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Semi-automatic production of highly detailed cave maps from LiDAR point clouds

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Remote sensing technology based on laser scanning (LiDAR) has found a wide range of applications in cave mapping for a high degree of accuracy, level of detail, and time efficiency of this method. Besides the multidisciplinary research, the acquired data representing the cave morphology in a form of a dense point cloud became an essential part of the exploration for understanding the cave speleogenesis alongside capturing the current state that is of great importance in natural and cultural heritage documentation. Traditional cave cartography can benefit from using the LiDAR point clouds by a highly detailed 3D cave model enabling the creation of contours, shaded relief, or geomorphometric parameters, and a practically unlimited number of cross-sections. Compared to the passive remote sensing methods, such as photogrammetry, limited by the light conditions and cave dimensions, laser scanning is an active light-independent method that records additional attributes for each captured point in addition to its 3D coordinates. The recorded intensity of the backscattered laser pulse is very applicable for mapping purposes as it reveals spectral properties of the surface material bringing new aspects not only for the point cloud visualization but also for material differentiation, identification, and spatial localization of the cave paintings. The presented study introduces innovation in the methodology of creating a high-detail cave map from the acquired LiDAR data by combining derived cave floor model and semi-automatic procedure for identification of surface type based on the geomorphometric analysis and recorded intensity. The main benefit of the proposed approach is in the reduction of the author´s subjectivity and cave geometry generalization. By further automatization of this process, maps for large cave systems can be produced in a high level of detail.