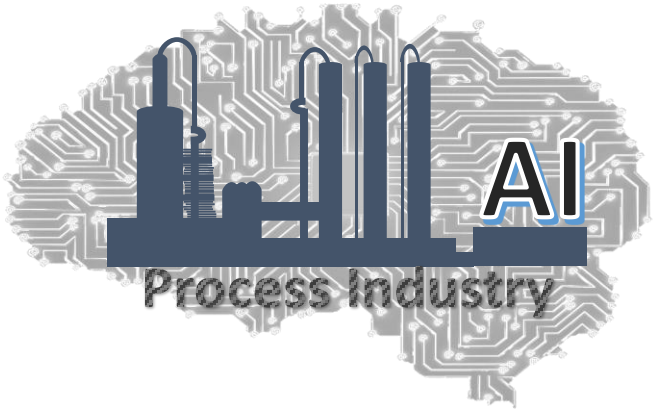
Statistical Techniques for Monitoring Industrial Processes



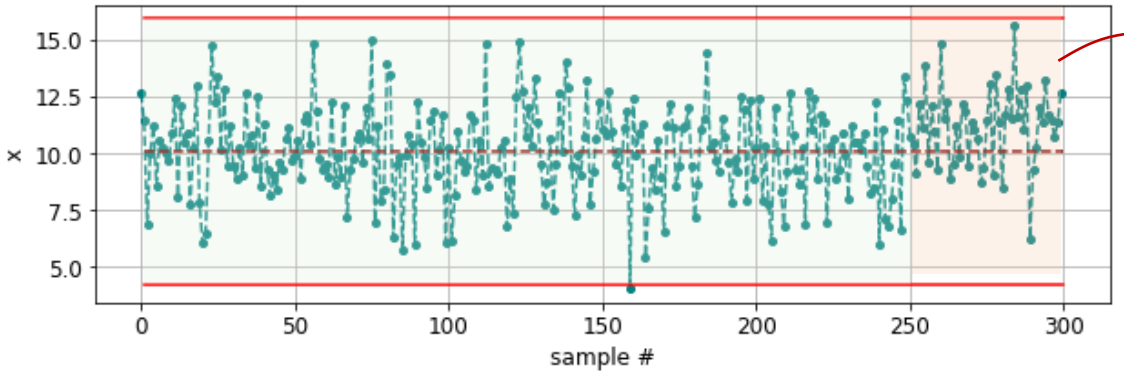
Lecture : CUSUM Control Charts

Module : Univariate SPM

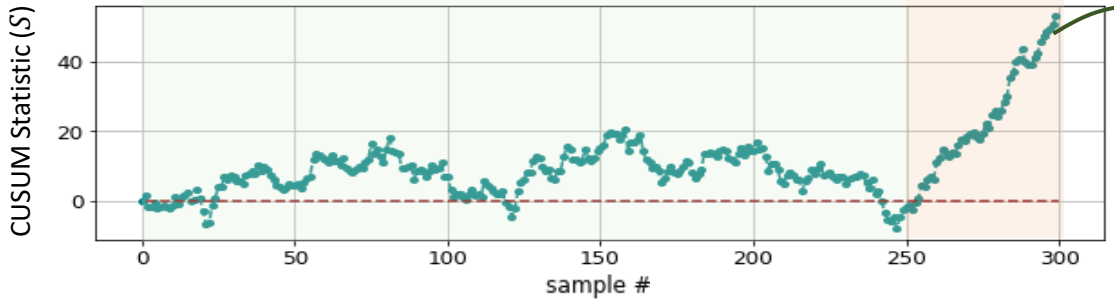
Course TOC

- ❑ Introduction to Statistical Process Monitoring (SPM)
- ❑ Python Installation and basics (optional)
- ❑ Univariate SPM & Control Charts
  - ➢ Shewhart Charts
  - ➢ CUSUM Charts
  - ➢ 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

