# On the Prediction Methods Using Neural Networks

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*Abstract: The paper aims to present the main ideas related to the prediction of time series using neural networks. The paper begins with an overview of the main concepts implied in neural networks, an identification of the similarities between biological nervous cell and the mathematic model is tried here. The main advantages and disadvantages of using neural networks are presented and also a general presentation of the methods used for multi step ahead prediction is made.*

*Keywords: neural networks, prediction, multi step ahead*

## 1   Brief Overview of the ANNs

An artificial neural network is made up of computing elements or processors i.e. mathematical models of the biological neurons connected by weights that are modified during use in order to satisfy a performance criterion. An artificial neuron basically sums the signal from its inputs multiplying them with the correspondent weights; if the result exceeds the threshold the neuron fires and a signal is transmitted at the output by a transfer function.

The main idea is that the network to adapt the weights in order to give the desired response at the output with a minimum error. The model described above (i.e. the artificial neuron) is the simplest model of neural network called perceptron. The processing units are usually densely interconnected forming diverse and possible very complicated models characterized by the network topology (the number of layers, number of neurons on each layer, the interconnections among the neurons, etc.), neuron characteristics and learning algorithm. [6]

The artificial neural networks are modelling at a very small scale the activity of the brain in order to gain knowledge or to give a response to a given stimulus. However, the mathematical model of the biological neuron is a very rough approximation of the latter at least from the point of view of its activation. In the brain a specific neuron can have at a given moment thousands of variable input

signals implying the threshold of the neuron to be also variable [2]. Hence, the principles of binary logic cannot be applied to the biological neuron because the biological neuron doesn't have a fixed and stable threshold due to the intense, dynamic and unpredictable activity in the brain.

An artificial neural network can be viewed as being formed by a multitude of parallel interconnected processors implementing the large scale parallel computing or an ANN can be also one of the many applications of the graph's theory [1].

An ANN is suitable to be used for the solving of the problems not having an exact set of rules or an algorithm to be followed in order to solve the problem. A neural network is able to analyze quickly complex patterns with a high degree of accuracy and to discover patterns in an incomplete or noisy data set. The neural networks are powerful tools when applied to problems whose solution implies knowledge difficult to be structured but for which there is lot of data (examples).

ANNs have some advantages and disadvantages, some of each are enunciated below:

- an ANN generally models a problem and gives the solution to a specific problem by adapting the weight (constructing an internal representation of the problems by means of the relations among the variables) but these weights have no relevancy for the humans, justifying a result obtained is usually an impossible task;

- an ANN is not a universal tool of solving problems, a methodology for choosing, training and verifying an ANN doesn't exists; [4]

- an ANN requires excessive training times

- an ANN is depending on the quality and the accuracy of the data set

- a neural network can learn very good an input data set and the responses at its outputs but may have poor generalization abilities

- a neural network deals well with incomplete and missing data sets

- a neural network are tools for discovering nonlinear relationships in time series analysis

- an ANN can be used successfully as tools for short term prediction and forecasting.

## 2 Neural Networks for Prediction

The beginning of the prediction of the time series was made in the 20's of the past century with the introduction of the autoregressive model for the prediction of the annual number of sunspots.

Time series are samples of system's behaviour over discrete time values. The neural networks ability to cope with the nonlinearities, the speed of computation, the learning capacity and the accuracy made them valuable tools of prediction. To predict the evolution over time of a process implies the prediction of the future values of the time series describing the process.

Time series prediction with classical methods relies on some steps to be followed in order to perform an analysis of the time series, including here modelling, the identification of the model and finally parameter estimation.

The most difficult systems to predict are: [3]

- those with insufficient amount of data in the data series (for instance chaotic signals);
- the systems whose data series are obtained through observation and measurements, in this case data being possibly affected by measurement errors;
- systems whose behaviour varies in time.

The artificial neuron for prediction receives at its inputs the delayed signal y(k-i), i=the number of inputs, the inputs are transmitted through i+1 multipliers for scaling, then the scaled inputs are linearly combined to form an output signal that is also passed through an activation function in order to obtain an output signal.
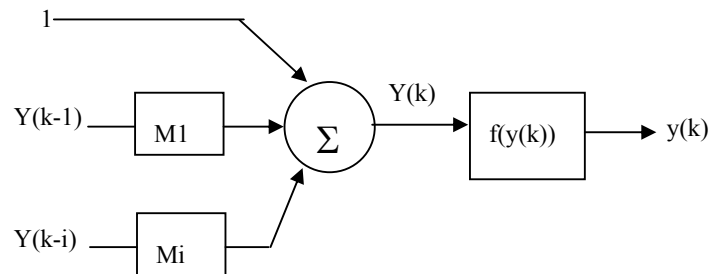
The model of the neuron is schematized below:



Figure 1
The artificial neuron for prediction ($M_1..i$ are multipliers)

Consider x(t) the time series data collected in order to build a model. The data in the data series are samples of x(t) with a time step k. The prediction of the time series values can be made single step ahead, in this case one looking for a good estimation $x_1(t+1)$ of x(t+1) or multi step ahead prediction, in this case looking for a good estimate $x_1(t+nk)$ of x(t+nk), n being the number of steps ahead.

