AI-driven Optimization, Monitoring and Decision Support for Batch Plants

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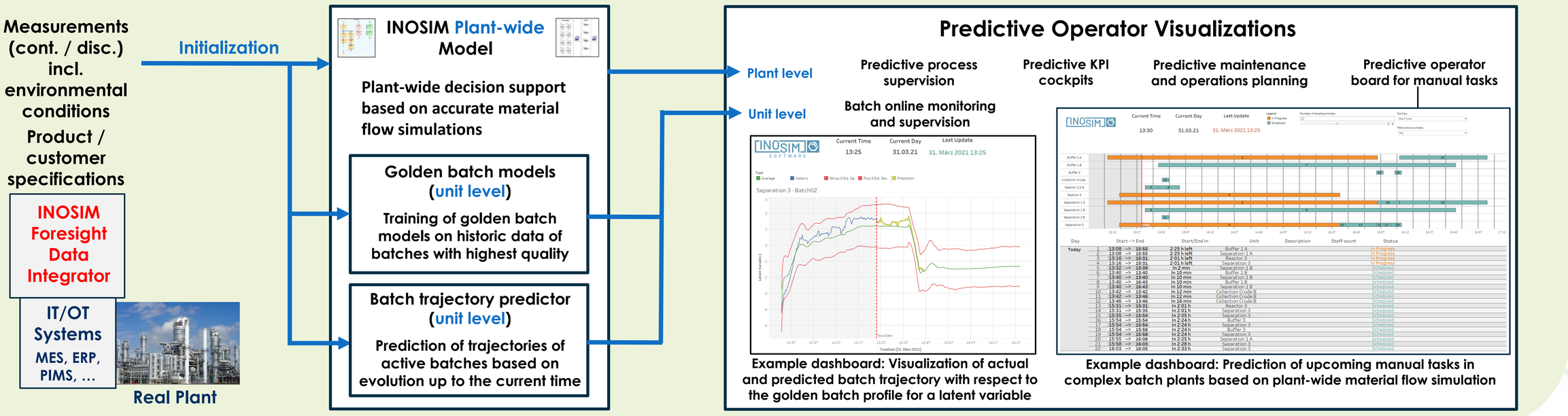
Motivation & Objective

- Modern batch plants are complex, “opaque” systems that are difficult to predict and to control
  - Lack of situational awareness of operations personnel
  - → **Decisions are often based on intuition, not on facts**
- Accurate real-time predictions and decision support are essential for operational efficiency and safety
- **Objective:** Harness the power of AI and material flow simulation to provide high-quality plant-wide and unit-wide **predictive decision support for batch plant operators**

Use Case

- **Plant description:** series of batch unit operations with multiple reaction and separation steps for a single product
- **Data characteristics:** historic time series data of batch runs covering years of operation
- **Challenges** are e.g.
  - Complex chemistry and process dynamics
  - Particularly strict product specifications
  - Application-based quality testing, results are hard to predict
  - Variety in targeted quality specs
- **Goal in KEEN**: Demonstration of the predictive decision support system on the real plant

The Decision Support System



Dynamic Model Identification for n-Step-Ahead Prediction

NARX-ANN:
Feedforward ANN on a moving horizon with state feedback

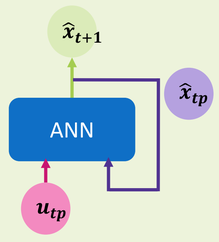
$$\hat{x}_{t+1} = f\,(\,u_{tp}\,,\,x_{tp}\,)$$

State predictions — Past inputs

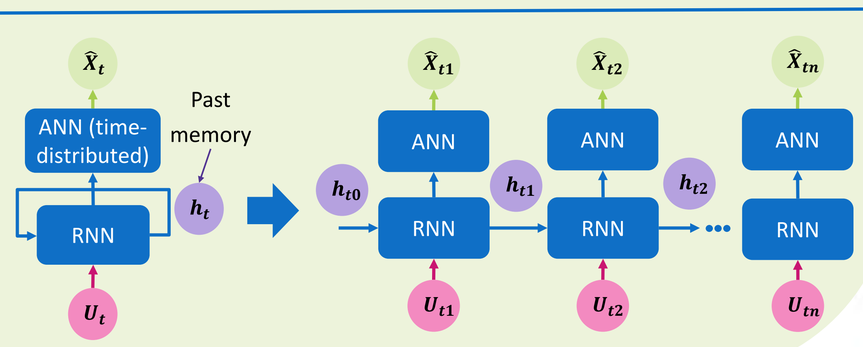
Series-parallel: Past true states
Parallel: Past predicted states

Series-parallel mode (training):

Parallel mode (prediction):

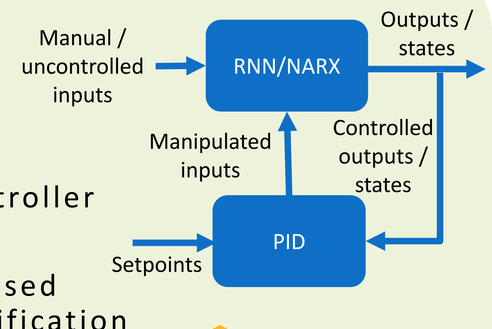


RNN:
Long-Short Term Memory cell [1] or Gated Recurrent Unit [2]



Next Steps

- **Modeling**
  - Optimize hyperparameters of the different models
  - Combine models with PID controller from the plant
  - **Goal:** Develop open-source-based tool for dynamic system identification



- **Decision support**
  - Model initialization and setup of IT/OT data architecture
  - Development of software for integration of model and AI components
  - Visualizations and scenarios for predictive decision support

[1] Hochreiter, S., & Schmidhuber, J. (1997). Long short-term memory. Neural computation, 9(8), 1735-1780.

[2] Cho, K., Merrienboer, van B., Bahdanau, D., Bengio, Y. (2014). On the Properties of Neural Machine Translation: Encoder-Decoder Approaches., Proceedings of SSST-8, Eighth Workshop on Syntax, Semantics and Structure in Statistical Translation, 103-111

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