A field data example of the U-Net-based adaptive subtraction applied to the double-focusing method

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Abstract

In the seismic method, the internal multiple reflections are coherent noises that cause misinterpretations of the subsurface's structures in seismic images. To remove them, some authors have developed methods that consist of first obtaining a multiples model and then applying an adaptive subtraction. The second step adjusts the amplitudes, phase, and frequency of the modeled multiples to the true multiples. Among these methods stand out the adaptive double-focusing method (DFM), a source-receiver Marchenko redatuming that allows us to obtain redatumed data without the effects from the overburden, after adaptive subtraction, i.e., the effectiveness of the DFM strongly depends on performing a successful adaptive subtraction step.

In field data, complex mismatches between primaries and internal multiples, associated with a lack of knowledge of the optimal global scaling factor (which is empirically estimated) diminish the effectiveness of conventional adaptive subtraction in DFM, especially when there is overlapping between primaries and internal multiples, causing incomplete removal of the multiples or degradation of the primaries. By considering the success of the DFM jointly with an adaptive subtraction based on a U-Net network in synthetic data, in this work, we extend its application to a marine seismic field dataset and demonstrate its robustness.

The U-Net-based adaptive subtraction solves a supervised learning problem where the input data are 2-D data windows of the modeled internal multiples obtained by DFM, and the labels are 2-D data windows of the data containing primaries and internal multiples. After training the method uses the learned weights and bias (filters) to predict the true multiples so that we can get the estimated primaries by a direct subtraction. The loss function is based on the regularized L1 norm and the optimal network parameters are estimated using the Adam optimization algorithm. The U-Net model was implemented using the TensorFlow framework and the hyperparameters were estimated by trial and error.

To evaluate the method's effectiveness, we applied adaptive subtraction to the redatumed common-shot gathers. Analyzing the redatumed data after subtraction makes it possible to note the removal of internal multiples from the overburden. Additionally, for comparison, we generated the RTM images of the redatumed data before and after adaptive subtraction. Results indicate attenuation and improvement in the continuity of reflectors in the RTM images, showing that the U-Net-based method can effectively attenuate the internal multiples caused by an overburden in field data, obtaining a seismic image of a target area with less spurious events. Therefore, the U-Net-based adaptive subtraction increases the potential of the DFM in attenuation of the overburden multiples.