Armed helicopter Combat power Index Assessment based on BP Neural Network

DONG Ze-wei*, LIU Xiao-qin, GAO Fu and TANG Xiao-chuan
Army Aviation Academy, Beijing, 101123
*E-mail: hktk0000@163.com

Abstract. According to the use characteristics of armed helicopter in wartime, this paper analyzes and studies the influencing factors of combat power index of armed helicopter, and explains each factor. Based on BP neural network, the evaluation model of combat power index of armed helicopter is established. The BP neural network was trained with 30 groups of training samples determined by experts. The results show that the evaluation method of combat power index based on BP neural network is feasible and effective, reduces the subjective factors in the evaluation process, and makes the evaluation results more accurate and reliable.

1. Introduction
Helicopter is the main battle equipment for the army to carry out three-dimensional attack and defense, and its weapon consists of artillery / gun, air-to-air missile, air-to-surface missile and rocket. The so-called combat power index of armed helicopter is to measure the ability of armed helicopter to carry out combat task by exponential method.

The battlefield situation is changing rapidly and the commander is able to grasp the information of the attack damage situation and the overall combat capability of the armed helicopter in a timely and accurate manner is the key to the victory of the war. The combat power index of the armed helicopter is an important parameter index to measure the combat damage situation and combat capability of the armed helicopter. At present, analytic hierarchy process (AHP), fuzzy comprehensive evaluation (FIC) and power exponent method are generally used to evaluate [1]. However, due to their subjectivity and lack of self-learning ability, they are easy to be judged randomness in practical evaluation. The subjective uncertainty and fuzzy cognition of the participants are restricted by many factors.

BP neural network (back propagation neural network) is a multilayer forward network with one-way propagation. By adjusting the scale of BP neural network (number of input neurons, number of output neurons, number of hidden layers and number of hidden layer neurons) and connection weights in the network, nonlinear classification can be realized. Moreover, any nonlinear function [2] can be approximated with arbitrary accuracy.

2. Analysis of influencing factors of combat power index
There are many factors affecting the combat power index of armed helicopter, which is a multi-index decision problem. The establishment of evaluation factor set is based on the target tree to determine all the factors that affect the evaluation target.

(1) Communication command capability: the ability to transmit operational information quickly, safely and reliably, and to receive or send instructions effectively to combat operations, recorded as.
Communication command capability mainly includes communication distance, communication quality, communication security, timeliness and so on.

(2) Maneuverability: the ability of helicopter gunships to perform tactical maneuvers flexibly and to achieve free transformation of multiple methods of warfare. The maneuverability mainly includes the maximum speed, the raising limit, the endurance performance, the turn slope and so on.

(3) Strike damage ability: timely target fire strike, effectively damage or destroy the enemy's living force, so that they lose combat capacity, recorded as. The ability of attacking damage mainly includes attack range, attack precision, launching speed, warhead performance, which is mainly related to weapon range, precision, firing speed, fire control system level, projectile capacity, warhead penetration and damage probability and so on.

(4) Electronic self-defense capability: refers to the ability of helicopter gunships to detect enemy targets in advance and are not easy to be found and not to be hit in the course of combat, and to ensure that airborne equipment is not vulnerable to harm under complex jamming conditions. The ability of electronic self-defense mainly includes detection and recognition, anti-interference, alarm, stealth and so on.

(5) Security capability: the ability of an armed helicopter to continue to perform a mission in a complex environment or after being hit by an enemy. The safety protection capability mainly includes the environmental reliability and the protective device resistance to destroy.

3. Combat power index evaluation model

3.1 The Establishment of Model

The combat power index evaluation model of armed helicopter based on BP neural network can be constructed as follows:

(1) The number of neurons in the input layer is determined. According to the analysis of the factors affecting the combat power index of armed helicopters, the main influencing factors include communication command ability, maneuvering ability, ability of attacking damage, capability of electronic self-defense and capability of security protection. The number of neurons in the combat power index of armed helicopter is 5. 5%.

(2) Determining the number of neurons in the output layer[3]. The evaluation results are used as the output layer of the network, and the number of neurons is 1. 5%.

(3) The determination of the number of hidden layers. The more hidden layers, the slower the learning speed of neural network is. According to Kosmogorov theorem, the three-layer BP network can approximate any continuous function under the condition of reasonable structure and proper weight, so the three-layer BP network with relatively simple structure is selected.

