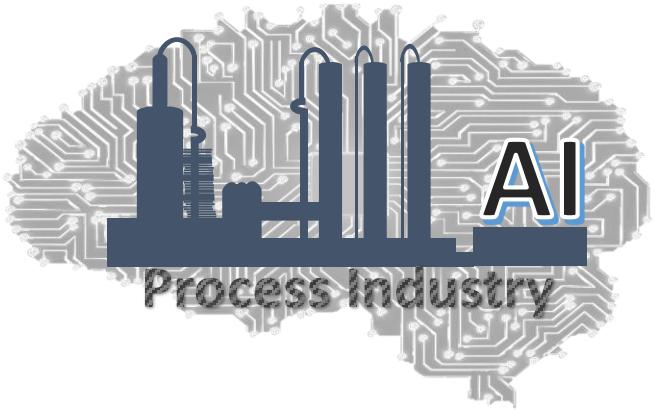
Statistical Techniques for Monitoring Industrial Processes



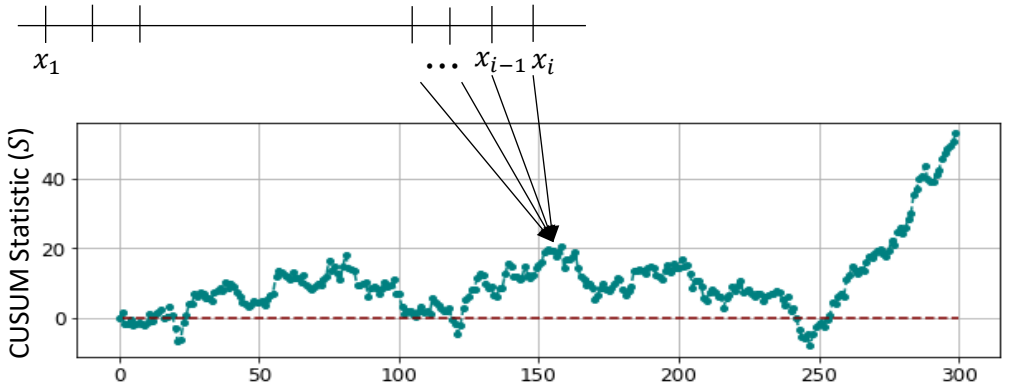
Lecture : EWMA Control Charts

Module : Univariate SPM

Course TOC

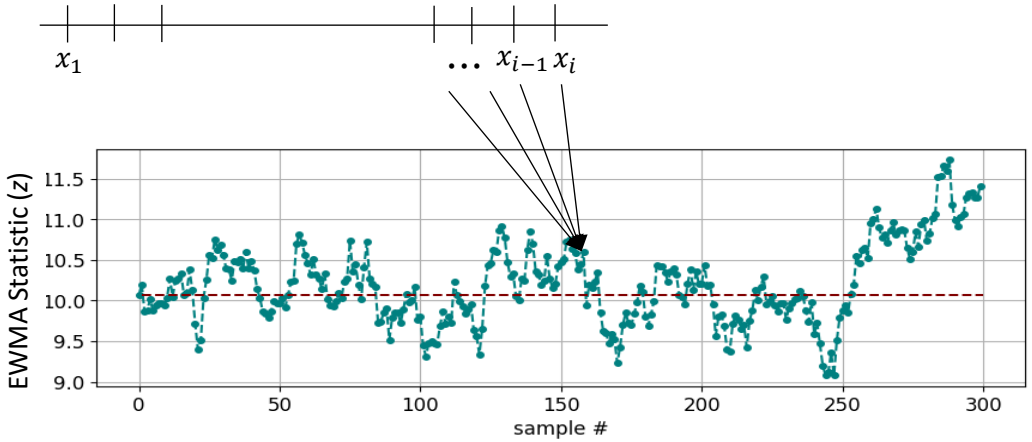
- ❑ Introduction to Statistical Process Monitoring (SPM)
- ❑ Python Installation and basics (optional)
- ❑ Univariate SPM & Control Charts
  - ➢ Shewhart Charts
  - ➢ CUSUM Charts
    - Application: Aeration tank monitoring
  - ➢ Assessing Performance of Control Charts
  - ➢ EWMA Charts
- ❑ Multivariate SPM
  - ➢ Fault detection using Principal Component Analysis (PCA)
  - ➢ Fault detection using Partial Least Squares (PLS) regression
  - ➢ Fault diagnosis using PCA/PLS contribution charts
  - ➢ Strategies for handling nonlinear, dynamic, multimode systems
- ❑ Deployment of SPM Solutions

