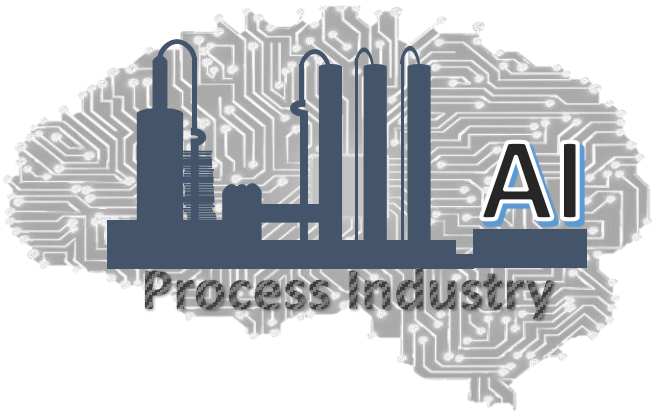
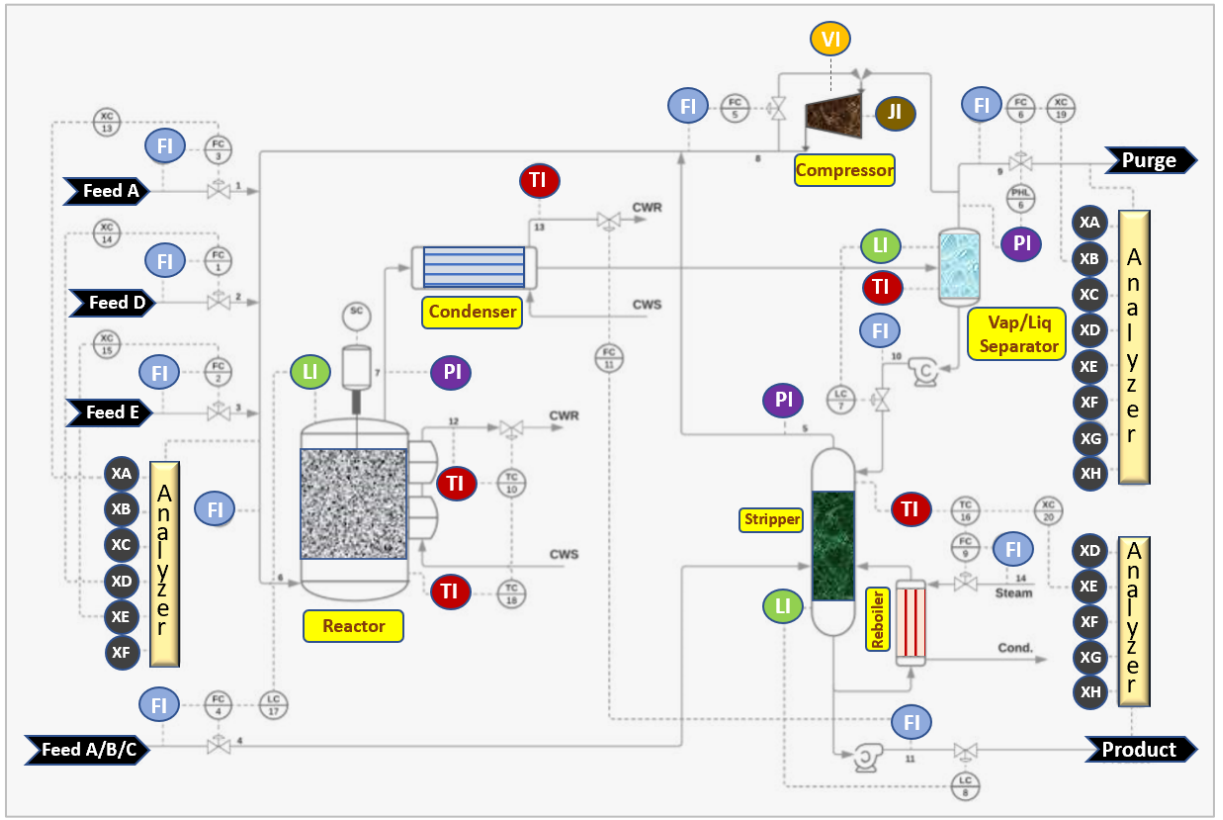
Statistical Techniques for Monitoring Industrial Processes



Lecture : Introduction to Statistical Process Monitoring

Module : Course Introduction

Why do we need monitoring tools?



*Typical Chemical Plant (Tennessee Eastman Process)**

- A typical modern chemical plant is complex and highly integrated
- Therefore, several avenues for things going wrong!

