Analysis of Model Rationality Verification Standards Based on Track and Field Sports

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ABSTRACT: *Athletics is a common sport that includes running, jumping, throwing, and walking races. In the training, competition, and teaching of track and field sports, various models are often used to help understand and improve the performance of athletes. To ensure the accuracy of these models, it is necessary to conduct reasonable validation. This article will analyze the validation criteria for the rationality of models based on track and field sports. In track and field sports, common models include biomechanical, physiological, and kinematic models. Biomechanical models can help us understand the movements and power distribution of athletes; Physiological models can predict the fatigue level of athletes under different conditions. Kinematic models can analyze athletes' exercise patterns and optimize their techniques.*

Keywords: BP Neural Network, Scoring Criteria, Track and Field Sports, Men's Almighty Decathlon

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1. Introduction

Track and field is a sport with a long history. It is one of the most medal-laden events in the Olympic Games, and it is also the most extensive sport in the world [1]. Therefore, as the mother of sports, track and field sport plays an important role in developing various projects. Meanwhile, track and field sport is the cornerstone of the Olympic Movement and best embodies the concept of "faster, higher and stronger".

As one of the most important sports in the national sport, athletics is not to be questioned. The all-around project is known as "the king of track and field". As is known to all, men's almighty decathlon sport is the most complex and comprehensive project in track and field sports [2]. It is composed of individual items in track and field, but it is not equal to the simple addition of personal items. It is an integral whole competition project. In the competition, deciding victory or defeat is based

on the total scores of athletes participating [3]. Therefore, decathlon is an inseparable and organic link as a whole. The all-around competition is a comprehensive assessment of the athlete's performance. "Athletics All-around Athletic Scoring Table" is the athletics all-rounders grand prix, which was scored for performance by checking the score sheet. This requires that all athletes in the same rules be equal before the grading standards, which aligns with fairness and fairness [4]. This involves the establishment of a white standard score to scientifically, reasonably and fairly evaluate and distinguish between different levels of exercise.

2. State of the Art

It reflects more expert experience in the existing track and field sports grading standards, but it is difficult to rule out various randomness and subjectivity in the process of formulation, which results in the distortion and bias of assessment. Therefore, we need to minimize human influence in the evaluation and objectively reflect the mathematical model of the relationship between the index data and the target value in the scoring system, making the assessment more accurate and effective and inevitably put it in front of us. As well as solve the problems existing in the current scoring table, obtain an effective and accurate scoring method to the maximum extent, and establish a qualitative and quantitative index in one [5-6]. Scholars pointed out that there is a severe deficiency in the preparation of the IAAF Universal Scoring Table, which is mainly reflected in the gradual increase of the scoring table scores did not reflect the principle of progressive scoring; the scoring table to the bottom of the score and the high limit level too much; the individual score difficult degree balance and some individual score not enough to apply [7]. It was also pointed out that the almighty scoring table is not only a very important basis for assessing the performance of athletes but also plays an important role in the training of the almighty. Some problems in the universal test scores published by the IAAF include whether the starting and ending points are appropriate, whether the scores are progressive or not, and whether the scores are balanced [8]. Scholars used the variable-parameter curve fitting method to improve the IAAF "Men's Decathlon Rating Scale", and appropriately modified the starting point and the endpoint of the original score table to make the score of the new score table more reasonable [9]. Based on the analytical study of "track and field sports scale", the various elements of its content were explored and evaluated. In view of its existing problems, "Track and Field Almighty Competition Difference Formula Evaluation Method" was put forward and argued [10].

3. Modeling of Track and Field Based on BP Model

3.1. Track and Field Score Standard Theory

Track and field is a physical fitness program of speed, height, distance and stamina. Some require maximum speed and strength in a short period, while others require maximum endurance in a long time. Therefore, this paper studied the definition, speed, distance, and stamina of track and field. Domestic and foreign academics do not form a unified and definite definition of "track and field", and any situation will have certain influence and restriction on people's cognition in this respect and the development of track and field in the professional field. According to the characteristics of track and field and people's cognition in this aspect, the definition of track and field is defined as "extension definition". IAAF track and field sports are composed of many sports, including track and field races, cross-country run, mountain running walking and other projects; this definition is consistent with the logic of the standard and fully demonstrates the track and field. Besides, this project has its own unique characteristics. The above definition of "track and field" has been more comprehensive and accurate in academia. Athletics has three distinctive characteristics: athleticism, fitness, and interest. The "*tripleness*" of the sport is somewhat inter-related. Figure 1 shows the track of some track and field events.

