Application of Neurogenetic Modeling in Optimization of Water Treatment Plant Based on the Temporal Monitoring of Water Input Quality

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ABSTRACT

This article addresses methods to adjust operating requirements in water treatment plants (WTPs) in order to increase the efficiency of water treatment plants based on the nature of the water inflows into the systems. In the past, various studies have suggested that the quality of water inflow into the WTP has an impact on the efficiency and economic viability of operating treatment plants. Among all other quality parameters, the concentration of dissolved oxygen (DO) is one of the basic indicators about the overall quality of the water. Identification of a temporal pattern can help the engineers to adapt the WTP operations and can save the unnecessary wasting of plant resources. That is why the present article has proposed a new model that can predict the temporal patterns of various chemical parameters with the help of an analytic neuronal network. The model was applied to the case of a WTP that responds to a peri-urban catchment, leading to regular variations in the DO of water inflow. According to the performance metrics utilized the model was able to predict the temporal pattern at a lag of 1 hour.

KEYWORDS

Analytic Neuronal Networks, Optimization, Water energy nexus, Water treatment

INTRODUCTION

Surface Water Treatment Plants (SWTP) are an integral part of the socio-economical development of a region. They play a vital role in maintaining public health and sanitation at the required levels and also support industries varying from agriculture to service provision. In effect water treatment plants are responsible for maintaining the basic requirement of life and health security of the society.

A major challenge that SWTPs face is the water quality dynamic that exists within the different phases of water treatment. The changes in concentration of different quality parameters often require engineers to adjust the dosing requirements. If a change in the incoming water quality remain unnoticed then possibility of health hazards in the supplied region is hard to avoid.

Naturally found water is frequently not pure water and contains many dissolved and suspended impurities, derived from the atmosphere, from catchment areas as well as from the soil. Hydrogen Sulphide, oxygen, ammonia, sodium and calcium carbonates (dissolved impurities) as well as clay, silt, sand, mud and microscopic plants (suspended) are some of the commonly found impurities of water. The most hazardous water pollution is caused by urbanization and industrialization. Industrial waste contains toxic agents ranging from metallic salts to complex synthetic organic chemicals. Whenever

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the water is polluted by these things, it creates serious health complications to animals, plants and human beings living in surrounding areas. In addition to changes in industrial patterns this temporal variation in the form of the monsoon also effects water quality by changing the volume of water in input sources. Daily variation in water quality is also seen owing to domestic consumption patterns.

Background
This study will focus on the dissolved oxygen (DO) parameter which is a term used to indicate the alkalinity or acidity of a substance as ranked on a scale from 1.0 to 14.0, where the acidity increases as the DO value gets lower. A summary of studies that identify its importance in water treatment systems is outlined in Table 1.

MAIN FOCUS OF THE ARTICLE
Study Objective
The objective of the present study was to develop a new model for the prediction of temporal variation of the chemical parameters like concentration of DO. In this regard a single input single output (SISO) model was developed to predict the concentration of the parameter after twenty-four hours from the time when input data was taken.

The novelty of the model includes cascading time-lagged output that helps to predict the concentration of any water quality parameter from 1 hour to 24 hours after the initial or actual data is sampled. The output of each sub model is used as the input of the next sub model. Owing to this cascading nature the use of only one set of data actually helped in obtaining specific time values to predict the output after 24 hours (maximum).

Methods Adopted
The study utilized the flexibility and adaptability of neural networks to develop the model. A brief description about Artificial Neural Network (ANN) is given in the next section along with strength and weakness of the method.

Artificial Neural Network
The artificial neural network (ANN) in the present days is widely used for solution of complex nonlinear and parallel problems of prediction and optimization. The neural network technology of signal processing mimics the same way the human nervous system functions while processing an input signal. In nature, a network of nerve cells connected by synapses that exist in between axon and dendrons communicate with the help of transmitter substances and process signals generated from different input stimuli. Based on knowledge and previous experience, stimuli are answered in the most optimal manner known to the system.

The signal processing in the ANN follows similar principles, in that the inherent nonlinearity that exists between the input and output variables are learned from the existing data of the input and output and changes in the weights assigned to each of the input connections. The weight change is proportional to the reduction of model errors that is represented by the difference between the actual and predicted data.

Within ANN models therefore, the selection of activation functions and the numbers of hidden interim processing layers is also subject to trial and error for selection of the optimal methodology. In effect, the activation function of the weighted average of the input connections is the output predicted by the neural networks. This function can be sinusoidal, tanh, sigmoidal, gaussian etc. Different activation functions perform differently for various problems. This is why a selection of suitable activation functions is also an important factor when considering the optimal performance of a neural model.
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