Transforming into a Predictive Enterprise

Optimisation of materials and processes

Dr. Ulrich Kerzel | @byanalytics_en
2008: Founded by CERN Data Scientists

Since 2011: Award-winning retail solutions

2014: International expansion, predictive applications
Blue Yonder History: Founded by CERN physicists

Photos: CERN, Blue Yonder
Digital Innovation

2014 Award for “Most Innovative Use of Data”:

2015 : 50 innovativste Unternehmen der Welt:

Blue Yonder Predictive / Prescriptive Analytics- Applications
Blue Yonder's European Data Science Academy

At Blue Yonder our motto is, “No problem is too complex for the right team.” A decade of research at CERN, KIT, and other leading scientific institutes and years of helping our clients to become predictive businesses has prepared us, a leading software provider for predictive analytics in Europe, to deliver groundbreaking new approaches to solving the world’s most challenging problems. For this reason, Blue Yonder has founded The Data Science Academy (DSA). The goal of the academy is to promote awareness of big data within business enterprises and to foster the progress of a data science revolution.

We would like to know what topics and forms of training interest you?

Simply fill out the questionnaire

This looks like an interesting training model. Please keep me up to date on it.

Register for Academy news

In order to use big data correctly, you need intelligent and well-trained people.

www.datascienceacademy.eu
The key to becoming a better company are **better decisions**. The key to better decisions is using your own data.
Everything becomes data
Big Data Landscape
Data Science is the sexiest Job …
Data Scientists are unicorns …

Source: guardian.co.uk

Source: Flickr (by J. Farthing, CC)
Data Science will transform our world

„Software is eating the world“
(Marc Andreessen - 2011)

Source: Wikipedia.org
(Netscape, Mosaic, Silicon Valley Venture Capital, …)
Data Science will transform our world

Qualification as maintenance engineer:

New EU wide industry norms

- DIN EN 13306 Terminology
- DIN EN 15628 Qualification of personnel
- DIN EN 15341 KPI
- ...

Source: New Scientist
Data Science will transform our world

Australian economy

Computers could replace five million Australian jobs within two decades

Report by the Committee for Economic Development of Australia predicts almost 40% of existing jobs will disappear because of technological advancements

Source: Guardian
Predictive Applications

- Foresight
- Strategy
- Business Intelligence
- Hindsight
- Dashboards & Visualization
- Execution
- Predictive Applications
- Predictive & Prescriptive Analytics
Predictive Applications Enable Ongoing Optimization
Humans are not capable of making statistical and quantitative decisions correctly on a permanent basis. They get frequently deceived.

-- D. Kahneman (Nobel Laureate for Behavioral Economics and author of “Thinking Slow and Fast”)

The truth about human decisions....

D. Kahneman
Behavioral Psychologist and Nobel Laureate
Impact of Decision Automation

5% average Out of Stock Rate

0.5% average Out of Stock Rate

Out of stock rate at a major German supermarket
IoT: Technology Pyramid

- **Sensors**
- **Machines**
- **Devices**
- **Connectivity**
- **Big Data Platform**
- **Smart Services**

**Sensors**
- Tracking the information by using an efficient embedded devices
- smaller, faster, cheaper,

**Machines & Devices**
- Sector specific devices, often the core business of device manufactures
- device centric optimization

**Connectivity**
- Gateways which allow to connect to the internet wireless or wireline
- mastering heterogeneous protocols

**Big Data Platform**
- Big data software framework with multiple tasks: collect, combine, predict
- capability that different frameworks can connect

**Smart Services**
- Goal of every smart service is to automate decisions based on validated data:
  - build and derive predictive applications

Source: goetzpartners
Clash of IoT Software Philosophies

**Top Down View:**
Digital business transformation

- Core philosophy: agile, try out, uncertainty
- Delivery model: X-as-a-Service

**Bottom Up View:**
Product/data centric approaches

- Core philosophy: specification, guarantees
- Delivery model: software, hardware, knowhow

source: goetzpartners
Production line optimisation

iProdict

USE CASE: STEEL PRODUCTION

- Complex sensor network exist for quality monitoring: chemical analysis data, quality checks, video streams.
- Blue Yonder’s predictive process has the task to predict quality fluctuations. Goal is to separate effects which can be optimized and effects which can be predicted.
- Long term goal: real time processing.

*Source: www.iprodict.com*
**Production line optimisation**

**iProdict**

**Intelligent Process Prediction**
Optimization and control of the steel bar production process at Saarstahl AG. Prediction of expected final steel quality during production process.

