New perspectives in production control: situation-aware decision making with machine learning approaches

by

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STC-O: Short technical presentations
Session on special discussion topic of revival of artificial intelligence (AI)
Manufacturing and data science: status quo and top trends

- Industrial digitalization is on the hype cycle peak
- Academia: new insights partner for enterprises
- AI and ML: the data scientist’s ultimate assistants
- Industrial IT: still behind the innovative needs
  - Relational data is still the most common
  - Problems with “dirty data”
  - Lack of experts

ML in production

- Predictive quality control
- Predictive maintenance
- Supply chain planning
- Other

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Barriers and challenges of applying ML in production

- Wrong questions → wrong answers
- Garbage in → garbage out
- Improper use of tools, use of improper tools

„Multi-factor productivity has been stagnant for the last decade due to separation of operations (OT) and information technology (IT)” [Nonaka, 2017]

„I began to imagine how incredibly frustrating it would be if I were a decision maker for a manufacturing company and I knew that we needed to act fast to kick off an Industrial Internet project but couldn’t be certain about the quality of information out there.” [Chu, 2016]
Tools and technologies: great opportunities
ML in PPC: towards situation-aware control

• Current lack of tight link between ML/analytics and decision making

• Situation-awareness
  1. Identify desired and/or avoidable situations
  2. Prescribe next best action or set of actions
  3. A combination of optimization, simulation and data analytics tools
     a) Predictive: Applying simulation-based optimization
     b) Reactive: Applying real-time data in e.g., complex-event processing
     c) Prescriptive: (Robust) optimization and decision making enabled by machine learning and data analytics

• New element: prescriptive scheduling with enabled by machine learning
A situation-aware control architecture

ERP
Scheduler
MES

Data lake

Log files
Event feeds
Data streams

Data processing layer

Wrangling
Cleansing
Complex Event Processing
Access/Query

Predictive analytics (forecasting, machine learning)
Business intelligence (dashboarding, reporting)

Data analytics layer

Physical layer

Terminal data
IPS/RFID data
Machine diagnostics/log data
Smart device data

See also:
- [Frazzon, 2018]
- [Zhong, 2018]

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Machine learning pipeline for PPC

1. Access requested data „from the lake” (machine log, job status’, ERP)
2. Prepare, filter and transform (unstructured)
3. Parse structured & unstructured data
4. Train regression model(s)
5. Fine tune of model parameters
   - Data mining: simulation model settings, e.g. stochastic parameters
   - Machine learning
     - Inject constraints to optimization models
     - Predict numeric parameters based on given input (e.g. job completion as APS module)
     - Predict uncertain parameters of robust optimization models

Periodic retrain or Online training

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Application results

- Accurate lead-time prediction for prioritization (>90%)
- Robust, prescriptive production planning (against cycle time and reject rate variance)
  - Reduced idle times (-14%)
  - Increased productivity (+6%)
- Reduced lateness (-15%)

**Data analytics layer**

- Predictive analytics (forecasting, machine learning):
  - True lead times
  - True stock levels
  - True reject rates
  - True cycle times
  - True workloads

**Data processing layer**

- Wrangling
- Cleansing
- Complex Event Processing
- Access/Query

**Data lake**

- Test results
- Product locations
- Machine states

**Physical layer**

- MES
- IPS/RFID data
- Machine diagnostics/log data

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Thank you for your attention!

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Related own works


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