IPTC 2024

IPTC-23370 Abstract

Quantum Accelerated Coherence Seismic Attribute

Author block: O. Alsalmi, Saudi Aramco; S. Al-Dossary, Saudi Aramco PE&D

Abstract

Objectives/Scope: 3D Seismic data attribute computation is an important process in the oil and gas industry for revealing complex geological structures such as faults, fractures and channels from seismic field data. It is also a computationally intensive operation, especially when applied to terabytes and petabytes of data acquired in a modern 3D seismic survey. To overcome the huge computational cost of computing seismic attributes, high-performance computing is used for successful and cost-effective execution of the process. Quantum computing is a rapidly evolving field in the high-performance computing which promises to change the landscape of computation (Yao et al., 2017). In this paper, we propose the industry first quantum-based seismic attribute for fault detection. Classical image processing methods, such as the Sobel filter, use a fixed size window which is passed on the seismic image highlighting large differences in neighboring traces magnitude revealing geological discontinuities (Gómez et al., 2021). On the contrary, our method leverages quantum mechanical states to encode and calculate such differences in one pass.

Methods, Procedures, Process: Qubits states scale exponentially with qubit count corresponding to 2n where n is the number of qubits. The number of qubits required to encode N-samples can be calculated by log2N (Zhang et al., 2021). We can leverage this property to devise the coherence seismic attribute algorithm. The seismic data samples are encoded in the qubit states and subsequently, the difference in magnitude is evaluated in one step.First, we initialize the image in the state (Quantum State). After initializing the pixels values we introduce an auxiliary qubit to apply the Quantum gate on the image. The joint state is represented by the tensor product. The gate transforms the encoded image samples into superposition generating two pairs. Mathematical and the physical operations and transformation will be shown in the presentation.

Results, Observations, Conclusions: The algorithm was run on IBM Qiskit runtime quantum simulator using 18 data qubits and 1 auxiliary qubit. A comparison between classical coherence seismic attribute and Quantum-Based coherence seismic attribute yielded similar results in terms of quality Figure 1 below. A channel feature is detected using both methodologies, highlighted by the orange arrows.

Novel/Additive Information: Coherence seismic attribute is an important step in the seismic interpretation workflow. However, the conventional methods are compute-intensive specially with the growing size of seismic volumes. We are the first in the industry to develop a geometric seismic attribute using quantum computing and applied it to 3D seismic data.