Industry Applications of Machine Learning and Data Science

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Can you predict the future?
Predictive Analytics finds the hidden patterns in big data and uses them to predict future events.

473ms
Machine Learning:
Pattern Detection, Trend Detection, Finding Correlations & Causal Relations, etc. from Data to Create Models that Enable the Automated Classification of New Cases, Forecasting of Events or Values, Prediction of Risks & Opportunities
Predictive Analytics Transforms Insight into **ACTION**

- **OBSERVE**
  - What happened

- **EXPLAIN**
  - Why did it happen

- **ANTICIPATE**
  - What will happen

- **ACT**
  - Operationalize

There are four levels of analytics:

1. **Analytics**
2. **Descriptive Analytics**
3. **Diagnostic Analytics**
4. **Predictive Analytics**
5. **Prescriptive Analytics**

Value is represented vertically.
Industry Applications of Machine Learning and Predictive Analytics
Customer Churn Prediction:

Predict Which Customers are about to Churn.

Energy Provider E.ON: 17 Million Customers.

=> Predict & Prevent Churn
=> Secure Revenue, Less Costly Than Acquiring New Customers.
Demand Forecasting:

Predict Which Book Will be Sold How Often in Which Region.

Book Retailer Libri:
33 Million Transactions per Year.

=> Guarantee Availability and Delivery Times.
Predictive Maintenance:

Predict Machine Failures before They Happen in order to Prevent Them, =>

Demand-Based Maintenance, Fewer Failures, Lower Costs
Predictive Maintenance
Predictive Maintenance

Customers Using RapidMiner for Predictive Maintenance, i.e. for Predicting & Preventing Machine Failures before they happen:

• Major German Car Manufacturers: Text Analytics of Repair & Service Reports to Identify Car Quality & Car Maintenance Issues, Audio Analytics

• Major European & South American Airplane Manufacturers and Major International Airplane Operators: Sensor Data & Text Mining Repair & Service Reports for Predictive Airplane Maintenance & Resource Allocation

• Major European Cement Producer: Cement Mill Failure Prediction & Prevention

• Major Chinese Energy Provider: Wind Turbine Failure Prediction & Prevention
Engine Quality Prediction

• **Task:**
  – Predict Engine Lifetime / Quality from Audio Data

• **Challenges:**
  – Audio Feature Generation

• **Solution:**
  – Automated Feature Generation & Selection
  – Automated Optimizers
  – Classification Problem
Product Surface Quality Optimization

• **Task:**
  – Image Analysis to Determine Product Surface Quality/Issues

• **Challenges:**
  – Image Feature Construction
  – Light Conditions and Their Variety

• **Solution:**
  – Automated Feature Generation & Selection
  – Automated Optimization
  – Classification Problem
Project Overview

- Develop new methodologies to improve the quality of the steel production by
  - Identifying causes for bad quality
  - Predict the quality of a product as soon as possible during the production process
- RapidMiner building and providing the analytic server infrastructure
- RapidMiner implementing the tools developed by the other partners
  - New algorithms for time series analysis
  - Visualization methods for provided data
“Predictive Sensor Data Mining for Product Quality Improvement”

Product Quality Prediction with Machine Learning on Time Series Data
- Product Variations
- Varying Form/Shape
  - From 10m blocks to 2km rolls
- Large Volume of Recorded Data
  - Hundreds of sensors and parameters
  - Value sensing frequency of 1-10Hz
  - Production data of many years
OPTIMAL MIXTURE OF INGREDIENTS?
Optimizing Mixtures of Ingredients

• Which mixtures will produce high quality products?
• Which mixtures will lead to quality issues?
• How much of particular expensive additives is needed?
• How to lower costs while ensuring high product quality?
• How to increase production process reliability & product quality?
• What variables are correlated to product quality and how?
• How to predict and ensure product quality?
• How much of each ingredient is optimal?
• How to configure the production process and machines?
• => Automated Predictions & Alerts & Action Recommendations
• => Lower Cost & Lower Risk & Higher Reliability & Higher Quality
Optimizing Mixtures of Ingredients

Customers Using RapidMiner for Optimizing Mixtures of Ingredients:

- Major European Tire Manufacturer: Optimizing the rubber ingredients to optimize product quality and features (e.g. durability, adhesiveness, etc.)
- Major European Metal Product/Part Producer (Components of Cars, Trains, and Appliances): Predicting & Optimizing Quality & Cost & Reliability (ensure required quality level while reducing cost of ingredients, e.g. reducing expensive additives as much as reasonable, but not beyond)
EVERYTHING OK?
BIG DATA CAN BE OVERWHELMING
Detecting & Predicting Critical Situations

- Big Data can be overwhelming – huge amounts of structured and unstructured data (e.g. texts) from many different sources
- How to find the relevant information to look at?
- How to effectively detect critical situations in a mass of data?
- How to predict and prevent critical situations?
- How to schedule maintenance early enough in advance?
- => Automated Alerts & Action Recommendations
- => Predicting and Preventing Machine Failures, Predictive and Preventive Maintenance
- => Resource Optimization & Planning
- => Lower Cost & Lower Risk & Higher Reliability & Higher Quality
Detecting, Predicting, and Preventing Exceeded Emissions & Critical Situations

Project “FEE” sponsored by the German Government
Project Overview

- Design and build a Big Data infrastructure to manage the data of production plants
- Develop methods for early detection and prediction of critical situations
- Develop methods to help users during critical situations or to avoid critical situations
- Build ad-hoc analysis functions to build intervention strategies
- Change from reactive to proactive action

Use cases:
- Predicting and prevent critical events
- Search historic data in support of improved planning
FEE – Data and System Landscape

Assistance Systems
- Early Warnings
- Anomaly Detection & Scenario Search
- Ad-hoc-Analysen & Prognosis

Interactive Usage

Early Warning

Learning from History

Machine Operators

Digital Shift book

Operation Manuals

Process Measurements

Asset Data

Laboratory Data

Alarms & Events

Engineering Data

Big Data Platform

Production Plant

FEE – Data and System Landscape

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Predicting Assembly Times & Assembly Plans for New Product Designs & Variants

Project “Pro Mondi – Predicting Assembly Plans in Digital Factories” sponsored by the German Government (BMBF)
Truck Manufacturing – Prediction of Assembly Times & Plans

• Uses RapidMiner to predict assembly times and hence assembly costs early in the design process of new truck engines
  – ... so that product designers can faster decide which design options are most cost-efficient, reducing assembly cost as well as design time and costs

• RapidMiner also predicts assembly plans for the new truck engine or engine component designs
  – ... supporting the assembly planer to faster provide final assembly plans for new truck engines and components

• This accelerates the product design and assembly planning phases and to lower the cost, thereby making the whole process faster and less costly
  – As a result, the process becomes cost-efficient even for more and smaller series and less frequent product variations, making the car maker more competitive

• Proof-of-concept demonstrator sponsored by the German government
Challenges

• **Input Data:**
  - Standard: Linear Feature Vector
  - Here: Complex 3D Structure of 100s or 1000s of components
  - Similarity Metric Based on Sub-Graph Matching Would Be NP-Complete => Not Scalable to Large Data Volumens

• **Output Data:**
  - Standard: atomic value, e.g. class or categorie or regression value
  - Here: complete assembly plan consisting of a long sequence of steps, for which the order is important

• **Solution:**
  - Simplify
  - Decompose to sub-problems
Model training for an automatic proposal of assembly work plans

1. Product BOMs of different subassembly types
2. Product BOM characterization with feature vectors
3. Model training for subassembly type classification
4. Bills of processes (BOPs) of different subassembly types
5. BOP characterization with PMTS codes and text vectors
6. Subassembly type specific process clustering
7. Storage of process cluster specific information (incl. process time)
8. Generation of a subassembly type specific mapping between product and process clusters

For Subassembly Type 1

- Operation 1: 1
- Operation 2: 0.5
- Operation 3: 0.5
- Operation 4: 1
- Operation 5: 1

- Operation 1: 1
- Operation 2: 1
- Operation 3: 0.6
- Operation 4: 0.9
- Operation 5: 0

- Operation 1: 1
- Operation 2: 1
- Operation 3: 0
- Operation 4: 0
- Operation 5: 1
Model application for an automatic proposal of assembly work plans

1. Product data extraction out of PDM system
2. Data preprocessing (background)
3. Classification into subassembly type
4. Classification into existing product cluster
5. Mapping of product and process cluster (including process cluster specific information)
6. Manual adjustment of proposed assembly work plans
Optimizing Product Design, Minimizing Assembly Costs, and Increasing Agility by Predicting Assembly Costs and Plans