The first and most common method for the prediction of time series consist in using M past values or M-tuples as inputs and one output. The method described above is called the sliding window technique represented in Figure 2.
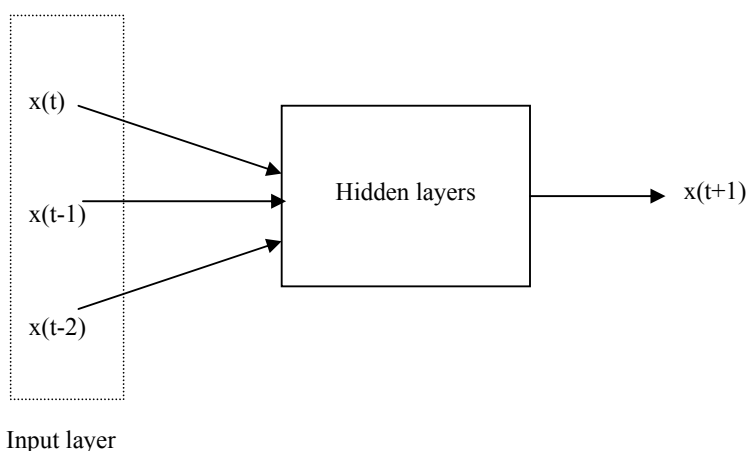


Figure 2
The sliding window method of time series prediction with a sliding window of 3 time steps

The window sliding method can be described analytically by the two equations below:

$$x( t ) = [ x[ t ], x( t - k ),....x(t - (M - 1)k )]$$ (1)

$$x_1(t + k) = f(x(t))$$ (2)

Due to the fact that artificial neural networks are universal approximators, multi-layer perceptrons and recurrent neural networks are used for prediction. An alternate method to predict time series is to introduce a memory of the past using a recurrent neural networks. The memory of the past is kept for a small window with length 1. The internal state of the model play the role of a memory.

$$s(t + k) = g(s(t), x(t))$$ (3)

$$x_1(t + k) = h(s(t))$$ (4)

where:

s(t) is the internal state of the model and $x_1(t+k)$ is the estimation.

# 3    Methods for Multi Step Ahead Prediction

There are several methods to follow in order to perform a multi step ahead prediction the most used being discussed in that follows.

The iterated prediction method is the most common method and consists in training a predictor for the single step prediction, predictor that is subsequently used recursively for the corresponding multi step ahead problem. The outputs corresponding for the next step are provided to the inputs of the model until the prediction length is reached. The models having very low errors on single step prediction perform well when used for multi step prediction. One can note that if the model for single step prediction has errors, these errors can disturb completely the model for the multi step prediction.

An improved method called corrected iterated prediction consists in training the predictor for the single step prediction using a learning algorithm that minimizes the error (for instance the backpropagation learning algorithm that minimizes the error through gradient descent). The model (neural network) is trained both for the single step and also for multiple step ahead prediction.

With the direct method the predictor is trained only for the multiple step ahead problems. The direct method gives the best results compared with the other two methods presented above.

There are many variants derived from the methods enunciated. For instance a method recently putted forward requires that a recurrent neural network to be randomly generated so that a large range of behaviour types to be associated with the input forms. Training such a network supposes that the behaviours to be combined in order to obtain the desired prediction. [5]

Another method chains neural networks and trains them independently each for a specific horizon of prediction so that one neural network uses as input the output provided by another network trained to predict for a previous time window and so on.

The prediction using wavelet neural networks has as main idea the decomposition of the initial time series in a certain number of sub series using wavelet decomposition algorithm. The ANN is constructed so that the inputs are from the sub series for the moment t and the output is the original time series at t+T. The key of wavelet networks is the decomposition algorithm and the structure of the neural network.

**Conclusions**

The prediction using neural networks is a very difficult, time consuming and sometimes impossible task. The methods presented in this paper are more or less poor when predicting chaotic time series for instance. A long time prediction for chaotic time series is possible now to be made using methods developed recently.

However the methods presented here need more study and a combination of these methods for prediction should be investigated.

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