Successful implementation of a customized predictive maintenance solution in industrial manufacturing

Bern, June 2017

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an EXXETA company

The mission of anacision

[ˌænəˈ sɪʒn] analytics + decision

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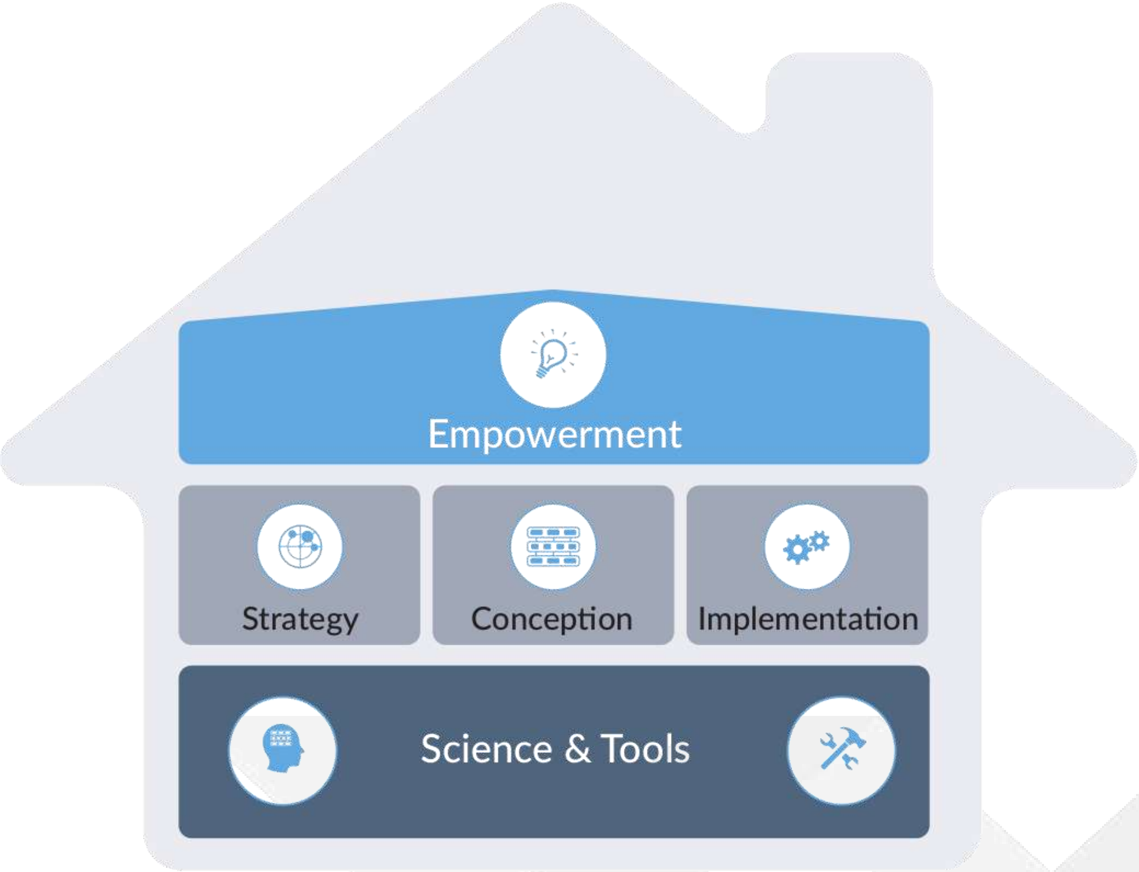
Our mission

We help to make better decisions
with intelligent data analysis.




FA-380

Hundreds of plants

More than 500.000 Sensors

Reactive, time based and condition based maintenance

Failures rare but expensive

Every day GBs of sensor data are collected centrally

Predictive Maintenance: Predict necessary maintenance activities and avoid unplanned shutdowns

Predictive Maintenance Strategic Approach

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Reactive Maintenance

"Run to Fail"
- No data collection
- Large spare parts inventory
- High cost of downtime

Accepted method for low risk, low impact equipment

Preventive Maintenance

Time Based
- No data collection
- Large spare parts inventory
- Low cost of downtime
- High maintenance spend

Time/OH as decision criteria

Condition Based: Monitoring
- Data aquisition/archiving
- Equipment specific
- Static equipment thresholds
- Experts for interpretation

