



Multidimensional EMD-based edge detection and the application to GPR imaging

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The edge detection is an effective approach in identifying object boundaries within a digital image. In recent years, it has been introduced to process geophysical data in the hope of enhancing the target boundary and improving the delineation of geological structures. However, most successful cases are applications to potential-field data. For GPR imaging, the edge detection is an emerging technique, and much effort is needed to make this method become an essential GPR data processing component. The major difficulty of applying edge detection to GPR data is that the GPR profile is orientation dependent, and a method successful in processing the digital image or potential-field data may not have the same achievement in GPR. Another concern for applying the edge detection is that the data must have acceptable signal-to-noise ratios, but the signal enhancement in GPR imaging has not been completely solved yet. In this study, we introduce a multidimensional EMD-based edge detection which can reduce the mentioned difficulties and improve the effect of edge detection. The proposed scheme suggests that the GPR data are pre-processed and reconstructed by using the multidimensional EMD to enhance the signal to noise ratio. This procedure is decisive because the adaptability of the EMD decomposition and the dyadic nature of the EMD components both allow the reconstructed data to have less noise and retain more signal than using conventional filters. In addition, the multidimensional EMD is efficient in identifying structure in different directions, which is suitable for processing orientation dependent data. Moreover, all the advantages gained in the multidimensional EMD do not rely on any prerequisite knowledge of the noise frequency band. After the multidimensional EMD process, we then apply the edge detection to the reconstructed data for the final interpretation. With the typical model study, the proposed scheme is also tested on the GPR data acquired in a buried hot spring area, and the processed result is better than those obtained solely using the multidimensional EMD or any one of the standard edge detection algorithms. This study implies that the multidimensional EMD edge detection can be a useful method in GPR imaging and that our strategy may provide an alternate approach to the development of edge detection.