(4) The determination of the number of neurons in the hidden layer. There is no uniform rule for determining the number of neurons in the hidden layer. In general, the number of neurons in the hidden layer is determined according to the convergence performance of the network. In this case, the number of neurons in the input layer is calculated according to the empirical formula mx2n1, which is the number of neurons in the input layer. The number of hidden layer neurons is initially set at 11 (the generalization ability of visual network is adjusted during training).

(5) The determination of activation function. The Sigmoid function is chosen as the activation function of the hidden layer and output layer of BP neural network.

\[ f(x) = \frac{1}{1+e^{-x}} \]  \hspace{1cm} (1)

(6) Determine the structure of the evaluation model. Based on the above analysis, the combat power index evaluation model of armed helicopter based on BP neural network is established, as shown in figure 1.
3.2 Selection of training samples
The performance of the network is closely related to the selection of samples, and it is directly related to the reliability of the evaluation results. In order to make the evaluation result accord with the objective reality and truly reflect the combat power of the armed helicopter, three principles should be followed when selecting the sample [4]: (1) network training, the law extracted from the network training should be contained in the sample, so the sample must be representative; (2) the selection of samples should pay attention to the equilibrium of sample types; (3) the organizations that try to make the number of samples of each category about the same number of samples should pay attention to the cross input of samples of different classes, or select input samples randomly from the training set.

3.3 Normalization of samples
In this paper, the method of linear transformation is used to convert the original training sample into a feasible training sample (the value of each influencing factor is taken between [0 / 1]), which can be divided into two situations:

(1) when the influence factor value is bigger, the combat power index is bigger, according to formula (2) carries on the normalization.

$$Y = \frac{X - \min}{\max - \min}$$

(2) when the factor value is smaller and the combat power index is larger, normalization is carried out according to formula (3).

$$Y = \frac{\max - X}{\max - \min}$$

In the formula: the original training sample value max (or min) is the maximum (or minimum) value of the current gunship helicopter for the same influence factor. For the values which are not easy to be quantified, the values of Maxima and min are obtained by using the method of expert scoring.

3.4 Network training
The standard BP algorithm uses the steepest gradient descent method to revise the weights, and the training process gradually reaches the minimum point from a certain starting point along the slope of the error function to zero error [5]. Because the standard BP algorithm is related to the order of input samples, the convergence rate is slow, it is easy to fall into local minima, and it is easy to cause oscillation effect. In order to overcome the shortcomings of the algorithm, an improved algorithm with additional momentum is adopted in this paper. The method is to add a value proportional to the change of the last weight (threshold) to the change of each weight (or threshold) on the basis of the backpropagation method, and to produce a new weight (or threshold) change according to the backpropagation method. The weight adjustment formula with additional momentum factor is:
\[ \Delta w(k + 1) = (1 - m_c)\eta \nabla f(w(k)) + m_c (w(k) - w(k - 1)) \]  \hspace{1cm} (4)

In the formula, it is a weight vector, a training number, \((0 \leq 1)\) a momentum factor (generally about 0.95), a learning rate and a gradient of the error function. It can be seen from formula (4) that its essence is to transfer the influence of the last weight (or threshold) by a momentum factor. With the improved BP algorithm program, the input matrix of the training sample can be input into the computer, and the network model can learn the training sample repeatedly until the precision of the network model meets the requirements. The threshold and connection weights of each neuron after learning are outputted.

4. Case analysis

In order to verify the accuracy and validity of the combat power index evaluation model of armed helicopter, a certain type of armed helicopter is taken as an example. Identify 30 groups of training samples by organizing experts and normalize them, as shown in Table 1. In this paper, we use the MATLAB neural network toolbox to study the training network, select the first 25 groups of samples as the learning samples of the neural network, and use the additional momentum method to train the network. The learning rate is 0.95, the momentum factor (MC) is 0.98, and the training error is 0.001. After 4695 times of training, the network achieves the precision requirement. The latter five samples are used as test samples and input into the trained neural networks. The test results are shown in Table 2.