* Adapted from the original flowsheet by Gilberto Xavier (https://github.com/gmxavier/TEP-meets-LSTM) provided under Creative-Commons Attribution 4.0 International License (https://creativecommons.org/licenses/by/4.0/).

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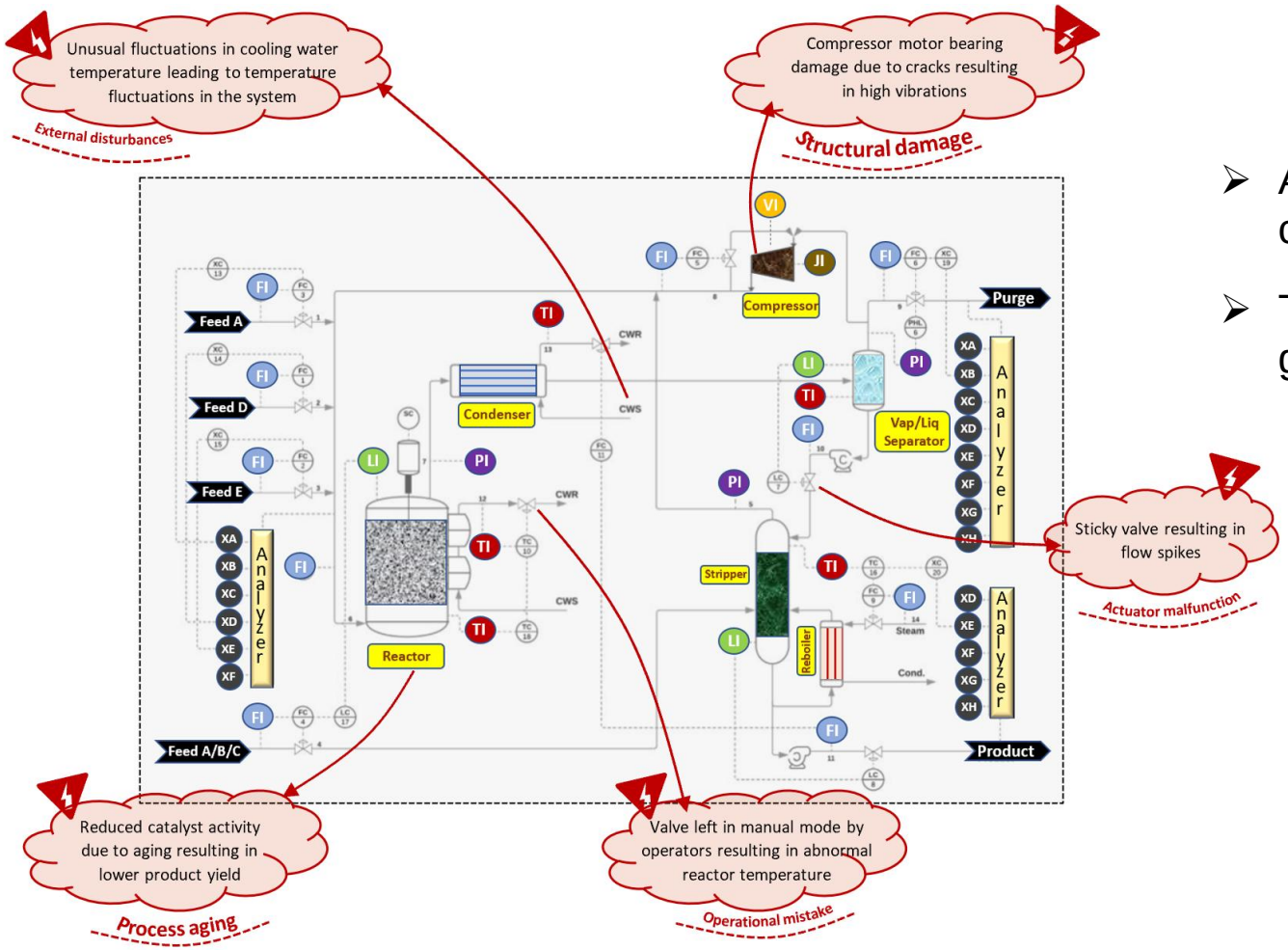

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Why do we need monitoring tools?

Consequences of failure in timely detection and correction of process faults can be severe

(2005) BP Texas City Refinery Explosion*

- 15 killed, 180 injured!
- Faulty level transmitter!

