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Individual Intervention and Assessment of Students' Physical Fitness Based on the "Three Precision" Applet and Mixed Strategy Optimised CNN Networks

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Abstract

With the development of network technology and intelligent application platforms, the "Three Precision" applet as a method of individual intervention for students' physical fitness can not only enable students to obtain the improvement of physical fitness and lifelong sports habits, but also establish a new bridge of cooperation between home and school. The analysis method of student physical fitness individual intervention assessment is affected by a variety of factors such as the framework design of the WeChat applet platform and the subjectivity of the intervention, which leads to the inefficiency of the student physical fitness individual intervention assessment method. To address this problem, we analyse the mode and content of students' physical fitness individual intervention based on the "Three Precision" applet, extract the feature vectors of students' physical fitness individual intervention, construct a system of students' physical fitness individual intervention assessment indexes, and establish a method of students' physical fitness individual intervention assessment based on big data technology and WeChat applet by combining the mushroom propagation optimization algorithm and convolutional neural network. Individual intervention assessment method based on big data technology and WeChat applet. The effectiveness and robustness of the proposed method are verified by using the data recorded in the "Three Precision" applet as the input data of the model. The results show that the proposed method meets the real-time requirements and improves the prediction accuracy of the individual intervention assessment method, which significantly improves the efficiency of the individual intervention assessment of students' physical fitness.

Keywords: "Three Precision" applet, individual intervention for student fitness, mushroom propagation optimisation algorithm, convolutional neural network

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1. Introduction

According to the analysis of Chinese adolescent health data, the physical fitness of Chinese adolescents continues to decline, and the most prominent problem is the continuous decline of speed, strength, endurance, explosive power and other qualities, while the student population continues to increase in obesity, myopia, poor psychological state, low adaptive capacity and other problems [1]. In the national health China programme, the goal of refinement and quantification of student health standard indicators is clearly put forward, which also fully confirms the importance of the national team to improve the physical fitness of students [2]. With the arrival of the era of information technology and intelligence, the physical health data based on the network platform contains the current state of students' physical fitness, and the mining and analysis of this data as a key link in the study of students' physical fitness, in line with the requirements of the times, to improve the physical fitness of students [3]. Therefore, the scientific and reasonable use of student physical fitness test data, from the whole or separate each student individual level to provide students, schools intuitive analysis results, accurate and intuitive reflection of the specific problems of students' physical fitness, the development of the most appropriate personalised program to help students to carry out physical exercise, in order to help China's students' physical fitness and health status [4]. With the development of network technology and intelligent application platform, the "three accurate" applet for the method of individual intervention of students' physical fitness can not only enable students to obtain the improvement of physical fitness and lifelong sports habits [5], but also can open the barrier between parents and schools, and establish a new bridge of cooperation between home and school [6]. Currently, individual intervention research on students' physical fitness mainly focuses on physical fitness standards, physical fitness and health surveys, physical fitness measurement and evaluation, the process of physical fitness test implementation, and the means of physical fitness big data to carry out to carry out [7]. Literature [8] study investigated the means of improving students' physical fitness and health level in various aspects to different degrees; literature [9] analysed the reasons for the gradual increase of students' vision and obesity problems, which mainly include the lack of attention to physical exercise, the lack of physical education, and insufficient financial investment; literature [10] analysed the ways of improving students' physical fitness for individual interventions, which mainly include family interventions, social interventions and school interventions. three aspects; Literature [11] analysed the method of student improvement from three dimensions of skill, form and spirit; Literature [12] proposed a method of student fitness testing that integrates the four factors of physical fitness, recreational sports, physical dance and physical exercise; Literature [13] investigated real-time fitness testing and status analysis using the WeChat mini-programme as a medium and the platform of individual students' physical fitness and daily exercise; Literature [14] used the "Three Precision" applet to accurately analyse student health data. To sum up the research results of domestic and foreign students' physical health intervention, the current theoretical research tends to be mature, the combination of network platforms and students' physical individual intervention is only in the stage of qualitative analysis, and there is a lack of quantitative analysis [15], especially the combination of data mining, artificial intelligence, small programs and other technologies for students' physical individual intervention, there are inaccuracies in the analysis and evaluation of the problem of strong subjectivity and other issues [16].

Aiming at the problems existing in the current assessment and analysis method of individual student physical fitness intervention mode, this paper proposes an assessment and analysis method of individual student physical fitness intervention mode based on the "Three Precision" applet and the optimisation algorithm to improve the deep learning network. In this paper, we analyse the content and mode of students' physical fitness individual intervention based on the "Three Precision" applet, extract the indicators of students' physical fitness individual intervention assessment and analysis, and improve the convolutional neural network by combining the bio-inspired optimisation algorithm to construct the "Three Precision" applet-oriented assessment and analysis method. Based on the intelligent optimisation algorithm and convolutional neural network, an individual assessment and analysis model of student physical fitness intervention is constructed. The feasibility and robustness of the proposed method are verified by recording the behavioural data through the "Three Precision" applet and comparing with other models.

2. Description of the problem of analysing individual student fitness interventions based on the "Three Precision" applet

2.1. Individual intervention model and content of students' physical fitness based on the "Three Precision" applet

This paper analyses and describes the implementation of individual student physical fitness interventions based on the "Three Precision" applet, using the individual student physical fitness intervention model as the object of analysis.