| No. | x_1  | x_2  | x_3  | x_4  | x_5  | x_6  | Expert assessment result |
|-----|------|------|------|------|------|------|--------------------------|
| 1   | 0.85 | 0.77 | 0.75 | 0.33 | 0.83 | 1.00 | 0.780                    |
| 2   | 1.00 | 0.85 | 0.85 | 1.00 | 0.67 | 1.00 | 0.891                    |
| 3   | 0.43 | 0.92 | 0.70 | 0.68 | 1.00 | 1.00 | 0.722                    |
| 4   | 0.88 | 0.85 | 0.50 | 1.00 | 1.00 | 0.77 | 0.714                    |
| 5   | 0.92 | 0.75 | 0.45 | 0.42 | 0.50 | 1.00 | 0.696                    |
| 6   | 1.00 | 0.60 | 1.00 | 0.84 | 1.00 | 0.84 | 0.790                    |
| 7   | 1.00 | 0.85 | 0.79 | 0.50 | 0.83 | 1.00 | 0.840                    |
| 8   | 0.75 | 0.58 | 0.22 | 1.00 | 0.58 | 0.83 | 0.570                    |
| 9   | 0.92 | 0.75 | 1.00 | 0.60 | 1.00 | 1.00 | 0.860                    |
| 10  | 0.85 | 0.50 | 0   | 0.85 | 0.83 | 1.00 | 0.540                    |
| 11  | 0.82 | 1.00 | 1.00 | 0.90 | 0.82 | 0.89 | 0.920                    |
| 12  | 1.00 | 0.68 | 1.00 | 0.60 | 0.50 | 0.83 | 0.776                    |
| 13  | 0.92 | 0.55 | 1.00 | 0.76 | 0.92 | 1.00 | 0.820                    |
| 14  | 0.50 | 0.56 | 0   | 0    | 0.83 | 0.67 | 0.250                    |
| 15  | 1.00 | 0.91 | 0.63 | 1.00 | 0.50 | 1.00 | 0.842                    |
| 16  | 1.00 | 0.75 | 0.87 | 0.55 | 0.84 | 0.83 | 0.770                    |
| 17  | 1.00 | 0.85 | 0.64 | 1.00 | 0.92 | 0.95 | 0.840                    |
| 18  | 0.84 | 0.59 | 0.41 | 0.75 | 0.92 | 0.75 | 0.590                    |
| 19  | 0.87 | 0.69 | 1.00 | 1.00 | 0.60 | 0.93 | 0.810                    |
| 20  | 0.92 | 0.78 | 0.78 | 0.45 | 1.00 | 0.92 | 0.780                    |
| 21  | 0.85 | 0.34 | 0.35 | 0.58 | 0.83 | 0.67 | 0.420                    |
| 22  | 1.00 | 0.50 | 0   | 0.83 | 0.75 | 0.92 | 0.580                    |
| 23  | 0.84 | 1.00 | 0.60 | 0.85 | 1.00 | 0.81 | 0.780                    |
| 24  | 0.68 | 0.75 | 0.75 | 0.85 | 0.33 | 1.00 | 0.710                    |
| 25  | 1.00 | 0.93 | 1.00 | 0.84 | 0.50 | 0.92 | 0.880                    |
| 26  | 1.00 | 0.62 | 0.72 | 0.67 | 0.83 | 0.67 | 0.580                    |
| 27  | 0.52 | 0.92 | 0.87 | 1.00 | 0.77 | 0.83 | 0.752                    |
| 28  | 0.55 | 0.58 | 0.50 | 0.75 | 0.84 | 0.92 | 0.570                    |
| 29  | 0.68 | 0.68 | 0.69 | 0.83 | 0.92 | 1.00 | 0.710                    |
| 30  | 0.68 | 0.27 | 0.25 | 0.83 | 1.00 | 0.83 | 0.424                    |
Table 2  BP neural network test results

| No | Armed helicopter combat power index | Error% |
|----|-------------------------------------|--------|
|    | Expert assessment results | Network output results |
| 26  | 0.580 | 0.5622 | 3.07 |
| 27  | 0.752 | 0.7739 | 2.77 |
| 28  | 0.570 | 0.5492 | 3.65 |
| 29  | 0.711 | 0.7374 | 3.86 |
| 30  | 0.424 | 0.4387 | 3.47 |

It can be seen from Table 2 that the output data of the network basically meet the scheduled requirements, and from the test results, the network output data are basically consistent with the expert evaluation results of the combat power of a certain type of armed helicopter, and the accuracy is relatively high. It shows that it is feasible and effective to evaluate the combat power index of armed helicopter by using this model.

5. Conclusion
According to the decision demand of wartime maintenance support, this paper synthetically considers all kinds of influence factors and interrelations, and makes use of the "black box" characteristic of neural network to find out more objectively the implicit relation between each factor and the influence on the combat power of armed helicopter. BP neural network is used to evaluate the combat power index of armed helicopter. The evaluation method reduces the subjectivity of the evaluation process and no longer depends on the expert to determine the weight of the influencing factors, which makes the evaluation results more accurate and credible, and has important practical significance to improve the command and decision-making ability of the commander.

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