

PS A Pattern Recognition Approach for Automatic Horizon Picking in 3D Seismic Data*

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Abstract

We present a new approach to auto pick horizons in 3D seismic data using a pattern recognition technique. This method was used as the basis of an innovative autotracking technology that has been utilized and proven by the interpretation community for almost two years.

In the practice of horizon picking, conventional methods usually employ a window-based approach in searching extrema. This approach only scans the adjacent trace vertically within a time window, while ignoring the lateral continuity. The very limited window context often incurs the “off cycle” effect, which means that the extrema points are incorrectly linked across seismic phase cycles. This effect can be more severe in seismic data with high-dip geologic structure. To preserve the lateral continuity of horizon picking, one needs to examine the seismic data pattern in a range of the neighborhood. The proposed method utilizes the context information to predict the horizon trend. We create a 3D data set constructed of directional pointers defined at every seismic data sample. It helps to determine the data pattern and direct the trace selection algorithm through the seismic volume. Combining the pointers set and a confidence-based trace selection mechanism helps to optimize the 3D horizon autopicking and obtain more accurate results compared to other conventional algorithms.

A Pattern Recognition Approach for Automatic Horizon Picking in 3-D Seismic Data

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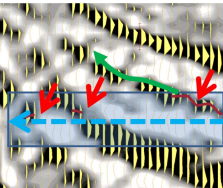
In the practice of horizon picking, conventional methods usually employ a window-based approach in searching extrema. This approach only scans the adjacent traces vertically within a time window, while ignoring the lateral continuity. The limited window context often incurs the “off cycle” effect, which means that the extrema points might be incorrectly linked across seismic phase cycles. This effect can be more severe in seismic data with high-dip geologic structure. To preserve the lateral continuity of horizon picking, one needs to examine the seismic data pattern in a neighborhood of seismic traces. The proposed method utilizes the context information to predict the horizon trend. We create a 3D data set constructed of vectors defined at every seismic data sample. It helps to determine the data pattern and direct the trace selection algorithm through the seismic volume. Combining the orientation vectors and a confidence-based trace selection mechanism (MST) helps to optimize the 3D horizon auto-picking and obtain more accurate results compared to other conventional algorithms.

Introduction

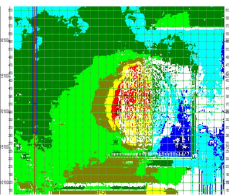
A horizon is characterized by seismic reflection properties in a depositional environment and can be represented as a three dimensional surface between rock layers (Faraklioti and Petrou,2004)

The goal of horizon auto-picking is to track a user selected phase of the horizon curve waveform automatically by a computer algorithm.

The challenges of horizon picking exist in both 2D and 3D data.

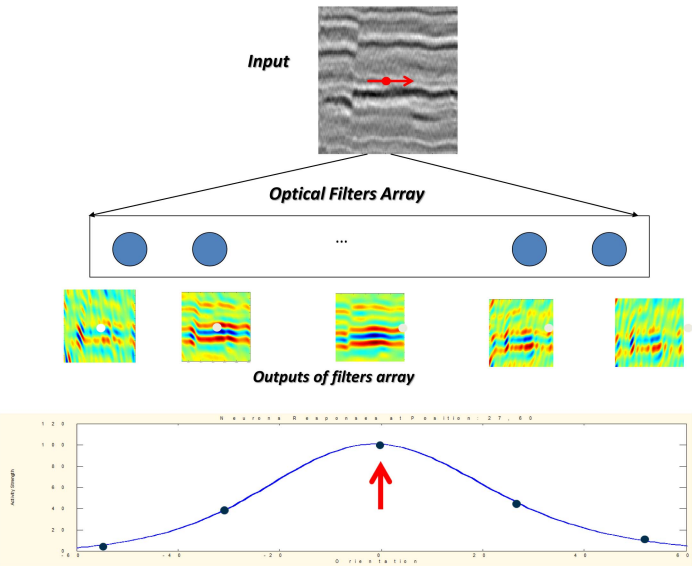


Across Cycle Effect in 2D



Inconsistent Picking Result in 3D

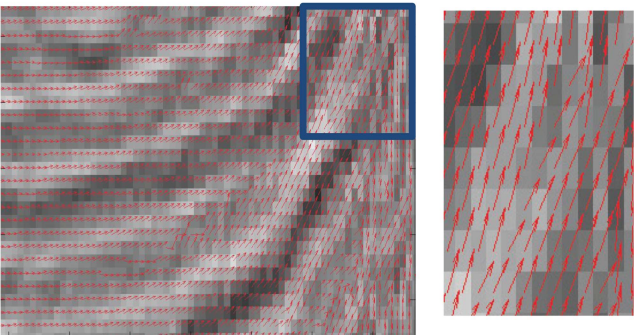
Orientation Vector Field (OVF) Workflow



Orientation Energy

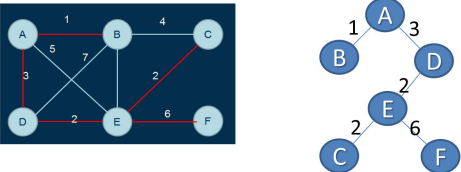
$$Y^i(x,y) = \sqrt{[Y_r^i(x,y)]^2 + [Y_{im}^i(x,y)]^2}$$

