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Towards biologically relevant indicators of forest structure using lacunarity approach based on voxelized LiDAR data

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Considering the forest as a porous material that consists of the trees and other vegetation (representing the grains or aggregated grain groups) and the empty space between the plants (as the porous space in the analogy) this geometrical model provides a new approach to study the structure of the vegetation. Lacunarity, defined by Mandelbrot (1982), is a straightforward measure of structured empty space divided by the vegetation. This approach may allow the application of various concepts developed for porous media like tortuosity, percolation, directed percolation, anisotropic behaviour etc.
The original LiDAR point cloud is voxelized using a voxel size determined by the point density. Our approach considers 2D and 3D lacunarities derived from the voxels; in 2D approach the topography-parallel and topography-perpendicular cross-sections are considered. In the latter case anisotropic behaviour can also be analysed.
The lacunarity curves are evaluated in order to quantify the structural diversity that is positively related to species diversity. The relationship of vertical profile structural diversity to the richness of bird community has been widely shown in a wide range of forest types. The proposed method is able to characterize the structural differences that later can be related to the recognized relationships. Lacunarity curves can be further analysed to focus on both fine-scale (<10 m) and coarse-scale (100 ha) behaviour; comparison and categorization of lacunarity curve sections may reveal hidden spatial structural context. Application of the technology on multitemporal LiDAR surveys allows to detect the structural development after natural and human disturbances.

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Mandelbrot, B. (1982): The fractal geometry of nature. Freeman, San Francisco.