3.2. BP Neural Network Algorithm Theory Research

With human brain structure and features as the premise, the neural network algorithm effectively uses neurons or nodes to form a large-scale parallel distributed information processing and nonlinear dynamics system, which can solve the problem of high efficiency that can't be dealt with by conventional information processing methods, especially about thinking, awareness and reasoning. The neural network learning algorithm is actually a typical error backpropagation learning algorithm in the field of BP neural networks. Figure 2 is a schematic diagram of a multi-layer feed-forward network structure with the BP algorithm as the core.

Error backtracking algorithm divides the learning process into positive and negative stages. In the forward propagation process, the input information needs to be given accurately according to the actual situation, and the input layer is used effectively to calculate the output value of each unit in practice according to professional specifications. In the reverse process, if the output layer can't obtain the expected output value effectively during the computation process, the error needs to be

calculated accurately by layer-by-layer recursion and the weight adjustment is effectively adjusted according to the specific error.

Figure 1. Part of the track and field competition

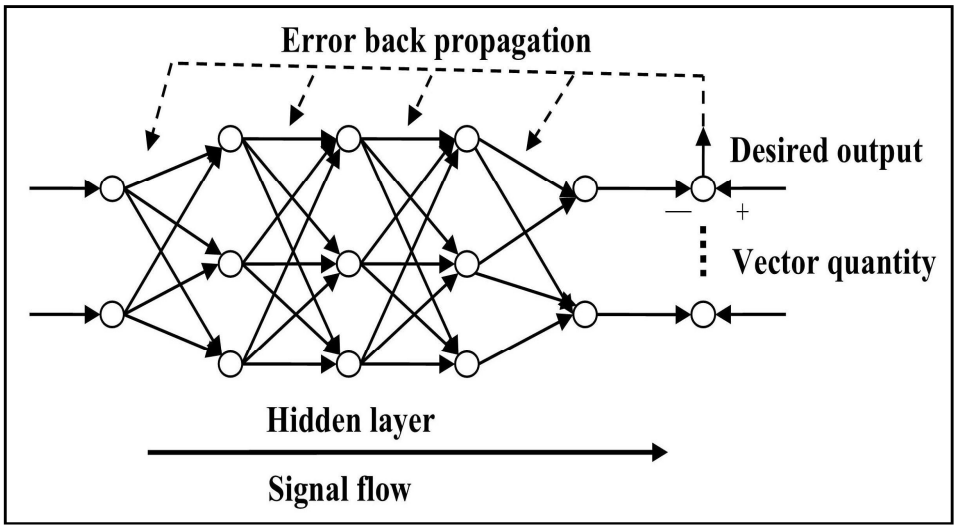

Figure 2. Aircraft engine fault detection process based on association rules

This network has input and output layer nodes but also one or more layers of hidden nodes. When dealing with the input information, it is necessary to propagate the corresponding information to the hidden layer node and use each unit's conversion function to analyze and calculate the information. Based on this, the information output by implicit nodes is propagated to the output node according to the professional norms and standards; at this time, the corresponding result will be given accurately. The forward propagation of neuronal states at all levels has a certain degree of influence and restriction on the next layer of neuronal networks. Suppose the output layer fails to obtain the expected output value during the calculation process effectively. In that case, there might be an error between the actual output value and the predicted output value due to some factors. In this case, the error signal needs to be effectively returned according to the previously connected paths during the backpropagation. The exact weighting of the corresponding neurons in each layer is continuously transmitted to the input layer for accurate analysis and calculation. And then through the forward propagation process, in fact, the forward and reverse processes are repeatedly used in the calculation, thus ensuring that the entire network learning process has the smallest error signal.