CUSUM Control Charts: Introduction

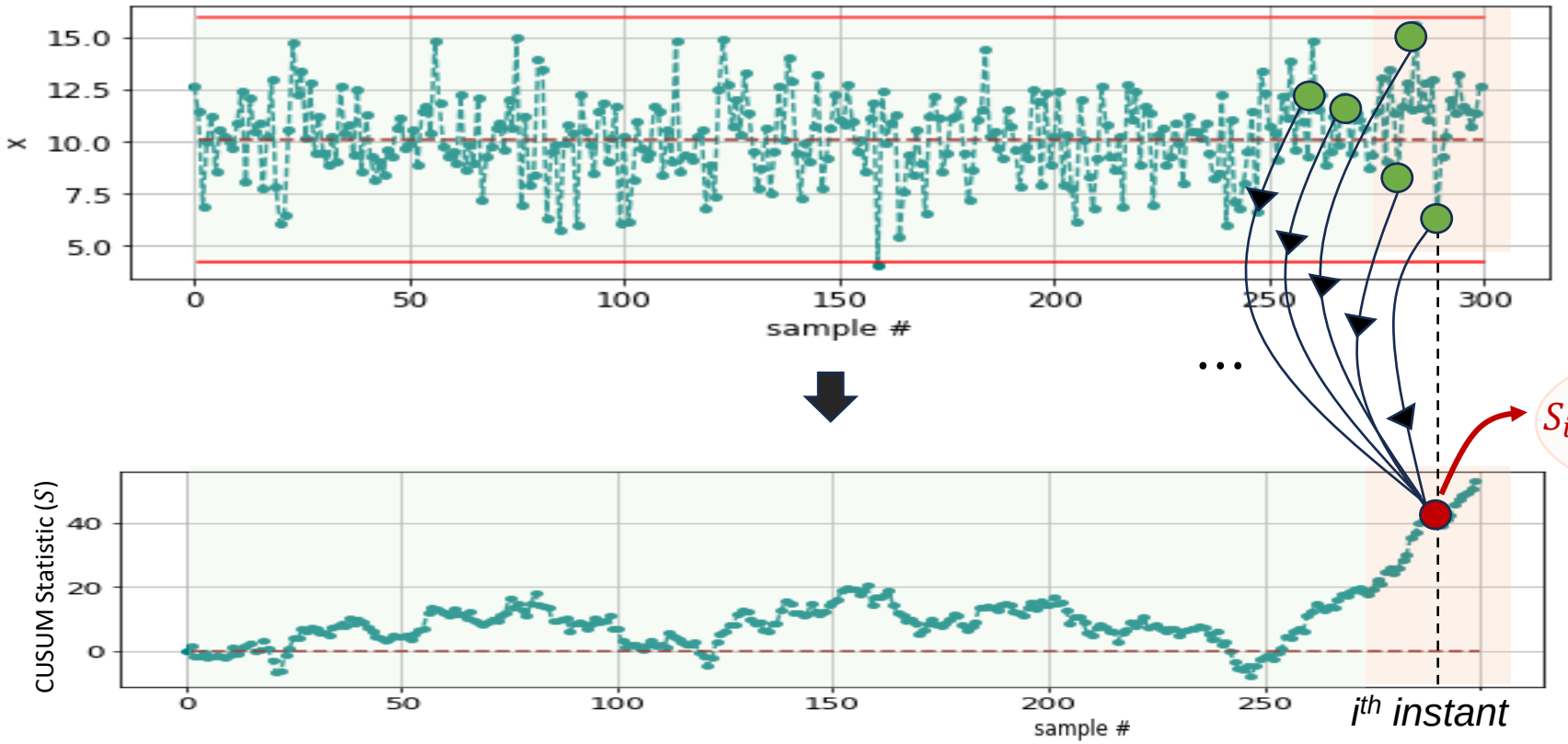


Last 50 samples generated with 0.5σ shift in mean



How did the drift become so obvious?