Alarm for instant reaction

Condition Based: Diagnostics
- Data analysis
- Component specific
- Expert systems/software
- Experts for interpretation

Planning of distinctive actions

Predictive Maintenance

Predictive Analytics
- Dynamic thresholds, gradients
- Dependant on parametric models
- Scalable, "fleet learning"
- Not time specific

Early warning of emerging issues

Prognostics
- Statistical prognosis
- Non-parametric
- Scalable, "fleet learning"
- Time specific, risk based decision support

Explicit time frame until outage

Predictive Maintenance
Strategic Approach

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Predictive Maintenance

Predictive Analytics
- Dynamic thresholds, gradients
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Early warning of emerging issues

Prognostics
- Statistical prognosis
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- Scalable, “fleet learning”
- Time specific, risk based decision support

Explicit time frame until outage

Pattern recognition
- Sensors detect the condition of plant components
- Search for patterns in the sensory data that lead to failures
- Only known maintenance cases can be found
- In any case, sufficient data must be available

Reduce maintenance and reduce maintenance costs

Continuous Monitoring
- Sensors detect the condition of plant components
- Create a model to detect unhealthy states
- Not limited to known maintenance
- Impact assessment partly more difficult

Avoid failures and reduce maintenance

Our approach to continuous monitoring of the health of industrial plants

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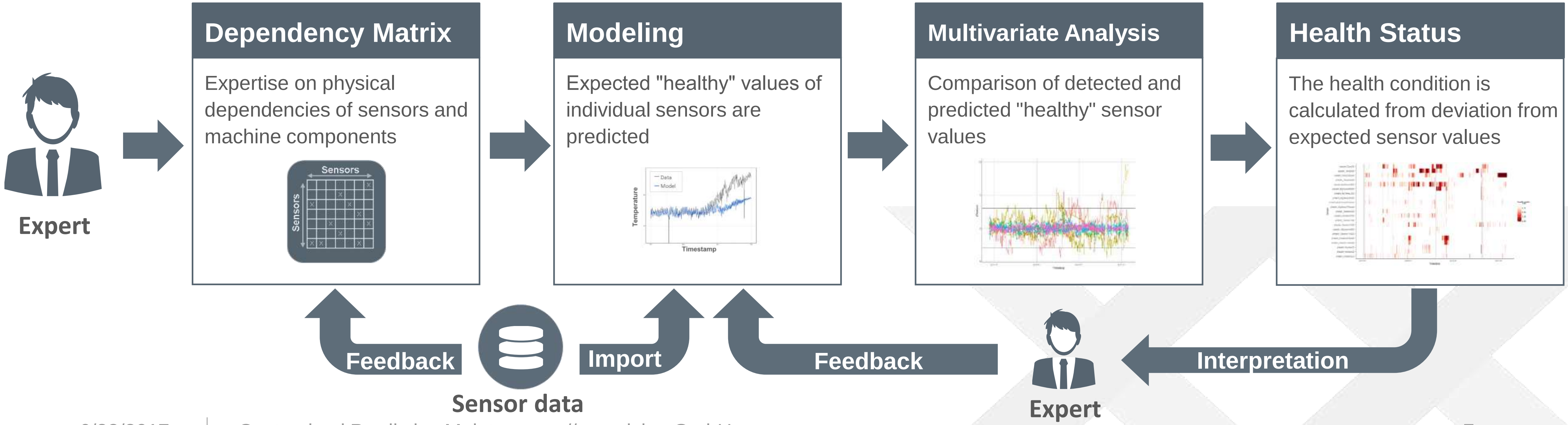
Goals

- Continuous measurement and interpretation of the health of industrial plants
- Automated early indicators for unhealthy developments
- Reduced maintenance costs and reduced plant downtimes