$$E(x,y) = \text{Max}_i(Y^i(x,y))$$



The Generated Orientation Vectors

Optimize the Traversal Order in 3D by Minimum Spanning Tree (MST)



In graph theory, a **spanning tree** is a sub-graph that is a tree connecting all vertices together. There are multiple spanning trees for the same graph. The **MST** is the spanning tree with the minimum costs.

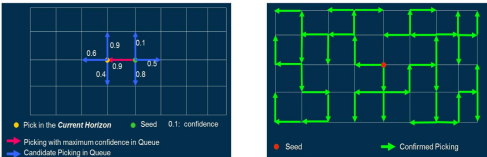
In Horizon Picking, the MST elements are mapped as follows:

Vertices: The pick on the trace

Edge: The picking from the parent trace to the child trace

Cost: The confidence of the picking. It includes factors of wave pattern and depth displacement.

Confidence $C_{p,q} = \rho e^{-k\delta}$



Procedures

1. Define **seeds**.
2. Picking to neighbor traces by OVF as **candidate pickings**.
3. Calculate their **confidence values**.
4. Select the candidate picking with the **maximum confidence**.
5. Add the winning pick into the **current horizon**, and the candidate picking becomes a **confirmed pick**.
6. Repeat steps 2 to 5 until no new pick can be added. The result is the final horizon.

Experiments

We tested the algorithm with a 3D Seismic Survey around a Salt Dome (Courtesy of FairfieldNodal). This 3D seismic volume is characterized by a large number of faults and a big salt dome in the center. The fault surfaces and salt dome were not picked prior the horizon picking.

Fig. A shows the resulting horizon picked with the algorithm as introduced. The seed horizon is on a single line at the north side of the dome.

Fig. B is the confidence of each pick in the resulting horizon.

Fig. C shows one vertical display line. The green lines are the resulting horizon picked automatically. Horizons are automatically matched across the faults.

Conclusion

- A pattern recognition-based horizon picking method
- Pick Selection: orientation vector guided
- Trace Selection: MST-based search, which traverses the horizon coherently, thoroughly and accurately.
- Reduce the costs and improve the quality for automatic horizon interpretation.

Acknowledgements

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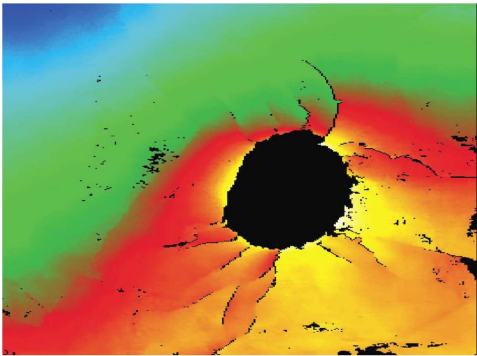


Fig. A. The Resulting Horizon Picked by OVF and MST

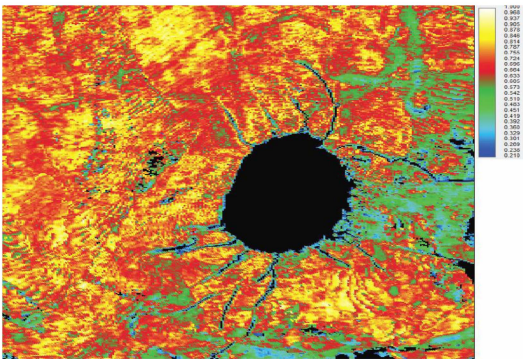


Fig. B. The Confidence Value of the Resulting Horizon

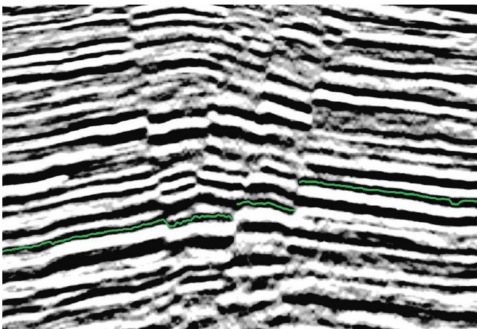


Fig. C. The Horizon on VSD Slice