Implementation of an Industrial embedded MPC for a Lab-scale Bioreactor

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Abstract: Bioprocesses are inherently nonlinear, and highly sensitive to operating conditions, making advanced control strategies essential for stable and efficient operation. Conventional control approaches often face limitations in handling process constraints, strong variable interactions, and unmeasured process states in real-time bioreactor applications.
This work presents the implementation of an embedded Model Predictive Control (MPC) framework for a lab-scale fed-batch bioreactor system aimed at improving process monitoring and control performance.
The proposed framework combines an optimization-based MPC controller with an Extended Kalman Filter (EKF) for online state estimation. The controller utilizes real-time process measurements such as dissolved oxygen while manipulating variables including air flow rate, feed rate, and agitation speed. Since several critical biological states are not directly measurable, the EKF is employed to estimate unmeasured states from available sensor data, thereby improving process observability and enabling enhances control performance.
The control framework is implemented using an embedded C++ MPC library deployed on an industrial control platform suitable for real-time execution. The study focuses on evaluating the feasibility of embedded MPC for constrained bioprocess systems and investigating its effectiveness in dissolved oxygen regulation, disturbance rejection, and actuator constraint handling.
The presented work contributes toward the development of scalable and intelligent automation solutions for modern bioprocess industries, bridging the gap between advanced control theory and practical industrial bioreactor implementation.