Individual intervention of students' physical fitness based on the "Three Precision" applet has three main aspects: precise measurement, precise analysis and precise intervention [17], in which precise measurement is the initial step of individual intervention, precise analysis is an important part of individual intervention, and based on the "Three Precision" applet is a key move of individual intervention. The "Three Precision" applet is the key move of individual intervention. The specific framework of the "Three Precision" applet is shown in Figure 1.

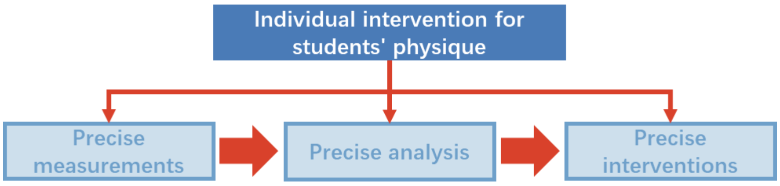


Figure 1 Framework "Three Precision" applet

(1) School Intervention Pathway Content

The school intervention pathway of students' physical fitness based on the "Three Precision" applet refers to the precise, comprehensive, and accurate testing of students' physical fitness and health status through school arrangements, so as to deeply grasp the substantive physical fitness problems of students. The content of the school intervention pathway includes accurate physical examination and evaluation of physical fitness [18].

(2) Family Intervention Pathway Content

The family intervention pathway of student physical fitness based on the "Three Precision" applet refers to the intervention of student physical fitness through family education and other means, including the creation of a good family sports atmosphere and supervision of students' exercise [19].

(3) Joint Home-School Intervention Pathway Content

The joint home-school intervention pathway for students' physical fitness based on the "Three Precisions" applet refers to the unified intervention of families and schools on students' physical fitness, including the "Three Precisions" students' health enhancement project school-level seminars, parent-teacher conferences, and home-school sports festivals [20].

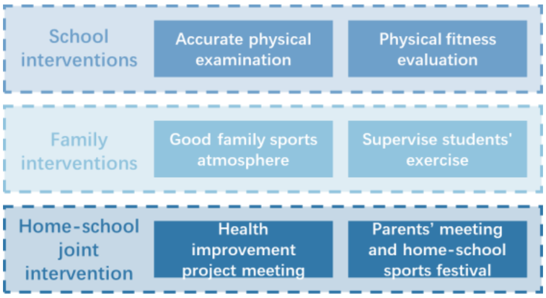


Figure 2 Content map of individual intervention pathways for student fitness

2.2. Indicators for Analysing Individual Intervention Assessment of Student Physical Fitness Based on the "Three Precision" Applet Extraction

In order to assess and analyse the indicator system of individual intervention for students' physical fitness, according to the implementation of individual intervention for students' physical fitness based on the "Three Precision" applet, the indicators of individual intervention for students' physical fitness were extracted from the three aspects of accurate measurement of students' physical fitness, accurate analysis of students' physical fitness level, and accurate intervention for students' physical fitness weaknesses [21], which are shown in Figure. 3. The specific extracted indicators are shown in Figure 3.

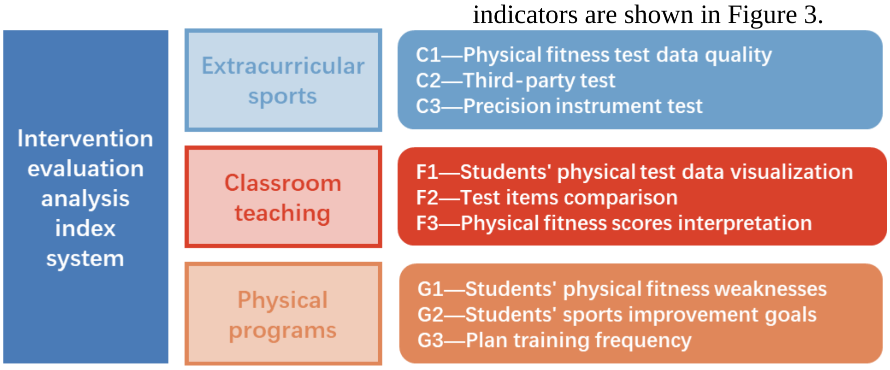


Figure 3 Extraction of indicators for analysing individual assessment of students' physical fitness based on the "Three Precision" applet.

(1) Precision measurement aspects

The main indicators extracted for the precision measurement aspect include the quality of physical fitness test data C1, third-party testing C2, and precision instrument testing C3.

(2) Precision analysis aspects

The main indicators extracted for precise analysis include visualisation of students' physical test data F1, comparison of each test item F2, and detailed interpretation of physical performance F3.

(3) Precision Intervention Aspects

The main indicators extracted for the precision intervention include the identification of students' physical fitness weaknesses G1, the development of students' sports improvement goals G2, and the planning of training frequency G3.

