

Fuzzy Modelling of S-Type Microbial Growth Model for Ethanol Fermentation Process and the Optimal Control Using Simulink

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Abstract. In this work, the fuzzy modelling of S(ubstrate)-type microbial growth model for ethanol fermentation process is built using the sector nonlinearity of Takagi-Sugeno (T-S) fuzzy system. The optimal control for the T-S fuzzy system is obtained using simulink. The motivation is to provide the optimal control by the solutions of the matrix Riccati differential equation (MRDE) obtained from an alternative approach. Accuracy of the solution of the simulink approach to the problem is qualitatively better. An illustrative numerical example is presented for the proposed method.

Keywords: Fuzzy modelling, Ethanol Fermentation process, Optimal control, Simulink.

1 Introduction

Fuzzy logic has shown to be the most suitable tools to represent biological system, analyzing biological data and capturing different uncertainties in biomedical and computational biology [1-3]. The potential of fuzzy control for biological processes was first recognized in the fermentation industry [1, 3] thus, in this work, the nonlinearity sector of T-S fuzzy model is used for representing the S-type microbial growth model for ethanol fermentation process. The S-type model assumed that (i) a linear relation is appropriate to describe the influence of substrate depletion on the microbial growth, (ii) there is no substrate consumption for maintenance, (iii) there is no substrate breakdown in the medium, (iv) no additional substrate is added during the growth process and (v) there is only one limiting substrate. The details of the S-type model can be found in Ref [4]. In the T-S fuzzy model, there are two types of T-S fuzzy structures which are denoted as affine and linear T-S fuzzy system. The affine T-S fuzzy system is also called as the nonlinear part. Both demonstrate to be universal approximations to any nonlinear systems [5, 6]. The only difference between these two structures lies within the existence of a constant singleton in the fuzzy rule consequence for the affine T-S fuzzy model.