THE VALUE OF DATA SCIENCE STANDARDS IN MANUFACTURING ANALYTICS

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BOSCH DATA MINING SOLUTIONS AND SERVICES
Data science standards in manufacturing analytics

Outline

- Bosch’s dual role in advanced manufacturing/Industry 4.0
- The need for standards in predictive analytics
- Case study in the use of PMML at Bosch
- How to improve existing standards?
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Two perspectives for Bosch on Industry 4.0

LEAD PROVIDER
System manufacturer view / production resource view

LEAD OPERATOR
Product manufacturer view / product view

Big Data

Decentralised intelligence

Business processes

Machine models

Production models

Software

Connectivity

Value added networks

First mover in the realisation of integrated concepts with equipment providers

Technology and solution supplier for OEMs and end users
Bosch's interest in Standards for Manufacturing Analytics

- As an user/operator
  - Vendor independence
    » Interoperability and Standardization of data collection, storage, retrieval, and presentation
    » Data-driven verification and validation for improving efficiency and quicker scaling
    » Use of best practices and standards to improve quality and traceability
    » Model auditing and update

- As a provider
  - Interoperability and Standardization
  - Sharing of success stories and best practices
  - Drive adoption of data-driven modeling, V&V
    » Bosch is a leading participant in ASME's initiative on verification and validation for advanced manufacturing
  - Creation of neutral testbeds and certification agencies
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Join the manufacturing analytics community

- **Predictive Modeling in Manufacturing Analytics Challenge**
  - Kaggle Competition to be launched on August 17\(^{th}\), 2016
  - Focus on improving product quality as a binary classification problem (0.6% in one class)
    - 1 year of a product manufactured in large volumes and probably in your car
    - Complete assembly and testing data
    - 3 million samples, 4000 features,
  - Public testbed for manufacturing data science innovation

- **IEEE Big Data for Advanced Manufacturing Special Symposium**
  2016 IEEE International Conference on Big Data
  Dec 5 – Dec 8 2016 @Washington D.C., USA
  [http://cci.drexel.edu/bigdata/bigdata2016/SpecialSymposium.html](http://cci.drexel.edu/bigdata/bigdata2016/SpecialSymposium.html)
  **August 31, 2016**: Results due for the manufacturing data challenge
  **Sept 20, 2016**: Due date for full symposium papers submission
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Analytics success stories in manufacturing

**Test and Calibration Time Reduction**
- Prediction of test results
- Prediction of calibration parameters

**Scrap Costs Reduction**
- Early prediction from process parameters
- Descriptive analytics for root-cause analysis

**Warranty Cost Reduction**
Prediction of field failures from
- Test and process data
- Cross-value stream analysis

**Yield Improvement**
- Benchmark analysis across lines and plants
- Pin-point possible root causes for performance bottlenecks (OEE, cycle time)

**Predictive Maintenance**
- Identify top failure causes
- Predict component failures to avoid unscheduled machine down-times
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Case Study: Test Time Reduction

**Business Objective:**
Reduce test and calibration time in the production of mobile hydraulic pumps

**Impact**
35% reduction in test and calibration time via accurate prediction of calibration and test results
Case Study: Test Time Reduction

Problem:
Bottleneck Test Benches

Approach:
1) Identify candidate tests for removal
2) Identify test ‘groups’ run in parallel
3) Use feature selection methods to identify least important test measurements.
4) Remove least important test measurements (saving test time)
5) Train a predictive model to predict test outcome from remaining measurements.
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Our analytics information workflow

"Data at Rest"

Extraction, Transformation, Loading
- DB Connectors
- Custom Scripts

Aggregate Data
- Hadoop
- MongoDB

Historic Training Data

Analytics, Machine Learning
- SAS
- IBM SPSS
- Python
- Alpine
- KNIME
- R
- RapidMiner

Descriptive Analysis

"Data in Motion"

Production

Prognosis, Decision (-Support)

PMML

Sales Data

Production Data

Warranty Data

Device Data

INST BDP

INST M2M

"Data at Rest"

"Data in Motion"
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Deployment using PMML

- Model (Boosted Trees) developed in R
- Implementation time ~1 month
  - Proposed a client-server architecture using the PMML implementation by ADAPA
  - No installation required at the client
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Alternatives to PMML use

- Deployment using R-server
  - Not robust enough for continuous and low latency deployment
  - Additional memory overhead for low cost machines in manufacturing
  - Need to create scoring logs

- End-to-end deployment using other freeware or commercial analytics software
  - Local installation required
  - Need to recreate solutions
  - Learning overhead for data scientists
  - Licensing costs
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Summary of first impressions in using PMML

- Vendor independence
- Freedom of development tools for the data scientist

- Each vendor implements PMML differently
- Model coverage is limited
  - Adapa had to be extended in our application; many thanks to Zementis for a quick response
- Commercial solutions have better support, but come at a higher cost
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How to improve existing standards?

- Certification of compliance by DMG
- Keep up with the innovation in modeling paradigms
- Standards have to cover the complete analytical workflow
  - ETL
  - Model creation
  - Model deployment
  - Validation
  - Interpretation and uncertainty quantification
  - Versioning and traceability
- Consideration of development and deployment environments