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List of research papers

An adaptive RFLANN model with PSO based training for Forex prediction

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***Abstract*— This paper investigates the recurrent nature of the neural network with the evolutionary optimization techniques to optimize the parameters of the neural network. For the simulation, recurrent FLANN is been used with PSO based learning techniques for the forecasting of foreign exchange rate (Forex) prediction. The proposed model is been tested to three Forex value. From the simulation result, we found that the proposed Forex prediction model shows the enhancement of the prediction performance in terms of root mean square error (RMSE) and mean absolute percentage error (MAPE) with respect to other similar type of neural networks with different learning algorithms.**

***Keywords*— Foreign exchnage rates (Forex) forecasting, Recurrent Functional link artificial neural network (RFLANN), Particle swarm optimization (PSO) and prediction**

I. Introduction

Foreign exchange rates (Forex) prediction is based on the Forex price data, is one of the most popular market analysis techniques used by many researchers in International market. It's analysis the overall health of the economy of the country. The price prediction of the exchange rate is affected by many complex factors such as political, economical growth and psychological factors. Therefore the accurate prediction of this time series data is a tedious job subject to huge error while forecasting. Foreign exchange rate is nothing but the price through which the money of one country can be exchange with another country's currency in respect to each other. This price is depending upon the supply and demand of the countries. Many researchers have developed many efficient prediction models by applying various machine learning techniques and soft computing methods. These models can be either statistical measure such as autoregressive moving average [1], autoregressive integrated moving average [2], GARCH etc. and soft computing based methods such as artificial neural network (ANN), fuzzy set theory (FST), support vector machine regression (SVR) etc. The nonlinear and dynamic nature of the financial data series makes it difficult for prediction by the common investors. Therefore a well planned investment strategy is required to meet the requirement of the investment. From the literature survey it is also been notice that for efficient prediction of financial time series data some methods are commonly used by the researchers such as artificial neural network (ANN) [3][4][5], support vector machine (SVM) [5][6][7], genetic algorithm (GA) [3][8] and so on.

Recent time many researcher applied different neural network based techniques to forecast financial time series data. This techniques are back propagation neural network (BPNN) [9], Functional Link Neural Network (FLANN) [10][11].Also, ARMA based on DE is develop to alleviate the problem of statistical based methods by Minakshi Rout et.al. [12]. By reviewing the various literatures, it is found that back propagation algorithm is frequently used for the optimizing of the parameters of the models, but it suffers from the slow convergence rate. So there is a need to develop a hybrid models that optimize the parameters fast and accurately. The main objective of this study is to develop a model that improve the skill of the time series model specially the exchange rate price with the help of machine learning approach and evolutionary method.

In this paper, a particle swarm optimization (PSO) based recurrent functional link artificial neural network (RFLANN) for exchange rate price prediction is proposed. In this model, PSO is used to update the weights of a recurrent FLANN neural network model.

Remaining paper is organized into following sections, RFLANN model is described in section II. PSO model is explained in section III. Section IV illustrates the development of Forex prediction model using PSO based RFLANN model. Section V describes different performance evaluation techniques used for Forex prediction. Data collection and feature extraction is put out in section VI. Experimental analysis and results are carried out in section VII. Finally the conclusion is put in section VIII.

II. Recurrent Functional Link Artificial Neural Network (RFLANN) Based Forecasting Model

In this section the development of a Forex price forecasting model using recurrent FLANN (RFLANN) structure and PSO [13] based training scheme are proposed.
Fig 1 shows PSO based RFLANN predictor structure with $(N+1)$ input nodes in an input layer, one node in output layer without any nodes in the hidden layer. The output of the model after a unit delay is feedback and passes as one of the input, $x_0(n)$ to the model. In the proposed prediction model, each set of input patterns is trigonometrically expanded into a

nonlinear manner to generate $(2t + 1)$ nonlinear elements using an expansion using sine and cosine expansion.
The expanded terms for $x_1(n)$ may be written as
$\{x_1(n), \sin \pi x_1(n), \cos \pi x_1 \dots \dots \sin t\pi x_1(n), \cos t\pi x_1(n)\}$ by using trigonometric expansion.
Similarly other terms of the input patterns are expanded. Therefore, for N number of inputs, $N(2t + 1)$ numbers of terms are formed. The recurrent input of the model $x_0(n)$ undergoes nonlinear trigonometric expansion to produce $(2t + 1)$ terms.
Let $W_1 = [w_0 w_1 w_2 \dots \dots \dots w_m \dots \dots \dots w_M]^T$ be representing the weight vector of the prediction model along with a unity bias weight $b(n)$. Then the output of the proposed model is evaluated by