EWMA Control Charts: Introduction



Statistic S_i is computed by giving equal weightage to all available measurements until sampling instant *i*

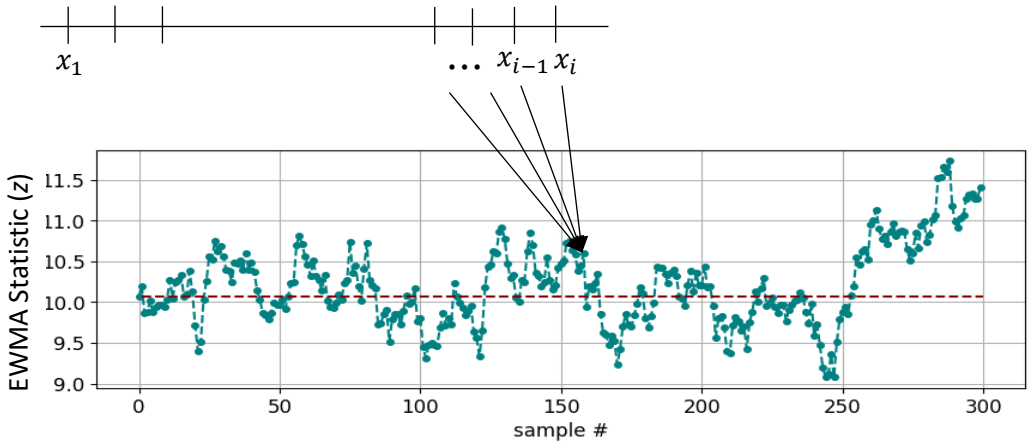
$$S_i = (x_i - \mu_0) + S_{i-1}$$
$$S_0 = 0$$



Statistic z_i is computed by giving less weightage to old measurements

$$z_i = \ell x_i + (1 - \ell) z_{i-1}$$
$$z_0 = \mu_0$$

EWMA Control Charts: Introduction



$$z_i = \ell x_i + (1-\ell) z_{i-1}$$

$$z_i = \ell x_i + (1-\ell)[\ell x_{i-1} + (1-\ell) z_{i-2}]$$

: after successive substitutions

$$z_i = \ell x_i + \ell(1-\ell) x_{i-1} + \ell(1-\ell)^2 x_{i-2} + \cdots + (1-\ell)^i \mu_0$$

