Condition-Based Maintenance In The German Public Rail Transportation System

Analyzing train door machine data using Splunk machine learning capabilities

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Our Company – ESE GmbH
Operational Divisions

- Rail Operations
- Automotive Production
- Manufacturing Industry

Range Of Services

- Software-Engineering
- Testing & Verification
- Assessment-Services
Problem
Reduction Of Maintenance & Repair Cost

► Maintenance & repair cost exceed expectations
  • Cost overruns influence the operational result

► Failure of systems cause interruptions of service
  • Repairs following interruptions are the most expensive
  • Door-controls are a leading source for interruptions
Problem
Causes For Door Locking Failures

**Cause A**
Weather and various environmental conditions
Temp. changes and constant influence of moisture

**Cause B**
Unequal distribution of load
Rush-hours and one-sided train-station positioning

**Cause C**
Improper use and vandalism
Brute force of daily public usage
Solution
Infusion of Trains With IoT-Technology

image source: de.bombardier.com

Bombardier TALENT 2
Splunk MLTK - DBSCAN
Integration Of Algorithms To Our Solution

Unsupervised Analysis
Structure of delivered data is independent from learning data

Data Uniformity
Small variety in expectancy values allows cluster analysis

Splunk Integration
One-step transformation from JSON-events to MLTK Input
Detecting Anomalies using DBSCAN

Splunk Commands And Visualization

```plaintext
var br442DoorLinechartOpenSearchString =
  'index=br442_asset_name=${br442AssetToken}$ ' +
  'message_type=curve_talent_door "content.direction"=Open ' +
  ' | mvexpand "content.actual_curve{}" ' +
  ' | streamstats count as LineNumber by _time ' +
  ' | xyseries _time, LineNumber, "content.actual_curve{}" ' +

  ' | fit DBSCAN eps=5 1* 2* 3* 4* 5* 6* 7* 8* 9* ' +

  ' | search cluster>-1 ' +
  ' | untable cluster Key Value ' +
  ' | chart limit=0 avg(Value) as Value over Key by cluster ' +
  ' | sort +Key' +
  ' | collect index=summary_doors_test marker=average_curve_open';
```
Splunk Dashboard
Starting Page And Map-Overview
Splunk Dashboard
Drilldown: Machine Data Analysis

Train Door - Machine Data Analysis

Asset: BR-442 336
Door-No: 63
Locking-Events: 12,645
Last Even: 06 / 12 / 2017 16:35:08

Analyse: Opening-Events
Detecting Anomalies using DBSCAN

Splunk Commands And Visualization

Energy-consumption (Ampere) over recent opening events

Anomaly → indicating door-locking malfunction!
Linking Machine Data and Weather Data

RESTful-Webservice Integration Of OWM

Open Weather Map

Measuring Time: 12.06.2017 / 14:52:37
Time-Delta: 4758 ms
Weather Station: Cologne
Temperature: 19 °C
Weather Description: Clear Sky
Humidity: 52 %
Wind Direction: 290 °
Wind Velocity: 14,0 km/h
### Prediction Premise

Analyzing First Results To Generate Thresholds

<table>
<thead>
<tr>
<th></th>
<th>Temperature earliest</th>
<th>Temperature latest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>16.81 °C</td>
<td>18.77 °C</td>
</tr>
<tr>
<td>Fahrenheit</td>
<td>62.27 °F</td>
<td>65.78 °F</td>
</tr>
</tbody>
</table>

![Graph showing temperature over time]
Expected Results
Benefits Of Implementing Condition-Based Maintenance

▶ Reduction of service interruptions
▶ Even distribution of stress to the mechanical components
▶ Foresight in failure-causing effects and when they occur
▶ Alerting and reporting at any moment through live-data
▶ Precise scheduling of maintenance cycles

Overall cost reduction!