

Continuous Process Analytics

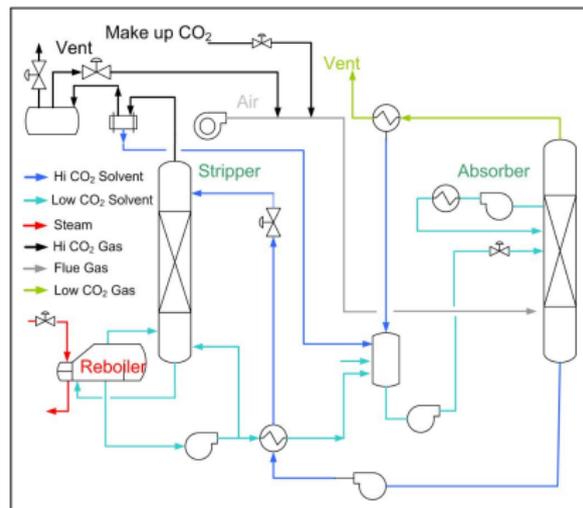
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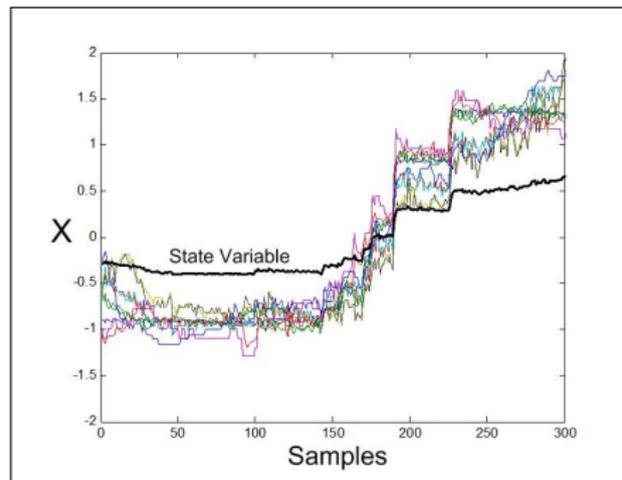
Multistate PCA: Motivation

- ▶ Multiway PCA has significantly enhanced process monitoring of batch processes.
- ▶ Continuous processes lack of an equivalent technology because of their flexible operations and undefined time duration.
- ▶ An example is the continuous CO₂ capture process.



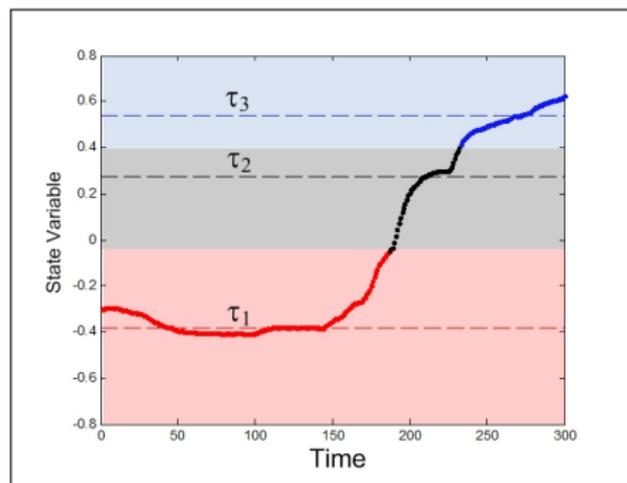
Multistate PCA: State Variable

- ▶ The definition of state variables allows to define modes of operation.
- ▶ State variables can represent physical measurements or empirical indexes.
- ▶ For the CO₂ capture process, one state variable is used to capture data variation.



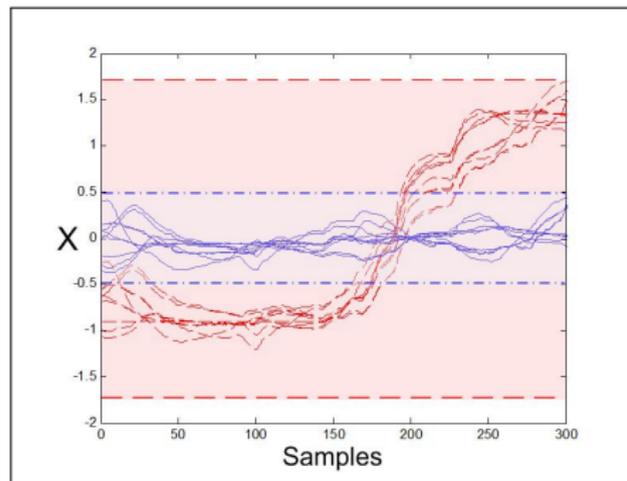
Multistate PCA: States of Operation

- ▶ States of operation represent the modes at which the process operates.
- ▶ Clustering techniques can be used to define such modes.
- ▶ The CO₂ capture process shows three modes, with most likely points of operation at τ_1 , τ_2 and τ_3 , respectively.



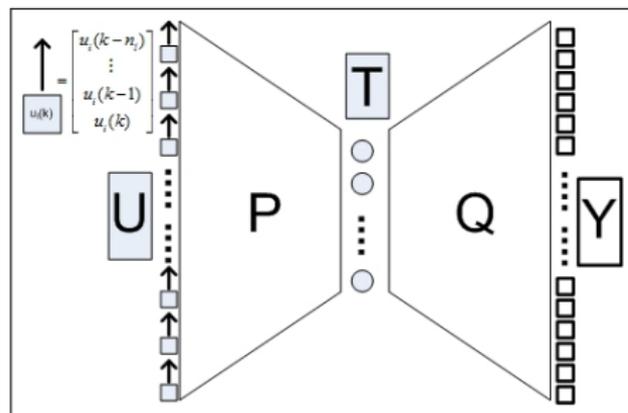
Multistate PCA: Process Monitoring

- ▶ States of operation allow to adjust data normalization for process monitoring.
- ▶ Confidence regions, data mean and variance are made state dependent.
- ▶ A compact confidence region for CO₂ capture data reduces the number of false alarms (blue).



Multistate PLS: Dynamic Data Filtering

- ▶ Multistate PLS is similar to Multistate PCA but it accounts for process inputs and outputs.
- ▶ Process dynamics are filtered to defined steady state modes of operation.
- ▶ Dynamic PLS is here used to filter process dynamics.



Multistate PLS: Scores and State Variables

- ▶ The scores (\bar{t}_1, \bar{t}_2) from Dynamic PLS are used as state variables.
- ▶ Modes of operation are determined by data clustering, with centroids τ_1 and τ_2 .
- ▶ Interpolation paths between cluster centroids are defined for process monitoring.