weights become smaller and smaller

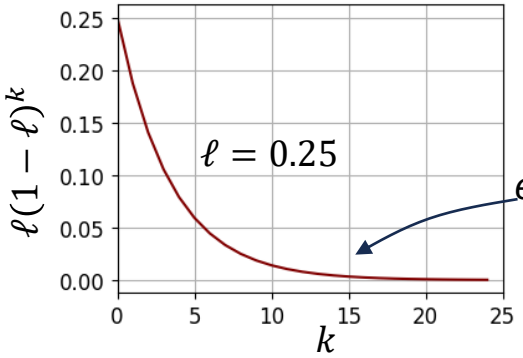
Quickly detects large faults

$\ell = 1 \Rightarrow$ Shewhart like

$\ell \to 0 \Rightarrow$ CUSUM like

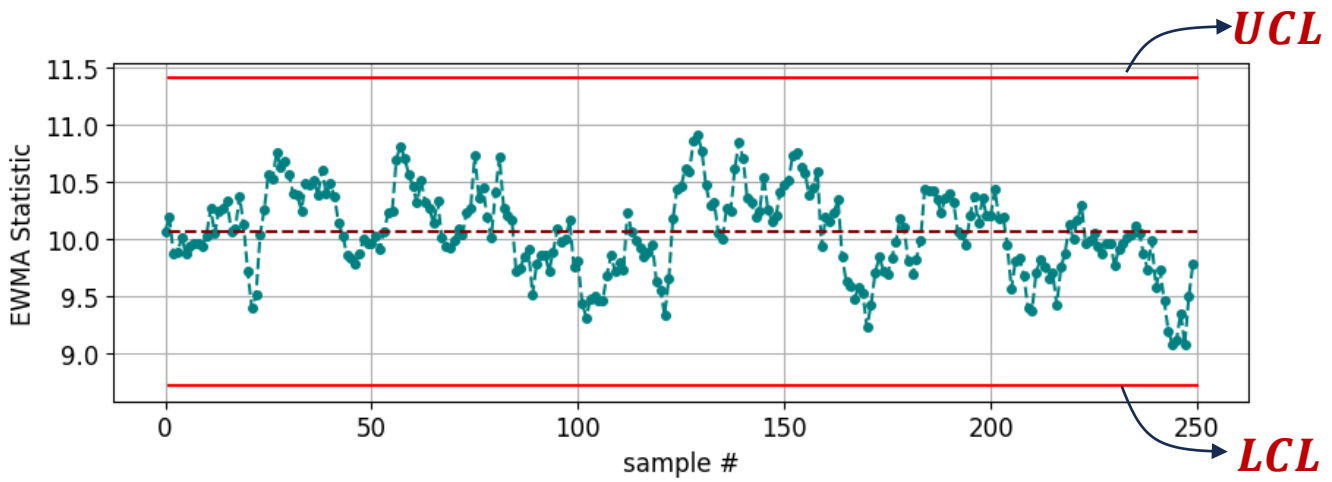
Able to detect small faults

$0.2 \le \ell \le 0.3 \leftarrow$ commonly set



exponential like decay!

Construction of EWMA Control Chart



3 sigma control limits

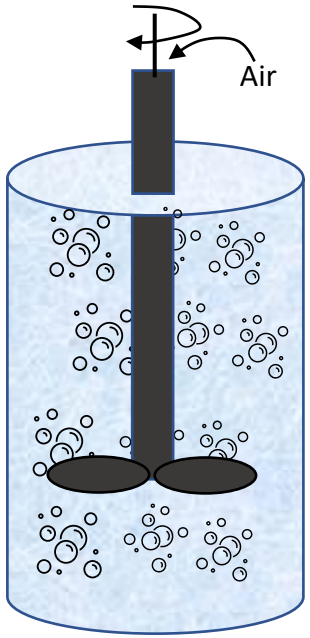
$$LCL = \hat{\mu} - 3\hat{\sigma}\sqrt{\frac{\ell}{2-\ell}}$$

$$UCL = \hat{\mu} + 3\hat{\sigma}\sqrt{\frac{\ell}{2-\ell}}$$

Historical in-control data

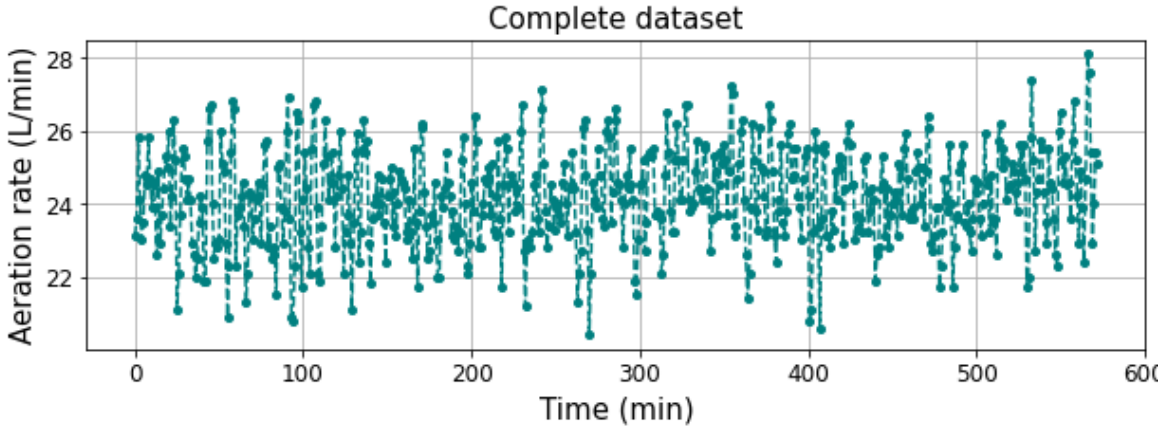
- $\hat{\mu}$ = sample mean
- $\hat{\sigma}$ = sample standard deviation

EWMA Control Charts: Implementation Demo



Aeration Tank

Aeration tank monitoring: Case study



Statistical Techniques for Monitoring Industrial Processes

Next Lecture : Shortcomings of Classical Control Charts

Module : Univariate SPM