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A new Hessian – based approach for segmentation of CT porous media images

Sizonenko Timofey (1), Karsanina Marina (2), Gilyazetdinova Dina (3), and Gerke Kirill (1)

(1) Institute of Physics of the Earth of Russian Academy of Sciences, Russian Federation (luckydevil2007@gmail.com), (2) Institute of Geosphere's Dynamics of RAS, Moscow, Russia, (3) Geology Faculty, Lomonosov Moscow State University, Moscow, Russia

Hessian matrix based methods are widely used in image analysis for features detection, e.g., detection of blobs, corners and edges. Hessian matrix of the imageis the matrix of 2nd order derivate around selected voxel. Most significant features give highest values of Hessian transform and lowest values are located at smoother parts of the image. Majority of conventional segmentation techniques can segment out cracks, fractures and other inhomogeneities in soils and rocks only if the rest of the image is significantly "oversigmented". To avoid this disadvantage, we propose to enhance greyscale values of voxels belonging to such specific inhomogeneities on X-ray microtomography scans. We have developed and implemented in code a two-step approach to attack the aforementioned problem. During the first step we apply a filter that enhances the image and makes outstanding features more sharply defined. During the second step we apply Hessian filter based segmentation. The values of voxels on the image to be segmented are calculated in conjunction with the values of other voxels within prescribed region. Contribution from each voxel within such region is computed by weighting according to the local Hessian matrix value. We call this approach as Hessian windowed segmentation.
Hessian windowed segmentation has been tested on different porous media X-ray microtomography images, including soil, sandstones, carbonates and shales. We also compared this new method against others widely used methods such as kriging, Markov random field, converging active contours and region grow. We show that our approach is more accurate in regions containing special features such as small cracks, fractures, elongated inhomogeneities and other features with low contrast related to the background solid phase. Moreover, Hessian windowed segmentation outperforms some of these methods in computational efficiency. We further test our segmentation technique by computing permeability of segmented images and comparing them against laboratory based measurements.
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