



## Seismic wave separation by the gray-scale Hough transform

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In a Vertical Seismic Profile (VSP) recording, the useful signal is composed of the superposition of two wavefields: 1/ a downgoing wavefield with positive apparent velocities, and 2/ an upgoing wavefield with negative apparent velocities. To make best use of them, they need to be separated. Several methods exist to perform this separation, each with its advantages and disadvantages. The most frequently used in the industry is median filtering which remains, however, unsuitable when amplitude preservation is critical.

In this study, we propose a new method based on the gray-scale Hough transform (GSHT) which is an extension of the conventional Hough transform used to detect straight lines and other curves. The GSHT has been proposed to detect thick lines or bands in a gray-scale image. The technique, we suggest here, directly maps the gray-scale PSV image, including the downgoing and upgoing events linear bands, in image coordinate space  $(x, t, G)$  to the gray Hough parameter counting space  $(\rho, \theta, G)$ . In this new space, the downgoing events appear in the negative angles  $\theta$  quadrant and the upgoing in the positive quadrant. The inverse GSHT algorithm, we developed, is then performed to extract the bands that satisfy the filtering conditions:  $\theta$  negative for the downgoing PSV wavefield and  $\theta$  positive for the upgoing PSV wavefield.

The experimental results on synthetic and real VSP datasets are convincing. The wave separation is well performed, even in the presence of loud noise levels, with signal to noise ratio improvement and amplitude preservation, in contrast to median filtering.

Key words: Conventional Hough transform - Gray-scale Hough transform – Inverse gray-scale Hough transform – VSP – Seismic wave – Upgoing wavefield – Downgoing wavefield.