**Value potential**
Avoiding unnecessary processing steps and energy costs for steel with final low quality.

**Blue Yonder’s contribution**
Real-time quality prediction with structured and unstructured data. Data input are preprocessed real-time video data together with process data gathered during production process.
Production line optimisation

iProdict

Title: iPRODICT
Intelligent Process Prediction based on Big Data Analytic

Optimization and control of the steel bar production process at Saarstahl AG. For this a real time prediction of quality becomes mandatory with a seamless integration with respect to the deployed business process intelligence.

Delivers business use case and data provider

Responsible for integration in business process logic

Real time quality prediction with structured and unstructured data

Project leader and experts in innovative business logic design

Expertise in Big Data infrastructure and analytics

Video pattern recognition preprocessing for input BY
Production line optimisation
SePiA.Pro

"Smart Service Welt" - Gewinner des Technologiewettbewerbs stehen fest


Sigmar Gabriel, Bundesminister für Wirtschaft und Energie: "Mit dem Technologieprogramm Smart Service Welt unterstützen wir die Wirtschaft darin, sich für die Zukunft richtig aufzustellen. Die digitale Revolution verlagert Wertschöpfung in rasanterm Tempo von den Waren hin zu Service-Plattformen. Daher können internationale Internetakteure auch zunehmend in die klassischen Märkte eindringen. Wenn die deutsche Wirtschaft ihre hochwertigen Produkte durch Smart Services ergänzt, können wir hier gegensteuern und die klassischen Stärken des Standorts Deutschland mit neuen Dienstleistungen so kombinieren, dass wir den 'Kontrollpunkt' zum Kunden in der Hand behalten."
Production line optimisation
SePiA.Pro

Users / Customers / Vendors

Abstraction layer: R&D - Production

Industrial Data Science Platform

Expert and domain knowledge

Production plant
Spare parts optimisation

USE CASE: SPARE PARTS

- Spare parts logistics is a delicate global task and a high degree of automation is very desirable.
- Sales histories, stock levels, minimum stock levels, shipment times are available as continuous data.
- Challenge is to find the right balance between spare part availability and cost of storage and delivery (for each single item).
- Blue Yonder forecasts allow to optimize the optimal order quantity given constraints and risk / cost functions.
Spare parts challenge

Stock vs. Demand pattern of spare part No. 27410924

- Actual Demand
- Stock (BoM)
- Stock (EoM)

- stock filled up to 200 pcs
- delivery of 150 pcs
- delivery of 120 pcs
- delivery of 200 pcs

shipment lead time
Spare parts challenge

- Stock vs. Demand pattern of spare part No. 27410924

- unnecessary overcapacities
- cost of capital and storage cost

- pricey unplanned “emergency” delivery
- unmet demand and out-of-stock situation

- stock filled up to 200 pcs
- delivery of 150 pcs
- delivery of 120 pcs
- delivery of 200 pcs

shipment lead time
Holistic optimisation

Blue Yonder Forecast

optimal order quantity given
- cost function
- probability distribution

Asymmetric Cost Function

<table>
<thead>
<tr>
<th>Cost of Storage</th>
<th>Cost of Capital</th>
<th>Emergency Deliveries</th>
<th>Reputation loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>warehouse cost, expiry date</td>
<td>per piece and interest rate</td>
<td>per piece / minimum order quantity</td>
<td>not quantified</td>
</tr>
</tbody>
</table>
Holistic optimisation

The different point estimates of the probability density

Forecasted expected value: number of pieces, which is sold on average

But a lot of days with higher sales

Quantity that needs to be kept in stock, so that the out-of-stock rate of products is not more than 5%

for a single item and a predefined time-horizon
Spare parts challenge with Blue Yonder predictions

Stock vs. Demand pattern of spare part No. 27410924 with BY suggestions

- Actual Demand
- Stock (BoM)
- Stock (EoM)

Stock filled up to 270 pcs
Delivery of 120 pcs
Delivery of 120 pcs
Delivery of 250 pcs

Shipment lead time
Example: Gas turbines

Scenario Description

► Gas turbines burn a lot of fuel during start up
► Start ups are not always successful
► Several conditions influence gas turbine operations
► Hundreds of sensor data available
► Most sensor data is not useful or redundant
# Engagement Model: Sensor Data