2.3. Construction of Indicator System for Analysing Individual Intervention Assessment of Students' Physical Fitness

The assessment and analysis index system for individual intervention of students' physical fitness is based on the linking steps of precise measurement of students' physical fitness status, precise analysis of students' physical fitness level, and precise intervention of students' physical fitness weak items as the first-level indexes, and the quality of physical fitness test data C1, third-party test C2, precision instrument test C3, visualisation of students' physical fitness data F1, comparison of various items of the test F2, detailed interpretation of physical fitness results F3, identification of students' physical fitness The six extracted indicators such as G1, G2, G3, G3, etc. are secondary indicators [22], which fully embodies the whole process of individual intervention of students' physical fitness and constructs an accurate and professional assessment and analysis index system for individual intervention of students' physical fitness.

3. Related Technologies

3.1. Optimisation algorithm for mushroom propagation

Mushroom reproduction optimization (MRO) [23] is a swarm intelligence optimization algorithm based on the natural reproduction process of mushrooms.The MRO algorithm mainly simulates the reproduction of mushrooms and their migration to nutrient-rich areas, which includes two optimization strategies: spore production (exploitation operation) and random distribution (exploration operation). The specific optimisation strategies and optimisation steps are as follows:

(1) Initialisation

Suppose a given community contains M initial parent mushrooms, which correspond to potential optimisation candidate solutions and are randomly distributed in the search space (optimisation space). Let X denote each candidate solution, $F(X)$ denote the fitness value, and the quality of the solution represents the richness of the distribution region. There is a parent mushroom that releases N spores.

(2) MRO Localised Reproduction Strategy

In the localised reproduction phase of the MRO algorithm, a parent is selected from the population and used to randomly release spores. If the population is in a rich area, the spores are released to grow and become new mature mushrooms. This natural phenomenon causes the population to explore locally, leading to the discovery of more high-quality solutions, and the local reproduction phenomenon is shown in Figure 4.

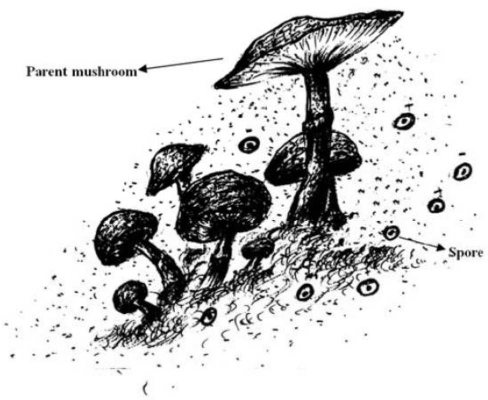


Figure 4 Localised reproduction of mushrooms

There are two strategies for selecting parent mushrooms at this stage: 1) optimal mushrooms in close proximity and 2) fitness value proportional selection strategy. The fitness value proportional selection strategy can be used to calculate the selection release probability from the fitness value:

$$P_j = \frac{F\left(X_{i,j}\right)}{\sum_{j=1}^{N} F\left(X_{i,j}\right)} \tag{1}$$

The new release position is defined as follows:

$$X_{i,j} = X_j^{parent} + rand\left(-r, r\right) \tag{2}$$

where $rand$ denotes the randomly generated number and r denotes the parent mushroom release radius.

(3) MRO Global Wind Strategy

If the living area does not contain enough nutrients, the mushroom releases spores that are transferred with wind transport. The wind strategy is to move the spores in different directions and to different parts of the problem space. This wind strategy provides the MRO algorithm with the opportunity to explore other search spaces. In the MRO algorithm, the most adapted individuals among the distributed spores are retained and the others are eliminated. The surviving spores are guided as shown in Figure. 5.The MRO global wind strategy is specifically modelled as follows:

$$X_{i,j} = X_j^{parent} + Mov_j^{wind} \tag{3}$$

$$Mov_j^{wind} \propto X_i^* - X_k^* \tag{4}$$

Where, X_i^* denotes the optimal solution for cluster i and X_k^* denotes the optimal solution for cluster k. Considering the relationship between the average fitness value and the total fitness value, the global wind strategy is further calculated as follows:

$$Mov_j^{wind} \propto \left(X_i^* - X_k^*\right) \times \left(\frac{Avg\left(i\right)}{T_{ave}}\right)^{-m} \tag{5}$$

Where, $Avg\left(i\right)$ denotes the average fitness value of cluster i, T_{ave} denotes the total average fitness value of the current iteration number, and m denotes the parameter for setting the wind intensity. In order to determine the direction of the wind, the direction factor δ is added and calculated as follows:

$$Mov_j^{wind} \propto \left(X_i^* - X_k^*\right) \times \left(\frac{Avg\left(i\right)}{T_{ave}}\right)^{-m} \times rand\left(-\delta, \delta\right) \tag{6}$$

In order to adjust the random step size, the inertia weights ω are added to the above equation:

$$Mov_j^{wind} \propto \left(X_i^* - X_k^*\right) \times \left(\frac{Avg(i)}{T_{ave}}\right)^{-m} \times rand(-\delta, \delta) \times \omega \tag{7}$$

Finally, a random position shift strategy based on the search radius r is added to the global wind strategy model:

$$Mov_j^{wind} \propto \left(X_i^* - X_k^*\right) \times \left(\frac{Avg(i)}{T_{ave}}\right)^{-m} \times rand(-\delta, \delta) \times \omega + rand(-r, r) \tag{8}$$

In short, the wind is moving randomly and so are the spores. Considering the difference between Avg and T_{ave}, the spores will be distributed differently. As the difference decreases, the spore propagation distance decreases. Finally, the inertia weight is reduced from 1 to 0, leading to a reduction in the random step, which enhances the exploitation function.

