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Causal latent space-based models for scientific learning in Industry 4.0

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Causality is a fundamental concept in the scientific learning paradigm. For this purpose, deterministic models are always desirable, but they are often unfeasible due to the lack of knowledge. In such cases, empirical models fitted on process data can be used instead. Moreover, the advent of Industry 4.0 and the growing popularity of the Big Data movement have caused a recent shift in process data. In this context, data scientists typically use machine learning models for correlation and prediction, but these models often fail to identify the underlying causal relationships.

By contrast, latent variable-based models, such as Partial Least Squares (PLS), allow for the analysis of large datasets with highly correlated data. These models do not only analyze the relationship between input and output spaces but also provide models for both spaces, offering uniqueness and causality in the reduced latent space. However, causal interpretation in the latent space is restricted to changes that respect the correlation structure of these models. This work focuses on causal latent variable-based models to:

- define multivariate raw material specifications providing assurance of quality with a certain confidence level for the critical to quality attributes (CQAs). Besides, an effective process control system attenuating most raw material variations is implemented by manipulating process variables.
- develop a latent space-based multivariate capability index to rank raw material suppliers. The novelty of this new index is that it is defined in the latent space connecting the raw material properties with the CQAs.
- process optimization using historical data.

Type of presentation

Talk

Classification

Mainly methodology

Keywords

Multivariate Raw Material Specifications; Partial Least Squares Regression; Industry 4.0

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