An Improved Neural Network Optimization Method

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Abstract. In order to solve the problem of temperature drift for fiber optic gyroscope, the neural network is used to construct the temperature drift model. The neural network is easy to fall into local minimum, the convergence speed is slow, the genetic algorithm is used to optimize neural network. The genetic algorithm has the problem of premature convergence is early in species, the mixed algorithm is used, the genetic algorithm is improved. The simulation results show that the neural network optimization method can predict the temperature of fiber optic gyroscope drift effectively.

Introduction

The neural network consists of a large number of nonlinear processing units, and it is formed by connecting a parallel information processing systems in dense. It has learning ability and powerful information representation capability, so it has been widely applied to pattern recognition, automatic control and decision system, and other fields. According to the structure, the neural network can be divided into two categories, such as forward neural network and recurrent neural network. At present, feed forward neural network learning is widely used in the back propagation learning algorithm (BP algorithm) and its variants. These algorithms essentially belong to the gradient descent algorithm, thus it has some flaws inevitably, such as: it is easy to fall into local minimum, it has slow convergence speed, etc.

In order to overcome the defect of the gradient descent algorithm, this paper adopts genetic algorithm to optimize the BP network, on this basis, the model the temperature changes and the gyro drift is established, actual data is simulated, and the simulation results show that the has better prediction effect.

BP network based on genetic algorithm

A.Genetic algorithm optimization strategy

Multilayer feed forward neural network uses BP algorithm to learn, because the BP algorithm uses a gradient descent method, so the network learning effect has greater dependence on initial weights, so it is easy to fall into local minimum, and it has slow convergence rate, even it has no convergence. Although many researchers have used various improvement measures, in order to overcome the above disadvantages, but because the traditional methods have not escaped from the local optimization, and it cannot fundamentally solve the problem. But the genetic algorithm is highly parallel, randomized, it has adaptive search performance, make it not solve the complex and non-linear problems by traditional search methods in processing, it has obvious advantages.

Therefore, genetic algorithm and neural network are combined, learning the weights and the topology of neural network by genetic algorithm, the neural network is improved, and it can improve the precision of neural network, but also improve the local search ability of genetic algorithm. The reconciliation ability and the reconciliation quality are improved. However, genetic algorithm is used to improve the neural network, it is difficult to solve its own populations of premature convergence phenomenon. Because of the existence of this phenomenon, the algorithm is very difficult to find the real optimal solution. Therefore, we must to improve the genetic algorithm.

Here, a new method is used, mixing is used to improve the genetic algorithm, a new algorithm called mixed genetic algorithm is obtained.

B.Mixed genetic algorithm CCGA

According to the biological theory of evolution, diversity is the basis of biological population evolution. Similarly, the diversity of population is the basic condition for GA to be able to search the global optimal solution. For genetic computing, the convergence is concerned, and the diversity of the population can ensure genetic algorithm evolution and recombination effects, crossover operator can maintain the diversity of the group invariant, the mutation operator is used to increase the diversity of population.

About the diversity of the population, the calculate method is given as follows:

Binary code space of the arbitrary optimization problem is $\{0,1\}^L$, The population size is set as n, the group contains individual set $P = \{a_1, a_2, ..., a_n\}$, where, $a_j = \{a_{1j}, a_{2j}, ..., a_{Lj}\}$, $j = 1.2...n$. The diversity measure is:

$$m(A) = \frac{1}{L*n} \sum_{l=1}^{L} \left(\max\left\{ \sum_{j=1}^{L} a_{lj}, \sum_{j=1}^{L} (1-a_{lj}) \right\} - \min\left\{ \sum_{j=1}^{L} a_{lj}, \sum_{j=1}^{L} (1-a_{lj}) \right\} \right) \qquad (1)$$

Apparently, $m(P) \in [0,1]$, while $m(P) = 0$, the diversity of the population disappeared completely; While $m(P) = 1$, the diversity of population is the largest, For the t population, the diversity measure is $m(P(t))$.

In practical optimization problems in calculation, the existence of GA does not always converge to the global optimal solution or satisfactory solution, even for monotone or unimodal function, the phenomenon is occurred. This kind of phenomenon is different from GA convergence to local optimal solution, the nature of the problem is not the same as cheating. The current group of the best bit string distance optimal solution remains a significant Hamming distance, but the evolution of population capacity has been lost basically.

