How Industrial Big Data & Analytics Can Optimize Assets and Operations

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Build your digital industry

Presented By
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Topics

① What is Industrial Data Science (iDS)?
② Key iDS applications & examples
③ How do you plan/do iDS
④ Digital Twin deep dive
GE Assets Are Generating Huge Volumes of Data

Sensor and asset health data are streaming in from:

- Wind Turbines
- Medical Equipment
- Gas Turbines
- Steam Turbines
- Generators
- Locomotives
- Oil and Gas
- Aircraft Engines

300,000+ Complex Assets Monitored World Wide

Illustrative

1 gas turbine blade with sensors: 500GB data/day
What is Industrial Data Science?
Industrial Data Science is the “magic” of the Industrial Internet.

- Platform capabilities
- Consulting & service delivery
- Integration with software, UX, & data management
Industrial Data Science is very different from traditional Data Science

<table>
<thead>
<tr>
<th>Event →</th>
<th>Equipment component failure</th>
<th>Ad click-thru</th>
<th>Media purchase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost/value per event</td>
<td>Huge</td>
<td>tiny</td>
<td>small</td>
</tr>
<tr>
<td>Freq of event</td>
<td>tiny</td>
<td>Huge</td>
<td>Large</td>
</tr>
<tr>
<td>Diversity/# of “cause” variables</td>
<td>Large</td>
<td>small</td>
<td>small</td>
</tr>
<tr>
<td>“Cleanliness” of data</td>
<td>low</td>
<td>Very high</td>
<td>Very high</td>
</tr>
<tr>
<td>Quantity of data</td>
<td>Widely varied</td>
<td>Huge</td>
<td>Large</td>
</tr>
<tr>
<td>Physics-based models</td>
<td>Many, highly relevant</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Legacy / process integration</td>
<td>Critical</td>
<td>Minimal</td>
<td>Minimal</td>
</tr>
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</table>

Therefore iDS & Industrial Internet Solutions must employ different:
1. ICT Infrastructures (data, connectivity, compute)
2. Types of people
3. Data Science techniques
4. Partnering approaches
5. Technology & business strategies
6. Deployment approaches
The Three Basic Components of Industrial Data Science

**Physics/engineering-based models**
- Need much less data
- Powerful, but difficult to maintain & scale

**Empirical, heuristic rules & insights**
- Easy to understand
- Capture knowledge of your experts

**Data-driven techniques – machine learning, statistics, optimization, advanced visualization, …**
- Usually not enough data
- Biased to parameter space of normal operation
- Easiest to maintain and scale – by far
Optimizing Assets: From Idea to Impact

Data Science
DEVELOP

Domain
- Physics
- Knowledge
- Experience
- Data (lots)
- Compute (lots)

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Optimizing Assets: From Idea to Impact

Data Science
- **DEVELOP**
  - Physics Knowledge
  - Experience
  - Data (lots)
  - Compute (lots)

Model

Data Science
- **DEPLOY**
  - Model
  - Data (less, low-latency)
  - Compute (less)
  - Workflow!!

Business Results

Learning...
Another Industrial Example: use advanced physical models to create new features for machine-learning (ML) approaches

New ML features:
1. Deviations from expected physics
2. Inferred or hidden parameter estimates

Provide much richer, less noisy data, resulting in much stronger predictions and models.
“Analytics-based Maintenance” (ABM) is the future of equipment health modeling & performance management

1. A broader approach to the concept of “wear”

2. Hybrid approach for integrating & extending physics-based models

3. Adding explicit stochastic elements to “deterministic” models

4. Utilizing Massive-Scale Feature Augmentation to scale the integration of domain/physics with big data approaches

4. The optimized maintenance & management policies based on these things

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Analytics-based Maintenance (ABM): rapid, scalable, lifing & performance analytics

Rapid creation of hybrid physics & big data models.

Automated synthesis of multi-factor wear models.

Out-of-the-box ability to configure and create new ABM models in any domain.

ABM Framework:

- Physics & Usage
- Time Series Data
- Operational
- Historical Data
- Cumulative Damage Index

Component ABM Models

- Replacement Forecast
- Inefficiency Identification
- Preventative Maintenance
- Dynamic Pricing
- Operational Optimization

Response Variable

Predictors

Component ABM Models
Execution Strategies
**Objective:** Deliver practical Data Science solutions quickly and predictably

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**Tactical data science field investigations**

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**DS Pilots and proof points**

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**Data-science driven solutions (UX/DS/SW)**

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**Predix integration & deployment**

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**“GET CONNECTED”**
- Machine & Equipment Health

**“GET INSIGHTS”**
- Reliability Response

**“GET OPTIMIZED”**
- Maintenance Optimization

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**Anomaly Detection**
- Suite I
- Case Comparison

