Empirical performance models using history matching

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# PhD – Interactive Visual Analysis of Process Data

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# Scientist, dad, PhD, software archaeologist, python aficionado, computer graphics, visualization and an overall über-cool computer geek.
OIL & GAS

1: Model building
2: History Matching
Performance Monitoring – I

• Ideal case
Performance Monitoring – II

• Real case
Performance Monitoring – II

• Data, with uncertainty on
  – Input
  – Running conditions
  – Output
The physics is theoretical, but the fun is real.
Statistical

Normal distribution

Paranormal distribution
Complex data require complex solutions

"Sollen wir am Sonntag nach Berlin fahren"
Multi-variate model building
Multi-variate model building
Data Driven Approach

«Similar» input gives «similar» output
Now what?
«Different» output means unknown, not measured or modeled, variable(s) affecting the system
or, system failure
Pump Example

• Measure
  – RPM
  – Vibration
  – Flow
  – Delta pressure
  – Power
  – Temperature
Pump Example

- Measure
  - RPM
  - Vibration
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\[ f(\text{RPM}, \text{vibration}, \text{flow}, \text{dp}, \text{power}) = \text{temperature} \]
Big data
Measured

- RPM
- vibration
- Flow
- dp
- power

Modeled

Temperature

Temperature
Measured

RPM
vibration
Flow
dp
power

Modelled

Temperature

Temperature

Compare
Measured

RPM
temperature
flow
dp
power

Modeled

vibration

Compare

vibration
Abnormality
This new data-sample, how normal is it?
Example:
Given a large historical database of traffic patterns, classify vessels in real-time traffic as normal or not
Satellite based AIS
History Matching
History Matching
Historical Samples
Historical Samples
Best fit
Best fit, poor match
Best fit, «forward in time»
Predict
Abnormality Detection

• Multivariate “Dimensional Space”
  – Latitude
  – Longitude
  – Length
  – COG
  – SOG
  – Wave height
Case 1
Case 2
OneSubsea – subsea pump case

Measured

RPM
vibration
temperature
dp
power

Measured flow

Modeled

flow

Compare
Empirical performance models using history matching
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Highly anomalous flow, but, little to no data to support this claim (color)
Empirical performance models using history matching

Underperforming flow vs. expected, and model has data to support this claim
History Matching

1. Store historical data
2. Find historical states «similar» to the current state
3. Interpolate, or show statistics
4. Compare
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