Artificial intelligence in seismic interpretation: transfer learning, active learning and other helpful tools

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Abstract

Deep learning have achieved great results in many computer vision tasks, such as image classification, image segmentation, image translation and photorealistic image synthesis. The application of these techniques to seismic shows great promise, and a great number of papers have already been published with good results.

The present work focuses on deep learning techniques that help overcome the specific difficulties inherent to seismic interpretation: small number of annotated examples, spatial limitations of the existing annotations, and low resolution and signal-to-noise ratio (seismic ambiguities). We apply the discussed techniques to seismic facies segmentation case study in brazilian pre-salt.

In face of the small fraction of annotated seismic sections, direct training of a 3D UNet architecture showed to be an inefficient strategy, resulting in overfitting. To overcome this difficulty, we have used transfer learning in this work, but instead of copying the weights of a network pre-trained on a completely unrelated domain (such as natural images, or city landscapes) we have trained our own base model on another seismic task. We found that pre-training our network on the horizon picking task was very beneficial to our seismic facies segmentation problem, due to the similar nature of the dataset, and because there is abundant annotated data for horizon picking, which allows for robust training of a 3D CNN architecture. Once, the network was trained on the horizon interpretation task, we fine-tuned the network weights (transfer learning) to the main task: segmentation of carbonate seismic facies.

Another challenge in seismic applications is that it is usually very hard to completely annotate even a single seismic section, due to the spatial changes in geological setting (laterally but mainly vertically). In the present work we use the concept of unknown regions, which is not a class and thus not taken into consideration in the loss function. Consequently, the geoscientists do not need to identify all the geological classes in a seismic section, neither are they required to identify all the instances of the class of interest. So, our training framework allows the specialists to annotate just the geobodies that they are sure of.

The seismic ambiguities are a third challenge; therefore, any seismic annotation has a high degree of uncertainty. This makes the use of a probabilistic paradigm mandatory for seismic segmentation/classification tasks. In the present paper we have used dropout layers, which is a first approach to handle uncertainty, but other techniques are applicable as well (such as Bayesian neural networks).

We show the benefits of an interactive workflow, known as active learning, where we intercalate annotation and training of the neural network to optimize the geoscientist´s annotation effort. In this kind of workflow, we quantify the neural network´s epistemic uncertainty and highlight regions with high uncertainty as areas to be prioritized during the next round of annotations.

In conclusion, we have applied some deep learning techniques and show that they make a significant contribution to the solution of the following challenges in seismic segmentation task: small number of annotated examples, spatial limitations of the existing annotations, and seismic ambiguities.