Prototyping Preventive Maintenance Tools with R

Erich Neuwirth, Julia Theresa Csar

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Introduction

• Machinery is constantly monitored
  • A lot of data is collected (rotation, temperature)

• Extract a low resource representation for the monitored data
  • to detect unusual behavior
  • to detect long time development
Example: Coffee Machine

• Noise of the crushing mill is constantly monitored

• The goal is the detection of
  • Low charging level of coffee beans
  • Level of grinding texture
  • Over long time: erosion
The 90%-confidence intervals of the crushing levels 2, 4 and 6 are shown in the background.
Extract multidimensional Representation

- Identify some important frequency intervals
  - Coffemachine: One Interval to identify the crushing level and one interval to recognize low bean charging level

- Calculate RMS over these intervals
  → Multidimensional Points

- Store those points and gain representing data points using the algorithm.

- Update those representation points frequently.

- The number of representation points is kept constant
Algorithm

- Based on the algorithm for incremental quantile estimation presented in „Monitoring Networked Applications With Incremental Quantile Estimation” by John M. Chambers et al.
- Generalisation for multidimensional data was reached by using adaptive principal components analysis
Algorithm

- **Parameters to set:**
  - \( m \)…Number of Representation Points
  - \( n \)…Number of new points used for updating

- **Buffering Datapoints**
  - Starting algorithm after buffer is filled with \( n \) new points
  - Updating the representation points using those new points
  - Reset representation points after some time
Algorithm

- **The Black Confidence Ellipsoids** are from the distribution used for generating random numbers.
- Random numbers were generated using function „mvrnorm“ from R-Package „MASS“.
- **The Red Ellipsoids** are derived from the calculated representation points using function „kde“ from R-package „ks“.
Two-Dimensional representation of Coffeemachine

- Identify two frequency intervals which contain information about the status:
  - Coffee bean charging level
  - Crushing level

- Use those points to gain the two-dimensional representation
  - Visualization: confidence ellipsoids
Two-Dimensional representation of Coffeemachine Status

Crushing level 4

- **Green**: OK
- **Orange**: Warning
- **Red**: out of coffee beans
Two-Dimensional representation of Coffee Machine Status

- Confidence Ellipsoids are different at each crushing level

- **Green:** OK
- **Orange:** Warning
- **Red:** out of coffee beans
Three Dimensional

Crushing Levels 4 and 6

Red: Crushing Level 4
Blue: Crushing Level 6
R-Packages Used

- **KS: Kernel smoothing, Tarn Duong**
  - **kde**: Kernel density estimate for 1- to 6-dimensional data.
  - **rmvnorm.mixt**: Multivariate normal mixture distribution

  - **mvrnorm**: Simulate from a Multivariate Normal Distribution
References