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The Effects of the Terrain Variation and Changed Parameters of the Moving Window on the LIDAR DEM Spectrum

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LIDAR (Light Detection And Ranging) data has become a highly used data source for modelling the terrain surface in recent years. In comparison to other surveying techniques, LIDAR measurements provide much denser (and affordable) sampling of the terrain in an automated manner. Higher density of data points results also in the better spatial resolution of DEMs (Digital Elevation Model) generated from these data.
Fourier transform (FT) is a technique for transforming the terrain information from the spatial into the frequency domain. Higher spatial resolution of the DEM enables more local approach for analyzing the terrain surface with the FT, since even for a smaller area many (enough) sampling points are given.
In this study 2D discrete Fast Fourier Transform (as implemented in MatLab) is applied to LIDAR DEM with a cell size of 0.5 m and therefore with a spatial resolution – in Fourier terminology - of 1.0 m. The chosen study area has different terrain characteristics, such as: different orientation of the lineaments, different aspects, different roughness. Our approach is to analyze the spectrum of the series of subareas ("moving window") of the DEM. This enables studying the response to the changes of different variables in the frequency domain. The changing variables were: (1) the size of the transformed area, (2) the offset between different positions of moving window, and (3) the orientation of the landforms with the respect to the moving window. Changes in all the variables influence the spectral information. We focus more on the results of changing the offset between moving windows, since these analysis are less explored. These offset changes reflect as the changes in the frequency domain due to a new relief structures included in the moving window.
Additionally, the possibilities for visualization of spectral information were explored. The purpose was to find an appropriate way to visualize a series of FT, which would raise the understanding of the relations between the changes in spatial domain and the responses in the frequency domain. Good results were achieved for visualizing the amplitude but for the phase information further investigation is suggested.
From geomorphometric point of view, the results can be interpreted as inherent properties of the terrain that was shaped by various endogenic and exogenic processes through longer time periods. Faulting and folding typically create quasi-linear or curvilinear features; they can be enhanced further by erosion, forming larger valley patterns. On the other hand, sedimentary processes tend to smooth the surface, by covering negative forms with sediments. Glaciation, as it is reshaping the current surface very rapidly, may modify the spatial spectrum considerably, removing higher frequency components. Post-glacial surface may inherit those properties and maintain them for longer time. Moving window FFT spectra are able to enhance hidden context (e.g., fault patterns), and rotation or deformation of original patterns can also be reflected in the succession of 2D Fourier spectra.