3.3. Establishment of Track and Field Scoring Model Based on BP Neural Network

Among the scoring standards promulgated by the IAAF, the score between each item and the athletic performance can be regarded as a kind of mapping, which may be a high dimensional non-linear relationship. Due to the neural network's ability to find potential non-linear relationships implied in the training samples, it is flexible and convenient to model multiple unknown coefficients. Regardless of the form between the evaluation index and the mapping of the evaluation results, the neural network can automatically learn the previous experience from the provided training samples and simulate it through training. Therefore, it replaces the review experts' cumbersome inquiry and presentation process. For those more complex factors, the higher the degree of non-linearity, the more noticeable this advantage of neural networks will be. This is because the neural network is highly adaptive, self-organizing and self-learning, and it is good at making decisions in uncertain, approximate and contradictory knowledge environments. Meanwhile, it can avoid determining indicators and related systems and other aspects of the calculation.

Based on the gradient descent method, the BP algorithm is usually used in the multi-layer neural network, which is often used in the academic field. Assuming that there is an arbitrary network of L nodes and n nodes in this phase, the cells in each layer only effectively receive the information output from the previous layer and transmit it to each unit in the next layer. The functional characteristics of each node at this stage are sigmoid type; in other words, they have continuously differentiable features. For ease of operation, it is commonly understood that the network only outputs y. Suppose at this stage, given N samples $(xk,yk)(k=1,2,...,N)$, the output of any node i is denoted as O_i. Mark an input as xk, the output in the network is denoted as yk , the output of node i is denoted as O_{ik}. A comprehensive study of the jth unit in layer 1 is performed. If the kth sample is output, the input of node j at this time is expressed as follows:

$$net_{ij}^{l} = \sum_{j} w_{ij}^{l} o_{jk}^{l-1} \tag{1}$$

$$o_{jk}^{l} = f(net_{jk}^{l}) \tag{2}$$

Among them, o_{jk}^{l-1} represents the output of the jth unit node when the kth sample is input to the layer l-1.

The error function used is as follows:

$$E_k = \frac{1}{2}\sum_{l}(y_{lk} - \bar{y}_{lk})^2 \tag{3}$$

Among them, $\bar{y}_{lk}$ is the actual output of unit j. The total error is as follows:

$$E = \frac{1}{2N}\sum_{k=1}^{N} E_k \tag{4}$$

Definition: $\delta_{jk}^{l} = \frac{\partial E_k}{\partial net_{jk}^{l}}$.

Available: $$\frac{\partial E_k}{\partial w_{ij}^{l}} = \frac{\partial E_k}{\partial net_{jk}^{l}} \frac{\partial net_{jk}^{l}}{\partial w_{ij}^{l}} = \frac{\partial E_k}{\partial net_{jk}^{l}} o_{jk}^{l-1} = \delta_{jk}^{l} o_{jk}^{l-1} \tag{5}$$

If node j is the output unit, then $o_{jk}^{l} = \bar{y}_{jk}$,

$$\delta_{jk}^{l} = \frac{\partial E_k}{\partial net_{jk}^{l}} = \frac{\partial E_k}{\partial \bar{y}_{jk}} \frac{\partial \bar{y}_{jk}}{\partial net_{jk}^{l}} = -(y_k - \bar{y}_k) f'(net_{jk}^{l}) \tag{6}$$

If node *j* is not an output unit, then:

$$\delta_{jk}^{l} = \frac{\partial E_k}{\partial net_{jk}^{l}} = \frac{\partial E_k}{\partial \bar{y}_{jk}} \frac{\partial o_{jk}^{l}}{\partial net_{jk}^{l}} = \frac{\partial E_k}{\partial o_{jk}^{l}} f'(net_{jk}^{l}) \tag{7}$$

In the formula, o_{jk}^{l} is the input to the next level (l + 1) level. Calculating $\frac{\partial E_k}{\partial o_{jk}^{l}}$ needs to be calculated from the (l + 1) level.