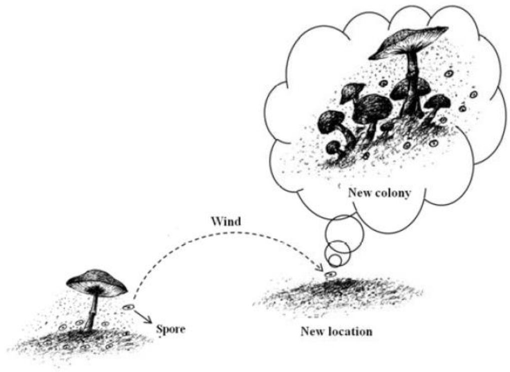


Figure 5 Mushroom wind transfer of spores

(4) Algorithm flowchart

According to the optimisation strategy of the MRO algorithm, the flowchart of the MRO algorithm is shown in Figure 6. During each iteration, an initial solution is randomly generated, and the final optimal solution is continuously obtained by evaluation with greedy selection strategy.

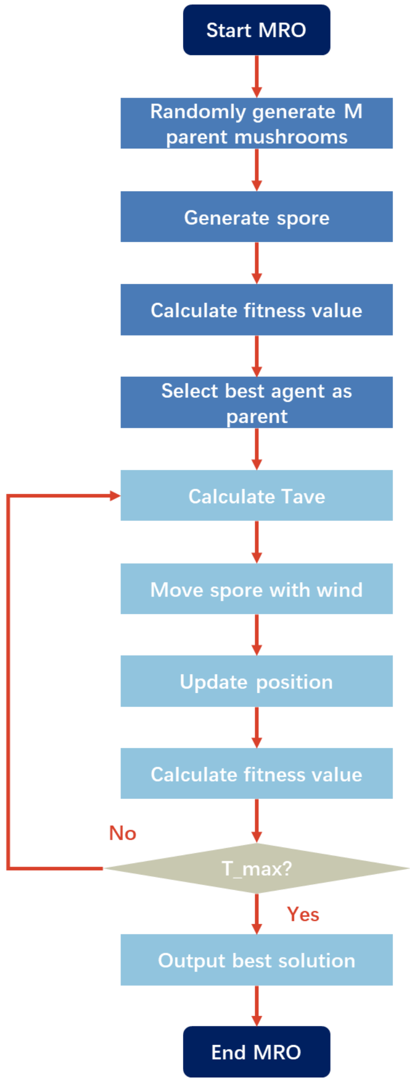


Figure. 6 FTTA algorithm

3.2. Convolutional Neural Networks

In order to increase the performance of the analysis method of individual intervention assessment of students' physical fitness based on the "Three Precision" applet, this paper adopts convolutional neural network as the analysis model of individual intervention assessment of students' physical fitness, and solves the problem that the training process of convolutional neural network falls into the local optimum.

Convolutional neural network (CNN) [24] is an artificial neural network that includes one or more convolution layers, i.e., at least one layer of neural network that uses convolution operations instead of general matrix multiplication operations.The structure of CNN is shown in Figure. 7. The convolution layer analyses each small piece of the input sample more deeply to obtain features with a higher degree of abstraction; the pooling layer does not change the depth of the output of the previous layer, and can reduce the size of its matrix, thus achieving the purpose of reducing the parameters in the real neural network; the fully connected layer mainly completes the classification task, and obtains the scores of each category by weighted summation of the learned feature representations; the last layer of the general classification problem is the Softmax layer. Softmax layer is used to map the scores from the previous layer to the sample labelling space.The features of CNN include sparse connectivity, weight sharing and pooling.

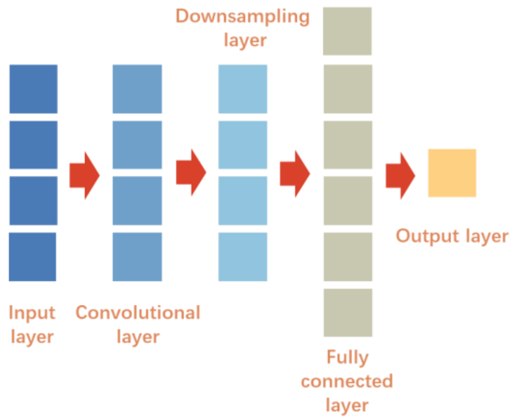


Figure. 7 Structure of convolutional neural network

The convolution operation of a convolutional layer is defined as follows:

$$z_j^{(l)} = \sum_{i=1}^{I} w_i^{(l)} a_{i+j-1}^{(l-1)} + b^{(l)} \tag{9}$$

Where i is the index of the convolution kernel, l flag indicates the current convolution layer, $l-1$ indicates the previous layer, I indicates the size of the convolution kernel. $z_j^{(l)}$ denotes the feature value of the convolution layer after the convolution operation, $w_i^{(l)}$ denotes the shared weights, $a_{i+j-1}^{(l-1)}$ is the activation output value of the previous layer, and $b^{(l)}$ is the bias of the convolution layer.

