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Comparison of ARIMA and RBFN Models to Predict the Bank Transactions

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Abstract: In this research, Radial Basis Function Networks (RBFN) and ARIMA models (Autoregressive Integrated Moving Average) are compared to their ability to predict time series values. RBFN gives good results in many cases but for some extreme values of time series, better approximations can be obtained using ARIMA models.

Key words: Time series prediction, radial basis function networks, ARIMA models, simulation, neural networks, function approximation

DESCRIPTION OF THE PROBLEM

In real world applications, many processes can be represented using time series models as below:

$$x(t-p), \dots, x(t-2), x(t-1), x(t)$$

For making a prediction using time series, a large variety of approaches are available. Prediction of scalar time-series $\{x(n)\}$ refers to the task of finding an estimate $\hat{x}(n+1)$ of the next future sample $x(n+1)$ based on the knowledge of the history of time-series, i.e., the samples $x(n), x(n-1), \dots$ (Rank, 2003).

Linear prediction, where the estimate is based on a linear combination of N past samples can be represented as below:

$$\hat{x}(n+1) = \sum_{i=0}^{N-1} \alpha_i x(n-i)$$

with the prediction coefficients $\alpha_i, i = 0, 1, \dots, N-1$.

Introducing a general nonlinear function $f(\cdot); \mathfrak{R}^n \rightarrow \mathfrak{R}$ applied to the vector $x(n) = [x(n), x(n-M), \dots, x(n-(N-1))]^T$ of past samples, we arrive at the nonlinear prediction approach $\hat{x}(n+1) = f(x(n))$ (Rank, 2003).

ARIMA MODEL

Traditionally, time series forecasting problem is tackled using linear techniques such as Auto Regressive Moving Average (ARMA) and Auto Regressive Integrated Moving Average (ARIMA) models popularized by Box and Jenkins (1976).

The general form of ARMA(p,q) model can be written as below:

$$X_t - \sum_{r=1}^p \phi_r X_{t-r} = \sum_{s=0}^q \theta_s \varepsilon_{t-s}$$

where $\{\varepsilon_t\}$ is white noise. This process is stationary for appropriate ϕ, θ (Box and Tenkins, 1976).

The general form of the ARIMA model is given by:

$$Y_t = \alpha_0 + \sum a_i Y_{t-i} + \sum b_j \varepsilon_{t-j}$$

$$I = 1, 2, \dots, p \text{ and } j = 0, 1, \dots, Q$$

where Y_t is a stationary stochastic process with non-zero mean, a_0 is the constant coefficient, ε_t the white noise disturbance term, a_i represents autoregressive coefficients and b_j denotes the moving average coefficients.

RADIAL BASIS FUNCTION NETWORK

The RBF network consists of 3 layers: an input layer, a hidden layer and an output layer. A typical RBF network is shown in Fig. 1.

Mathematically, the network output for linear output nodes can be expressed as below:

$$y_k(x) = \sum_{j=1}^m W_{kj} \phi_j(\|x - \bar{x}_j\|) + W_{k0}$$

Where x is the input vector with elements x_i (where i is the dimension of the input vector); \bar{x}_j is the vector to determine the center of the basis function; ϕ_j with elements \bar{x}_{ji} ; W_{kj} 's are the weights and W_{k0} is the bias (Duy and Cong, 2003). The basis function $\phi_j(\cdot)$ provides the non-linearity.

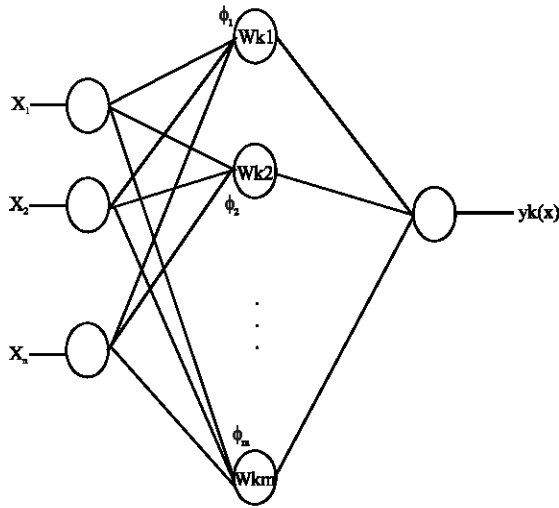


Fig. 1: Typical RBF network

BASIS FUNCTIONS

The most used basis functions are Gaussian and multiquadratic functions. They are given below:

- Gaussian $\phi(x) = \exp(-x^2/2\delta^2)$ for $\delta > 0$ and $x \in \mathfrak{R}$
- Multiquadratic $\phi(x) = (x^2 + \delta^2)^p$ for $\delta > 0$ and $x \in \mathfrak{R}$ p is between 0 and 1. Usually p is taken as 1/2.