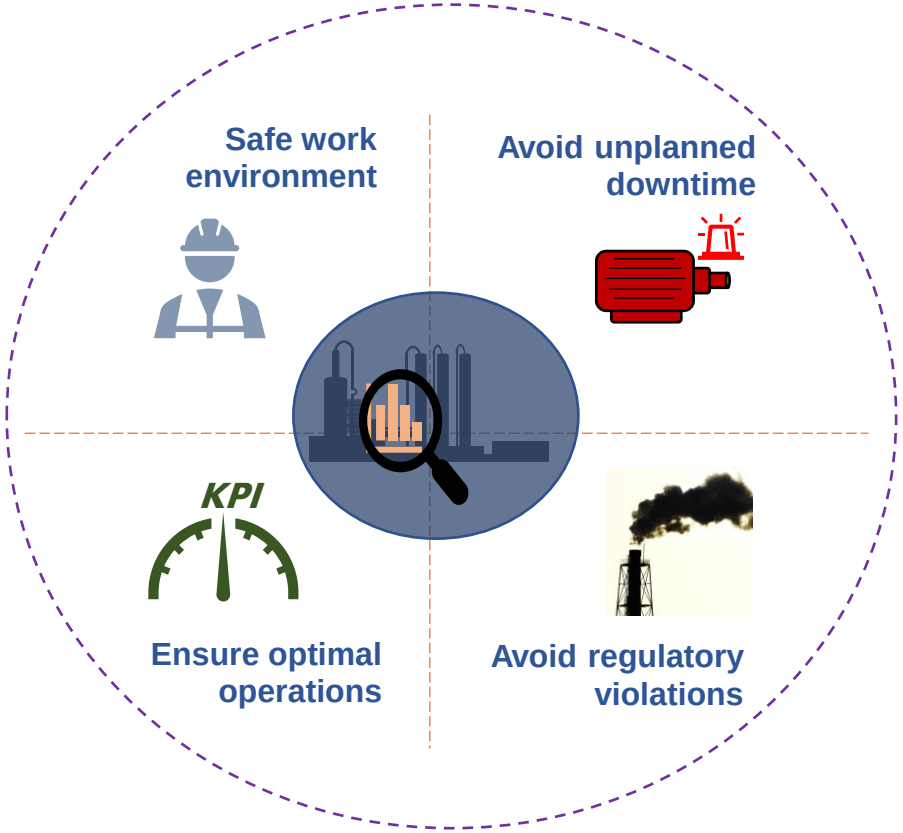
(2019) Philadelphia Energy Solutions Refinery Explosion*

- Huge economic loss!
- Leak from a corroded pipe!

* Provided in the reports provided by U.S. Chemical Safety and Hazard Investigation Board

Why do we need monitoring tools?

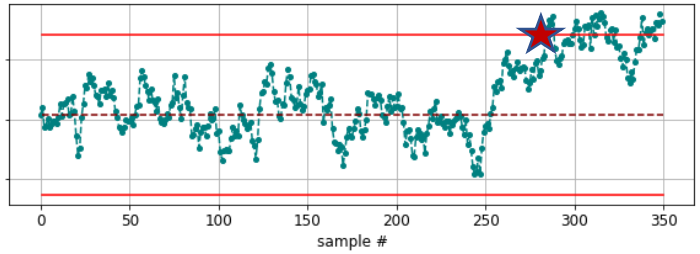
Use-cases of proactive plant monitoring



Process Monitoring: Status-quo in Industry

A typical plant control room*

- Critical variables (temperature, pressure, level, flow…) are compared against fixed (upper and lower) thresholds



!! However, this is not sufficient !!

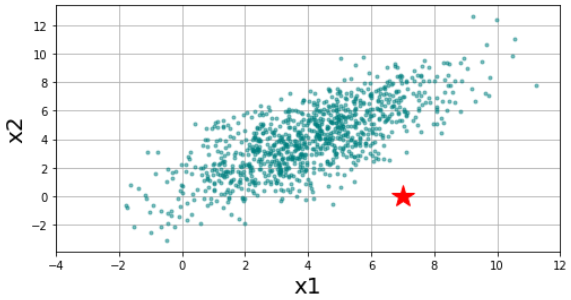
- Plants don't operate around a single fixed point
- Plant load (and other variables) changes due to changing external environment (product demand, etc.)
- Plant operators cannot manually be on the look out for small deviations all the time!

  ⇒ incipient abnormal deviations may go unnoticed

* A power station control room. Picture shared under Creative-Commons Attribution-Share Alike 4.0 International License (https://creativecommons.org/licenses/by-sa/4.0/).

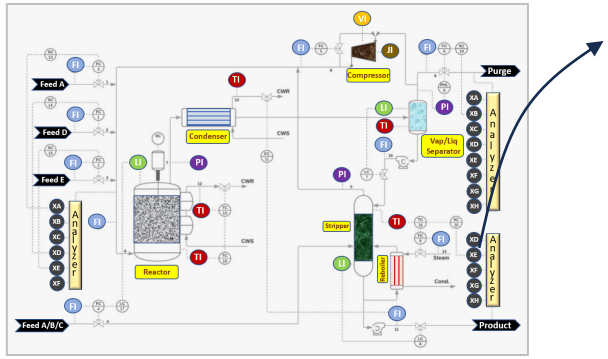
How SPM can help?

