AMIDST

Analysis of MassIve Data STreams

Use Cases in Drilling Domain

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Greetings from Norway!

Outline

1. Automatic Formation Detection
2. Mechanical Specific Energy

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Motivation for Automatic Formation Detection a

- Optimization of casing positions

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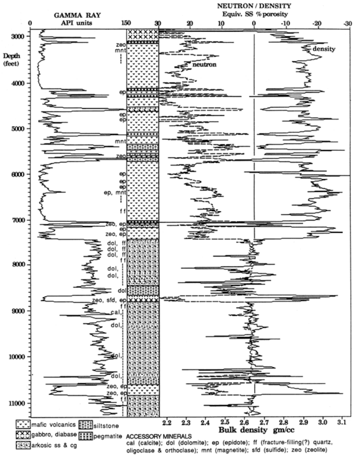
- Identification top and bottom of reservoir
- Optimization of drilling parameters
- Detection of drilling inefficiencies (with MSE)
- Better diagnostics of improper hole cleaning, instability and vibration issues
- Important step on the path to automation

- Manual inspection of:
  - Petrophysical measurements from the LWD tool
  - Drilling parameters at the bit
  - Cuttings analyses at lag depth
  - Lithology chart



Current Solution to Formation Detection

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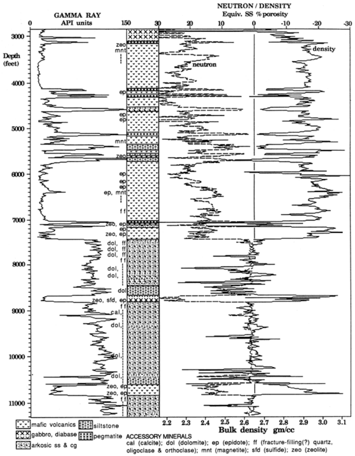
- Drawbacks with manual inspection:



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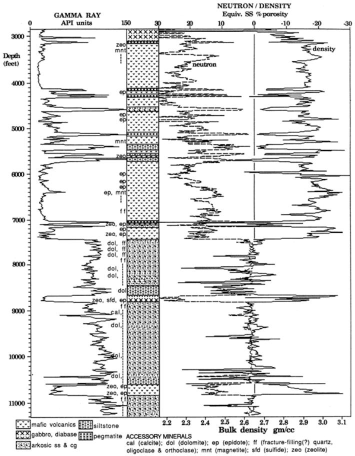

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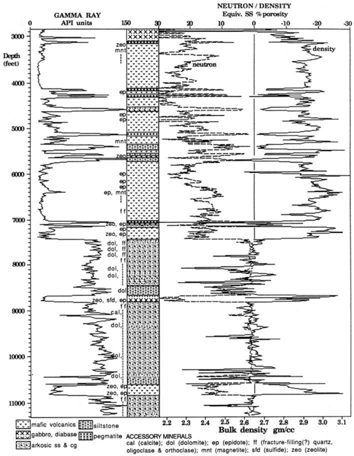

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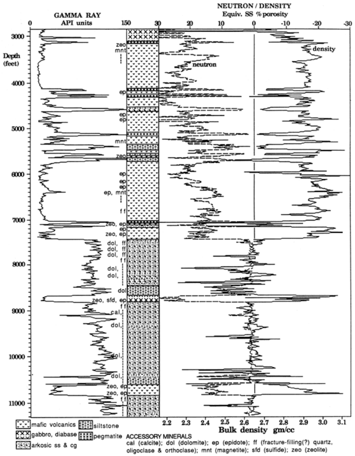

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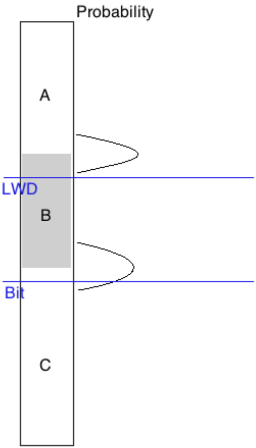

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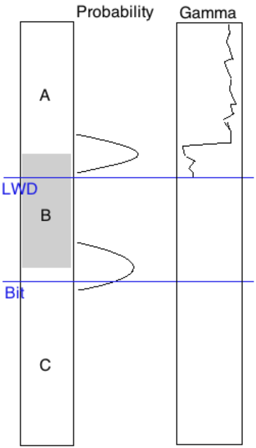

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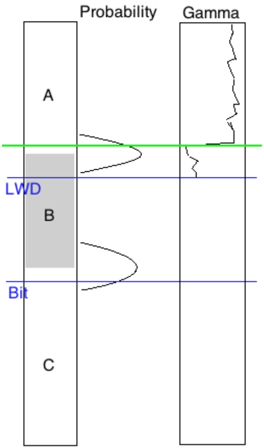
  - Detect the most likely lithology chart above the LWD tool



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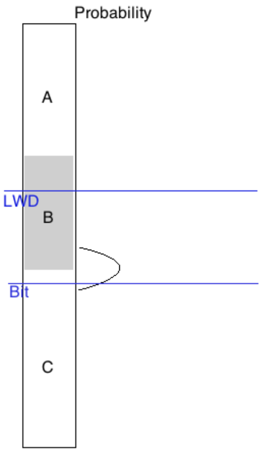

