Obtaining Multiple History Matched Models Under Uncertain Geological Scenarios

Hyucksoo Park & Jef Caers
Modeling Uncertainty in Metric Space (Park, 2011)
What if there are “Several” Geological Scenarios?
What is the benefit?
What is the benefit?

![Graph showing data and posterior from Scenario 1. The x-axis represents time in days, ranging from 0 to 900, and the y-axis represents WCT fraction, ranging from 0 to 0.14. The graph includes a red circle labeled 'Data' and a blue line labeled 'Posterior from Scenario 1.' The graph is labeled 'SCRF 2011.'}
What is the benefit?

What is the probability of each scenario?
Reservoir Geometry
Define Uncertain Geological Scenarios with Gaussian model

Scenario 1: Anisotropy at 135°

Scenario 2: Anisotropy at 45°
Define Uncertain Geological Scenarios with Binary model

Training Image 1  Training Image 2

- Sand
- Mud
Define Uncertain Geological Scenarios with Binary model

Scenario 1: Sand Proportion = 0.2

Scenario 2: Sand Proportion = 0.3
Metric Space Modeling

- $g$ is a forward simulator
- $m_i$ is a $i^{th}$ model
- $g(m_i)$ is a production data
- Define the distance as

$$d(m_i, m_j) = \sqrt{(g_i - g_j)^T (g_i - g_j)}$$

$$g_i = g(m_i)$$
MDS Mapping
MDS Mapping
Methodology

- $X$ represents the location on the MDS map
- $f_X(x)$ is a density function
Methodology

\[ f_X(x|\theta_1) \quad f_X(x|\theta_2) \]

- 45° model
- 135° model
Methodology

\[ P(\Theta|d) \] is represented by \[ P(\Theta|x) \]

\[
P(\Theta_1|x) = \frac{f_X(x|\Theta_1)P(\Theta_1)}{f_X(x|\Theta_1)P(\Theta_1) + f_X(x|\Theta_2)P(\Theta_2)}
\]

\[ P(\Theta_1) = P(\Theta_2) = 0.5 \]
Adaptive Kernel Smoothing
Adaptive Kernel Smoothing

\[ f_X(x | \theta_2) \]
Adaptive Kernel Smoothing
Example Results

\[ P(\theta_1|d) \]

0.00369
Rejection Sampler
Comparison with Adaptive Kernel Smoothing

• Test with several different production data sets
• Obtain $P(\theta_1|d)$ for each data set
• Compare with rejection sampler
Comparison with Adaptive Kernel Smoothing

Case 1: Gaussian Model

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<th>Rejection Sampler</th>
<th>Adaptive Kernel Smoothing</th>
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## Comparison with Adaptive Kernel Smoothing

**Case 2: Binary Model**

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Conclusion

• History matching is **Not** needed for obtaining probability of each geological scenario.

• Accurate at a fraction of the cost of rejection sampling.
THANK YOU