Approach

- Combination of expert knowledge and sensor data to predict unhealthy states



From expert knowledge to dependency models

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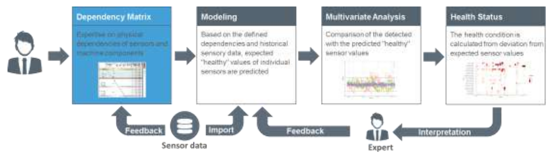
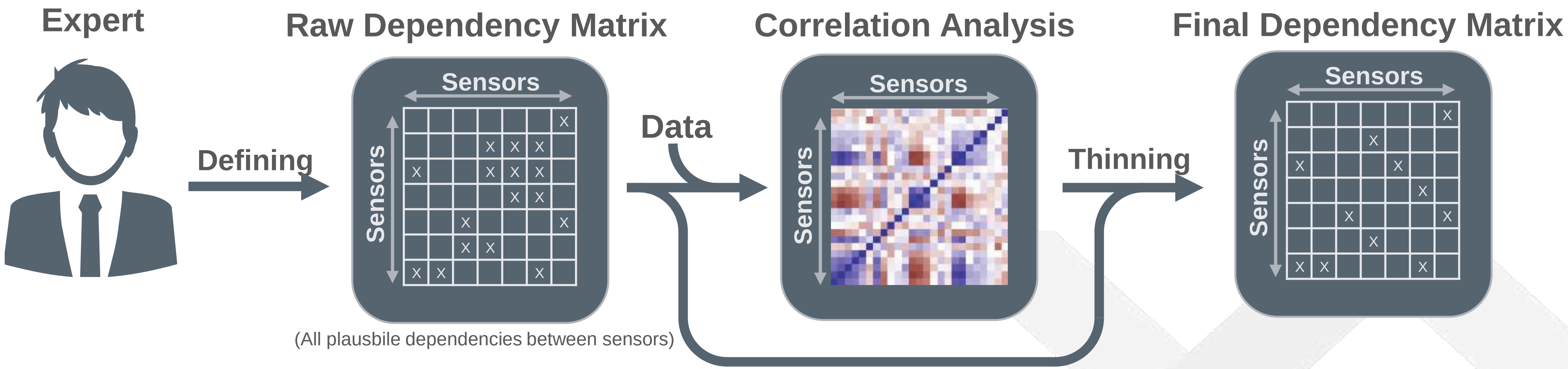


// A high number of potential correlations were identified, but
- some correlations can be spurious correlations resulting from a shared influence
- statistical models can be unreliable in case of many highly correlated predictors (multicollinearity)

→ The dependency matrix has to be thinned out in order to generate reliable and expressive models



From influence matrix to linear regression models

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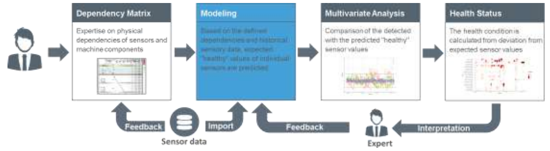
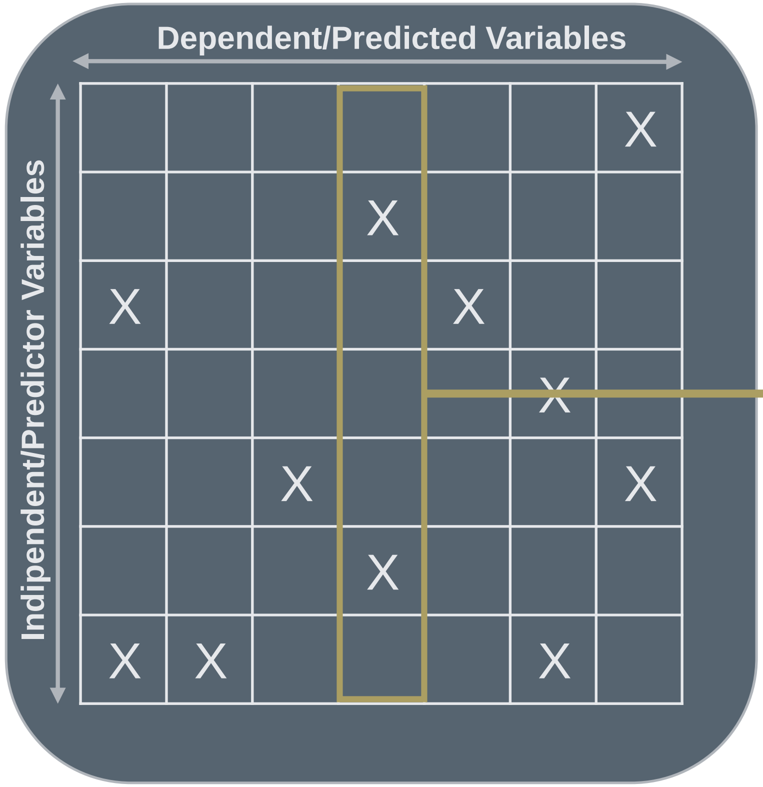


