Lehrstuhl Steuerung,
Regelung und Systemdynamik

Master Thesis

Programming

Model-free reinforcement learning-based modeling of consolidated bioprocessing

Keywords: bioethanol, reinforcement learning, microbial consortia

Conditions:

Duration:	6 months
Requirements:	MATLAB or Python knowledge (demonstrated)
Language:	English
Target group:	Master students

Contents:

In the context of bioprocess engineering, consolidated bioprocessing (CBP) is considered one of the most promising routes for the cost-effective production of biofuels and biochemicals. In CBP, enzyme production, cellulose hydrolysis, and fermentation are integrated into a single step, leading to higher efficiency but also introducing strongly nonlinear, dynamic, and coupled process behavior. Model-free reinforcement learning (RL) offers a data-driven alternative by learning system dynamics directly from process data without the need for explicit mechanistic equations. In this thesis, a reinforcement learning framework should be configured, trained, and optimized to simulate and model CBP dynamics.

First, suitable process variables must be identified by literature research and also method-oriented sensitivity tests. Simulation data and/or secondary experimental datasets must be organized and processed using appropriate feature extraction and normalization techniques. The implemented reinforcement learning-based framework must be trained on a well-defined reward function, such as maximizing product yield or productivity. Finally, the trained RL model must be verified by comparison with existing kinetic models or additional test cases.

The goals of this work are:

- Identification of key state and action variables relevant to CBP
- Preprocessing of process data using filtering and feature extraction methods
- Implementation and optimization of a model-free RL algorithm
- Adaptation and training of the RL agent to capture CBP dynamics
- Verification of the learned model against mechanistic models and/or test datasets
- Complete and detailed documentation/presentation of the research results

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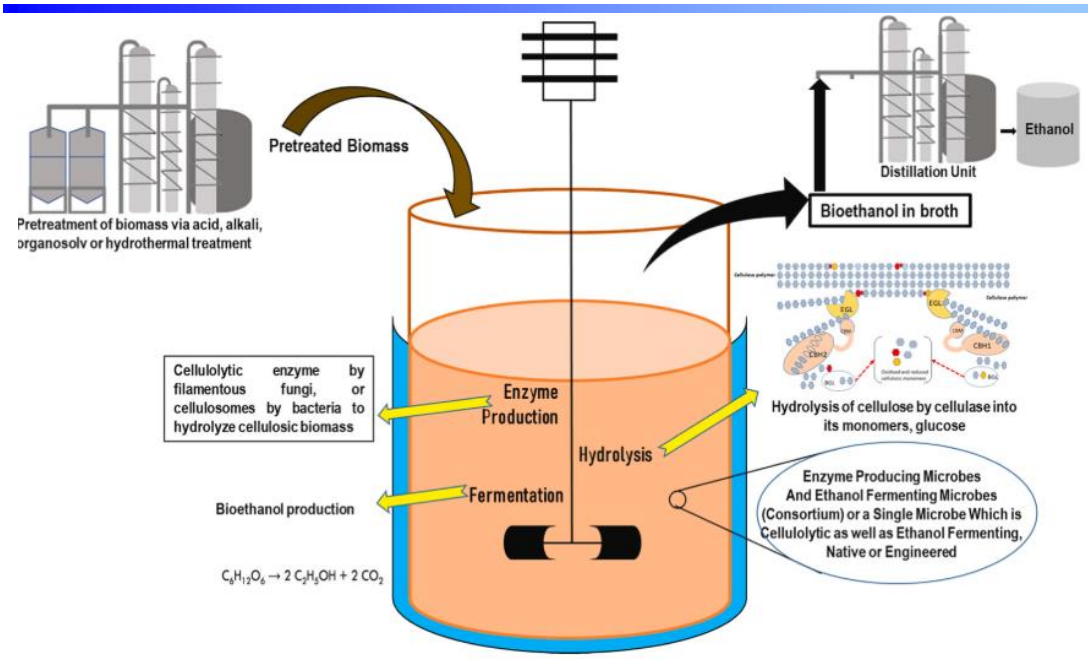

Figure 1: Consolidated bioprocessing for the production of bioethanol via a consortium (Singhania et al., 2022)

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