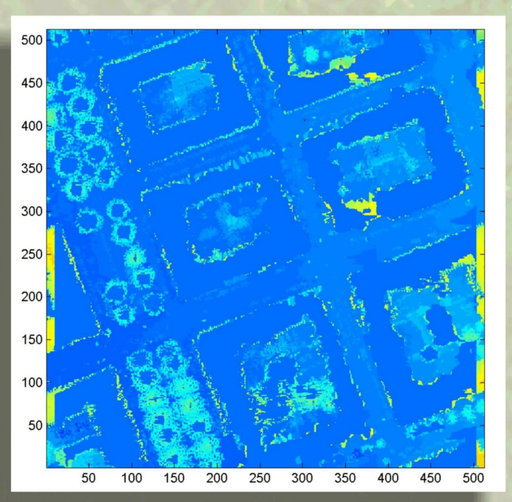
Data



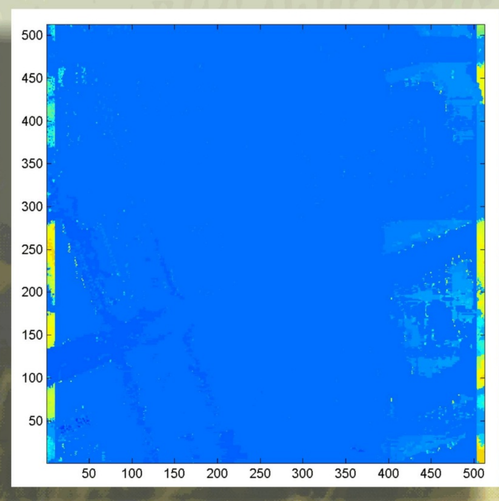
Reconstructed signal from the modified spectrum



Masced buildings



Buildings removed



Smoothed data after removing of the buildings.
Defects on the margins are separately to remove.

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