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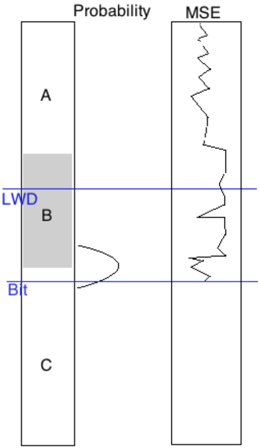

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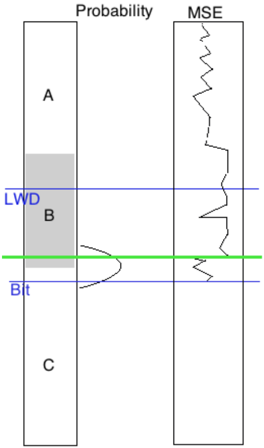
  - Detect *changes* in drilling parameters
  - Decide what is the most likely lithology chart above the bit



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- And there are data driven approaches...

Data Driven Approach to Formation Detection

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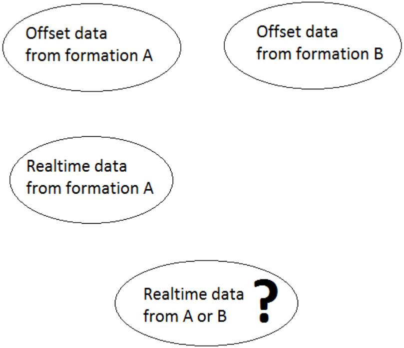
- Classification problem



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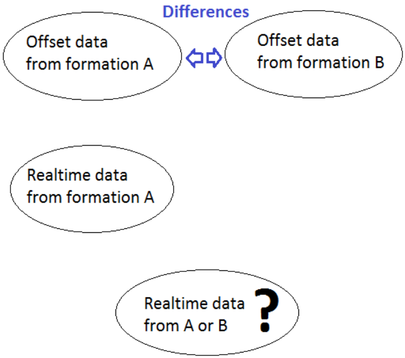

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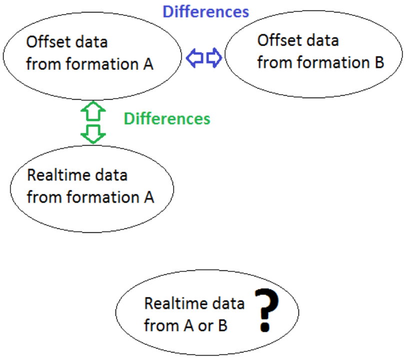

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  - Flow -> pressure
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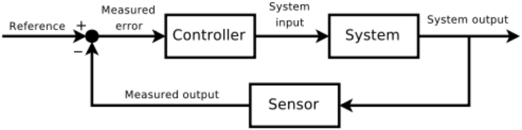

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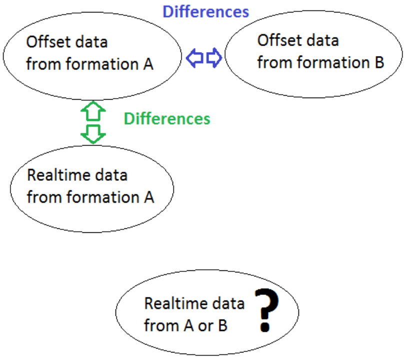

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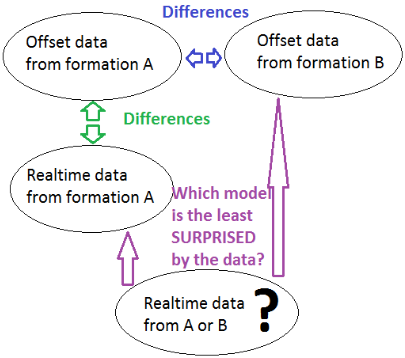

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Mechanical Specific Energy MSE

- Definition:

$$MSE(d) = \frac{\sum_{k \in S} W_k d_k + \frac{\pi}{30} \sum_{k \in S} T_k N_k t_k}{\pi r^2 \sum_{k \in S} d_k}$$

S is set of data points that are measured less than a distance $b/2$ from the current depth d. d_k and t_k are depth and time increments. W_k, T_k and N_k are weight, torque and rotation speed at measurement k.

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- MSE is a measure of compression strength of the formation, but also how effective the drilling operation is.

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- Challenges with this measure:
  - What is downhole torque? Estimate from surface or differential pressure?
  - Drifting of WOB. When is it calibrated?
  - How to set the smoothing parameter b?

Optimizing smoothing parameter for MSE

- Definition of normalised RMS-measure:

$$RMS = \frac{\sum_{i=1}^{n}(S_i - f(MSE_i))^2}{\sum_{i=1}^{n}(S_i)^2}$$

S_i is sonic measurements (or equivalent) at i and f is some monotone function.

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- RMS is a measure of how well the shape of MSE fits the shape of the sonic data.
- Advantages:
  - More intuitive interpretation of MSE graphs when compared with downhole data.
  - Potential input to formation detection at the bit algorithm.

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