CALCULATING THE OPTIMAL VALUES OF WEIGHTS

A very important property of the RBF Network is that it is a linearly weighted network in the sense that the output is a linear combination of m radial basis functions, written as below:

$$f(x) = \sum_{i=1}^m w^{(i)} \phi_i^{(i)}(x) \text{ (Duy and Cong, 2003).}$$

The main problem is to find the unknown weights

$$\{w^{(i)}\}_{i=1}^m$$

For this purpose, the general least squares principal can be used to minimize the sum squared error:

$$SSE = \sum_{i=1}^n [y^{(i)} - f(x^{(i)})]^2$$

With respect to the weights of f, resulting in a set of m simultaneous linear algebraic equations in the m unknown weights $(A^T A) w = A^T y$

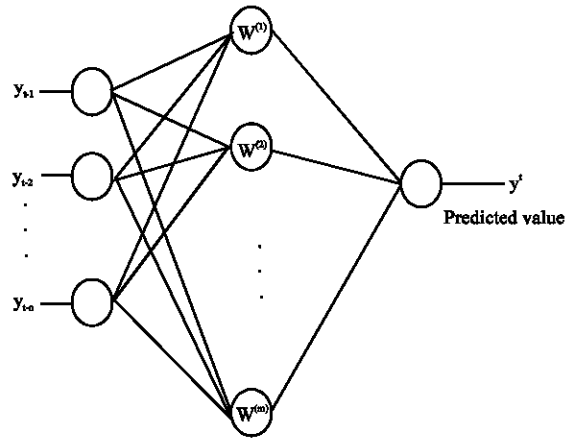


Fig. 2: Finding predicted value y'

Where

$$A = \begin{bmatrix} \phi^{(1)}(x^{(1)}) & \phi^{(2)}(x^{(1)}) & \dots & \phi^{(m)}(x^{(1)}) \\ \phi^{(1)}(x^{(2)}) & \phi^{(2)}(x^{(2)}) & \dots & \phi^{(m)}(x^{(2)}) \\ \vdots & \vdots & \ddots & \vdots \\ \phi^{(1)}(x^{(n)}) & \phi^{(2)}(x^{(n)}) & \dots & \phi^{(m)}(x^{(n)}) \end{bmatrix}$$

$$w = [w^{(1)}, w^{(2)}, \dots, w^{(m)}]^T$$

$$y = [y^{(1)}, y^{(2)}, \dots, y^{(n)}]^T$$

In the special case where n = m, the resultant system is just Aw = y (Duy and Cong, 2003).

The output y(x) represents the next value of y in time t taking input values x₁, x₂, ..., x_n that represent the previous function values set with values y_{t-1}, y_{t-2}, ..., y_{t-n}. So, x_n corresponds to y_{t-1}, x_{n-1} corresponds to y_{t-2} etc. as in Fig. 2.

SIMULATION RESULTS

For this work, the time series data of American Express Bank is used. Monthly log data consists of 324 data items. The first 162 data items are used for training and the remaining 162 data items are used for forecasting.

Figure 3 shows the results of simulation run with $\sigma = 1.5$ and 18 neurons in the hidden layer of the Radial Basis Function Network with the results of ARIMA model for the same data.

As in Fig. 3 and 4, RBFN approach provides better results than ARIMA model in a big part of data interval except the peak points.

In this points, ARIMA model gives better results than RBFN approach.

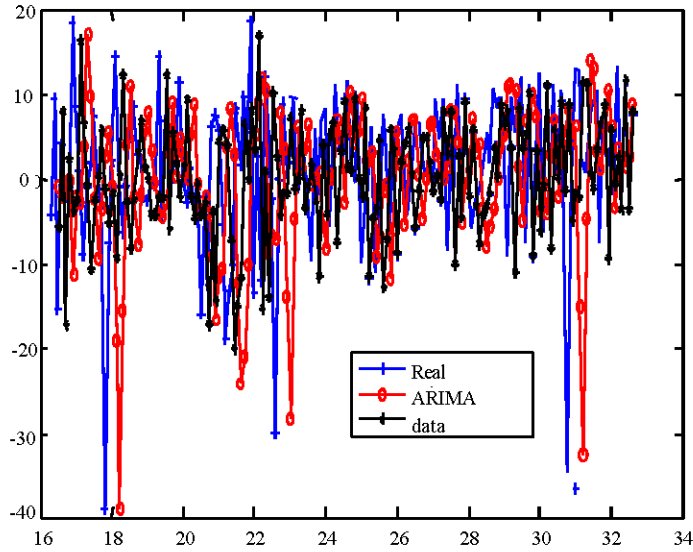


Fig. 3: Simulation Results for ARIMA and RBFN models

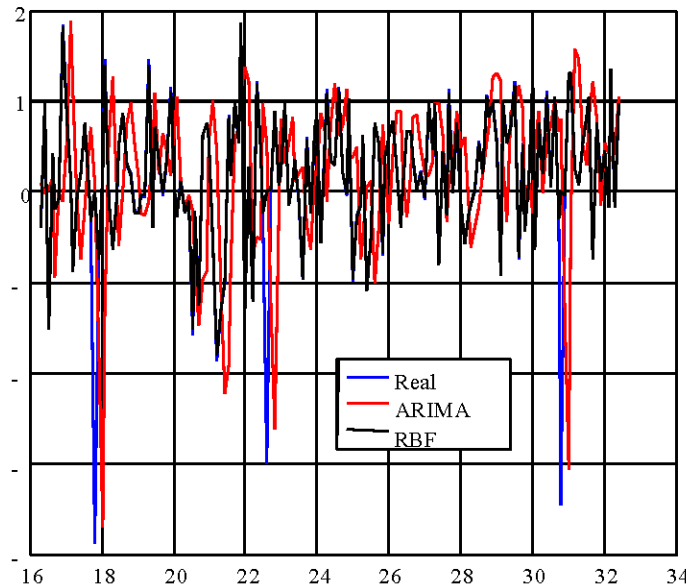


Fig. 4: Simulation results for ARIMA and RBFN models with a different format

CONCLUSIONS

Radial Basis Functions Networks provide a good way to predict the future values in a time series. In the peak points of the original data, ARIMA model gives better results than RBFN approach.

In order to obtain the best results of the whole interval of the data, a hybrid model that consists of ARIMA and RBFN approach can be used to predict the future values of the time series.

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