A NEURAL NETWORK BASED MODELING APPROACH TO PROCESS OPERATION AT LOW COST

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ABSTRACT

The use of dynamic process models is predominant for control and decision-making in industrial processes. The development of advanced approaches to construct accurate dynamic models is crucial to design high-performance industrial automation systems. These approaches usually require detailed process knowledge, while incomplete or incorrect knowledge may result in a significant discrepancy between the real process dynamics and the estimated models. A black-box approach is convenient for model development, but it usually gives a dynamic model that cannot be interpreted physically, requires excessive amounts of process data, and may not give accurate enough results. In this work, we present a modeling framework suitable to develop a dynamic model for complex nonlinear processes. The approach combines fundamental knowledge to formulate a model structure and use of recurrent neural networks (NNs) to approximate complex functions in the model that may not be easily parameterized.

The effectiveness of the proposed methodology is investigated in a common pasteurization process [1]. The manipulated input variable is the flow rate of the raw material, and the output variables are the flow rates of utility streams and product quality. Using a simulated time series of these process variables, the parameters of physics-informed NNs are calculated by minimizing an error function, through an iterative training process, with the use of the PyTorch open-source library [2]. The trained NNs are then capable of predicting the required utility streams, as well as the inactivation kinetics of microorganisms and destruction of product components.

Finally, the developed dynamic model, with enough physical insight of the process, was further investigated in the steady-state operational economic optimization of the pasteurization process. To that end, an optimization function was defined by the economic cost which considers supply of raw materials, selling price of the product based on its quality, and operational costs. We demonstrated the efficacy of this modeling framework to develop dynamic models with accurate steady-state economic predictions, from a relatively small and easily obtainable dataset.

KEYWORDS: Neural Networks, Process Model, Data-Driven Modeling, Cost Optimization

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