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# A sensor-software based on a genetic algorithm-based neural fuzzy system for modeling and simulating a wastewater treatment process

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ABSTRACT

In this paper, a software sensor based on a genetic algorithm-based neural fuzzy system (GA-NFS) was proposed for real-time estimation of nutrient concentrations in a biological wastewater treatment process. In order to improve the network performance, self-adapted fuzzy c-means clustering algorithm and genetic algorithm were employed to extract and optimize the structure of the network. The GA-NFS was applied to a biological wastewater treatment process for nutrient removal. The simulative results indicate that the learning and generalization ability of the model performed well and also worked well for normal batch i.e., two data points. Real-time estimation of COD, $NO_3^-$ and $PO_4^{3-}$ concentration based on GA-NFS functioned effectively with the simple on-line information on the anoxic/oxic system.



## 1. Introduction

Owning to increasingly stringent requirements on effluent quality, monitoring and controlling the wastewater treatment processes have become very significance and essential in facilitating operations, and saving manpower and energy [1,2]. On-line sensors include important information from the state of the plant, so it can be utilized by plant operators to apply real-time control strategies and optimize process performance. However, due to the lack of suitable on-line sensors for monitoring key variables of the process, such as nitrogen concentrations, phosphorus concentrations and chemical oxygen demand (COD), the effective monitoring and control for the effluent quality especially is hampered in biological wastewater treatment [3]. Although these concentrations can be measured by laboratory analysis, it is usually unavoidable that there is a significant time delay which ranges from minutes to hours. In the light of influent fluctuation and other disturbances, it is too late to come out these results usually to achieve a well-timed adaptive process control, especially for advanced wastewater treatment which requires more precise and timely controls. Hence, in order to overcome these problems, it's necessary to develop software sensors to estimate hard-to-measure process variables from other on-line measurable process variables [1].

Intelligent techniques have been proven to be able to approach nonlinear systems and applied to modeling various non-linear processes [4]. The most significant advantage of intelligent technique is that the intelligent technique does not need precise mathematical model and it can well approximate any nonlinear continuous function and overcome shortcomings of the traditional control which depends on an accurate mathematical model. Recently, it became popular that the neural network (NN) was applied to modeling the biological wastewater treatment process [5]. NN can map a set of input patterns onto a corresponding set of output patterns after learning a series of past processing data from a given system. Furthermore, a NN model has a distinctive ability of figuring out non-linear functional relationships without modeling the structural knowledge of the process. There are several successful software sensors based on the NN approach [6,7]. According to Yilmaz et al., a novel approach based on the NN model has been developed to provide better predictions of the effluent COD in upflow anaerobic filter (UAF) reactor [8]. Moreover, Curteanu et al. reported a neural-networks-based optimization technique for modeling the electrolysis process in wastewater treatment [9]. The

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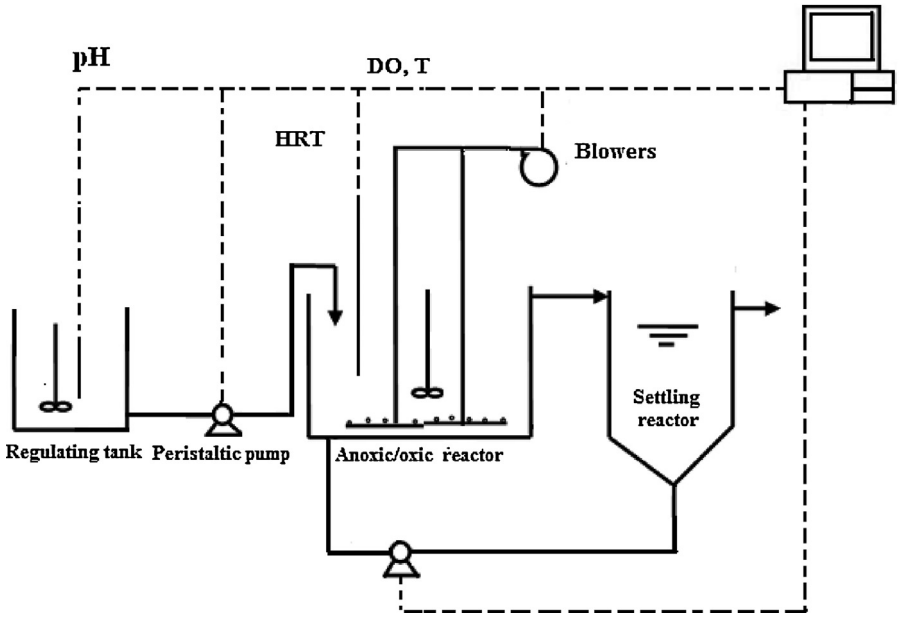


