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Attenuation compensation of GPR signal based on generalized S-transform

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Ground penetrating radar (GPR), as a nondestructive technique, has been widely used in civil engineering. Due to the complexity of the engineering conditions and attenuation of the GPR signal with depth, the radargram contained deep information usually shows a low resolution and S/N ratio. It might be one of the most difficult problems to GPR data interpretation, which limits the further application of the GPR method in civil engineering. The traditional way, such as a manual or automatic gain technique, was commonly used to enhance the weak GPR signal of deep target. However, due to the non-stationary of GPR signal, only the energy compensation in time or frequency domain may be not appropriate while using the manual or automatic gain methods. In this sense, neither the automatic gain compensation nor the other gain method seem likely difficult to obtain better results. In fact, it's not reasonable to separate the information in time and frequency domain from GPR data. The S-transform is a time-frequency analysis technique, which makes it possible for analyzing the GPR signal in time and frequency domain simultaneously. In addition, use S-transform to GPR data can preserve the original information in a wide frequency range. Here, we proposed a generalized S-transform based on exponential function and used it to the attenuation compensation of GPR signal. Firstly, the GPR data were transform to time-frequency domain using generalized S-transform trace by trace. Then the high-frequency component will be weighted at each time sample according to the attenuation ratio of low-frequency component. In this way the spectrum difference of each frequency component between late and early sampling time have the same ratio factor, which greatly compensates the attenuation of high-frequency component. Finally, the well compensated GPR data were obtained by inverse S-transform. Synthetic and real GPR data were used to verify the effectiveness and robustness of the proposed method. Compared with the standard automatic gain control (AGC), the proposed method has the ability to enhance the high-frequency components in GPR signal and better resolution, especially in deep areas. Also, GPR data after attenuation compensation can give more reasonable interpretation result. The generalized S-transform proves to be a convenient and reliable way for the attenuation compensation of GPR signal.