Available at the (*m* + 1)*th mth* unit:

$$\frac{\partial E_k}{\partial o_{jk}^{l}} = \sum_{m} \frac{\partial E_k}{\partial net_{mk}^{l=1}} \frac{\partial net_{mk}^{l+1}}{\partial o_{jk}^{l}} = \sum_{m} \frac{\partial E_k}{\partial net_{mk}^{l+1}} w_{mj}^{l+1} = \sum_{m} \delta_{mk}^{l+1} w_{mj}^{l+1} \tag{8}$$

Substituting (8) into (7), then:

$$\delta_{jk}^{l} = \sum_{m} \partial_{mk}^{l+1} w_{mj}^{l+1} f'(net_{jk}^{l}) \tag{9}$$

To sum up the above results, it can be shown as follows:

$$\begin{cases} \delta_{jk}^{l} = \sum_{m} \delta_{mk}^{l+1} w_{mj}^{l+1} f'(net_{jk}^{l}) \\ \frac{\partial E_k}{\partial w_{ij}^{l}} = \delta_{jk}^{l} o_{jk}^{l-1} \end{cases} \tag{10}$$

Therefore, the steps of the backpropagation algorithm can be summarized as follows: (1) Initial value of the selected weight coefficient. (2) Repeat the following procedure until the error-index meets the precision requirements, then: $E = \frac{1}{2N} \sum_{k=1}^{N} E_k < \varepsilon$,ε is the accuracy. (3) End.

3.4. The Establishment of Track and Field Score System

First of all, to construct the neural network model to examine the relationship between each index and the core index in the existing evaluation index system, the conflicting samples are divided by a fuzzy membership function. Secondly, the remaining samples are selected to as modelling data to model and verify the model predictions. Then, on the premise of reliable model verification, based on the model combined with sensitivity analysis, the relationship between each assessment index and core index is investigated. The specific steps are as follows:

To investigate the correlation between the predicted value and the true value of the model, the correlation between the model's predicted value and the true value of the verification sample is analyzed to directly evaluate the quality of the neural network training. The quantification index for judging the relative merits is the square of the sample decision coefficient *r*, also known as the coefficient of determination (*r*2). In general, the determination coefficient ranges from 0 to 1. The greater the coefficient of determination, the better the correlation will be; the smaller the coefficient of determination, the worse the correlation will be. The correlation coefficient *r* is as follows:

$$r = \frac{\sum_{i=1}^{n} (x_i - \bar{X})(y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n} (x_i - \bar{X})} \sqrt{\sum_{i=1}^{n} (y_i - \bar{Y})}} \tag{11}$$

To further assess the reliability of the model, sensitivity analysis can be used. The simple method of calculating the sensitivity

coefficient is the ratio of the state variable's relative change to the input parameter's relative change due to the input parameter's change. The calculation method is shown in equation (12).

$$SC_i = \frac{\Delta Y_i / Y_i}{\Delta X_i / X} \tag{12}$$

In the formula, *SCi* represents the sensitivity coefficient of the ith input parameter, $\Delta Xi/X$ and $\Delta Yi/Y$ represent the relative rate of change of the ith input parameter and the corresponding output variable. The sensitivity coefficient, calculated by Eq. (12) has no dimension, so the sensitivity of different parameters can be directly compared. The magnitude of the absolute value of the sensitivity coefficient reflects the degree of influence of the input parameter on the output result. The positive and negative of values sensitivity coefficient represent the effects of the parameter on the output result of the model. In other words, the positive value means that the output value increases as the input parameter increases, while the negative value is vice versa.

4. Analysis of Examples

4.1. Neural Network Model Prediction Results

The contradictory data in the neural network training sample will lead to the low accuracy of the model established by the sample learning training and affect the network training and test results. Moreover, the existence of contradictory samples in the training often results in the difficulty that the network training converges to the target error. Therefore, before the establishment of the neural network model, the fuzzy mathematics membership function is used to judge the similarity of variables to remove the contradictory samples of the model data, which can improve the accuracy of the model and reduce the model training time to improve the modeling efficiency.