## 5 work packages

<table>
<thead>
<tr>
<th>Step</th>
<th>Detail</th>
<th>Outputs</th>
<th>Outputs</th>
</tr>
</thead>
</table>
| Requirements / Kickoff| Understand exactly what problem the organisation is trying to address with predictive analytics and whether predictive analytics can aid.                                                                 | • Signed requirements document  
• Business case hypothesis | • Signed requirements document  
• Business case hypothesis |
| Data cleansing / Sensor scoping | Define which sensor data can be extracted from the organisation’s systems. Support IT in creating the extract and ensure data quality.                                                                 | • Data definition specification  
• Data extract  
• Quality and feasibility insights  
• Data stories | • Data definition specification  
• Data extract  
• Quality and feasibility insights  
• Data stories |
| Statistical Analysis  | Statistical analysis to identify data quality. Gain deep data understanding and develop data stories.                                                                                                  | • Identify diversity of the fleet  
• Ranking of mandatory sensors | • Identify diversity of the fleet  
• Ranking of mandatory sensors |
| Fleet benchmarking    | Comparison across fleet members and identification of diversity and predictability of certain targets.                                                                                                 | • Predictive analysis  
• Business Case validation | • Predictive analysis  
• Business Case validation |
| Sensor importance assessment | Key for predictive applications is the proper handling of sensor data. Sensor data have to be ordered and analysed with respect to impact and significance.                                                 | • Strategy proposal  
• Execution roadmap | • Strategy proposal  
• Execution roadmap |
| Initial predictive application | Build predictive models based on problem definitions and sensor data. Leverage domain expertise to optimize business case.                                                                                  | • Executive summary  
• Business Case validation | • Executive summary  
• Business Case validation |
| Prepare for roll-out  | Define next steps to establish a continous predictive service. Find additional and related predictive application use cases.                                                                                | • Final reports  
• Training materials  
• Documentation | • Final reports  
• Training materials  
• Documentation |
Data Cleansing

- Harmonize data representation (sensor metadata and engine metadata)
- Treat typical data challenges (missing values, outliers, wrong values)

Sensor Scoping

- Verify identical sensors / labels validity across engines
- Define events, triggers, decision-points, i.e. defined observation/target events
- Map to comparable time steps (e.g. 5 minutes) and frequencies

Data foundation to work with: Smart data instead of big data
Analytics

descriptive analytics
discover the right drivers for ROI

predictive analytics
valuable action suggestions

% successful startups

% cold/warm/hot startups

descriptive analytics
discover the right drivers for ROI

predictive analytics
valuable action suggestions
# Business impact

## Optimize startup fuel efficiency by

<table>
<thead>
<tr>
<th>Savings/yr</th>
<th>1 Turbine</th>
<th>10,229 Euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fleet</td>
<td>1,022,853 Euro</td>
<td></td>
</tr>
</tbody>
</table>

### Number of turbines in fleet

- 100 turbines

### Avg. starts/yr

- 80 starts/yr

### Avg. fuel/start (to MSL)

- 40,000 kg/start

### Avg. start fuel/yr per turbine

- 3,200,000 kg/yr

### Fleet avg. start fuel/yr

- 320,000,000 kg/yr

### Natural Gas fuel heating value

- 45 MJ/kg
- 0.043 mmbtu/kg

### Price

- 3 Euro/mmbtu

### Avg. cost start fuel/yr per turbine

- 409,141 Euro/yr

### Fleet avg. cost start fuel/yr

- 40,914,128 Euro/yr
Predictive Applications on a chip

The next frontier:
Require decision every 5 ns, whether data is important enough to be read out to a computer

NeuroBayesExpert@Hardware - Chip

R&D: KIT / Blue Yonder:
First massively parallel NeuroBayes-Hardware-Implementation runs with 2 billion decisions per second!
Predictive Applications on a chip: Decide before data can be processed by computers
Platform Engagement with Industry Clients

Blue Yonder

BY Data Science Platform

- Infrastructure
  - secure
  - high availability
  - fast
  - (hosted in Germany)

- joint development
  - BY data scientists
  - Client data scientists
  - modern development stack
  - predictive applications

- operations
  - predictions as a service
  - performance monitoring
  - model improvements
  - different SLAs

Platform Client

- Data
- Data Scientists
- Subject Matter Experts
  - Business Owners
Blue Yonder Platform

Flex Storage
Relational, Flat File and In-Memory Storage Service

Auto APIs
RESTful APIs for easy integration and data access

Job Control & ML Toolkit
Pluggable machine learning pipelines

Application Runtime
HTML5 based Web UI and API Builder

Data Services
Public data prepared for machine learning

Multi-Tenant Runtime Environment

Secure Micro Cloud Infrastructure
BY Platform for industry

All in-one platform
- one platform for
  - data collection
  - processing
  - decisions
  - batch/streaming
  - proprietary algorithms

Joint Development
- joint development
  - BY data scientists
  - client know-how
  - scalable apps
  - combine the best of both worlds

Machine Data
- customized solutions
  - broad set of customizable functionality
  - steady development and adjusting to client needs
  - industry focus