

ARTIFICIAL INTELLIGENCE, DATA MINING, ARTIFICIAL NEURAL NETWORK AND SWARMS OF PARTICLES IN WATER MANAGEMENT

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ABSTRACT

This manuscript exposes the essential considerations in water management of the applicability of data mining, artificial neural network and swarm of particles techniques, as an input for prediction and planning in the management, using artificial intelligence.

Keywords: Artificial intelligence, management, water

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1. INTRODUCTION

There is the conception of explaining a conceptual abstraction of reality or interpretation of reality (Maldonado, 2010), through the formulation, evaluation and application of mathematical models. There is a variety in the types of models and their classifications, among these can we mentioned the heuristic models (based on explanations of the causes), empirical (based on direct observations), deterministic (depending on cause-effect relationship, without considering the possibility of response with uncertainty of realization), stochastic (considers the random nature of some characteristics of the process being modeled, in which uncertainty is taken into account), agglutinated (the characteristics of the control

volume are considered, that is, concentrated in one point), distributed (it has a spatial variation of the domain characteristics, parameters and process variables) (Dominguez, 2000; Refsgaard, 1996; Fernández, 1997), management or collaborative (identifies the information to be used and the resources involved for making-decision), in this last type of model, two or more decision makers are involved, to the representation of a specific reality that you want to model, for making decision according to the objective function, data, indexes, sets and restrictions (Alarcón, 2009). The foregoing leads to a simplification in some cases of the real system or of the problem analyzed, which can be represented in a linear or gaussian way (Gaussian distribution) with analytical resolution or numerical methods, that is, a reduction in the behavior of a phenomenon, patterns or system behavior. The objective of this manuscript is to establish an analysis of the data mining, artificial neural network and swarm of particles techniques in water management, as an input in the ordering for prediction and planning.

2. DEVELOPING

2.1. Data Mining Applied to Water Management

Data Mining or discovery knowledge in databases, consists of extracting information from the data, giving them meaning and drawing useful conclusions from them, by describing patterns in large data sets provided, to find intelligible models from them. Among the different fields, the search for missing parameters and parameter estimation is considered (Ssali, 2008). This computational technique can cover various areas of knowledge where there is a way to acquire a determine data or database which can be conducted studies of different types (Zhun, 2016) with the aim of obtaining relationship or prediction of one or several variables of the data available. Many models describe the behavior of different physical phenomena that require complicated calculations and are not adaptive models (Chapra, 1987; Chapra S, 2008)], however with data mining, relevant information necessary to estimate missing data can be obtained and of course approximate the knowledge and behavior of the natural phenomena analyzed.

This technique is an approximation method where there are no mathematical equations, however the uncertainties and complications of the model are included in the procedure of descriptive diffuse inference. The applications of techniques are usually in the modeling of surface and groundwater quality, estimation of water quality through satellite images, earthquake prediction, prediction of the levels of a basin (Bonansea, 2015; Harvey, 2015), recognition of water quality patterns and sustainable use of water, identification of ecosystem functioning models, improvement management and control of wastewater treatment plants, urban planning.

2.2. Artificial Neural Network Applied to Water Management

The Artificial Neuronal Network (ANN) was the technique use to assess the environmental quality of the Bogotá River. This technique has different training algorithms such as Backpropagation, Newton, Levenberg Marquardt (LM), among others, the most common and used is BackPropagation; but in the case of the present investigation the better results were obtained with Levenberg Marquardt (LM). LM artificial neural network is a feed -forward neural network. This network is composed of individual processing elements called neurons that resemble brain neurons (Zhou, Zhang, Yuan, & Liu, 2008). The model of each neuron can be represented as $A = F(WP + b)$ where $W = [w_{1,1}, w_{1,2}, \dots, w_{1,R}]$ y $P = [p_1, p_2, \dots, p_R]$, the vector P are the inputs, W is the vector of the weights of each input, the parameters $w_{1,R}$ and b are adaptive (Zhu & Hao, 2009). Each neuron adds the weighted inputs and then applies a linear or non-linear function to the resulting sum to determine the outputs, among the most used functions are the step, sigmoid and ramp function (Cano, Alfredo, & Estéfano, 2012).

Neurons are layered and combined through excessive connectivity. This allows the specification of multiple input criteria and the generation of multiple output recommendations (Zhou, Zhang, Yuan, & Liu, 2008). The Levenberg-Marquardt (LM) algorithm is a non-linear optimization algorithm based on the use of second-order derivatives (Cano, Alfredo, & Estéfano, 2012). The LM algorithm finds the minimum of the function $F(x)$ which is a sum of squares of nonlinear functions.

$$F(x) = \frac{1}{2} \sum_{i=1}^m [f_i(x)]^2 \quad (1)$$

Take the Jacobian of $f_i(x)$ which is called as $J_i(x)$, so the Levenberg-Marquardt method looks for the solution of P given by the equation

$$(J_k^T J_k + \lambda_k I) P_k = -J_k f_k \quad (2)$$

where λ_k are non - negative scalar and I is the identity matrix (Gill, Murray, & Wright and 1981) .