In the modelling process, a three-layer neural network model is used to select the existing data group as a verification sample to verify the model's predictive effect (The remaining groups are training samples to the network training). The dynamic construction method is used to determine the number of hidden nodes. Then, the Bayesian Regularization Algorithm is used to train the model, and the maximum training step, training target error and correction weight are set. The input layer, implicit layer and output layer node excitation function are tangent type and linear function, respectively. The above process is achieved through software programming. Moreover, after step-by-step training, the mean square error of the network after weight correction is reached, and the average error curve during the training process is shown in the figure.

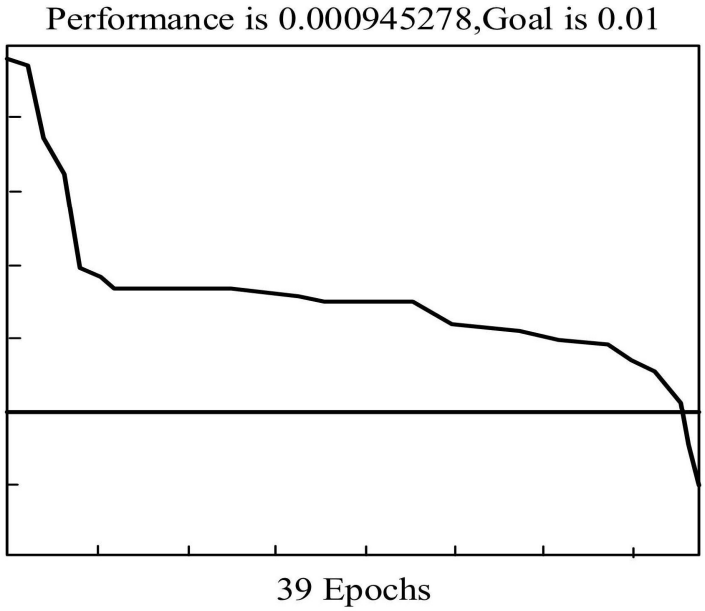

Figure 3. Average variation error in network training

After the men's almighty decathlon special skills assessment index system neural network model training is completed, the model needs to be verified. Select the remaining group of data as a sample to verify the model predictive results to verify the results in Table 1.

Number	True values	Predicted values	Relative error (%)
1	8893	8767	1.4
2	8508	8701	2.3
3	8943	8783	1.8

Table 1. The Results of Prediction of BP Neural Network Model

The relative deviation between the model predictive value and the experimental value in the verification sample is between 1.4 and 2.3. The average relative deviation between predicted and experimental values is 0.18%, the correlation coefficient r is 0.9040, and the NSC is 0.9986. Finally, the results show that the model is reliable.

4.2. Model-based Parameter Sensitivity Analysis

After the neural network model is established and validated, the neural network is used to evaluate the impact of different assessment indicators on the comprehensive evaluation results of athletes' unique skills. Because of the deterministic of the algorithm, the sensitivity results calculated for any set of assessment data are consistent. Then, the neural network model's sensitivity is analyzed by selecting the data. Respectively, the input variables of each model are reduced to keep the other input values unchanged, and the model's output is predicted using the built neural network. The sensitivity calculation results are shown in figure 4.