- Competitive Pressure in the Automotive Industry
  => Faster Product Life Cycles & More Product Variants
  => Time Pressure & Cost Pressure

- Product Design Decision Have an Impact on Assembly Times & Costs

- Leveraging the Expertise of Experienced Produkt Designers & Assembly Planers Using Machine Learning from Product Designs & Assembly Plans of Previous Products
  => Support Product Designers & Assembly Planers with Predicted Assembly Times, Costs, and Assembly Plan Recommendations Using Data Mining and Text Mining
  => Automatically Predict Assembly Plans & Costs Early in the Product Design Process for Alternative Designs to Select Cost-Optimized Design Early in the Process
  => Saving Time & Resources During Product Design, Assembly Planning, and Assembly
  => Faster Process, Lower Cost, Higher Agility, Implicit Know-How Transfer

- Use Case at Daimler Trucks for Truck Engines & Components ("Pro Mondi" Project)
Predicting Assembly Plans

• Given the hierarchical design of a new product or variant, predict an appropriate assembly plan and its associated costs.
• Input Data: Product design consisting of components consisting of parts, i.e. multi-level hierarchy of components & parts, highly varying structure, and no one-to-one mapping of parts to assembly steps.
• Need to consider types and numbers of parts and components used, textual descriptions of components and parts, physical measurements, materials, and other properties and features (multi-criteria metrics).
• Desired Output: Assembly plans = sequence of assembly steps.
• => Complex & Challenging Prediction Task
• => Accurate Predictions with RapidMiner
• => Use Case at Daimler Trucks: Assembly Time & Assembly Plan Prediction
Process **Mining**

- **Financial Audits**
  - Compliance / regulatory audits
  - Operational audits
  - Transactional services (M&A)
- **IT Audits**
  - IT Service management
  - Cyber security
  - Systems compliance
  - IT forensic services
- **Manufacturing**
  - Identifying assembly bottlenecks

- Manufacturing and business processes leave footprints and audit trails
- ... typically log files
- Use process process mining to:
  - Collect
  - Normalize
  - Correlate
  - Analyze
- Unlike BAM this analysis has no defined dimensions
- Use RapidProM from the RapidMiner Marketplace
Process Mining – RapidMiner [with ProM]


Appl. A → Log File App A
Appl. B → Log File App B
Appl. C → Log File App C

Log File Normalization and Merge

Process Log Data Lake

RapidMiner with ProM

Process Documentation
(Bottom up model generation, determination of reference processes)

Process Harmonization
(Compare against to-be processes and show deltas)

Process Optimization
/Runtime Analysis, late runners, waiting times, unexpected stops, congestion

Social Collaboration
Social Graphs Analysis

http://www.rapidprom.org
„Sozio-technische Gestaltung und Einführung cyber-physischer Produktionssysteme in nicht F&E-intensiven Unternehmen“

Web-basierte Auswahlhilfe für CPPS-Lösungen
+
Intelligentes Assistenzsysteme für Angebots-Erstellung und Einkauf

Konsortium:

unterstützt durch:
Process **Mining**

- Financial Audits
  - Compliance / regulatory audits
  - Operational audits
  - Transactional services (M&A)

- IT Audits
  - IT Service management
  - Cyber security
  - Systems compliance
  - IT forensic services

- Manufacturing
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Social Collaboration
Social Graphs Analysis
## CASE STUDY

### Text Analytics to Improve Research Effectiveness

<table>
<thead>
<tr>
<th>The Challenge</th>
<th>RapidMiner Solution</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Over 10,000 researchers struggle to communicate, collaborate.</td>
<td>• Data science team created a text analytics process using RapidMiner, eliminating manual tagging.</td>
<td>• Reduce millions of cost through improved productivity</td>
</tr>
<tr>
<td>• Research requires a team of “indexers” who read, tag, categorize, and organize 100 years of research.</td>
<td>• RapidMiner categorizes, tags, and deploys research documents to correct location in the research library.</td>
<td>• Reduced duplicate efforts, resulting in cost savings</td>
</tr>
<tr>
<td>• As many as 1000 new research papers are submitted each day.</td>
<td></td>
<td></td>
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</tbody>
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Process Customer Feedback In Multiple Languages To Increase Retention Rates

**Challenge:** Applying basic voice-of-the-customer-concepts and text analytics to customer feedback in over 60 countries worldwide.

**Solution:** Use RapidMiner’s Platform to detect churn and identify customer service issues regardless of time, location or language.

