Failure prediction and process monitoring using Machine Learning at MONDI Gronau

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Plant

Mondi Gronau GmbH

Jöbkesweg 11
48599 Gronau, Deutschland

Local: ~ 850 employees
Global: ~ 25,000 employees

Mildenberger & Willing -> Nordenia -> Mondi

Production Volume: 170 Mio. kg
Waste Volume: 15 Mio. kg
Number of rolls: 1.7 Mio. Stk.
Yield: 421 Mio. €
Energy Consumption: 71 Mio. kWh
Production Time: 24/7 hh/dd
Square meter: 104 k. m²
Facts & Figures: Machines

Extrusion Lines

- Monoextrusion
- Coextrusion n-Layer
- Film thickness: 10 – 300µm
- Film width: 850 – 3.000mm
Facts & Figures: Machines

Processing Types

- Coating / Siliconizing
- Slitting
- Rotogravure Printing
- Lamination
Facts & Figures: Products

Benefits Mondi Gronau GmbH

Good Product

- Advanced Quality Monitoring
- Reduction of Waste Material
- Customer Satisfaction
- Yield Optimization

Waste Product
Monitoring: In-Line

Integrated Monitoring System

- Laminated Film Surface Detection
- Traffic Light System
- Quality Index
- Additional Systems: Colour, Thickness
Parameters/ Features (100 – 500)
- PLC (Programmable Logic Controller), Data Collector
- 4-5 PLC per machine for real-time acquisition
Data Processing
First Step in Visualization

- **Acquisition**
- **Pre-Processing (ETL)**
- **Limits/ Targets from Customer Specifications**
- **Visualization On-Line/ Off-Line**

**Processing**

Quality Data (OCS, Laboratory)

MES, SAP

PLC (Programmable Logic Controller)

SPC (Statistical Process Control)
Next Step in using Prediction Methods

- Acquisition
- Pre-Processing (ETL)
- Machine Learning Methods/ Models
- Visualization On-Line/ Off-Line
Next Step in understandable Visualization

- Reduction of information to understandable level (1, 2, 3 dimensions)
- Visualization in real-time

Up to 200 parameters in one point [temperature, pressure, speed,…]
Acquired per minute
Stored on an Oracle database
Processed for visualization in lower dimensions
Next Step in Software Development

Acquisition Loop

- Acquisition of more Datasets
- Pre-Processing (ETL)
- Extended Machine Learning Methods/ Models
- Version 3.0 of Visualization On-Line/ Off-Line
Human-Machine-Interface
Human-Machine-Interface: Industrie 4.0

Processing Loop

- Open Processing Loop
- Recommendation System

Machine Sensory Locations

Data Stream

Field Bus

PLC Data Collector

TCP/IP

MDE Server

TCP/IP SQL Query

Manual Adjustment by worker

Machine Interface
Application requirements

Retrieve, analyze and visualize machine data

● Up to 40 machines with up to 500 sensors
● Updated once per minute - near real time
● Alarm events and error logging
● Intuitive user interface
● High robustness
● Expandability
● Failure forecasts for increased quality / downtime reduction
Application requirements
Retrieve, analyze and visualize machine data

- Up to 40 machines with up to 500 sensors
- Updated once per minute - near real time
- Alarm events and error logging
- Intuitive user interface
- High robustness
- Expandability
- Failure forecasts for increased quality / downtime reduction
Prozesskennzahl v3.0 / Key features

- Monitoring state and forecast
- Update time ~30 seconds
- Alarm events via automated emails
- Error-Logging / avoiding crashes
User Interface

- Current machine status
- Visualization for up to 72 hours
- Main status
- Summarized Info
- Visualize sensor data
- Limits to trigger alarms and warnings
- Forecast analysis
Plug-In feature

- Add new machines without code changes
- Customized calculation and visualization per machine
- Code for plug-in and main application separated
Process Monitoring Algorithms and Software

Sensor Data (10-100/plant) - update ~ 1min.

Quality State - update ~ 60-90 min.

Which sensor measurements indicate machine failure?
Process Monitoring Algorithms and Software

Basic Workflow

1. Preprocess Data
   - Choose Algorithm
   - Fit Model
   - Evaluate Model
   - Choose Model
   - Make Predictions
Process Monitoring Algorithms and Software
Pre-Processing

Sensor data and quality states are aggregated (per time stamp)
Process Monitoring Algorithms and Software - Train a prediction model

Basic Workflow

1. Preprocess Data
2. Choose Algorithm
   - Fit Model
   - Evaluate Model
   - Choose Model
   - Make Predictions
Process Monitoring Algorithms and Software—Train a prediction model

Possible Classification Methods

Statistics and Machine Learning

Nearest Neighbor Classification

Support Vector Classification

Classification Trees

Bayes Classification

Discriminant Analysis

Neural Network
Process Monitoring Algorithms and Software - Train a prediction model

Basic Workflow

1. Preprocess Data
2. Choose Algorithm
3. Fit Model
4. Evaluate Model
5. Choose Model
6. Make Predictions
Process Monitoring Algorithms and Software – Train a prediction model

Fit model based on historic data

PredictionModel = fitctree(PARAMETER, STATE)

Training Data
- e.g. 60% of historic data (3 months)

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Process Monitoring Algorithms and Software - Train a prediction model

Basic Workflow

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2. Choose Algorithm
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Process Monitoring Algorithms and Software – Train a prediction model

Validation Data, e.g. 40% of historic data (3 months)

predictedState = PredictionModel(\text{Parameter})

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Misclassification rate 1 of 7: 14.28%
Basic Workflow

1. Preprocess Data
2. Choose Algorithm
3. Fit Model
4. Evaluate Model
5. Choose Model
6. Make Predictions
Process Monitoring Algorithms and Software - Application

Predict current machine states during operation

- Sensor Data (10-100 /plant)
- Quality State
- Prediction Model
- State is: ok
- Predicted State (now)
- Train Prediction Model (historic data)
Process Monitoring Algorithms and Software - Application

Fehlerrate 14.85 %
Abgleichsrate 0 %

State is: ok
Thank you!

Questions?