After going through each forward propagation calculation, the gradient of the loss function with respect to the weights and biases needs to be back propagated through the neural network. The optimisation algorithm used in this paper for weights and biases is the Adam optimisation algorithm.

4. Individual assessment and analysis of students' physical fitness based on the MRO algorithm, improved CNN network and the "Three Precision" applet

(1) Design of coding method

In order to improve the prediction accuracy of CNN's individual intervention assessment method for student fitness, the CNN parameters, i.e., the network parameter weights and biases, were optimised using the mushroom propagation optimisation algorithm.

(2) Adaptation function design

In order to improve the accuracy of CNN analysis, the root mean square error function is used as the objective function of the MRO-CNN algorithm, which is calculated as follows:

$$\min RMSE = \sqrt{\left(\sum_{i=1}^{M} (\hat{y}_i - y_i)^2\right) \Big/ M} \tag{10}$$

(3) Steps and Processes

The method of individual intervention assessment of students' physical fitness based on the MRO algorithm optimised CNN network is mainly to construct the mapping relationship between the assessment analysis indicators and the assessment values by taking the assessment analysis indicators as input and the assessment values as output. The flowchart of the individual intervention assessment method of students' physical fitness based on the MRO-CNN algorithm is shown in Figure 8. The specific steps are as follows:

Step 1: Construct an indicator system for the assessment and analysis of individual student physical fitness interventions for the "Three Precision" applet; divide the data set into a training set, a validation set and a test set;

Step 2: The CNN network parameters are encoded using the MRO algorithm, and the algorithm parameters such as population parameters and iteration times are initialised; the population is initialised and the objective function value is calculated;

Step 3: Update the population position according to the MRO algorithm local reproduction strategy and global wind strategy;

Step 4: Calculate the fitness value and update the optimal solution;

Step 5: Determine whether the termination condition is satisfied, if so, exit the iteration, output the CNN network parameters, and execute step 3, otherwise continue to execute step 6;

Step 6: Decode the optimised CNN network parameters based on the MRO algorithm, obtain the optimal convolutional neural network parameters, and construct an individual intervention assessment model for student fitness based on the MRO-CNN algorithm;

Step 7: Test and analyse the current test set using the trained individual intervention assessment model for student fitness and output the corresponding test results.

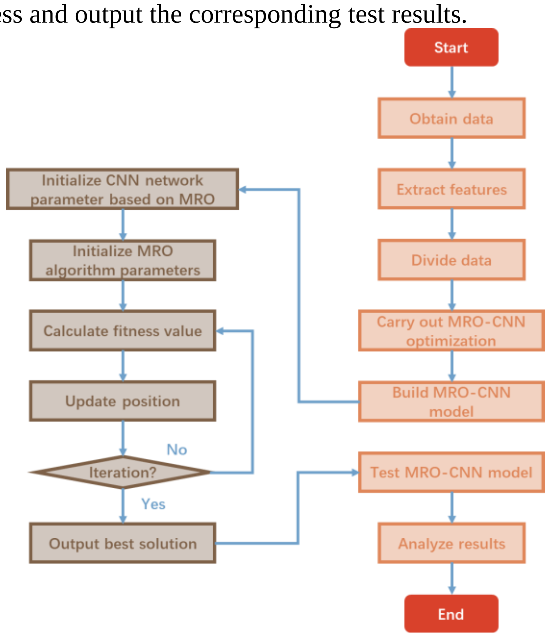


Figure. 8 Flowchart of the MRO-CNN-based method for assessing individual interventions for students' physical fitness

5. Experiments and analysis of results

In order to verify the advantages and disadvantages of the analysis method of individual intervention assessment of students' physical fitness proposed in this paper for the "Three Precision" applet, four analysis methods are selected for comparison, and the specific parameters of each algorithm are set as in Table 1.The experimental simulation environment is Windows 10, with a CPU of 2.80GHz, 8GB of RAM, and programming language Matlab2022a.

Table 1. Parameter settings for individual intervention assessment methods for student fitness

arithmetic	parameterisation
CNN	The number of nodes in the hidden layer of the CNN network is given by the following parametric analysis using Adam's technique
HHO-CNN	The number of nodes in the hidden layer of the CNN network and the population size of the FTTA algorithm is given by the following parameter analysis, the Levy flight parameter of the HHO algorithm is 1.5
SOA-CNN	The number of nodes in the hidden layer of the CNN network and the number of populations of the SOA algorithm are given by the following parametric analysis, and the frequency control parameter fc of the SOA algorithm is 2
FTTA-CNN	The number of nodes in the hidden layer of the CNN network and the population size of the FTTA algorithm is given by the following parameter analysis
LEA-CNN	The number of nodes in the hidden layer of the CNN network and the number of populations of the LEA algorithm are given by the analysis of the following parameters, the LEA algorithm convergence constants of 0.7 and 0, an acceptance rate of 0.5 and an adaptive rate of 0.5
MRO-CNN	The number of nodes in the hidden layer of the CNN network and the population size of the MRO algorithm is given by the analysis of the following parameters

(1) Parameter impact analysis

In order to analyse the impact of the population size of the MRO algorithm and the number of hidden layer nodes of the CNN network on the assessment method of individual intervention for students' physical fitness, this paper compares and analyses the performance of the assessment method of individual intervention for students' physical fitness under the conditions of different population sizes and the number of hidden layer nodes of the network. Figures 9 and 10 show the results of the evaluation accuracy and evaluation time of different population sizes and the number of hidden layer nodes of the network, respectively.

