Optimized Back propagation Learning in Neural Networks with Bacterial Foraging Optimization to Predict Forex Gold Index (XAUUSD)

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Abstract

This paper aims to build systems that can predict the gold price index with the back propagation method so that the back propagation method can run faster and get more accurate results. Back propagation method optimized in weight and bias...
with bacterial foraging optimization. Proven by adding bacterial foraging optimization method, it involve the back propagation method can run 50% faster and accuracy increased 2% average. System performance testing was conducted 1000 times using many different data. Sample data and test data normalization is immersely affect the system performance.

**Keywords**: back propagation, bacterial foraging optimization, forex.

1 **Introduction**

International monetary market needs important data to its trade from forex rate. The index value is influenced by many factors such as economics and politics, and also traders and investors psychological condition. All of that factors make the gold index are very difficult to predict. People that involved in the field of international monetary exchanges have been searching for an explanation to improve the prediction ability. It is this ability to correctly predict gold index rate changes that allows for the maximization of profits. Trading at the right time with the relatively correct strategies can bring large profit, but a trade based on wrong movement can risk big losses. Using the right analytical tool and good methods can reduce the effect of mistakes and also can increase profitability [2][8].

Artificial neural networks has been extensively used in these days in various aspects of science and engineering because of its ability to model both linear and non-linear systems without the need to make assumptions as are implicit in most traditional statistical approaches. ANN has been a aggressive model over the simple linear regression model [1][5][9][10].Neural network algorithms can predict foreign currency exchange rate. Because of back propagation algorithm is used with AFERFM, which gives the 11.3 percentages more accurate than the HFERFM[6].

BFO algorithm is a novel evolutionary computation algorithm, it is proposed based on the foraging behavior of the Escherichia coli (E. coli) bacteria live in human intestine. Natural selection tends to eliminate animals with poor foraging strategies such as locating, handling and ingesting food and favor the propagation of genes of those to achieve successful foraging [7]. The foraging behavior of E.Coli bacteria is adopted for the evolutionary computation algorithm, and it is named as Bacterial Foraging Optimization (BFO). BFO is an optimization technique based on the population search and efficient for global search method[3][4].
2 Determination of the Architecture

Architecture determination is conducted to assign inputs number on neural, hidden layer, output layer, sample data and test data date of use. The number of input will affect to how many number of history data that will be used in back propagation process. For example if the hidden layers input which entered is 5 and the date is 2011-01-01 to 2011-01-20, then the sample data that will be formed after being normalized is as follow:

Table 1 Sample data

<table>
<thead>
<tr>
<th>1 days ago</th>
<th>2 days ago</th>
<th>3 days ago</th>
<th>4 days ago</th>
<th>5 days ago</th>
<th>today</th>
<th>date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0820704</td>
<td>0.0936164</td>
<td>0.102236</td>
<td>0.138942</td>
<td>0.17167</td>
<td>0.088500</td>
<td>2011-01-10</td>
</tr>
<tr>
<td>0.0885004</td>
<td>0.0820704</td>
<td>0.0936164</td>
<td>0.102236</td>
<td>0.138942</td>
<td>0.091023</td>
<td>2011-01-11</td>
</tr>
<tr>
<td>0.0910233</td>
<td>0.0885004</td>
<td>0.0820704</td>
<td>0.0936164</td>
<td>0.102236</td>
<td>0.103515</td>
<td>2011-01-12</td>
</tr>
<tr>
<td>0.103515</td>
<td>0.0910233</td>
<td>0.0885004</td>
<td>0.0820704</td>
<td>0.0936164</td>
<td>0.111172</td>
<td>2011-01-13</td>
</tr>
<tr>
<td>0.111172</td>
<td>0.103515</td>
<td>0.0910233</td>
<td>0.0885004</td>
<td>0.0820704</td>
<td>0.109315</td>
<td>2011-01-14</td>
</tr>
</tbody>
</table>

3 Determination of the Bacteria Dimension

Bacterial foraging optimization will be optimized weight and bias before using back propagation method, where weights and bias optimized result eventually will be used in back propagation process. To determine cost value on bacterial foraging optimization, it can be calculated with augment feed forward process. Where dimensions of bacteria is weights and bias as on back propagation, then data which included is average value per colom on sample data.

How many dimension of the bacteria is determined in accordance to neural architectural, calculated as [3][4]:

\[ \text{Dimension} = (\text{Input} \times \text{Hidden}) + (\text{Hidden} \times \text{Output}) + \text{Hidden} + \text{Output} \]

\[ \text{Dimension} = (3 \times 2) + (2 \times 1) + 2 + 1 = 11 \]

Fig 1 Architectural BPBFO
The bacteria foraging optimization algorithm is:

1. **Chemotaxis**: Bacteria has a habit to move to approach a food source. This process is the way how bacteria determine its movement between dip and fall because of flagella. Bacteria will automatically move to an error optimum (nutrient source). It contains two steps as follows: [3][4]:
   - **Tumbling**: Is the process how bacteria falls to the best nourishment position, to get minimum errors of ANN.[3][4].
     \[
     \theta^t(j+1,k,1) = \theta^t(j,k,1) + C(i) \times \frac{\Delta(i)}{\sqrt{\Delta^2(i)\Delta(i)}} \tag{3.1}
     \]
     Where
     \[
     \Delta(i), \Delta : \text{Random vectors on } [-1,1]
     \]
     \[
     \frac{\Delta(i)}{\sqrt{\Delta^2(i)\Delta(i)}} : \text{The unit walk in the random direction}
     \]
     \[
     C : \text{Run length unit}
     \]
     \[
     \theta^t(j,k,1) : \text{It may represent by } P(i,j,k,ell)
     \]
     \[
     \theta^t(j+1,k,1) : \text{It may represent by } P(i,j+1,k,ell) \text{ that represents the next location of bacterial}
     \]
   - **Swimming**: A Bacteria will move towards a certain direction that has a growing number of nourishment (rich nourishment) [3][4].

