Hydraulic systems condition monitoring

(Analytics Hackathon Use-Case 4)

# Basic Premise

We have entered the age of IoT, and analytics of sensor data for system condition monitoring and maintenance prediction is becoming a commonplace affair. The datasets comprise sensor time series data, and characterize the system under monitoring both for normal and anomalous conditions. The aim of this hackathon problem is to generate a model that can be used effectively for condition monitoring and failure prediction from time series sensor data.

# Criteria for Evaluation

1. Accurate prediction of anomalous conditions
2. Low number of false alarms
3. Capability of the system to explain the basis of predictions
4. Ability to improve on performance reported in cited paper

# Data Set Information

Link to the dataset: <http://archive.ics.uci.edu/ml/machine-learning-databases/00447/data.zip>

The data set was experimentally obtained with a hydraulic test rig. This test rig consists of a primary working and a secondary cooling-filtration circuit which are connected via the oil tank [1]. The system cyclically repeats constant load cycles (duration 60 seconds) and measures process values such as pressures, volume flows and temperatures while the condition of four hydraulic components (cooler, valve, pump and accumulator) is quantitatively varied.

## Attribute Information

### Sensor data

The data set contains raw process sensor data (i.e. without feature extraction) which are structured as matrices (tab-delimited) with the rows representing the cycles and the columns the data points within a cycle. The sensors involved are:

**Sensor Physical quantity Unit Sampling rate**

PS1 Pressure bar 100 Hz   
PS2 Pressure bar 100 Hz   
PS3 Pressure bar 100 Hz   
PS4 Pressure bar 100 Hz   
PS5 Pressure bar 100 Hz   
PS6 Pressure bar 100 Hz   
EPS1 Motor power W 100 Hz   
FS1 Volume flow l/min 10 Hz   
FS2 Volume flow l/min 10 Hz   
TS1 Temperature °C 1 Hz   
TS2 Temperature °C 1 Hz   
TS3 Temperature °C 1 Hz   
TS4 Temperature °C 1 Hz   
VS1 Vibration mm/s 1 Hz   
CE Cooling efficiency (virtual) % 1 Hz   
CP Cooling power (virtual) kW 1 Hz   
SE Efficiency factor % 1 Hz

### Target condition

The target condition values are cycle-wise annotated in “profile.txt” (tab-delimited). As before, the row number represents the cycle number. The columns are:

1. **Cooler condition / %**:

3: close to total failure   
20: reduced efficiency   
100: full efficiency

1. **Valve condition / %**:   
   100: optimal switching behavior   
   90: small lag   
   80: severe lag   
   73: close to total failure
2. **Internal pump leakage**:   
   0: no leakage   
   1: weak leakage   
   2: severe leakage
3. **Hydraulic accumulator / bar**:   
   130: optimal pressure   
   115: slightly reduced pressure   
   100: severely reduced pressure   
   90: close to total failure
4. **stable flag**:   
   0: conditions were stable   
   1: static conditions might not have been reached yet

# Relevant Papers and data reference:

1. Nikolai Helwig, Eliseo Pignanelli, Andreas Schatze, “Condition Monitoring of a Complex Hydraulic System Using Multivariate Statistics”, in Proc. I2MTC-2015 - 2015 IEEE International Instrumentation and Measurement Technology Conference, paper PPS1-39, Pisa, Italy, May 11-14, 2015, doi: 10.1109/I2MTC.2015.7151267.