As can be seen from Figure 9, as the number of MRO algorithm populations increases, the prediction accuracy of the student physical fitness individual intervention assessment method also gradually increases; as the number of network hidden layer nodes increases, the prediction accuracy of the student physical fitness individual intervention assessment method gradually increases. From Figure 10, it can be seen that as the number of populations of MRO optimisation algorithm increases, the prediction time of the individual intervention assessment method of student physical fitness gradually increases; as the number of nodes of the hidden layer of the network increases, the prediction time of the individual intervention assessment method of student physical fitness gradually increases. In summary, the intelligent optimisation algorithm population size selected in this paper is 50, and the number of CNN hidden layer nodes is 100.

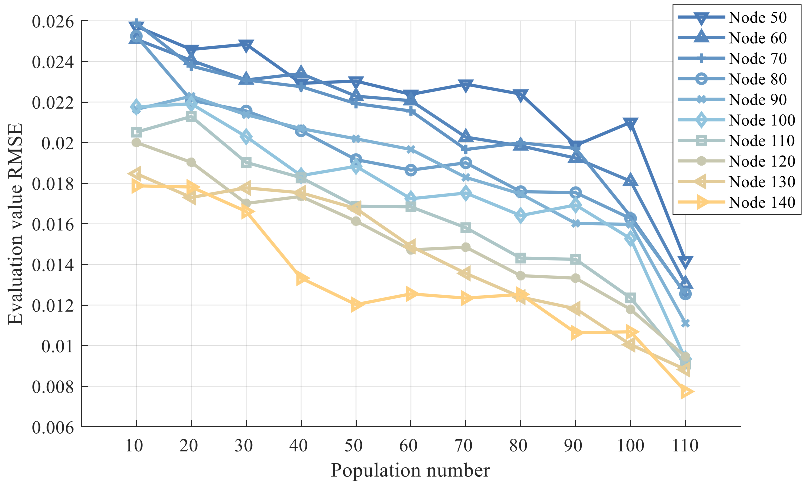


Figure. 9 Effect of different population sizes and number of CNN hidden layer nodes on the accuracy of individual intervention assessment of student fitness

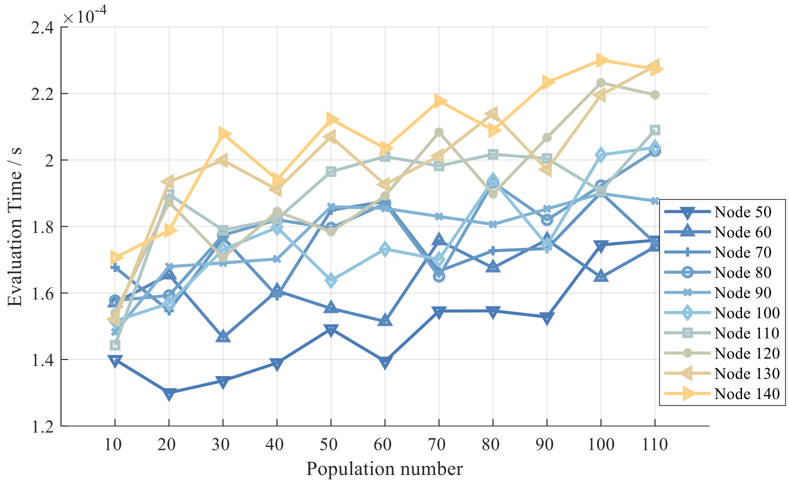


Figure. 10 Effect of different population sizes and number of CNN hidden layer nodes on the time to assess individual interventions for student fitness

(2) Comparative analysis of algorithms

In order to verify the effectiveness and superiority of the individual intervention assessment method of student fitness based on MRO-CNN algorithm, the individual intervention assessment method of student fitness based on MRO-CNN algorithm was compared with the algorithms based on CNN, HHO-CNN, SOA-CNN, FTTA-CNN, and MPA-CNN, and the performance results of each model are shown in Figures 11, 12, and 13.

Figures 11, 12, and 13 give the results of predicted value, relative error of prediction, and prediction time of the individual intervention assessment method of students' physical fitness based on each algorithm, respectively. As can be seen from Figure 11, the predicted values, prediction errors, and prediction trends of the individual intervention assessment methods for student fitness based on the MRO-CNN algorithm are the closest to the change characteristics of the true values.

As can be seen from Figure 12, the MRO-CNN algorithm based on the individual intervention assessment method for student fitness has the smallest relative error in prediction, and its value is controlled within 0.02; the remaining algorithms ranked by error are MPA-CNN, FTTA-CNN, HHO-CNN, SOA-CNN, and CNN, and their error ranges are controlled within 0.052, 0.064, 0.083, respectively, 0.11, and 0.115 within.