2. **Swarming**: While bacteria is in a group, they have a censor from a dangerous place, and automatically will stay y from it by following nutrient gradient that generated by a group of bacteria that obtain nourishment [3][4].

   \[
   j_{cc} (\theta, P(j,k,1)) = \sum_{i=1}^{s} j_{cc} (\theta, \theta^t(j,k,1))
   \]

   \[
   = \sum_{i=1}^{s} [-d_{attract} \exp(-w_{attract} \sum_{m=1}^{p} (\theta_m - \theta_{m}^{t}))]
   \]

   \[
   + \sum_{i=1}^{s} [h_{repellant} \exp(-w_{repellant} \sum_{m=1}^{p} (\theta_m - \theta_{m}^{t}))] \tag{3.2}
   \]

   Where
   \[
   d_{attract} \text{ depth attractant to set a magnitude of secretion of attractant by a cell}
   \]
   \[
   w_{attract} \text{ width attractant to set how the chemical cohesion signal diffuse}
   \]
   \[
   h_{repellant} \text{ height repellant to set repellant}
   \]
   - **Reproduction**: The fitness value from bacteria sequenced in the array sequences that order the lowest value to the highest value [3][4].

   \[
   j_{health}^j = \sum_{j=1}^{N_c+1} j(i,j,k,l) \tag{3.3}
   \]
   Where \(N_c\) is the chemotaxis steps and \(j\) is the value of error.
Elimination and Dispersal: In the real world, bacteria have probability and spread to a new location. Here begins by generating random vector. [3][4].

4 Bacterial Foraging Optimization Optimized Back propagation

The optimized backpropagation process is as follows:

![Diagram]

Sample data is calculated, the average is used in bacterial initialization process, then the process is continued on bacterial training to detect the lowest cost value which eventually is the weight value and the optimal bias. After weights value and the optimal bias are found, it will be continued on backpropagation process to find the weights result and bias that will be used to predict.

5 Result of Experiment

Result of experiment with sample data and data test from 2011-01-01 to 2011-12-31 and 2012-01-01 to 2012-12-31. The architecture was formed by input layer is 5, hidden layer is 10, output layer is 1. Bacterial foraging optimization process that uses chemotaxis is 5, swim step is 5, reproduction is 4, dispersal is 4, dispersal probability is 0.5, and movement size is 0.5. Backpropagation learning rate process is 0.05, momentum is 0.01, max epoch is 2000, means square error target is 0.000001.
Table 2 Comparation BP with BPBFO

<table>
<thead>
<tr>
<th>Sample data</th>
<th>Method</th>
<th>Interaction</th>
<th>epoch</th>
<th>mse</th>
<th>time (second)</th>
<th>Accuration Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>BP</td>
<td>232460</td>
<td>788</td>
<td>0.0000008</td>
<td>216</td>
<td>92.43%</td>
</tr>
<tr>
<td>2011</td>
<td>BPBFO</td>
<td>134225</td>
<td>455</td>
<td>0.0000007</td>
<td>141</td>
<td>94.60%</td>
</tr>
<tr>
<td>2012</td>
<td>BP</td>
<td>51744</td>
<td>176</td>
<td>0.0000006</td>
<td>43</td>
<td>95.20%</td>
</tr>
<tr>
<td>2012</td>
<td>BPBFO</td>
<td>31458</td>
<td>107</td>
<td>0.0000005</td>
<td>26</td>
<td>96.26%</td>
</tr>
</tbody>
</table>

Table 2 shows the processing result of backpropagation method and the backpropagation method was developed by bacterial foraging optimization and comparison between the result accuracy from backpropagation method and backpropagation method that optimized with bacterial foraging optimization.

![Fig 3](a) BP Result, (b) BPBFO Result test data 2011

![Fig 4](a) BP Result, (b) BPBFO Result test data 2012

Fig 3 and fig 4 shows the comparison of test data and the predicted results where the red line is the target of the data test and the blue line is the predicted outcome.

6 Conclusion

This experiment concludes that predicting gold price can be conducted by mathematics methods with using data history from the gold price index. The selection of the sample data architecture and great influence in the prediction
results by using back propagation. Sample and data test should be tested against the data history of stable gold index is not in a state of crisis. Proved that after optimized with bacterial foraging optimization method it get significantly better in terms of iterating, epoch, and the value of accuracy. Forex gold index prediction can be developed with another neural network method to give better accuration. In further developments, this paper is expected to be a reference in the development of other forex gold index prediction to make better accurate prediction.

References


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