Benchmarking: Use of Clustering for Offshore Well Construction

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2. Methodology applied
3. Case Studies
4. Automatic well allocation in Clusters
5. Conclusions
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1. Motivation of benchmarking

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3. Case Studies

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5. Conclusions
Goals

Clustering

Benchmarking

Wells

Experts

Well Project Improvement

Well Operation Improvement
Wells

70 variables

Open Wells

Geographic Information System
Variables selection

Most relevant variables for well clustering

<table>
<thead>
<tr>
<th>TVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pos Salt Interval</td>
</tr>
<tr>
<td>Max Mud Weight</td>
</tr>
<tr>
<td>Salt Interval</td>
</tr>
<tr>
<td>Drilled Interval</td>
</tr>
<tr>
<td>Mud Weight at TD</td>
</tr>
<tr>
<td>Total Number of Casing</td>
</tr>
<tr>
<td>Final bit Size</td>
</tr>
<tr>
<td>Max Angle</td>
</tr>
<tr>
<td>Complex Ratio</td>
</tr>
</tbody>
</table>
Variables Selection Analysis

Most relevant variables for well clustering:
- TVD
- Pos Salt Interval
- Max Mud Weight
- Salt Interval
- Drilled Interval
- Mud Weight at TD
- Total Number of Casing
- Final bit size
- Max Size
- Complex Ratio

Variables selected to fit the model as expected by the expert:
- TVD (m)
- Pos Salt Interval
- Max Mud Weight
- Salt Interval
- Drilled Interval
- Mud Weight at TD
- Total Number of casing
- Final bit size
- Max Angle
- Complex Ratio
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Clustering

- K-means
- Fuzzy C means
- Kmedoid
Clustering

K-means

Fuzzy C means

Kmedoid
K-means - How to find the ideal K

Silhouette Score Methodology:

\[
\text{Silhouette Score} = \frac{b-a}{\max(a,b)}
\]
K-means - How to find the ideal K

Ilustration of the method:

Silhouette Score = \frac{b-a}{Max(a,b)}

K=2

K=3

K=4

K=5
**K-means - How to find the ideal K**

**Silhouette Score**

\[ \text{Silhouette Score} = \frac{b-a}{\text{Max}(a,b)} \]

For this work:

- **INTRA-CLUSTER**
  - C1
  - C2
  - C3

- **NEAREST-CLUSTER**
  - C1
  - C2
  - C3
K-means

- Simplest unsupervised learning algorithm

Collect / Choose variables → Choose K → Validate Result → Result
Clustering

K-means

Fuzzy C means

Kmedoid
Fuzzy C Means

- Similar to K-MEANS
- Advantage of enlightening the degree of relevance of each well in each cluster.

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>Winner Cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>X Well</td>
<td>0.563</td>
<td>0.342</td>
<td>0.095</td>
<td>C1</td>
</tr>
<tr>
<td>Y Well</td>
<td>0.321</td>
<td>0.572</td>
<td>0.107</td>
<td>C2</td>
</tr>
</tbody>
</table>
Clustering
K-Medoids (Currently in use)

- One of the wells to be the “Well Type” and not just one point between the sample wells
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Case Study 1 - External Benchmarking

*Comparison of similar wells between Petrobras and operator X*

<table>
<thead>
<tr>
<th>Operator</th>
<th>Cluster 1</th>
<th>Cluster 2</th>
<th>Cluster 3</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrobras</td>
<td>4</td>
<td>3</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>X</td>
<td>0</td>
<td>7</td>
<td>16</td>
<td>23</td>
</tr>
</tbody>
</table>
Case Study 2 - Internal Benchmarking

- Validation Pre Salt clusters (defined by specialists)
## Case Study 2 - Internal Benchmarking

- **Validation Pre Salt clusters (defined by specialists)**

### Cluster 1 - Duration

<table>
<thead>
<tr>
<th>Field</th>
<th>Wells</th>
<th>Cluster 1</th>
<th>Cluster 2</th>
<th>Cluster 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>116</td>
<td>0</td>
<td>115</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>33</td>
<td>0</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>D</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>E</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>F</td>
<td>26</td>
<td>23</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

### Cluster 2 - Duration

- P90(Y): 14.86
- P10(Y): 7.02

### Cluster 3 - Duration

- P90(Y): 16.34
- P10(Y): 5.37

### Previous knowledge
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Allocation / Prediction of new Wells

New Well

Cluster 1  Cluster 2  Cluster 3

10 Most relevant variables

Cluster 3
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Conclusions

- More assertive analysis, improving the definition of our drilling duration goals
- Propagation of Benchmarking use for well concept design
- The present approach has a good practical application, as presented in the case studies
- Future: Clusterization and automatic allocation for Completion and Workover. Also, use of geological variables.

“Data is the new oil”

Clive Humby
Questions?

- Any further questions, please contact Flávia Petersen
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