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150,000 customer comments and tweets in almost every language processed on RapidMiner

**Data Science Hero Spotlight**

“Business executives, who hold the power to allocate text analytics resources, are beginning to see and realize the benefits to help better focus and solve business problems.”

-- Han-Sheong Lai
Director of Operational Excellence & Customer Advocacy

**Accelerate**
Process massive amounts of text at high speed

**Connect**
Analyze multiple silos of global customer data

**Simplify**
Automatically determine intent-to-churn
Quickly Prototype Analytics Models for Under Armour Challenge Wearables Data

**Challenge:** Quickly prototype analytics processes for Under Armour wearable data, for the Under Armour39 Challenge.

**Solution:** Use RapidMiner’s code free, drag and drop GUI to quickly design 11 analytics processes, iterate them for optimization, and win the challenge.

**Data Science Hero Spotlight**

“RapidMiner is extremely powerful, has the best operators, and can handle Big Data from wearables. It also allows us to rapidly prototype sophisticated analytics, machine learning and classification applications, saving time and money.”

-- Kevin Logan
CEO

1.8M data points analyzed, per hour, by the Under Armour39 wearable

**Accelerate**
Prototype multiple analytics processes quickly and easily

**Connect**
Analyze Big Data from wearables devices

**Simplify**
Use code free, drag and drop GUI for analytics
**Challenge:** Search millions of patents online and automatically mine image data for applicable information.

**Solution:** Use RapidMiner text and image mining to quickly and easily identify several thousand images of interest.

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**Data Science Hero Spotlight**

"Some years ago (the patent team) had tried a dedicated patent classification tool that didn’t work - RapidMiner does. It provides a framework for substantially reducing the time it takes us to find interesting patents."

-- Thomas Hartmann
Business Engineer

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**Accelerate**

Automatically mine millions of online patent images

**Connect**

Search through a wide variety online data sources

**Simplify**

No programming required to connect insights to action

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Drive Broadcast Revenues and Customer Retention with Streaming, Real-Time Analytics

**Challenge:** Better understand TV viewing habits to prevent churn and optimize advertising.

**Solution:** Process streaming Big Data from three million TV viewers, in real-time, to make program content recommendations and target advertising.

<5s

**Data Science Hero Spotlight:**
“RapidMiner allows us to leverage Big Data, in real-time, for the TV industry.”

-- Avi Bernstein
Professor at the University of Zurich, Department of Informatics

**Accelerate**
Personalized recommendations < 5s

**Connect**
Stream and analyze from set-top boxes, mobile devices and PCs

**Simplify**
Code free design of streaming analytics

This work was supported by the FP7 ICT SME initiative on Digital Content and Languages programme of the European Commission under grant agreement No 296126.
New Major Research Projects 2019 - 2021: Data Stream Processing, Industry 4.0, IoT, Web Mining

AKKORD: Smart Analytics Services Platform for Industry 4.0 & IoT Applications
• Partners include Miele, Volkswagen, IPS TU Dortmund University, etc. (Industry 4.0 Cloud).

DaPro: Optimization of Industrial Production Processes with Data Mining (here with example processes from the beer brewing industry)
• Partners include beer brewing companies Bitburger Group and Augustiner, machine builder Syskron/Krones, and IPS, TU Dortmund University.

INFORE: Real-Time Large Scale Data Stream Processing, Monitoring, and Analytics
• Partners include NATO, Maritime Traffic Monitoring, Medical Partners, etc.

TechRad: Automated Web Mining & Monitoring for a Technology Trend Radar
• Partners include eGo Car (Electric Car Manufacturer), RWTH Aachen University, etc.
DaPro
Data Driven Process Optimization in the Brewing Industry

Started 01/2019
INFORE
Interactive Extreme-Scale Analytics and Forecasting

Started 01/2019

• ATHENA - Research and Innovation Center (coordinator)
• NCSR Demokritos
• Barcelona Supercomputing Center
• The Centre for Genomic Regulation
• Spring Techno
• NATO Centre of Maritime Research and Experimentation (CMRE)
• MarineTraffic
Data Science on HPC Infrastructure

• **Goal:** Handling massive data flows from multiple sources and allow real-time interactive analytics

• **Use cases:** Data Streaming, High Performance Computing, *In-Silico* simulation

• **Verticals:** Finance, Maritime (ship movement), Medical (cancer research)
High-Level Overview

