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GPR image signal enhancement and feature extraction using contemporary multidimensional EMD methods

Yih Jeng and Chih-Sung Chen
National Taiwan Normal University, Department of Earth Sciences, Taipei, Taiwan, ROC (geofv001@ntnu.edu.tw)

Although the empirical mode decomposition (EMD) method has been introduced to the geophysical community for more than one decade, most applications are limited to one dimensional (1D) time series analysis or the likes. However, the EMD has long been prone to multidimensional, and the algorithm has been renovated from pseudo type to real multidimensional. There are two parallel novel multidimensional algorithms have been proposed in recent years, i.e. the multidimensional ensemble empirical mode decomposition (MEEMD or MDEEMD) and the multivariate empirical mode decomposition (MEMD). Probably due to the complexity of algorithms and high computation cost, these two multidimensional EMD methods are very little employed to process geophysical data. In this study, we mainly apply the MEMD to the ground penetrating radar (GPR) data processing which, to the best of authors' knowledge, hasn't been done before. The MEMD determines the multidimensional envelopes by projecting data on hyperspheres which extends the 1D algorithm to multidimensional, and the extrema of the data are determined by considering the data in all directions consequently. This renovation technique improves the alignment of intrinsic mode functions (IMFs) and reduces the mode mixing and aliasing problems of the EMD. We demonstrate this method using GPR field data acquired from an area of poor reflection quality. Some modifications of the computation procedures are made to facilitate the application of this approach in the geophysical data processing. To evaluate the success of this approach, MDEEMD results are also presented for comparison.