

Research on Oil Ferrographic Prediction Based on BP Algorithm

Liu Yubing^[1] Tang Lei^[2] Dan Dongli^[2]

(1 Department of Military Traffic & Transportation of Xuzhou Air Force College,Xuzhou Jiangsu 221000;

2 Graduate Administrative Group,,Xuzhou Air Force College , Xuzhou Jiangsu 221000)

Abstract: This article first Introduces the BP algorithm , then predicts the trend with BP algorithm based on the data of Oil ferrographic Parameter.And the forecast programe is also designed by means of matlab toowlbox The results desmontrate that the algorithm is reasonable and it is suited for the prediction of oil ferrographic parameter.

Key words: BP Algorithm ferrographic Analysis Prediction Matlab

1 Preface

There are two aspects of Ferrographic analysis technique,they are quantitative analysis and qualitative analysis.The quantitative analysis is mainly to ascertain abrasive particl concentration and relative content to proceed quantitative evaluation of the wearing progress of the accessory.

In the Ferrographic quantitative analysis,there is a staple and important quantitative parameter called intensity indice I_s .

$$I_s=(D_L+D_S)(D_L-D_S)$$

(1)

(D_L+D_S) is aggregate abrasion ,

(D_L-D_S) is abrasion intensity.Thus it can be seen that the chang of the I_s has something to do with aggregate abrasion and abrasion intensity,it not only reflects the change of abrasion state in different time ,but also characterizes the degree of machine wear-out failure or distress condition. Wherefore,it is an important condition diagnostic parameter which can be used for diagnosing and predicting.

The artificial neurul network is a kind of mathematics model which reflects the structure and function of human brain.. It has t characters of highly dispersed memory mode and holographical association which are rather fit for forecast

research.

2 BP Algorithm

BP network is a sort of single-track propagative multilayer forward network, which includes input-layer,hidden-layer and output-layer. While study smaples are supplied for network, the neuronc activation values are spreading from input-layer to output layer through hidden-laywer,then the input response is obtained at output-layer. subsequently,the connection weights are amended from layer to layer to decrease the error.Such algorithm is called error back propagation algorithm□namely BP algorithm.The structure of BP as figure 1:

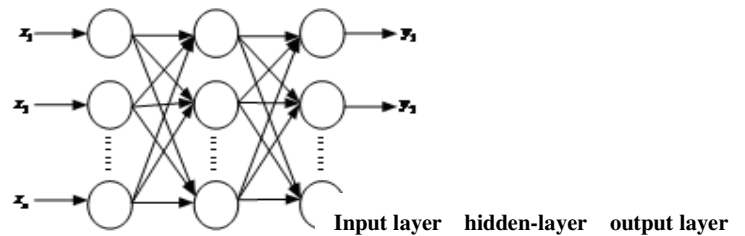


Fig 1

Structure of BP Network

BP network usually has one or more hidden-layer, neurons of which all adopt S-type activation function and those of output-layer neuron adopt linearity transfer

function. If the last layer of BP is S-type activation function, the outputs is limited in a minor range; if linear activation function, the output can be arbitrary value.

Steps of BP neural net prediction model are as follows:

- Initialize with small random numbers;
- Input samples and calculate O_j of each layer,

$$net_j = \sum_i w_{ij} O_{ij}$$

$$O_{ij} = \frac{1}{1 + e^{-net_j}}$$

- Compute the δ_j of the output layer, $\delta_j = (y_j - O_j) O_j (1 - O_j)$;
 - Compute the δ_j of each hidden-layer, $\delta_j = O_j (1 - O_j) \sum w_{ij} \delta_k$;
 - calculate and preserve correction data of each weight, Δ
- $$w_{ij}(n) = -\eta \delta_j O_i + \alpha \Delta w_{ij}(n-1);$$
- $w_{ij}(n+1) = w_{ij}(n) + \Delta w_{ij}(n)$;
 - Input another sample, turn to step ②, Until the network converges and output error is smaller than permissible value.

Table 1 Experimental data

Runing time	2	3	4	5	6	7
Is	2.17	1.12	2.17	1.80	1.65	1.35
Runing time	8	9	10	11	12	13
Is	1.05	1.44	1.58	1.92	1.71	1.64

The select of the hidden-layer neurons is very complex. Meanwhile, it has something to do with the prediction accuracy. Generally, it is ascertained according to constructor's experience. There is a reference formula, $P = \sqrt{N + M} + A$.

3 Experiment data and mold of neural network

The data comes from Cummins 6BT5.9 diesel engine experimentize on engine experiment table. After engine runing Two hours we collect experimental data, afterwards pick every second hour. so, the collection of lubricating oil is done on steady behaviour of the engine and the periodicity is 1 hour. Oil samples are taken from oil level of engine sump tank, according to dynamic equilibrium of the abrasive grain, the abrasive particles can be reputed that they are procreated within a complete alternation and would not contain sediment particle in the lower part of drain pan. The quantitative analysis equitment is ZTP-X2. The experimental datas are as follow.

This BP prediction model adopts 3 layers, and the hidden-layer employs hyperbolic tangent S-type transition function, output layer adopts linear transmission function, the former N data act as input, and the next is the target output, then experimental data from the second to N+1 act as input. The experimental data as table 1:

Here:

M is output-layer neuron numbers;

N is input-layer neuron numbers;

A is a constant between 1 and 10.

Then, P can be adjusted to ascertain a reasonable number.

4 BP predict and MATLAB Carry out

We choose six group of experimental data to be one input sample, its neural network training sample as table 2

Table 2 Training

Data

input	output
2.17, 1.12, 2.17, 1.80, 1.65, 1.35	1.05
1.12, 2.17, 1.80, 1.65, 1.35, 1.05	1.44
2.17, 1.80, 1.65, 1.35, 1.05, 1.44	1.58
1.80, 1.65, 1.35, 1.05, 1.44, 1.58	1.92
1.65, 1.35, 1.05, 1.44, 1.58, 1.92	1.71

P=12,MATLAB program is as follows:

```
P=[2.17 1.12 2.17 1.80 1.65 1.35;
1.12 2.17 1.80 1.65 1.35 1.05;
2.17 1.80 1.65 1.35 1.05 1.44;
1.80 1.65 1.35 1.05 1.44 1.58;
1.65 1.35 1.05 1.44 1.58 1.92]';
T=[1.05;1.44;1.58;1.92;1.71]';
threshold=[0 3;0 3;0 3;0 3;0 3];
net=newff(threshold
1),{'tansig','purelin'},'trainlm');
net.trainParam.epochs=10000;
net.trainParam.goal=0.00001;
LP.lr=0.01;
net=train(net,P,T);
P_test=[1.35 1.05 1.44 1.58 1.92 1.71]';
Out=sim(net,P_test)
TRAINLM, Epoch 0/10000, MSE 1.87816/1e-005,
Gradient 28.5774/1e-010
TRAINLM, Epoch 3/10000, MSE
1.81489e-007/1e-005, Gradient
0.00798171/1e-010
TRAINLM, Performance goal met.
Out = 1.6590
```

In turn,the real value is 1.64,the error is 1.12%. Thus it can be seen that oil ferrographic analysis parameter prediction based on BP is reasonable.

5 Conclusions

This article first Introduces the BP algorithm , then predicts the trend with BP algorithm based on the data of Oil ferrographic Parameter. The results desmontrate that the algorithm is reasonable

and it is suited for the prediction of oil ferrographic parameter.

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