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Automated Bioreactor Compartmentalization Using Unsupervised Machine Learning

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Digital Twins are essential in Bioprocessing 4.0 as virtual representations of bioprocess components. Existing coupling methods between Computational Fluid Dynamics (CFD) and biological models focus on simple metabolic approaches, resulting in complex simulations that strain high-performance computers.

We propose an automated compartmentalization approach for bioreactors using unsupervised machine learning and cellular metabolic state analysis, addressing limitations of prior techniques reliant on spatial discretization or 2-D compartmentalization and based on fluid flow characteristics. We also examine the optimal number of compartments for accurate bioreactor representation.

Our approach enables more complex metabolic models and reveals statistical trends in cellular performance through CFD and black-box model integration. This innovative solution advances Bioprocessing 4.0 by providing a precise understanding of the interplay between physical and biological systems in bioreactors.

This 250-word abstract showcases our groundbreaking work on bioreactor compartmentalization using machine learning and metabolic state analysis, contributing to the optimization and efficiency of bioprocessing techniques.

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