The Artificial Neural Networks (ANN), as an artificial intelligence technique, has worked on the centralized cooling of ice water, prediction of water consumption and river flows, in the assessment of the quality of drinking water, in the control of processes of water treatment, management of wastewater treatment plants, groundwater purification and in the identification of sources of water pollution, in terms of dioxins and sediments in rivers (Babea, 2010). Other results of studies of Hamoda (1999) and Grieu (2005) have established that the performance of PTARM can be predicted by a neuronal network and also other studies such as Hamed (2004) and Mjalli (2007), Tomenko (2007) have shown that neural networks have surpassed the regression models used in wastewater treatment plants (West D, 2011). Also, studies by Lin (2008), Dogan (2009) and Singh (2009) using neural networks have been carried out the prediction of river water quality in river basins. However it has also been found an effect of accumulated error in period of several years in studies by Beck (2005), which even generates considerable approximation cumulative predictions in multiple time periods, it is highly significant and influential in the water quality of the river basin (West D, 2011) . Another application has been in the analysis and diagnosis of a wastewater treatment plant (activated sludge technology), due to the high variability of the concentrations of raw wastewater (tributary) and the knowledge of the process and unitary biological operations performance present in the wastewater treatment plants, therefore, an analysis was carried out through neural networks, to discover dependencies between the process variables and the behavior of the wastewater treatment plants and the potential for application to others wastewater treatment plants (Hong YS, 2003) .

2.3. Applied of Swarm Particles to Water Management

It is an artificial intelligence technique inspired by the social behavior of groups of individuals or insects such as swarms of insects, which transmits the event of each individual to the other individuals in the group, generating a synergistic and therefore the location of food or a special place, that is, the population of individuals is the swarm and each individual is a particle, which flies over the decision space or hyperspace of the problem, in search of optimal solutions or classified as swarm intelligence (Novoa, 2013; Hinojosa, 2012; Gonzalez, 2017). It is an adaptive method of particles or agents that move in the decision space, uses the principles of evaluation (stimulus to evaluate, distinguish characteristics), comparison and imitation (acquisition and maintenance of mental abilities) (De Los Cobos, 2014). Also, it is used to solve nonlinear and multidimensional optimization problems, which

mimics natural evolution through collective behavior or emerging intelligence, which germinates from a population. The expression can be established like this (Lima, 2006; Alonso, 2011; Bermeo, 2015): Each particle in the N decision space, knows its position, $X_i = [x_{i1}, x_{i2}, \dots, x_{iN}]$ then has a speed $V_i = [v_{i1}, v_{i2}, \dots, v_{iN}]$, the best position is $P_i = [p_{i1}, p_{i2}, \dots, p_{iN}]$ and the best position found within the swarm is $G = [g_{i1}, g_{i2}, \dots, g_{iN}]$. This technique has applications, in predicting the state of the rivers, real-time forecasts of river levels, water supply, convergence rates in the optimization of environmental problems, analysis of laminar and turbulent flow, (Cuevas, 2015; Schweickardt, 2014; Espitia, 2016.) . Other research that has used the particle swarm technique is that of (Qu & Lou, 2013), this research applied the particle swarm technique (PSO) for the allocation of water resources in Zhoukou , the result obtained was the optimization of the allocation of water resources in the planning years, from 2015 to 2025 under the 50% guarantee rate. Respect to works carried out to evaluate the environmental quality using a swarm of particles, is the one carried out by (Zhou, Zhang, Yuan, & Liu, 2008) , in this work PSO was used to optimize the model of the Qinhuangdao environmental quality assessment which used a Backpropagation neural network , in which the PSO used to optimize the initialized weights of the BP neural network, and then based on the optimized result, the BP neural network is used for additional optimization, thereby achieving that the model was faster and more accurate. Finally, there is the research carried out by (Xiaoting, Feng, Qi, Weixing, & XiaoFeng, 2013), in this research they proposed a new prediction model to predict the quality of effluent water from a wastewater treatment process, they took the ASM2 model to imitate the wastewater treatment process, and the PSO algorithm to adjust the parameters of the model, the results obtained showed that the new model simulates the behavior of wastewater treatment efficiently with great precision and accuracy.

3. CONCLUSIONS

The interesting thing is to integrate the particular or atomized intelligence to solve a specific problem in water management and social collaboration to seek a criterion of a group of users whose intelligence can be integrated, recognizing potentialities for the analysis of relationships and interactions, which facilitate robustness, flexibility and self-organization. The application of these computational techniques has been focused on very specific optimization problems (calibration of water distribution models, allocation of environmental flow, reservoir operation and drinking and waste water treatment systems) in water resources, but little or rather nothing, in the environmental water planning of a river basin.

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