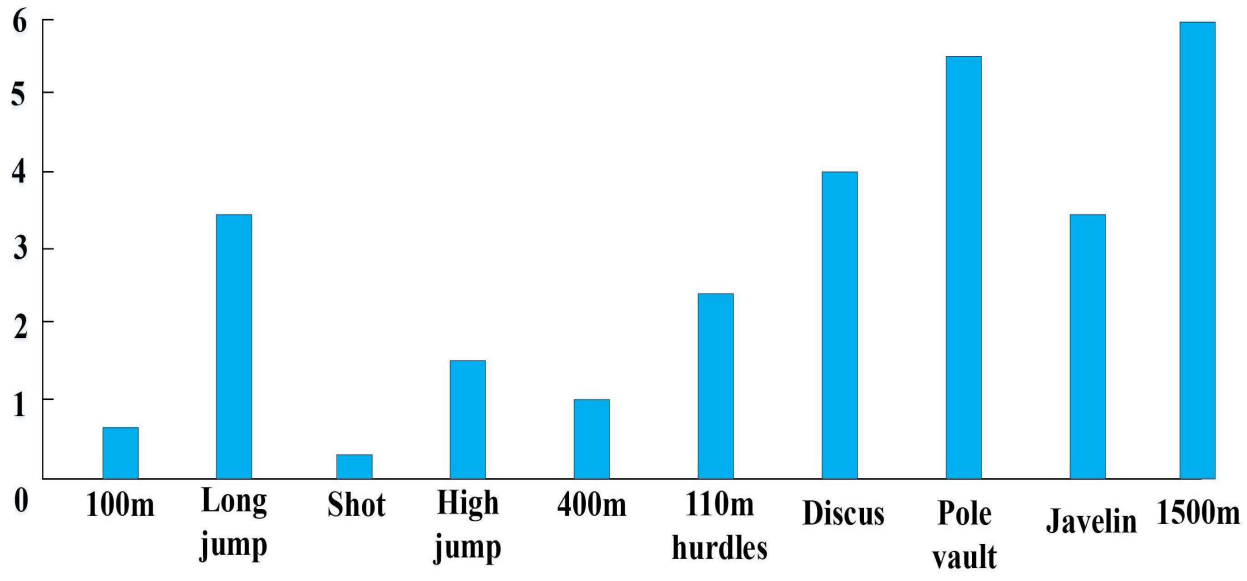

Figure 4. Sensitivity analysis of the men's all-around ten items

From the sensitivity analysis results of the figure, it can be clearly seen that the three assessment indexes that have the greatest influence on the evaluation results of the comprehensive skills of special skills are 1,500 meters in succession among the items in the ten omnipotent skills tests, and the struts, the discus, the javelin, long jump. It is followed by 110 meters hurdle, high jump, 400 meters, 100 meters and shot put.

4.3. Assessment Index System Improvement

This paper, after the above modeling of the men's almighty decathlon evaluation index system, analyzes the correlation between the different project evaluation indexes. It examines the rationality of the evaluation index setting. The model sensitivity analysis results and expert questionnaire survey results are combined, and the improved men's almighty decathlon evaluation index system is shown in the table. In this study, the scale method combined with the results of sensitivity analysis of neural networks is used to set up the scores of each assessment index, and the results of calculating the proportion of the evaluation indexes in each semester are shown in Table 2.

Items	**100m**	**Long jump**	**Shot**	**High jump**	**400m**
Score proportion	10%	8%	9%	10%	12%
Items	110m hurdles	Discus	Pole vault	Javelin	1500m
Score proportion	11%	12%	9%	12%	7%

Table 2. The Men's all-around Ten Assessment Index System

Men's almighty decathlon is a systematic combination of projects. In the practice of training, every single item should be considered. It should not be overlooked but be balanced. While dealing with the emphasis on training, we also attach importance to the role of individual items in performance so that the weak items are not weak and the ones with stronger items are stronger, then the level of each individual item in the ten items will increase.

5. Conclusion

Track and field is one of the most popular sports in the world and is also one of the oldest sporting events in the world. Track and field and swimming, shooting is considered as of the three major projects of the Olympic gold medal, which has 51 gold medals. "Athletes who have the world" is also come from this. The scoring standard is not only an important basis for assessing the performance of track and field athletes, but also plays an important guiding role in the training of track and field sports. Whether the men's almighty decathlon rating scale is reasonable or not, it is directly related to the further development of the omnipotence movement. In this paper, first of all, the artificial neural network technology was used to establish the model to realize the mapping of the non-linear relationship between the existing evaluation index system and the athlete's special skills. Secondly, based on the relative sensitivity calculation results, the relationship between the existing assessment index and the core index of students' comprehensive quality was investigated through sensitivity analysis. And it was combined with the scale method to set the score of each assessment index. Artificial neural network technology, as a new intelligent algorithm, has been widely used in various fields. However, it was the first attempt to study the standard system of track and field score. This study successfully uses the common methods such as BP neural network technology to study the track and field score system, which provides a reference for the research on the track and field score standard.

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