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Learning more with less: Hybrid Models, Transfer Learning, and Calibration Designs for Efficient Knowledge Transfer in Industrial Settings

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Industrial process development often follows a repetitive pattern, relying on the same experimental approach for each new product, despite incorporating knowledge into process templates (e.g. in form of platform processes which are widely spread in the (bio)pharmaceutical industry). While risk analysis under the Quality by Design (QbD) paradigm enables some vertical knowledge transfer, capturing the functional process behavior remains a challenge. Current efforts to develop generic mechanistic models face limitations due to their rigid structure, prompting the integration of machine-learning approaches for improved variability handling. This contribution explores the application of transfer learning in hybrid models, utilizing dummy variables, embeddings, and meta learners to transfer knowledge between molecules. Additionally, we present the concept of calibration designs, demonstrating how experiments can efficiently uncover process behavior for new molecules. Finally, we emphasize the necessity of establishing a standardized, self-learning environment for all stakeholders to effectively leverage model-derived knowledge in process development and tech transfer.

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