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GPR data filtering with sub-image MRA technique

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Ground-penetrating radar (GPR) has been successfully applied to obtain high-resolution image of shallow structures in the past two decades. However, the analysis and interpretation of the data can be very intricate if the data section is interfered with noisy events. Some standard techniques such as frequency filtering and f-k filtering are applied routinely in the GPR data processing, but these conventional methods of data procession using Fourier-based techniques may result in an abundance of spurious harmonics without any physical meaning. In this study, we propose a new approach based essentially on multiresolution wavelet analysis (MRA) for noise suppression. The 2D GPR section is similar to an image in all aspects if we consider each data point of the GPR section to be an image pixel in general. This technique is an image analysis with sub-image decomposition. We start from the basic image decomposition procedure using standard MRA approach and establish the filter bank accordingly. With reasonable knowledge of the noise to the data and the basic assumption of the target, it is possible to determine the components of signal and eliminate the noisy ones. The MRA procedure is performed further for the components containing both signal and noise. We deal with that component (a sub-image) as an original image and applied the MRA procedure to it with a mother wavelet of higher resolution. This recursive procedure with finer input allows us to extract features or noise events from GPR data more effective than standard process.
We test this method on a synthetic model and two sets of 400 MHz GPR data recorded at sites of geological significance. Comparing the results of our method with conventional filtering techniques demonstrates the effectiveness of the sub-image MRA method, particularly in removing ringing noise and scattering events.
Keywords: Wavelet analysis; Multiresolution wavelet analysis; GPR