Use of Generative Adversarial Networks to Mimic Seismic Inversions

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Abstract

Hydrocarbon industry works with seismic reflection as a chief indirect method for investigating subsurface data. Seismic volume provides inaccurate geometries of geological structures, inferring rock properties based on seismic amplitude. Ones consider it as an ill posed inverse problem. In order to obtain reliable information, we need to perform seismic inversion processes, as they are very important for correct reservoir characterizations, although expensive and time-consuming. The aim of acoustic seismic inversion process is to obtain an impedance volume through a recursive process by minimizing the error between the original seismic data and a synthetic seismic data. Progressively, updates occur in this model until the error reaches to a desired threshold. Incorporation of well log information and interpreted seismic horizons as boundary conditions enable the full process to expand original seismic volume frequency bandwidth. Iterdec (Iterative Deconvolution of Seismic Data) is a process that targets to improve reflectors definition, increasing resolution. It is an important first-order approximation, applicable to a seismic trace in which the pulse phase is null and the value of reflection coefficient is proportional to the amplitude of the same central peak. Each of seismic trace local maximum and local minimum represents an approximation of a valid reflection coefficient. Full Waveform Inversion (FWI) is another seismic inversion technique. However, it uses pre-stacked seismic data to obtain a high-resolution interval velocities model. As FWI takes place with pre-stacked seismic data (three orders of magnitude greater than the traditional seismic volume), it becomes computationally very expensive and time-consuming. Its use has only become industrially feasible recently, with the increase in available processing. Convolutional neural networks (CNN) are getting popular in many applications, typically in classification and segmentation tasks. Moreover, recent studies have demonstrated the feasibility of geophysical modeling using CNNs. Among CNN architectures, generative adversarial networks (GAN) go beyond the traditional classification and segmentation tasks; GANs stand out for their ability to learn how to mimic data provided to them by capturing their statistical and spatial distributions. GANs are generative models that learn to generalize rules of how to transform a random noise vector z to output image y (G:z→y). The pix2pix GAN architecture is a conditional GAN (cGAN), which has as its input the sum of the random noise vector z with an image x, to find a rule to translate this input to image y (G:{x,z}→y). To accomplish this task, pix2pix uses two networks competing against each other. While one network generates synthesized images (generator), the other judges whether these images are valid (discriminator). The training of Generator G produces output images that are indistinguishable from the actual images by a discriminator D, which in turn is trained to improve its performance on detecting the generator's fake images. In this work, we present a method using an image-to-image translator (pix2pix) based on a conditional generative adversarial network (cGAN) to translate an input data (post-stack seismic image combined with some seismic processing subproducts) into three seismic inversion volumes: Acoustic Seismic Inversion, Iterdec and FWI, for a faster reservoir characterization.