CUSUM Control Charts: Introduction

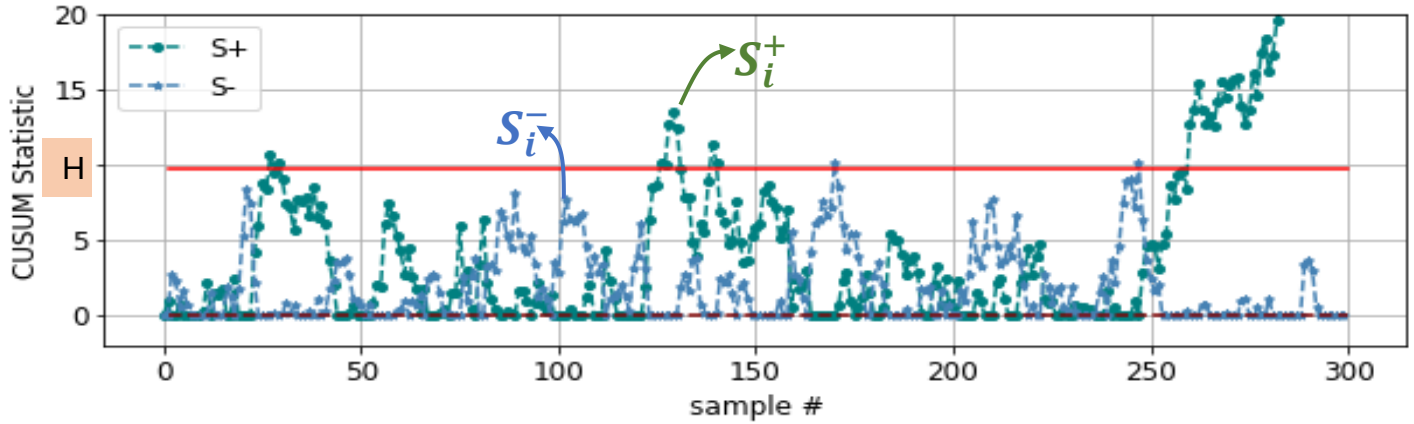


$$S_i = \sum_{j=0}^{i} (x_j - \mu_0) \quad ; i \geq 0$$

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

Two-Sided CUSUM Control Charts

Violation of control limit by either S^+ or S^- indicates process not being in statistical control



S_i^- tracks negative shift in mean

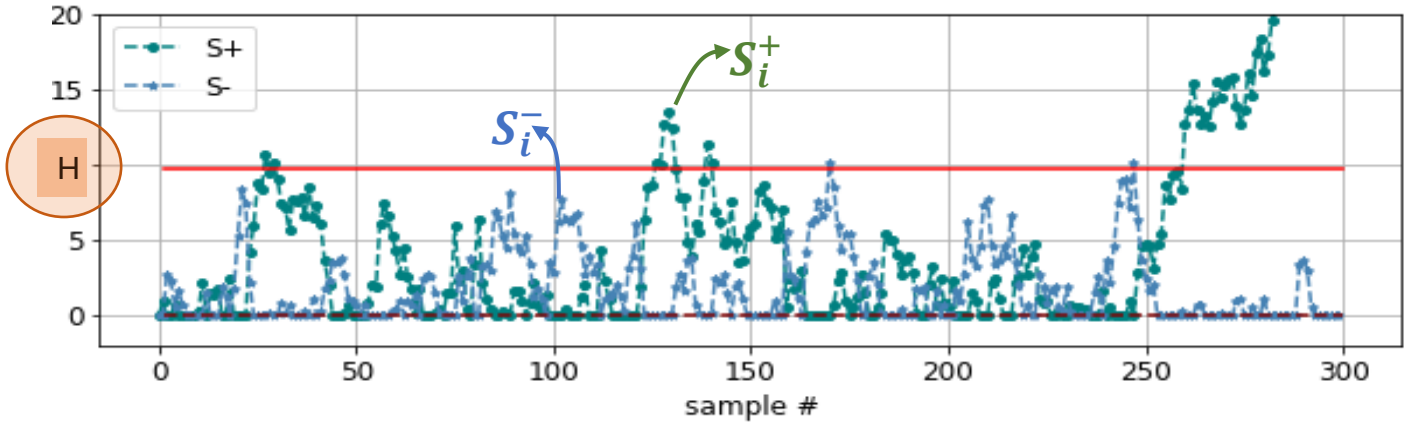
S_i^+ tracks positive shift in mean

$$S_i^+ = \max[0, x_i - (\mu_0 + k) + S_{i-1}^+]$$

$$S_i^- = \max[0, (\mu_0 - k) - x_i + S_{i-1}^-]$$

- $k \geq 0$
- Deviation from mean greater than k increases S^+ or S^-
- k is usually set to be ½ the size of mean shift that we want to detect quickly

Construction of CUSUM Control Chart



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Historical in-control data

- $\mu_0 \approx$ sample mean
- $\hat{\sigma} =$ sample standard deviation
- $H = 4\hat{\sigma}\ or\ 5\hat{\sigma}$

CUSUM Control Charts: Implementation Demo

2 Case studies

1. Product purity mean value changes by 0.5σ due to process upset

2. Product purity mean value changes by 2σ due to process upset

CUSUM Charts: Pros & Cons

Pros

- Easy to interpret
- Easy to implement
- Can detect small mean deviations

Cons

- Shows delay in drift detection

Shewhart Charts	CUSUM Charts
Quick detection of large drifts	Detection of small drifts
Fails for small drifts	Delay in detecting drifts

EWMA charts provide a good compromise between detection of small mean shifts and quick detection of large shifts

Statistical Techniques for Monitoring Industrial Processes

Next Lecture : Monitoring Airflow in an Aeration tank

Module : Course Introduction