Statistical Techniques for Monitoring Industrial Processes

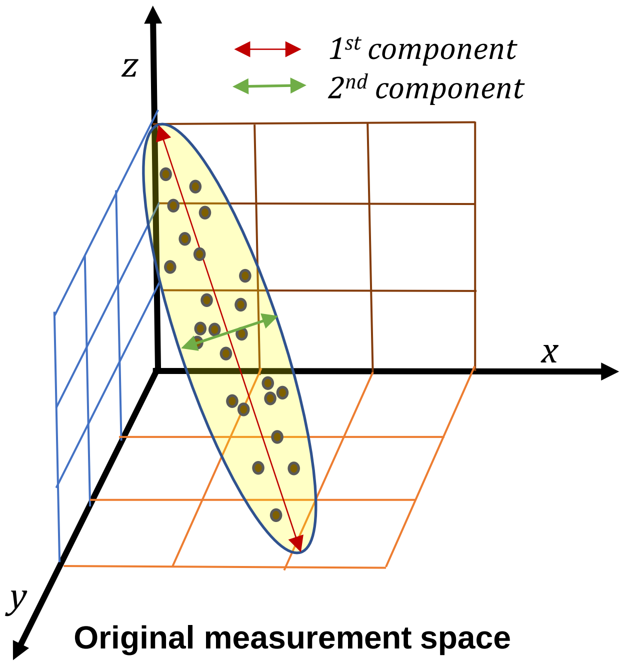
Lecture : Introduction to PCA

Module : PCA-based MSPM

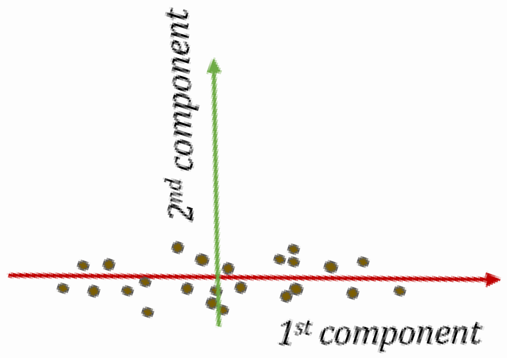
Course TOC

- ❑ Introduction to Statistical Process Monitoring (SPM)
- ❑ Python Installation and basics (optional)
- ❑ Univariate SPM & Control Charts
  - ➢ Shewhart Charts
  - ➢ CUSUM Charts
  - ➢ EWMA Charts
- ❑ Multivariate SPM
  - ➢ Principal Component Analysis (PCA)-based MSPM
    - ➢ Fault detection & diagnosis (FDD) using PCA
    - ➢ Application to a Polymer Manufacturing process
  - ➢ Partial Least Squares (PLS) regression-based MSPM
  - ➢ Strategies for handling nonlinear, dynamic, multimode systems
- ❑ Deploying SPM solutions