**Degradation Assessment**
- Machine Health
- Early Warning

**Optimization**
- Engines, generator, pump, motors, heat exchanger etc.

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**Customer Solutions Inputs**
- Model As a Service...
- Fast model development at a scale
Maximize the value and performance of Assets

### Machine & Equipment Health
- CONNECTIVITY
- ANOMALY DETECTION
- ASSET CONDITION MONITOR
- DATA WORK BENCH
- ANALYTICS WORK BENCH

### Reliability Response
- PREDICTIVE DIAGNOSTICS
- NOTIFICATION MANAGEMENT
- CASE MANAGEMENT
- RESPONSE MANAGEMENT
- KNOWLEDGE MANAGEMENT

### Maintenance Optimization
- PERFORMANCE BENCHMARK
- ASSET MAINTENANCE STRATEGY/SCENARIOS
- FINANCIALLY OPTIMIZED ASSET STRATEGY
- WORK SCOPING & PRIORITIZATION
- INVENTORY OPTIMIZATION

Asset Performance is optimized with a wide array of algorithms:
- Shift Verifier
- Trend Verifier
- Temporal anomaly detector
- Multi-sensor pattern detector
- Regime detector
The Asset Optimization Journey...

- Basic Reporting
- Advanced Reporting
- Anomaly Detection
- Alerts
- Prescriptive Analytics
- Predictive Analytics
- High-value guidance
- Highly-actionable management info
- Sophisticated, optimized management of business operations

Data completeness, breadth, quality

Data Science Complexity
Digital Twin: Driving Customer Outcomes

Presented By
Mark Grabb
Achalesh Pandey

GE Global Research

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Big Data + Physics = Analytics + Digital Twin
Can the Digital Twin Time Travel?

Go backwards to understand what happened
Go forward to understand what to do
Customers Want Outcomes

Asset Performance Mgmt.

- Single Asset
  - Reduce unplanned down time
  - Maintenance optimization

  Analytics Based Maintenance

  Life Models: Per Asset, Per Part and Per Failure Mode
  - Heterogeneous & Big Data

Operations Optimization

- Group of Assets
  - Reduce operating cost
  - Increase output

  Plant Level Optimization

  Accurate Performance Models
  - Complex Interactions

Business Optimization

- Complex Operations
  - Increased revenue
  - Cost reduction

  Trip Optimizer, Movement Planner

  Market Conditions
  - Interactions at scale
Digital Twin

Necessary Attributes

1. The model is applied per asset
2. The model must be used to create demonstrable business value.
3. The model must be adaptable.
4. The model must be used in a continuous update capacity.
5. The model must be scalable.
A Scalable Framework for Industrial Analytics

Engineering models that continuously increase insights in each asset to deliver specific business outcomes.

- Data Lake and Predix Cloud
- Performance Models
- Life Models
- Asset Performance Management Operations Optimization Business Optimization

Data Layer
Model Layer
Application Layer
Digital Twin Business Outcomes
Improved Availability

Customer Experience – Value Stream Co-Creation

Prioritize inspections/maintenance and proactively manage and optimize fleet on per engine basis

Saving tens of $MM in unnecessary service overhauls (per customer)

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Digital Twin Business Outcomes
Improved Reliability

Compressor Blade Health Monitoring

Challenges:
- No direct measurement
- Supersonic tip speeds
- Operational variations & S/N ratio

Digital Twin for Crack Simulation

24x7 Continuous Monitoring

Magnetic Sensors
Digital Twin Business Outcomes
Improved Performance & Reliability

High fidelity Digital Twins
Asset specific, adaptable, scalable & continuous learning

Business Outcome:
• Degradation monitoring for diagnostics and forecasting for performance optimization
Digital Twin: Using Artificial Intelligence
Improved Model Fidelity

Automated Inspection

Deep Learning changes Inspection Paradigm

Incoming image data

Data Preprocessing
Multi-modal data fusion
Anomaly detection

Inspection Agent

Measurement & Characterization
Localization
Classification

Inspection insight

Automated anomaly detection & classification

Data Quality & Imputation

Deep Learning, physics knowledge & machine learning to clean & impute the data (multiple strategies)

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Digital Twin Modeling Framework

Physical + Digital at Scale
Key Enabling Technologies for Digital Twin

Innovation, Speed, and Scale

1. Domain Data

Automated Data Pre-processing

2. Physical + Digital Engineering Models

Cumulative Damage

3. Industrial Analytics

Model Generation & Automation

4. PREDIX PLATFORM

Inspection Capabilities

Dynamic Performance Estimation

Knowledge Extraction
Conclusion

Digital Twin: What it is...
• Asset specific with continuous updates
• Deep physics models and advanced analytics
• Scalable & automated modeling framework

Digital Twin: What it does...
• Quantifies asset health in physical terms
• Provides continuously improving insights
• Predicts asset health, leveraging data & domain
• Enables a spectrum of customer outcomes