Shahrood University of Technology

JOURNAL OF RESEARCH ON APPLIED GEOPHYSICS

(**JRAG**)

2019, VOL 5, NO 1

(DOI): 10.22044/jrag.2018.6646.1175

TV and GSTV denoising performance improvement in DTRADWT and RADWT domains

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Received: 14 January 2018; Accepted: 16 May 2018

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Keywords

Ground penetrating radar (GPR)
Random noise attenuation
Rational dilation wavelet transform (RADWT)
Dual-tree rational dilation wavelet transform (DTRADWT)
Total variation (TV) denoising
Group sparsity total variation (GSTV) denoising

Extended Abstract

Summary

Ground penetrating radar (GPR) method is a non-destructive method for detecting shallow subsurface objectives based on the transmission of electromagnetic waves into the earth and the recording of received reflections from the sent waves. Noise recording of GPR data is inevitable. Noise attenuation is one of the most important and most significant steps in GPR processing. GPR data contains a variety of noise types. Random noise during data acquisition affects the quality of the data. Several noise reduction techniques have been proposed in various papers. In this paper, two methods of total variation (TV) and group sparsity total variation (GSTV) are used to reduce noise from GPR data in rational dilation wavelet transform (RADWT) and dual-tree rational dilation wavelet transform (DTRADWT) spaces. The TV method is an inversion method for noise attenuation of data. The developed type of TV is called GSTV. TV and GSTV methods are very effective in noise attenuation. However, due to the presence of random noise in all frequencies of the data, it is difficult to reduce noise in the data.

Introduction

The geophysical method of GPR is increasingly being used for near-surface studies. Due to kinematic analogies between electromagnetic and mechanical waves, GPR data are currently processed by techniques developed for reflection seismic, although there are remarkable differences, both in wave field properties and in the geometries used to collect the data.

Methodology and Approaches

In this study, at first, GPR data were taken to the RADWT and DTRADWT domains and the noise reduction was made using two denoising inversion methods of TV and GSTV on both artificial and real data. For the case of artificial data, in addition to the qualitative review of the data, the power spectrum of the actual signal, the noisy signal, and the noise attenuated signal were obtained and investigated. Finally, the denoising methods and the results of TV and GSTV for noise reduction were compared.

Results and Conclusions

The results of this study show that the DTRADWT space, by providing time-frequency analysis based on rational coefficients, has been able to create significant noise reduction and enhancement in the implementation of proposed methods. The most important reason is that the scale-scale analysis to the GPR signal and the acceptable resolution of the DTRDWT method, due to the use of rational dilatation coefficients, have led to a decrease of aliasing in the time domain and also a decrease in the overlapping of the surfaces. The process of noise generated by the TV implementation in the time domain is the event elongation in the direction of the axis of time and is due to the loss of accuracy in the identification of random phenomena in the time domain by the TV noise reduction interface algorithm.

However, the generation of artificial noise in the GSTV de-destabilization method is much less than that of the TV. By examining the performance of these two filters in the DTRADWT environment, it is concluded that both the TV and

GSTV transformations have similar behavior in low-frequencies and are successful in noise elimination. In intermediate frequencies, these two denoising methods also behave similarly, and their noise reduction and the variation in the signal are approximately equal. However, the main difference between these two methods is in the removal of high-frequency noise. The GSTV method is more successful in reduction of high-frequency noise than the TV method because the TV power spectrum is close to that of the data, and even at some high-frequency points, the power spectrum is equal to that of the noisy data. From the structural point of view, the effects of the parabolic and boundary layers in the GSTV are much sharper than those of the TV. The results also show that the wavelet domain is more effective at reducing noise rather than time and FX space domains. Furthermore, in the wavelet domain, DTRADWT compared to RADWT has better frequency resolution.