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Modeling and analysis of caves using voxelization

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Although there are many ways to create three dimensional representations of caves using modern information technology methods, modeling of caves has been challenging for researchers for a long time. One of these promising new alternative modeling methods is using voxels. We are using geodetic measurements as an input for our voxelization project. These geodetic underground surveys recorded the azimuth, altitude and distance of corner points of cave systems relative to each other. The diameter of each cave section is estimated from separate databases originating from different surveys. We have developed a simple but efficient method (it covers more than 99.9 % of the volume of the input model on the average) to convert these vector-type datasets to voxels. We have also developed software components to make visualization of the voxel and vector models easier. Since each cornerpoint position is measured relative to another cornerpoints positions, propagation of uncertainties is an important issue in case of long caves with many separate sections. We are using Monte Carlo simulations to analyze the effect of the error of each geodetic instrument possibly involved in a survey. Cross-sections of the simulated three dimensional distributions show, that even tiny uncertainties of individual measurements can result in high variation of positions that could be reduced by distributing the closing errors if such data are available. Using the results of our simulations, we can estimate cave volume and the error of the calculated cave volume depending on the complexity of the cave.

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