Application of Deep Learning in 2D Seismic Analysis

Marcio Lemos, Neida Ilana, Carlos Saraiva, Vanessa Lira, Juliana Fernandes, IesBrazil Technology and Innovation

This paper was prepared for presentation during the 4th Joint SBGf/SEG Workshop on Machine Learning held in Rio de Janeiro, Brazil, 03-04 December 2024.

Abstract

Machine learning (ML) in seismic exploration is growing faster than applications in other industry fields, mainly due to the large amount of data acquired by the exploration industry. Machine learning (ML) in seismic analysis can reveal intricate patterns and features within seismic data that may not be readily discernible to human interpreters and identify anomalies that might be overlooked in traditional interpretations. These algorithms are predominantly applied to 3D data rather than 2D data due to the required preprocessing. The aim of this work is to use 2D offshore seismic data from the Santos Basin to analyze the ability to use machine learning techniques on this type of data.

One of the factors contributing to this disparity is that the preprocessing of seismic data becomes more complex when dealing with 2D datasets. The use of VDS (Volume Data Storage) as an open seismic format facilitates the organization and retrieval of large datasets, enabling efficient storage solutions and optimization of data handling and preprocessing. By providing a structured framework using brick format, fast slices, and random access, VDS allows the use of 2D data, enhancing the ability of machine learning algorithms to access and analyze seismic information quickly and effectively.

Twenty 2D seismic lines from the R0003_GRAND_SANTOS survey were converted into a single VDS. This VDS was fed into supervised deep learning software that uses the interpreter's labels as input and uses a convolutional neural network created for the data needs, allowing maximum control of the results. ENET networks were created in this process, and only one seismic line (5% of the seismic data) was labeled in two different phases.

The first phase separated three stratigraphic classes in the seismic: seabed, post-salt, and a class combining salt, presalt and basement. This network was trained for 25 epochs, resulting in a probability cube for the three classes covering all 2D seismic lines. The second phase consisted of using only the post-salt in the previous phase as a stratigraphic mask to label faults in this sequence. This network was trained for 20 epochs, which resulted in a post-salt faults probability cube covering all 2D seismic lines. These outputs are given in VDS and converted back to 2D SEGY, making it easier to use in other applications.

The methodology has proven effective in separating stratigraphic classes and mapping faults, revealing structural fault behavior on all mapped 2D lines, making it easier than mapping line by line. The enhancement provided by the deep learning tool allows a more comprehensive understanding of subsurface structures, ultimately leading to improved accuracy in identifying geological formations, fault lines, and other critical features. The challenge concerns the number of 2D lines in a single VDS to work with deep learning. Currently, our work has been restricted to a small number of 2D lines, and we know that there are a lot of long lines that cover kilometers of area.