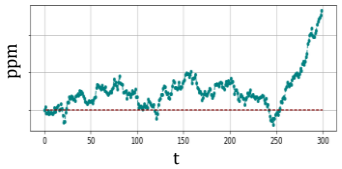
- Multivariate SPM takes into account the joint distribution of the process variables



- faulty sample does not violate the individual limits of x_1 and x_2 variables
- however, in the 2D plot, the abnormality becomes evident
- Monitoring values separately would have failed to catch the problem

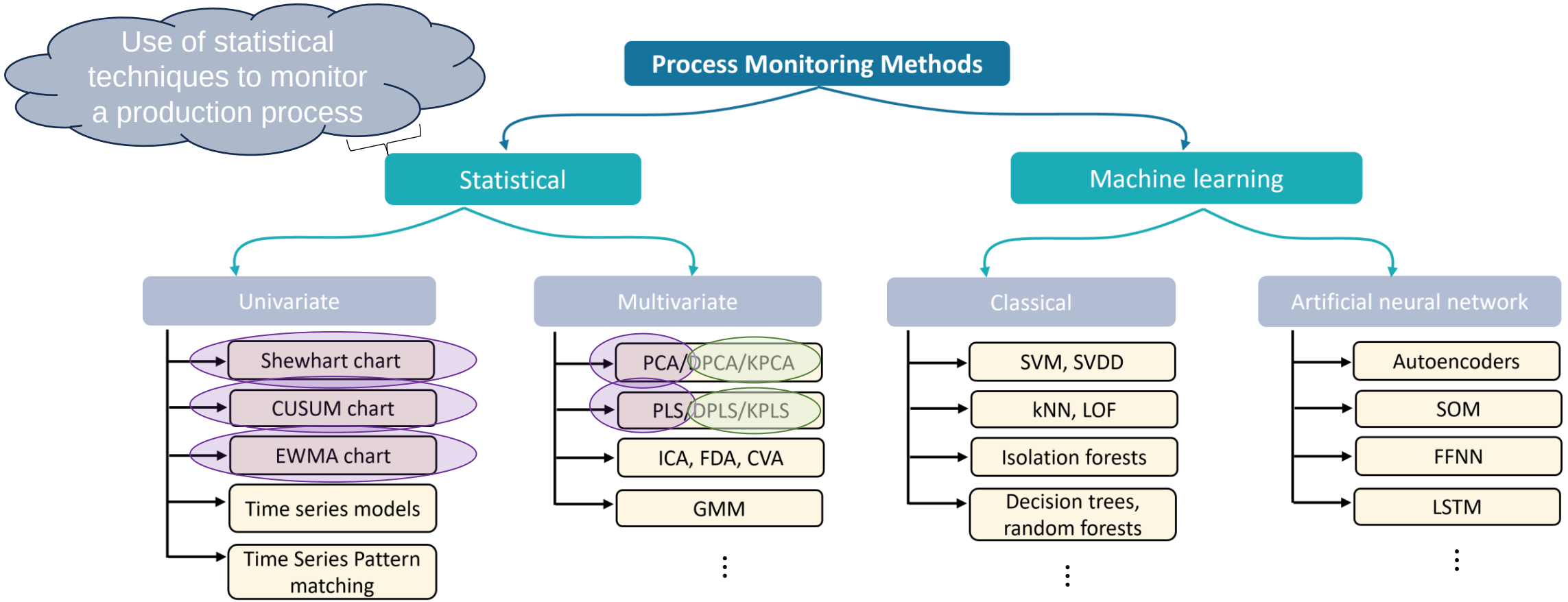
- SPM can analyze the correlation structure of process variables and help locate the 'troublesome' variables in case of process fault





- purity is drifting
- Which of the hundreds of process variables may be the leading causes of the purity issue?

SPM & the Process Monitoring Tools Landscape



SPM in the Deep-learning era?

Why study SPM when everyone is using artificial neural networks (ANNs) and deep learning for everything?

- SPM has been and will remain the bedrock of health monitoring for complex process plants
- SPM techniques are easy to implement and provide interpretable results
  - therefore, are widely popular
- Simple SPM models can provide as good, if not better, results as those from ANNs for most of the industrial systems

Statistical Techniques for Monitoring Industrial Processes

Next Lecture : Python Introduction & Installation

Module : Python Basics