// Models are generated dynamically based on defined dependencies in the influence matrices



// A linear regression model for the variable Y is defined as

$$Y = \beta_0 + \sum_{i=1..p} \beta_i X_i$$

with predictor variables X_i, constant β_0 and coefficients β_i for all p predictor variables (“X” in dependency matrix)

// Example: Temperature

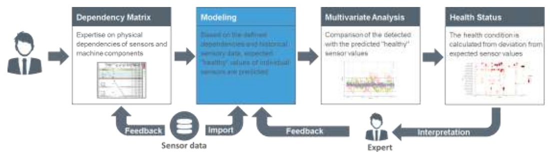
$$Temp = \beta_0$$
$$+\beta_{Pressure} \cdot Pressure$$
$$+\beta_{Ambient\ Temperature} \cdot AmbientTemperature$$

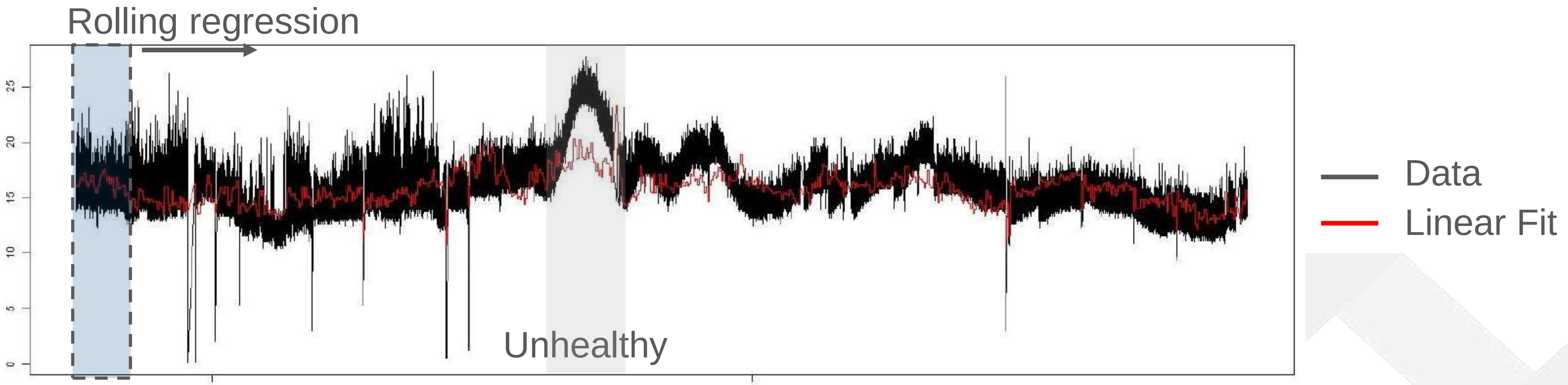
Linear regression model representing „healthy“