Introduction to PCA



Original measurement space

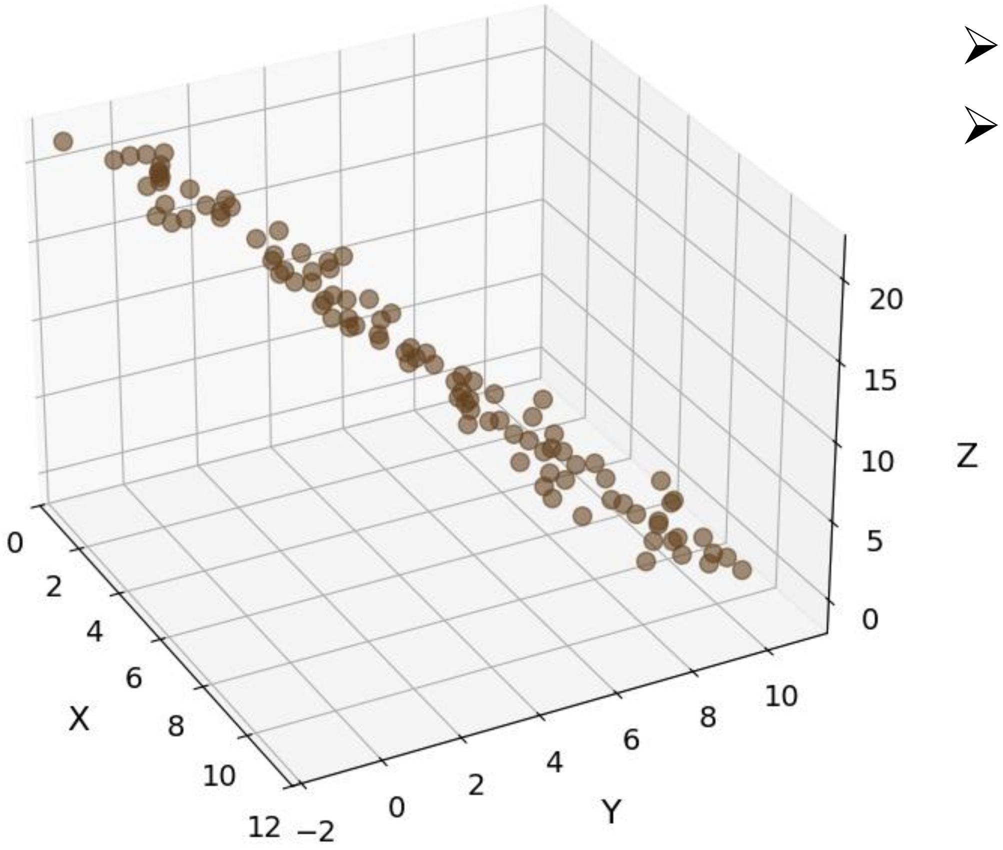


Latent variable space

- ❑ PCA is primarily a dimensionality reduction technique
- ❑ PCA separates variations in data into systematic variations and noise

PCA Implementation using Sklearn

Simple numerical dataset

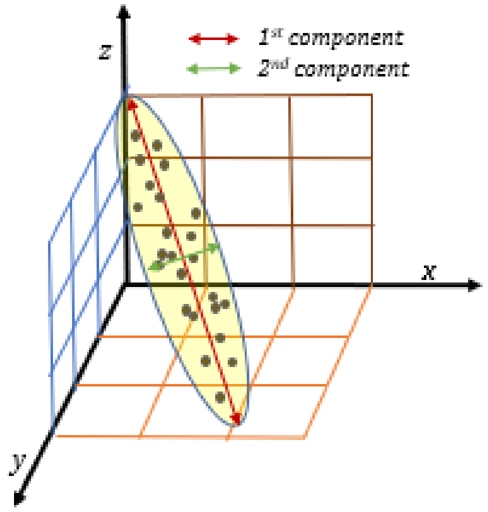


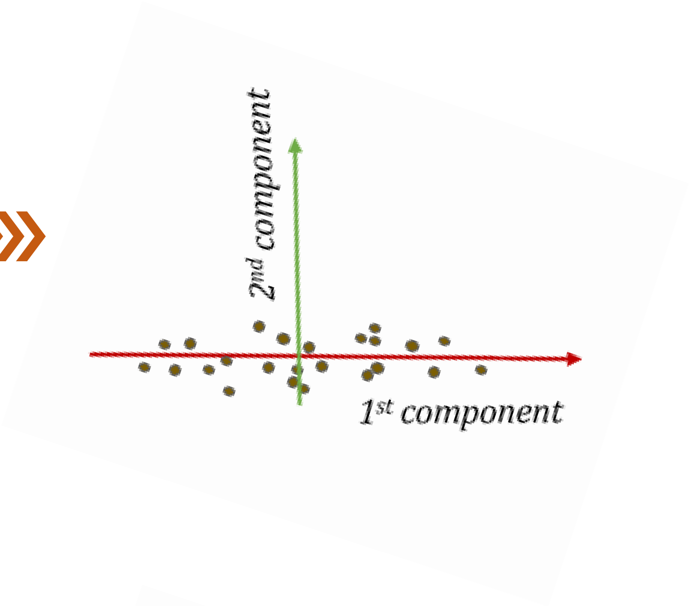
- Convert the 3D dataset to a 1D dataset
- Find the ‘line’ along which samples lie

