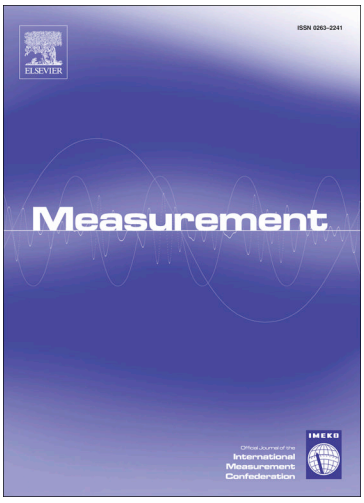

Integrated Soft Sensor with Wavelet Neural Network and Adaptive Weighted Fusion for Water Quality Estimation in Wastewater Treatment Process

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Integrated Soft Sensor with Wavelet Neural Network and Adaptive Weighted Fusion for Water Quality Estimation in Wastewater Treatment Process

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Abstract: It is difficult to estimate the water quality of the wastewater treatment process, because the operating conditions are frequently changed. This paper gives an effective adaptive estimation method, which uses Hammerstein with wavelet neural networks, adaptive weighted fusion, and approximate linear dependence (ALD) analysis. Adaptive stable learning algorithm for the local Hammerstein with wavelet neural networks is proposed. A novel synchronous learning of fusion weighs is discussed. On-line calibration of operating centers with ALD improves the estimation accuracy. The experimental results show that the proposed estimation method for the water quality COD (Chemical Oxygen Demand) is satisfied compared with the laboratory results even when the operating conditions are changed frequently.

Keywords: wastewater treatment process; soft sensor; Chemical Oxygen Demand; stable learning

1 Introduction

The progresses of urbanization and industrialization lead to the increases of municipal sewage and industrial wastewater. Due to the monitoring lag of water quality and low automation level, existing wastewater treatment plants (WWTPs) are difficult to be maintained in stable operation in the case that influent water qualities are frequently varying. One of the main reasons is the lack of on-line sensors in WWTP to monitor the water qualities, so it is difficult to realize close-loop control effectively. Therefore, on-line method to measure water quality is urgently needed.

Soft sensor of key water quality built according to process characteristics, process data and operating point has been paid much attention so far. Existing soft sensor of water quality include: empirical model (Wang et al. 2006), mechanism model of activated sludge process (Leith et al. 2000; Smets et al. 2003), data-driven model (Jérôme and Gujer, 2012; Krueger et al. 2015), hybrid model (Lee et al. 2005; Cong et al. 2015). Data-driven soft sensor of water quality can achieve high prediction performance without complex mechanism of activated sludge process, since rich process information is extracted from operational data. Qin et al. (2012) built a wastewater quality monitoring system incorporating measuring instruments and Boosting-Iterative Predictor Weighting-Partial Least Squares (Boosting-IPW-PLS), the monitoring system can be used for online monitoring of water quality, but the authors pointed out the highly fluctuating background definitely weaken the predictive ability of the weak learners, as well as the Boosting model. Nevertheless, WWTP is complicated biochemical process with strong nonlinearity, uncertainty, time-varying characteristics and large lag, so biochemical reaction rates of the microorganisms and the parameters are varying with operating conditions nonlinearly under the circumstance that influent load fluctuates affected by various factors such as weather, temperature and residential habits. The performance of above methods will deteriorate when influent load fluctuates and