As can be seen from Figure 13, under the five test conditions, the RMSE values of the individual intervention assessment methods for student fitness based on each algorithm are ranked as MRO-CNN, MPA-CNN, FTTA-CNN, HHO-CNN, and SOA-CNN is comparable to CNN in terms of the performance of the RMSE values; the R2 values of the individual intervention assessment methods for student fitness based on each algorithm are ranked as MRO-CNN, MPA-CNN, FTTA-CNN, HHO-CNN, and SOA-CNN has comparable performance with CNN in terms of R2 value; the ranking of the assessment time of the individual intervention assessment methods for student physical fitness based on each algorithm is MRO-CNN, MPA-CNN, FTTA-CNN, SOA-CNN, HHO-CNN, and CNN in the order of ranking.

In summary, the MRO-CNN algorithm-based individual intervention assessment method can solve the problem of individual intervention assessment of students' physical fitness based on the "Three Precision" applet, and the prediction error is better than other algorithms, with the best real-time performance.

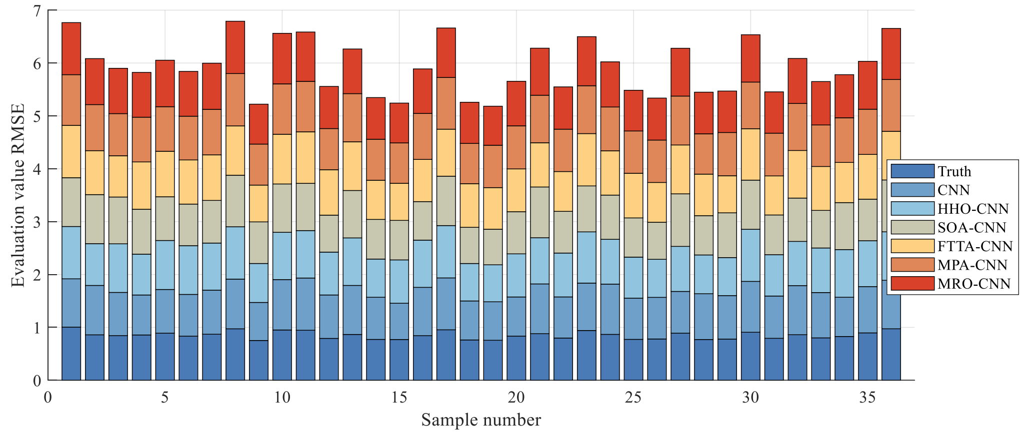


Figure 11 Predicted results of individual intervention assessment methods for student fitness based on each algorithm

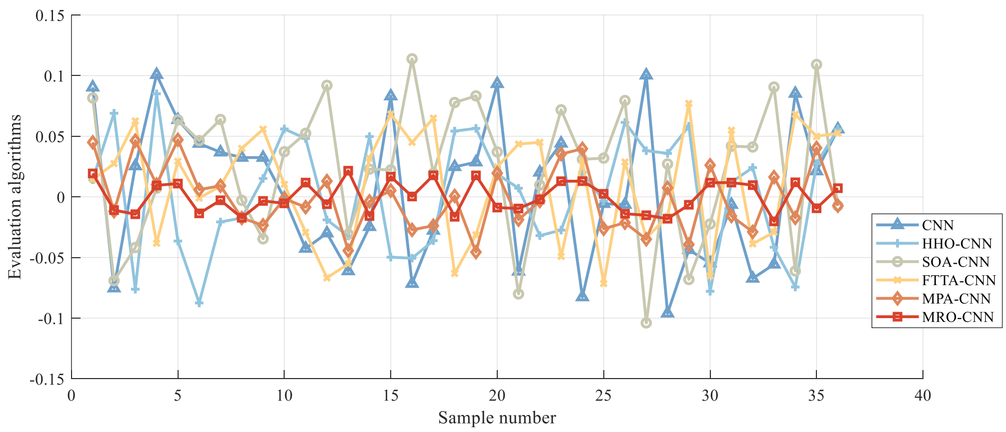
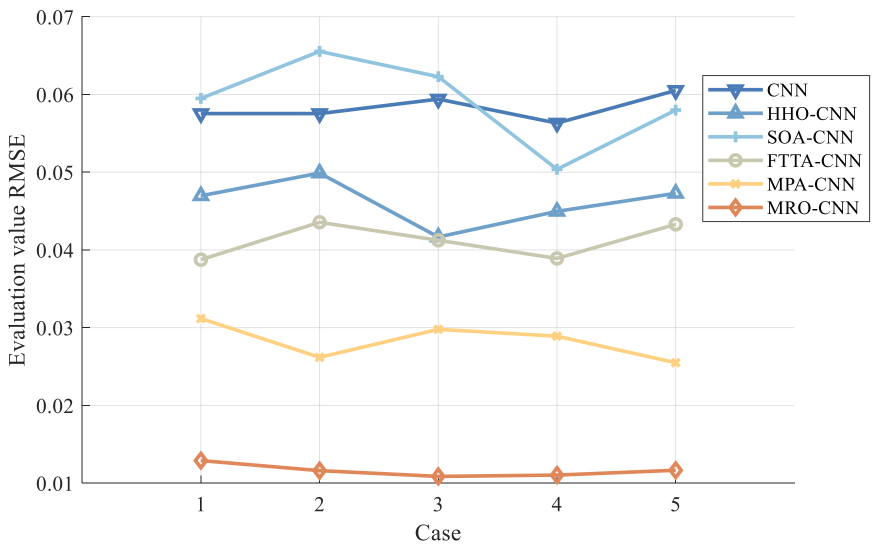
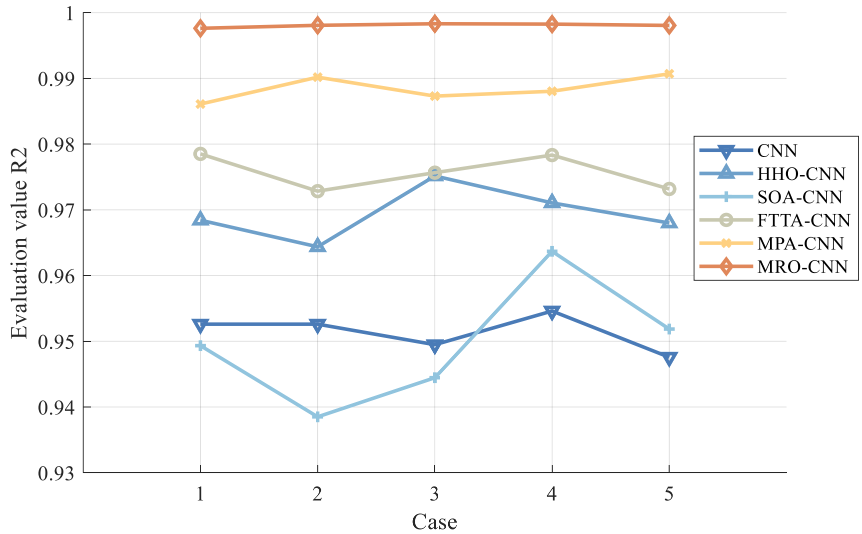