Linear Regression Model

Anomaly Detection

Rolling Regression





From real-time sensory data to continuous evaluation of health state

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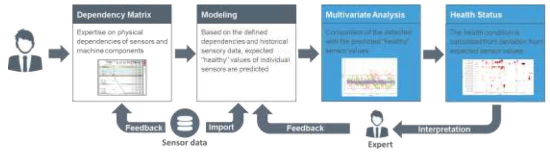
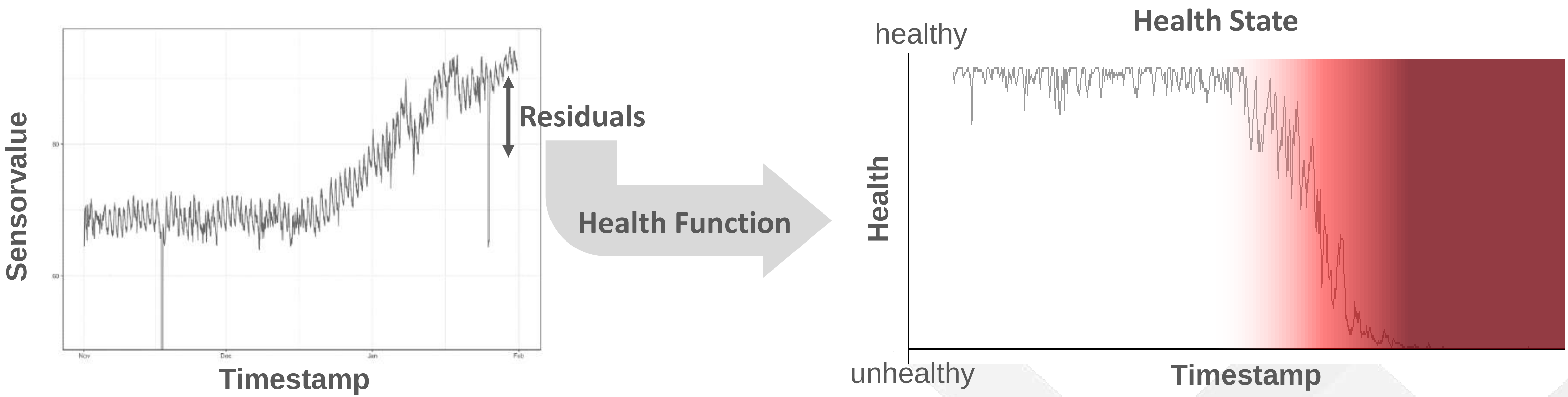
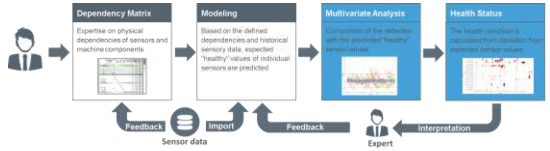
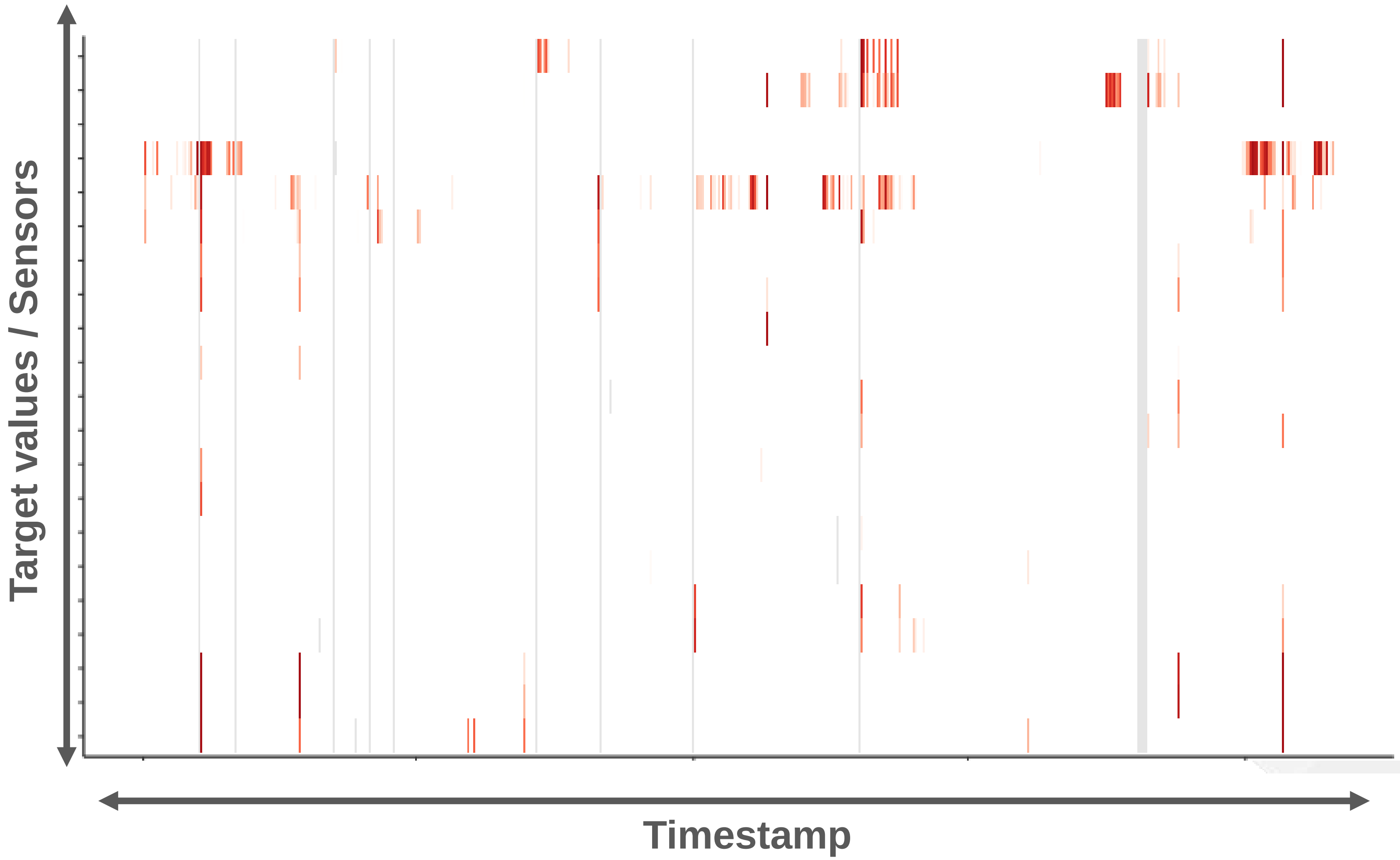
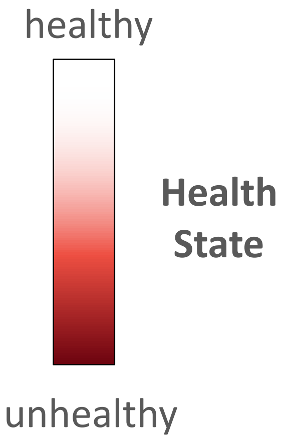