• Funding: European Union, H2020
• Duration: 3 years (2019-01 – 2021-12)
• Topics & Goals:
  – Analyze huge datasets and pave the way for real-time, interactive extreme-scale analytics and forecasting
  – RapidMiner is the main driver for the technical development
  – Three use cases:
    ▪ Monitoring global marine traffic
    ▪ In-Silico analysis of tumor growth
    ▪ Real-Time analysis of online trading
Online Media Monitoring

• What do you customers like/dislike about my products & services and about those of my competitors? (e.g. Android SmartPhone X vs. Apple iPhone Y)
• Web Crawler: Automatically collect opinion from the web: social media like Facebook and Twitter, internet discussion groups, product reviews (e.g. Amazon), etc.
• Automated Text Classification: Automatically focus on relevant pages and statements based on content and sentiment
• Determine top words and phrases indicating positive / negative sentiment, i.e. reasons for like / dislike, e.g. preferred product features or service issues or pricing policies, etc.

=> Better understand customers & market
=> Tailor product better to demand
Demand Forecasting

• **Task:**
  – How many cars of each model and configuration will be sold in a given future time period?

• **Challenges:**
  – Large number of products and configuration variants

• **Solution:**
  – Consider clusters of products and/or configurations
  – Consider customer information requests and online configurations
  – Consider overall market trends (economic up-/down-turns etc.)
  – Consider social media discussions and e-mail communications to detect trends and preferences
  – Analyse historic sales data for trends and patterns (seasonal, colors, etc.)
Demand Forecasting & Supply Chain Mgt.

• How often will each product / service be sold?
• Customer: Leading Telecom Equipment Supplier
• Solution: Demand Forecasting
  => Optimize Planing & Time of Orders (Prices)
  => Optimize Supply Chain Management
• Related: Price Forecasting & Dynamic Pricing
• Related: Network Load Forecasting, Bottleneck Prediction
Product Market Fit & Regional Issues

• **Task:**
  - Analyse Product Failures & Issues
  - Detect Regional Issues & Opportunities

• **Challenges:**
  - Long-Term Task & Data Collection across Supply Chain & Product Lifecycle
  - Data Silos

• **Solution:**
  - Comprehensive Data Collection
  - Breaking Data Silos
RapidMiner Studio

All-In-One Data Science Workflow Designer

Lightning Fast
Visual interface for rapidly building complete analytic workflows

Powerful
Rich library of algorithms and functions to build the strongest possible model for any use case

Open & Extensible
Open source innovation keeps pace with changing business needs
Team Collaboration
Central repository facilitates sharing of data sources, analytic processes & best practices

Frictionless Operationalization
Flexible execution options streamline deployment, maintenance & embedding of analysis

Dynamic & Continuous Model Management
Individual and customizable processes to check for accuracy drifts or shifts
#1 Data Science Platform & Marketplace  
#1 Open Source Community

**Number of Registered Users**

- **Emerging**
  - 2007: 2,500
  - 2010: 15,000

- **Expanding**
  - 2013: 75,000
  - 2016: 125,000

- **Intensifying**
  - 2019: 480,000+

http://community.rapidminer.com/
Signature Customers

PayPal™  TD Ameritrade  Caliber Home Loans

Jaguar  Land Rover

Intel®  Daimler

Volkswagen  Deutsche Telekom  P&G  BMW
Selected RapidMiner Customers & Partners

- Automotive: BMW, Daimler, Jaguar Land Rover, Nissan, Volkswagen
- Automotive Components: Bosch, Conti (Continental), ThyssenKrupp Presta
- Airplane Manufacturers & Aviation: Airbus, Embraer, Lufthansa
- Metal & Steel Industry: Arcelor Mittal, Bosch, ThyssenKrupp Steel, Mannesmann Salzgitter, Deutsche Edelstahlwerk (DEW)
- Electronics & Manufacturing Related: ABB, General Electrics, Intel, KHS, Miele, MTM, Schneider Electric, Siemens
- Chemical Industry: AkzoNobel, BASF, Covestro, Dow, Ineos, PCK, Sanofi
- Energy & Oil Industry: CEPRI, Chevron, E.ON, RWE, Saudi Aramco, TOTAL
- Telecom Industry: Deutsche Telekom, mobilkom austria (A1.net), Nokia, SmartSoft (OEM), SwissCom, Telenor, T-Mobile International
THANKS.

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