Where Do We Lack Information?

MPS Realizations Can Tell you Where to Drill

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Content of Presentation

- MPS – A quick overview
- The MPS workflow in GeoScene3D
- The workflow of the Methodology
- The Study Area and Data
- Some Definitions – Gaussian Kernel, Convolutions, Entropy
- Results
- Concluding Remarks
Motivation

- Developed MPS tools in GeoScene3D
- Involvement in different R&D Projects
- How to utilize MPS – realizations?

Where Do We Lack Information?
The Fundamental Problem

\[ f_I(\bar{m}) \propto \prod_i f_{I_i}(\bar{m}) \propto f_{I_{Tl}}(\bar{m}) f_{I_{hard}}(\bar{m}) f_{I_{Soft}}(\bar{m}) \]
MPS Workflow in GeoScene3D

1. Make a Training Image
2. Define Hard/Soft Data
3. Run Simulations
4. Alternatively compute E-Maps

Step 1. Generate Soft Data
- Resistivity Data
- Resistivity Grid
- C1 - Prob
- C2 - Prob

Step 2. Generate Hard Data
- Borehole Data
- Category Grid
- Training Image

3. Run Simulations
4. E Maps
Workflow of the Methodology

- Run MPS Simulations
- Compute the Entropy
- Convolve with a Gaussian Kernel
- Find Maximum Entropy
The Simulation Area
The Training Image (TI)

- 3D Grid: 61x61x21 Voxels
- Total # Voxels: 78141
- Voxel Size: 50x50x10 m
Hard and Soft data

Borehole Data

Resistivity data

3D interpolation

Categorize and make Hard data Grid

Probability of Sand

Probability of Clay

Borehole Data

Resistivity data

3D interpolation

Hard and Soft data

Categorize and make Hard data Grid

Probability of Sand

Probability of Clay
Simulation Setup:
- The Snesim Algorithm
- Template Size: 5-5-3
- 5 Multiple Grids
- Random Simulation path

4 realizations

The Mode Model

Simulation Results

- FP_C2 - Sand
- FG_C1 - Clay
The Shannon Entropy from Information Theory:

\[ S = - \sum_i (P_i \log_2 P_i) \]

- S is proportional to uncertainty
- S = 1 indicates max uncertainty – No information
- S = 0 indicates no uncertainty – Fully informed.

- Equal number of outcomes for all categories in a pixel/voxel from a simulation result in S=1
- All outcomes in pixels/voxel has the same category: S=0
1-Entropy Grid with no convolution
Smoothed Dirac Delta in 3D.

3D Gaussian Kernel with ellipsoidal shape of 11*11*5 cells. 500m x 500m x 50m
Std. of 3, 3 and 1

Horisontal slice

Verticle Slize
Results

1 – Entropy in the upper 10 meters.

\[ WHU = \frac{1}{n} \sum_{n} (1 - S(n)) \]
Results

1 – Entropy in the upper 10 meters.

\[ \text{WHU} = \frac{1}{n} \sum_{n} (1 - S(n)) \]
MPS Realizations represent different Geologic scenarios

The Entropy provides information on the certainty of our probabilistic model

Convolving the Entropy model allows including the surrounding information content

Obtaining information (e.g. by drilling) at the location with highest entropy will update the probabilistic model the most