PCA: Model Training and Deployment

Model training

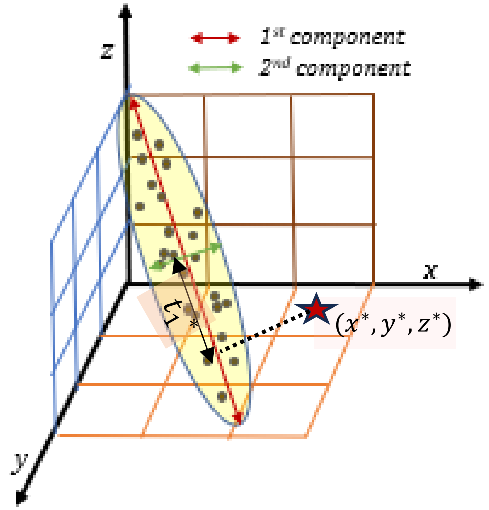
Finding the directions of the principal components (PCs)

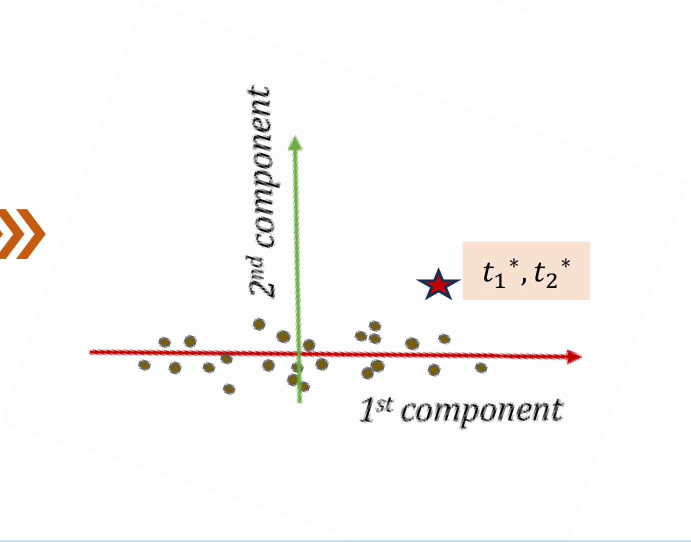




Model inference

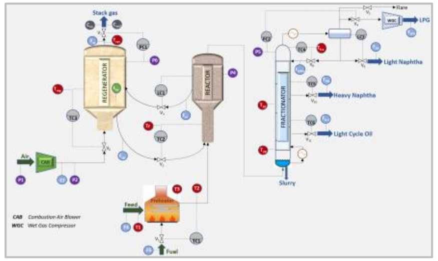
Projecting new sample onto the PCs and getting the transformed coordinates





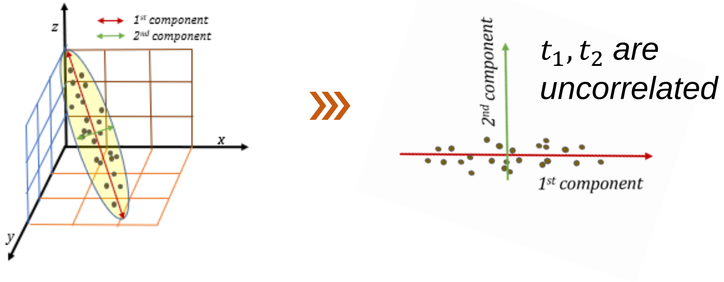
PCA: Why do we care?

- Typical modern process plant have hundreds of variables, but operate in lower dimensional space



variables are correlated

- Working with reduced dimensions is convenient



t_1, t_2 are uncorrelated

- PCA separates systematic variations from the noisy variations

$$\left[X \right] \ggg \left[\hat{X} \right] + \left[E \right]$$

only systematic variations *only noise*

Statistical Techniques for Monitoring Industrial Processes

Next Lecture : PCA – Under the Hood

Module : PCA-based MSPM