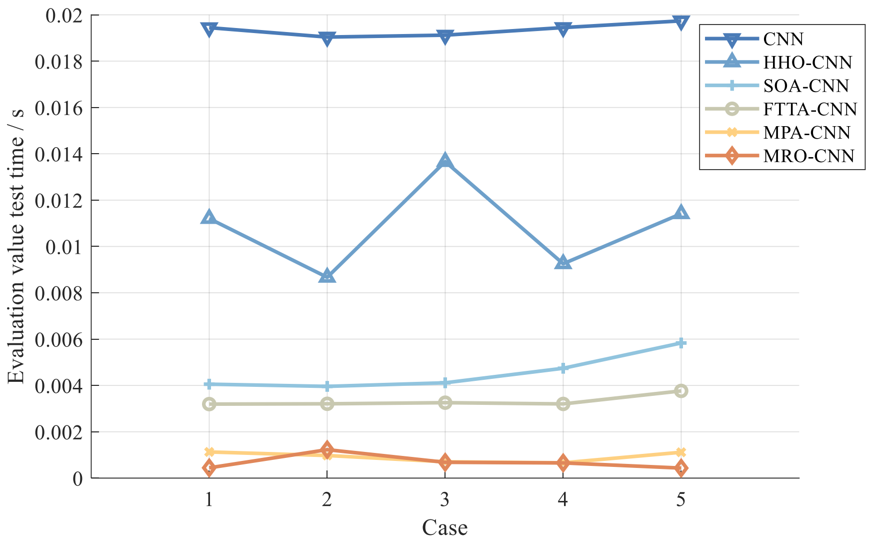
Figure. 12 Results of the relative error in the prediction of individual intervention assessment methods for student fitness based on each algorithm



(a) RMSE



(b) R2



(c) Test time

Figure. 13 Comparison of the prediction performance of individual intervention assessment methods for student fitness based on each algorithm under different working conditions.

6. Conclusion

Aiming at the problems of poor accuracy, low robustness, lack of real-time, and non-objective feature selection in the current individual intervention assessment method of student physical fitness, this paper integrates the mushroom multiplication heuristic optimisation algorithm with convolutional neural network to construct the individual intervention assessment model of student physical fitness based on MRO-CNN, and carries out an analysis of the effectiveness and robustness of the assessment method of student physical fitness based on the data recorded by the users of the "Three Precision" applet. The effectiveness and robustness of the individual intervention assessment method for students' physical fitness were analysed with the recorded data of the "Three Precision" applet. The results show that the indicator system of student physical fitness individual intervention assessment based on the "Three Precision" applet contains 12 features; in the analysis experiment of the population size of MRO and the number of nodes in the hidden layer of the CNN network parameter optimisation algorithm, it is found that the population size of the selected intelligent optimisation algorithm is 50, and the number of nodes in the hidden layer of the CNN is 100; By analysing the MRO-CNN evaluation model and other comparative models, it is found that the prediction accuracy of the MRO-CNN algorithm is the smallest, and the prediction time meets the real-time requirements and is controlled within the range of 0.002s. In this paper, the selection of influencing factors in the model is not preprocessed and analysed, which consumes too much time and energy. In the future, the kernel principal component analysis technique can be introduced to further improve the analysis efficiency of the model.

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