Overview of the health status of one plant



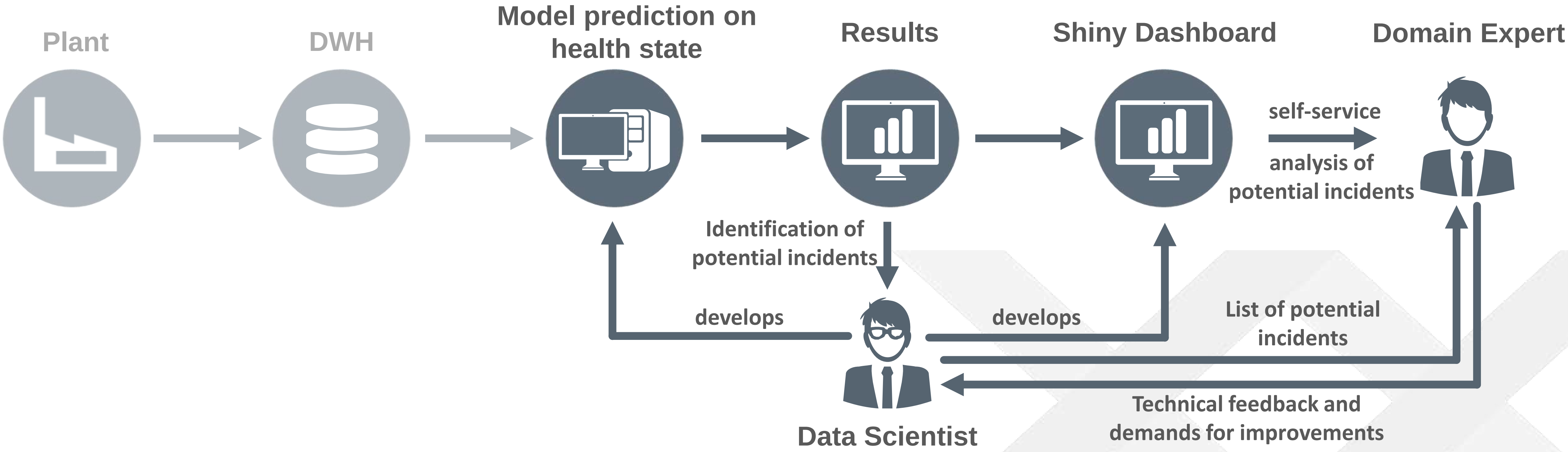




Project setup and lessons learned

Customer has analyzed a large number of standard solutions available on the market without success.

Key success factor:
Customized Solution with continous exchange between data scientists (anacision GmbH) and domain experts (customer).



Summary

Continuous monitoring can provide elementary advantages over pure pattern-based procedures

Easy to transfer to other machines and industries

Proofed in various projects, among others in a German DAX Company

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