

Principal Components in Parallel Coordinates

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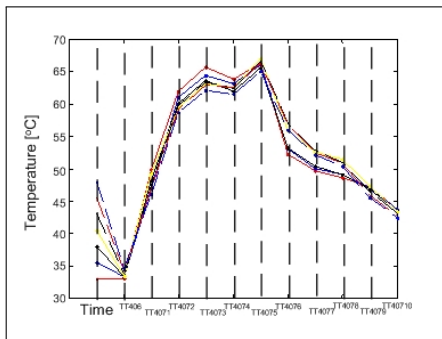
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Motivation

- ▶ In parallel coordinates the data points are represented by an unlimited number of adjoining parallel axes.
- ▶ This data visualization is suitable for process monitoring applications in industrial facilities where a significant number of sensors are used to detect and identify abnormal operating conditions.
- ▶ This work makes use of parallel coordinates with principal components for process monitoring, named PC².
- ▶ The capabilities of PC² to visualize, evaluate and compare faulty events are study in this research work.

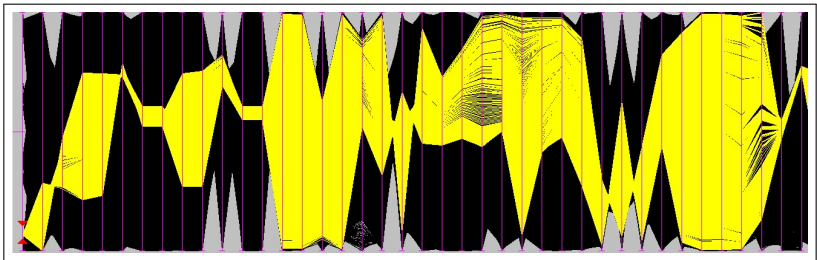
Parallel coordinates in process industry

- ▶ Parallel coordinates have been used to demonstrate temperature profiles in separation columns.
- ▶ Each polyline represents an operating point.



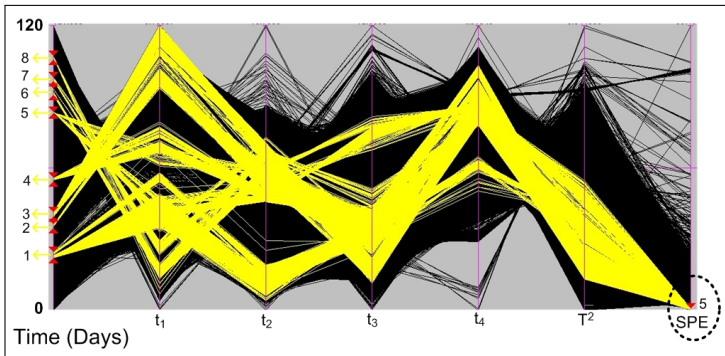
Parallel Coordinates Features and Issues

- ▶ Many sample points can clutter the plot. However, data that satisfy conditions can be highlighted (yellow).
- ▶ It is difficult to track all variables simultaneously, but data compression can reduce the number of axes.



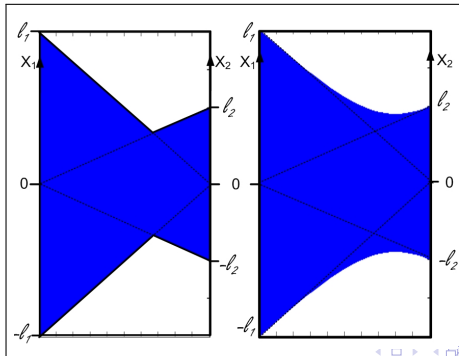
PCA model based on flooding data

- ▶ Eight flooding events in 120 days of operation.
- ▶ PC^2 with $SPE < 5$ highlighted in yellow.



Confidence Regions

- ▶ Multivariable linear constraints are represented by 'bowtie shaped' regions (left).
- ▶ Multivariable nonlinear constraints are represented by 'nozzle shaped' regions (right).



Parallel Coordinates allow:

- ▶ Simultaneous visualization of several faulty events of the same nature. In the example, all flooding events were visualized in one plot.
- ▶ Model comparison when using different number of principal components. SPE for different number of PCs can be visualized simultaneously.
- ▶ Fault detection and identification in the same plot. Hotelling T^2 , SPE and scores are visualized in the same plot.

