Neural Networks and Air Pollution Control System

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Abstract. In this communication we present a neural network to forecast the SO_2 level in the neighbourhood of a power plant. We compare this prediction to the one made by a semiparametric model.

Keywords. Neural networks, backpropagation, prediction, atmospheric pollution.

1 Introduction

Endesa Generación has a power plant in As Pontes, in the northwest of Spain. Since 1992 that power plant has an air pollution control help system developed by the Department of Statistics and Operation Research of the University of Santiago de Compostela in cooperation with the Environment Department of the power plant. This system works, basically, forecasting the level of the SO_2 concentration.

2 Neural Networks

The artificial neural networks are composed of little simple processors: artificial neurons, interlinked. We must achieve the neural network acquire enough knowledge to react correctly to each stimulus we give. This knowledge is obtained working on examples or patterns.

Let $\mathbf{X} = (x_1, x_2, ..., x_M)^t$ be a vector of inputs and $\mathbf{Y} = (y_1, y_2, ..., y_N)^t$ its response vector. We must find a neural network whose vector of outputs $\mathbf{O} = (o_1, o_2, ..., o_N)^t$ reproduces, the best as possible, the real response **Y** for each **X**. We can write each output of the network as:

$$o_k = f_k^o\left(q_k^o + \sum_{j=1}^{L} w_{kj}^o f_j^h\left(q_j^h + \sum_{i=1}^{M} w_{ji}^h x_i\right)\right) \qquad k = 1, ..., N$$

where w_{ji}^h, w_{kj}^o are the weights, q_j^h, q_k^o are the trends and f_j^h, f_k^o are the activation functions of the neural network.

There are different algorithms to determine the weights of the connections of the neural network. We have used the Backpropagation Algorithm based on the steepest descent algorithm [1].

3 Application to the environmental problem

Every 5 minutes we can calculate the mean of SO_2 concentration values in the last hour for each station in the Atmospheric Quality Control System of the power plant. The interest series is $\{x_t,\ t = ..-2,-1,0,1,2,..\}$ where x_t represents, on instant *t*, the average of the SO_2 concentration values of the last hour. We are interest in forecasting values of this time series with half an hour horizon, that is, at the instant *t* we will make a prediction for x_{t+6}.The neural network we have designed to give forecasts, half an hour before, of the one hour mean SO_2 quality air values x_{t+6} [2], has the form:

$$\hat{x}_{t+6} = o_1 = \sum_{j=1}^{L} w_{1j}^{o} f_j^{h}\left(q_j^{h} + w_{j1}^{h} x_{t-3} + w_{j2}^{h} x_t\right) \text{ with } f_j^{h}(z) = \frac{1}{1+e^{-z}} \text{ for every } j\,.$$

3.1 Results

We have compared the prediction given by the neural network with the one given by a semiparametric model [3], [4], [5]. The results show that the errors made by the neural network improve those made by the semiparametric model.

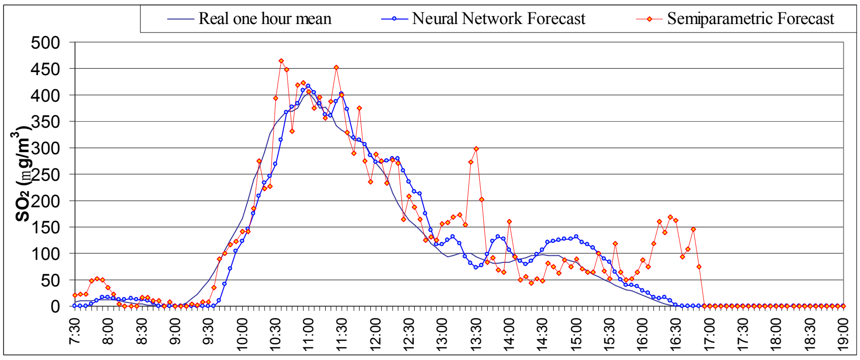

Fig. 1: Quality air level episode on 20 May 2000. Comparison of forecasts performed by neural networks and semiparametric model.

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