The author's point of view is proposed based on the above discusses in the background. The "Mixed" is given out in the first selection in gene again with good genes. The mating opportunities are given, and it can avoid the premature convergence phenomenon, it can retain all the good genes to produce the parent. To retain the rate of Px in the parent generation, the poor genes are selected randomly, in the mating process the future, it will retain all breeding, gene variation, competition and selection, etc. The next generation is processed in accordance with the above methods, so as to maintain the population diversity, it will not get stuck in "pre saturated". The processing procedure is shown in Figure 1.
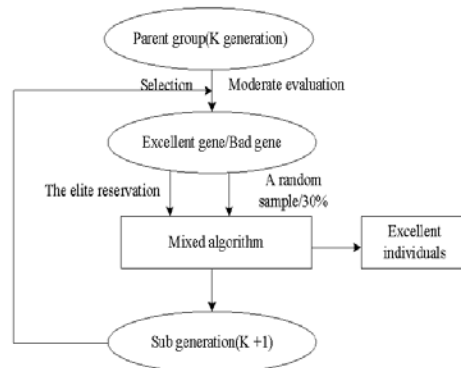

Fig.1 Schematic diagram of mixed genetic algorithm

Algorithm realization：

Genetic-Algorithms ()

{

Generate initialization population randomly;

Initialization parameters and generates strings of symbols stored in the Group;

do
{
Call genetic algorithm:
Compute Group symbols in the string value size from big to small order:
Compute the average fitness value Q*：
Compare Qi and Q*, Keep all greater than Q* strings of symbols and with probability Pb retained 30%： small Q* strings of symbols, to form a new Group;
for (i=1;i<=GroupNum/2;i++)
{
Remove the two strings of symbols and the crossover operation with probability PC call from Group
if(crossover operation occurs)
Generated strings of symbols to join Temp;
else
The original symbol string join Temp;
}
For every symbol in Temp series, with probability PM, \ call mutation algorithm;
if(Mutation operation occurs)
The new generation of strings of symbols to join Newsgroup;
else
The original symbol string join Newsgroup;
}
while(The algorithm has yet to meet the convergence criteria):
}
Termination criteria:
You can use two kinds of termination criteria as follows:
1) Using cyclic maximal degree as a termination criterion;
2) Using group optimal individual gene multi generation unchanged as a termination criterion.
Various rules above can be used alone, but it can also be used in combination.

Simulation experiment

Performance parameters of gyroscope are sensitive to changes in environmental temperature, and the effect of each component on the error of fiber optic gyro drift is very complicated in nonlinear equation. Fiber optic gyro measurement data is shown in Figure 2. (Temperature changes from -18 to 9 DEG C, the rate of rise of temperature is 54 DEG C /h), the output voltage and the temperature variation curve is obtained. The gyro output voltage and drift is a linear transformation, at a constant temperature, the magnitude order is 10^{-6}.

Figure 2 (temperature changes from -18 to 9 DEG C, the rate of rise of temperature is 54 DEG C /h) are developed for a study of the polarization maintaining fiber coil all fog when the temperature changes, the output voltage and the temperature variation curve of gyro. Between the gyro output voltage and drift is a linear transformation between, at a constant temperature of the magnitude order of magnitude.
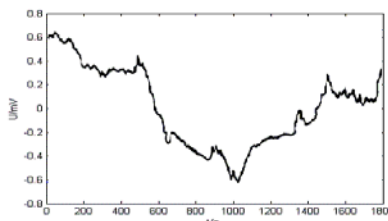

Figure 2 Fiber optic gyro measurement data

The temperature drift of fiber optic gyro modeling is obtained, and it is composed of a multilayer feed forward network, in order to use genetic algorithm to learn the connection weights tuning feed

forward network, connection weight coding is taken. In this paper, multi parameter mapping coding method is taken, and assumed there are m network weights, the code is:

P1   P2   …   Pm

W11,W12,…W1m1 W21,W22,…W2m2   …   Wm1,Wm2,…WmPm

Where, $W_{ij} \in \{0,1\}$，optimization object is to the network, and the activation function is:

$$f(x) = \frac{1}{1 + \exp(-x)} \tag{2}$$

If the neural network selects three layer BP network, according to the practical experience, the author summarizes the formula as:

$$M = M_i M_h + M_h M_o + M_h + M_o \tag{3}$$

Where, M is the number of weights in general, M_i is the number of input vectors, Mo is the number of output vectors, M_h is the number of nodes in the hidden. In practical application, the BP network takes 1-10-1 structure, the input is the current moment of temperature value, the output is the output voltage. Select the error index SSE (sum squarer error), network simulation results are shown in Figure 3. In the figure, the solid line shows the measured curve, the dotted line represents the predicted curve. It shows that the output of the network is same with the actual measurement results, the maximum relative error of the predicted results is less than 1%, which indicates that the network has high accuracy.
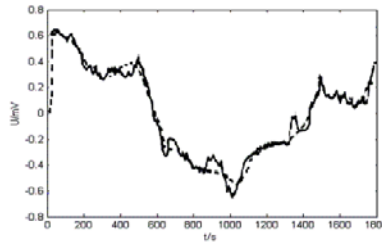

Figure 3 Network output value and the actual value

Conclusions

In order to solve the problem of temperature drift for fiber optic gyroscope, the neural network is used to construct the temperature drift model. The neural network is easy to fall into local minimum, the convergence speed is slow, the genetic algorithm is used to optimize neural network. The genetic algorithm has the problem of premature convergence is early in species, the mixed algorithm is used, the genetic algorithm is improved. The simulation results show that the neural network optimization method can predict the temperature of fiber optic gyroscope drift effectively.

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