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Improved Spatial Autocorrelation Method for Dispersion Imaging of Ambient Seismic Noise

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The determination of shear (S) wave velocities within near-surface earth layers holds paramount significance in the realms of hazard assessment and geotechnical applications. In the fields of geophysics and civil engineering, ambient noise surface wave methods have garnered considerable attention due to their effectiveness in determining shear wave velocities within near-surface layers, particularly in densely populated urban areas. The spatial autocorrelation (SPAC) method, introduced in 1957 for the analysis of ambient noise dispersion, has maintained enduring relevance and widespread utilization within the realm of engineering geophysics in recent years[Aki 1957; Hayashi et al.,2022].

However, the dispersion energy generated using the SPAC (Spatial Autocorrelation) method is susceptible to contamination, especially at high frequencies, resulting from the occurrence of 'crossed' artifacts[Cheng et al.,2023]. The presence of these 'crossed' artifacts leads to the intersection and distortion of dispersion energy within the frequency–velocity domain[Xi et al.,2021]. These artifacts emerge from the simultaneous fitting of both inward and outward propagating cylindrical wavefields, encapsulated within the Bessel function. To mitigate the impact of these artifacts, we advocate for the exclusive fitting of the outward propagating cylindrical wavefield. To achieve this, a combination of the spatial autocorrelation coefficient and its Hilbert transform is employed, facilitating the construction of the outward propagating cylindrical wavefield.

In our proposed improved SPAC method, we replace the Bessel function with the Hankel function for fitting the constructed outward propagating cylindrical wave. Both synthetic and real-world field examples substantiate the efficacy of the proposed method in enhancing the accuracy of surface wave multimode dispersion measurements. This modification not only eliminates the 'crossed' artifacts but also underscores the robustness of our approach in refining the precision of dispersion analysis, particularly in scenarios involving complex wavefields and varying geological conditions.

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