Study and analysis of water consumption patterns for demand forecasting of the urban water supply system

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Abstract

Water demand forecast models are extremely important for logistic and political issues. In this sense, the present research aims to develop an Artificial Neural Network (ANN), able to predict in the short term, future water demands. Because of the high precision with time series data, the NARX (Nonlinear Autoregressive with External Input), a type of ANN, was chosen. Several tests were conducted in order to find the best forecast model, and the results showed that the NARX is an efficient predictor of water demand, requiring a good database for the ANN training phase.

Key words: artificial neural network, water demand, forecasting.

Introduction

Demand forecasting models are needed to develop operational policies and to plan for investments in the complex water supply and distribution systems, in order to use effectively the economic and natural resources available [Hansen and Narayanan, 1981][1]. That said, the goal of the research is the development of an ANN able to predict in the short term, the daily water demand of a real network. The intention is to improve the structuring and implementation of water distribution infrastructure, recognizing the relationship between the physical and temporal variables with water consumption pattern.

Results and Discussion

Data for the study were taken from the city of Franca, Sao Paulo, Brazil, and are time series, therefore it was decided to use the NARX, a type ANN, as it would be the most ideal for the challenge of the research, since it has high precision when the problem has sequential type of data.

The NARX was tested by changing its parameters and input data in order to enhance the network and thus achieve better results. It was noted that the main contributor to the improvement of the network were the input data. At first it was used daily data entry, they being the temperature, rainfall amount and the day's water demand, and despite high correlation of the variables, the network showed high errors. Subsequently, we used hourly data entry, taking into account the temperature, humidity, wind speed, month of year, day of week, time of day and holidays, increasing the sample space for the steps of training, validation and testing of the NARX. By changing the data entry, there was evidence of great potential of prediction with significant reduction of errors. In Chart 1 it can be seen such potential due to the R^2 values, that reached values close to one, showing strong correlation of the variables used, and the small errors in the network's prediction step.

Chart 1. The R^2 values and errors in the NARX's prediction step, varying the number of hidden nodes.

	R^2			Error
Hidden Nodes	**Training**	**Validation**	**Test**	**Five hours ahead prediction**
10	0,98411	0,98505	0,98045	0,7496
15	0,98475	0,98543	0,98205	0,5183
20	0,98366	0,98199	0,98085	0,6563
25	0,98487	0,98219	0,97931	0,6027
30	0,98551	0,97905	0,98222	0,8533

Conclusions

The ANN has shown to be an efficient mechanism of water demand forecasting representing a pattern very close to the actual consumption, and it can be used as a tool to circumvent stress on existing infrastructure of supply and distribution of water.

Acknowledgement

I would like to thank SAE / UNICAMP for the financial support and SABESP of the city of Franca for providing the data.

[1] HANSEN, Roger D.; NARAYANAN Rangesan. A Monthly Time Series Model Of Municipal Water Demand. **Water Resources Bulletin-American Water Resources Association**, v. 17, n. 4, p. 578–585, aug. 1981.