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FINITE-TIME CONTROL OF A BIOREACTOR SYSTEM USING TERMINAL SLIDING MODE

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Abstract. *In this paper, finite-time control technique is applied to a bioreactor process described by two first-order nonlinear differential equations. Based on terminal sliding mode control theory, a continuous finite-time controller is presented to make the substratum concentration track the reference signal in finite time. The tracking error can not only be controlled to the sliding manifold from any initial state in finite time but also converge to zero along the sliding manifold in finite time. The global finite-time stability of the tracking error system is rigorous proved. Simulation results are presented to validate the effectiveness of our method.*
Keywords: Bioreactor, Finite-time control, Terminal sliding mode, Nonlinear system

1. **Introduction.** It is known that a bioreactor system is difficult to control due to its high nonlinear dynamical behavior. Nonlinearities may be intrinsic to the process and complicated differential equations are used to describe the system dynamics. Although few states are involved in the plant model, the complexity of a bioreactor usually does not permit classic linear controllers to provide good performance for the closed loop system [23]. Thus, advanced control approaches are developed for the bioreactor system.

Most control strategies of the bioreactor are based on mechanism model. Linear models are used in [11, 22, 24]. An H-infinity robust controller is designed in [11] for the linear model with bounded parameter variations. A two degree of freedom controller design based on a linear parameter varying model is proposed in [22]. The control structure consists of an analytic inversion of the plant and a gain scheduling controller. In [24], multiple-input-multiple-output (MIMO) control is implemented by internal model principle. Although such approaches can be applied for controlling nonlinear processes by obtaining a linearized model, this is only valid in a limited region.

Generally nonlinear model of the bioreactor is directly used to design the controller. On one case, two first-order nonlinear differential equations are used to describe the bioreactor processes [15, 16, 26, 33, 34]. One is for the biomass state and the other is for the substrate concentrations state. In [34] the problems of set point change and disturbance rejection are considered. Sliding mode control is developed with intervals of process parameters and output variable which is the only on-line measurement variable. In [26], intervals of process parameters and disturbance are not needed. In [16], a continuous feedback control law is constructed to asymptotically stabilize the uncertain system to