$$s(n) = W^T Z + b(n) \quad (1)$$

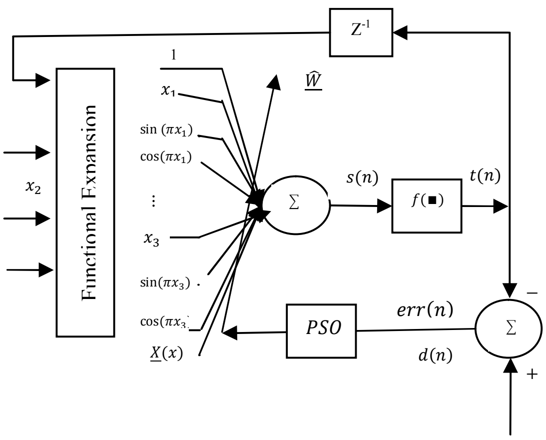

Fig. 1. Hybrid PSO based RFLANN forecasting model

Then the activation function is applied in the output node of the proposed model is a nonlinear sigmoid function.
The error term of the model, err(n) is calculated by

$$err(n) = d(n) - t(n) \quad (2)$$

where $d(n)$ and $t(n)$ is the desired and target value respectively.
Then the output $t(n)$ is feedback to the input of the model to form one input for the next operation. The simulation is continued until the mean square error (MSE) reaches a minimum value or constant value in the ith experiment, which is defined as

$$MSE(i) = \frac{1}{N} \sum_{n=1}^{N} err^2(x) \quad (3)$$

After the training process, the connecting weights of the proposed model are frozen and these weights are used for the model for testing with well known Forex rate price and for future prediction.

III. PARTICLE SWARM OPTIMIZATION

In 1995, James Kennedy and Russell Eberhart introduced a meta-heuristic search algorithm known as Particle swarm optimization (PSO)[13][14][15]. In this algorithm, a population of particles is randomly initialized with initial position and velocity by the system and each particle of the system keeps track of its own position and velocity. Let the position vector be represented by $\vec{P_i} = (p_{i1}, p_{i2}, \dots \dots, p_{in})$ and velocity vector by $\vec{V_i} = (v_{i1}, v_{i2}, \dots \dots, v_{in})$ of the ith particle in the n-dimensional search space.

The first best value is the best solution or *pbest* of the particle achieved so far and *gbest* represented the best position so far in the neighborhood. Let the *pbest* of the ith particle be denoted as $\overrightarrow{P_i^b} = (p_{i1}^b, p_{i2}^b, \dots \dots, \dots p_{in}^b)$ and the *gbest* be denoted as $\overrightarrow{P_i^g} = (p_{i1}^g, p_{i2}^g, \dots \dots, \dots p_{in}^g)$. For every iteration, the position and velocity of the particles is updated by the equations:

$$V_{ij} = w * V_{ij} + c_1 * r_1 * (P_{ij}^b - P_{ij}) + c_2 * r_2 * (P_{ij}^g - P_{ij}) \quad (4)$$

$$P_{ij} = P_{ij} + V_{ij} \quad (5)$$

where $j = 1 \; to \; n$ and set the value of $w, c_1, c_2 \geq 0. w$ is the inertia weight, $c_1 \; and \; c_2$ is the acceleration coefficients.$r_1 \; and \; r_2$ are the random numbers lies between 0 and 1.

IV. DEVELOPMENT OF FOREX PREDICTION MODEL USING PSO BASED RFLANN MODEL

In this paper, the particle swarm optimization (PSO) algorithm is used to train the weights of RFLANN neural network with the knowledge of evolutionary techniques. The algorithm of developing an RFLANN-PSO based Forex prediction is proceeds as follows:

1. Firstly, generate a random population of N particles with random position and velocities. The weights of the RFLANN are represented by the position vector of a particle. The initial position represents the current *pbest.*
2. Then evaluate the fitness value for each particle of the population with the help of fitness function.
3. Find out the particle best (*pbest)* by comparing the particle's current fitness value with particle previous *pbest* and update the *pbest.* If current value is smaller than *pbest* then set the current value as *pbest* otherwise do not change.
4. Now, compare the current fitness value with the population's global previous best value (*gbest)* and update *gbest.*
   If current value is smaller than *gbest* then set the current value as *gbest.*
5. Update the parameters (weights) by changing the velocity and position of the particles by evaluating from the equations (4) and (5)
6. Repeat the step 2 to 5 until the number of iterations reaches its maximum value or all the particles in the system attains constant values.