**Fig. 1.** Diagram of the anoxic/oxic reactor system.

simulation results illustrated that the NN, as a function of initial characteristics (initial values of *chlorophyll a*, total suspended solids and COD) and operation conditions (temperature, electric power, time, electrode distance, and electrode type), can facilitate accurate predictions of a treated waste's main system outputs.

Although some NN-based software sensors were designed successfully, NN schemes still have several limitations which are caused by the possibility of getting trapped in local minimum and the choice of model architecture. If the performance can be further enhanced, better operation strategies will follow. To

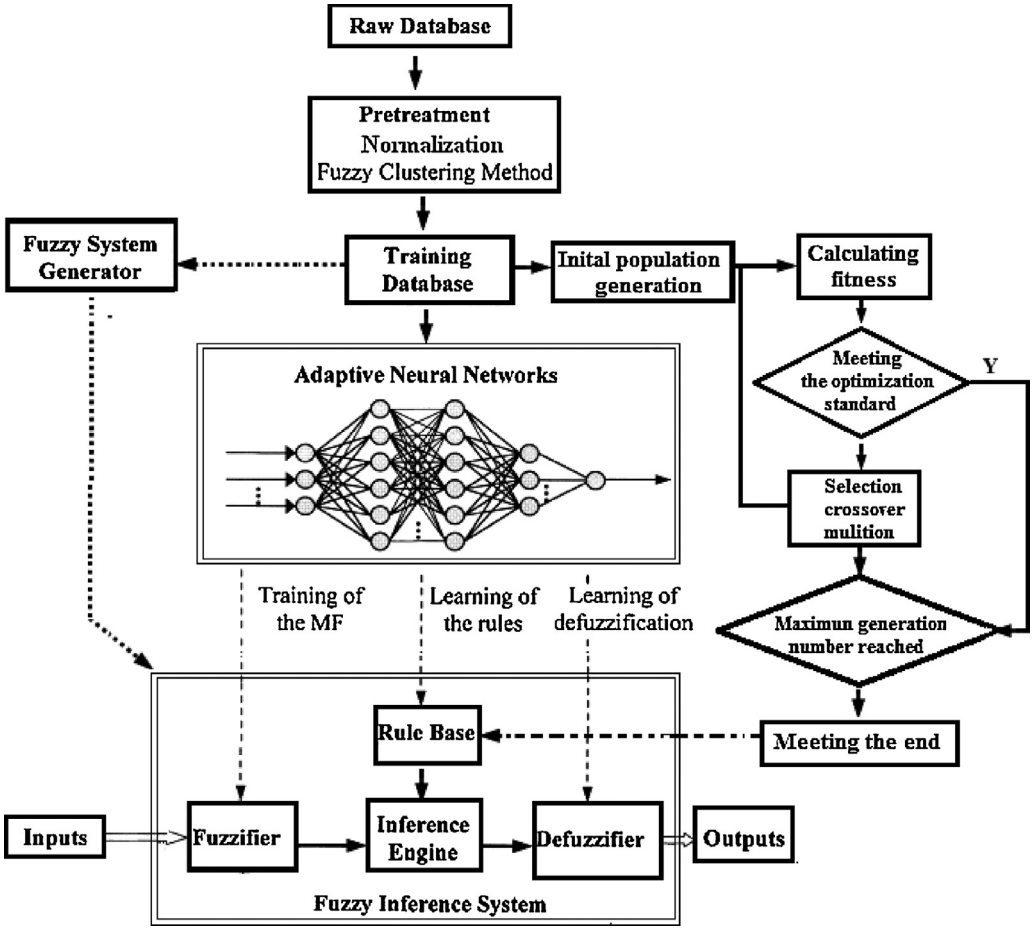


**Fig. 2.** Architecture of the GA-NFS model for anoxic/oxic process.