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AI Techniques for Seismic Super-Resolution

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Introduction

In recent years, machine learning techniques have proven to be highly powerful in the field of computer vision. If in the early 2010s there was a great evolution in the use of convolutional networks for image classification tasks, the increase in computing capacity in the second half of the decade has led to the use of machine learning techniques to attack increasingly complex problems. Among such problems, one that has received special attention is the use of neural networks to increase the resolution of an image, bringing back details that were lost in the acquisition, reproduction, or processing of that image.

In this work, we propose the application of techniques employed for super-resolution of conventional images over 2D seismic images. In the case of natural images, the definition of resolution is different from the definition of resolution used for seismic images: while in natural images "resolution" is the number of pixels or samples in each direction, in seismic we associate the resolution with the dominant frequency of the wavelet. Our work proposes, therefore, to use machine learning and convolutional neural networks to increase the frequency band of an image, bringing details that were not properly imaged using a lower frequency band.

Method

For the training, we take a set of inlines and crosslines from a known property model (SEAM Subsalt), and model and process an acquisition on these lines with wavelets containing different frequency bands. The network is then trained to take the lower frequency images to the higher frequency images.

Preliminary Results

Our preliminary results were obtained with a dataset of 181 inlines and 151 crosslines of the SEAM Subsalt model. On each of these lines, a streamer acquisition with two different frequencies was modeled and imaged: 30 Hz and 40 Hz. These images are divided into 60% for training, 20% for validation and 20% for testing. The dataset for the network is created from the random clipping of equivalent 256x256 patches in the images, for a total of 234366 pairs of patches for training, 78458 for validation, and 79590 for testing. The network used, a U-Net with 5 downsample blocks and 5 upsample blocks, is trained by 100 epochs. We arrived at a PSNR validation of 47dB, comparable to the best current techniques when applied to natural images, and visually we noticed that reflectors that appear on the targets are being very well recovered in the higher frequency band.

This research line is ongoing, and we expect to compare the results from this U-Net to new results using different architectures, such as GANs, neural operators and diffusion models.