Preliminary Investigation of Using Distances for Modeling Structural Uncertainty

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Structure

• Introduction to Problem
• Similarity Distance
• Implicit Representation
• Implicit Distance
• Initial Experiments
History Matching Workflow

Suzuki et. al. 2006
Challenges

• This requires
  – Generating all prior structural models explicitly
  – Running flow simulation on all models
• Flow Simulations are computationally complex
• Generating and Gridding prior structural models is also complex
• History Matches are only as good as the priors
Challenges

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• This requires
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• Flow Simulations are computationally complex

Do fewer flow simulations

• Generating and Gridding prior structural models is also complex

Generate fewer structural models
Why we need so many models?

Prior Structural Uncertainty

Modeled by multiple migrations

Migration Uncertainty

Structural Interpretation Uncertainty

Modeled with multiple interpretations by experts

Modeled by independent stochastic perturbation across faults

Horizon Correlation Uncertainty Across Faults

Top Horizon Positioning Uncertainty

Gross Thickness Uncertainty*

Fault Positioning Uncertainty

Modeled by stochastic perturbation

* Equivalent to bottom horizon positioning uncertainty

Suzuki et. al. 2006
Why we need so many models?

• Adequate matches
• Purpose: reduce prior uncertainty
• How?
  – Incorporate production data
  – Look for the prior that reproduces that data
• History Matching
• Search and Select
Similarity Distance

Quantify the similarity of structural geometry between grids

- Parameter space for History Matching
- Suzuki and Caers, 2005
  - Parameterise using distance between prior models
  - Stochastically search for models that provide adequate history matches
Neighborhood Algorithm

Step 1

Step 2

Step 3
Problem

• Initial problem requires
  – Generating all prior structural models explicitly
  – Running flow simulation on all models

• Flow Simulations are computationally complex
  – Fixed!

• Generating and Gridding prior structural models is also complex
  – But we need this to measure distance

Generate fewer structural models
Implicit Representation

- Use information available before generating model explicitly
- Implicit representation of surface
- Isovalue in a monotonic volumetric function (YACS, SPE97271)
- Represent fault network as a hierarchical tree (Cherpeau et al. 2009)
Implicit Representation

• Use information available before generating model explicitly
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Fault Network as Hierarchy

Hierarchy Representation (Implicit)

Structural Representation (Explicit)
Hierarchical Distance

<table>
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<th>Level</th>
<th>No. of faults (left)</th>
<th>No. of blocks (left)</th>
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Binary Implicit Distance: 0 1 10 6
Decimal Implicit Distance: 0 1 2 12
Hierarchical Distance

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Binary Implicit Distance: 0 0 0 0
Decimal Implicit Distance: 0 0 0 0
Experiment

• Hierarchical distance
  – Coarse metric
  – Find correlation with difference in production data.
  – Can this or a function of the above be used as a distance metric prior to structural modelling?
Experiment: Sources of uncertainty

- The Hierarchy
  - Different fault network
Experiment: Sources of uncertainty

- The Hierarchy
  - Different fault network
- The Realisation
  - Orientation of fault
Experiment: Sources of uncertainty

• The Hierarchy
  – Different fault network

• The Realisation
  – Orientation of fault
  – Position of fault
Experiment: Sources of uncertainty

- **The Hierarchy**
  - Different fault network

- **The Realisation**
  - Orientation of fault
  - Position of fault
  - Intensity of fault
Experiment: Implicit to Explicit
Experiment: Implicit vs. Explicit
Experiment: Implicit vs. Explicit

Implicit

Explicit?
Experiment: Implicit vs. Explicit

Implicit

Explicit?

Explicit?
Experiment: Implicit vs. Explicit

Implicit

Explicit
Initial Results

Correlation = 0.338
Experiment: Implicit vs. Explicit
Experiment: Implicit vs. Explicit

Implicit

Explicit

AVERAGE
Experiment: Implicit vs. Explicit

Why?
The mean gives us a better measure between two random realisations
Initial Results

Mean Values (Correlation = 0.6767)
To Explore

• Can we do better?
  – Coarse Distance + Small-scale Distance combinations?
    • Modified Hausdorff distance
    • Proximity Distance

• Can we define a Voronoi space for history matching with less structural modelling?