Application of Multimedia Simulation Teaching in Youth Physical Fitness Training

Huiying Dai, Hubei University of Education, China*
So Hee Yoon, Hannam University, South Korea

ABSTRACT

The multimedia simulation teaching mode introduces students into virtual scenes for learning. Whether it is enhancing students' interest in learning or enhancing their physical fitness, it is a new teaching mode. This article discusses the establishment of a BP neural network model to study the prediction of students' physical fitness and conducts experiments on predicting and evaluating adolescent physical fitness. The results indicate that the BP neural network model better reflects the functional relationship between various indicators of student physical fitness and the total test score, providing a more reasonable mathematical model for evaluating adolescent physical fitness.

KEYWORDS

Curriculum Teaching, Multimedia Simulation, Physical Training, Youth

INTRODUCTION

With the rapid development of multimedia technology, multimedia resources are widely used in subject teaching. However, the application of multimedia resources in sports training lags far behind other disciplines, especially in the process of youth physical fitness training (Lin, 2022). Nowadays, the competition on the sports field is not only about the physical fitness of athletes but also about the comprehensive strength of the country's technological strength and training level. To improve the training level, it is necessary to organically combine traditional sports training with high-tech (Liu & Pu, 2021). The application of multimedia simulation teaching in physical fitness training is a good combination of the two.

As teenagers, their reasoning and comprehension abilities are not yet very strong. This has increased the difficulty of sports training, especially for the students in sports schools in China, whose cultural course foundation is not very good (Varghese et al., 2022). If multimedia teaching can be introduced into their training, it will achieve twice the result with half the effort. This is because the multimedia training assistance system can accurately display the key points and difficulties of sports training in a deep and detailed manner by people, effectively helping teenagers deepen their understanding and mastery of training content and mobilizing multiple senses to present knowledge to athletes at multiple levels, angles, and dimensions, creating a good learning environment (Yao et al., 2021).

DOI: 10.4018/IJWLTT.338321 *Corresponding Author

The neural network evaluation method is mentioned in the literature review of designing and developing an adaptive gamification framework in physics education (Zourmpakis et al., 2023), along with analysing the influence of gamification methods on the motivation and learning of primary school students in science education (Papadakis et al., 2023), using computer simulation and cloud-based intelligent technology to promote successful open learning (Zourmakis et al., 2022), and discussing how students' information search knowledge can improve their information problem-solving behaviour (Papadakis et al., 2023).

Multimedia simulation technology is a virtual environment that combines multimedia elements, such as images, audio, and video, used to simulate actual situations or processes to support training, education, and simulation experiences (Song, 2021). It is a new teaching mode to use multimedia simulation technology to simulate the real-scene teaching mode and introduce students into the virtual scene for learning, whether to improve students' learning interest or strengthen students' physical training (Xiao et al., 2021). This article aims to utilize the characteristics and functions of multimedia-assisted teaching to create the most ideal teaching environment for students' physical fitness training. Firstly, this article explores the application of multimedia-assisted teaching in youth physical education teaching. Then, utilizing the function mapping ability of the back propagation (BP) neural network, this article establishes a BP neural network model to study the prediction of students' physical fitness and provide reference for youth physical fitness training courses.

RELATED WORKS

Adolescence is a critical period for individual growth, development, and physical fitness cultivation, and physical fitness training plays an important role in the health and development of youths. Traditional physical training methods often have limitations in effectiveness and low learning motivation (Bishop & Girard, 2013). As an emerging teaching method, multimedia simulation teaching has brought new possibilities for youth physical fitness training (Parissi et al., 2023).

Multimedia teaching mainly integrates various media, such as images, sounds, animations, and images, to present information from different perspectives, multiple perspectives, all directions, and dynamically. It is more intuitive, vivid, rich in content, easy to accept, and has better effects than traditional training methods (Tian, 2021). Multimedia teaching can provide a richer and more engaging training experience, increase the interest and participation of teenagers, and provide demonstration and guidance on correct training techniques and posture. In addition, it can help improve training effectiveness and cultivate healthy exercise habits. The combination of science and technology with sports training practice has always been a key, difficult, and critical point in the development of sports in China (Zhou, 2021). The difficulties of combining science and technology with sports training practice include dealing with complex and diverse sports elements, developing personalized plans, following up on evolving scientific knowledge, and investing a large amount of funds and resources (Ren & Cui, 2020). Despite these challenges, the integration of science and technology with sports training remains an important goal for the development of Chinese sports. This is because combining science and technology can improve training efficiency, improve athletes' competitive level, reduce injury risks, and promote the development of sports research, thereby keeping China competitive in international sports competition. Therefore, although the combination of the two is difficult, it is worthwhile to strive to overcome these obstacles, which is crucial for the long-term development of Chinese sports.

Traditional physical fitness training for teenagers focuses on enabling students to inherit existing knowledge, experience, and feelings and evaluating training based on the quality of students' imitation and inheritance (Guerra et al., 2019). In situations where teenagers have poor understanding and difficulty controlling their body muscles, traditional youth sports training has certain drawbacks (Han, 2015). For example, traditional youth sports training often lacks attractiveness and entertainment, personalization, and real-time feedback and monitoring, making it difficult to maintain motivation and causing injuries due to insufficient guidance and supervision, which greatly limits the development of youth sports. In the era of online information, combining multimedia with traditional training in youth physical fitness training will achieve twice the result with half the effort (Tzanetakos et al., 2017). For example, teenagers use fitness application programs (apps) to develop personalized training plans and train through video guidance within the app. These applications can also track their progress and grades, provide feedback, help them set goals, and maintain motivation. In addition, teenagers can participate in online challenges, compete with friends or other athletes, and share their training results on social media. This social interaction can stimulate competitive awareness and encourage exercise. Therefore, it is necessary to change the evaluation principles based on imitation and inheritance, fully cultivate the cognitive abilities of trainers, such as attention, memory, imagination, thinking, and judgment, and cultivate their correct discrimination, selection, understanding, and application of various information to create new knowledge, new ideas, and new concepts (Zhao & Ying, 2021). While increasing emphasis is placed on the application of multimedia teaching in youth sports training, it is necessary to clarify their relationship. Multimedia simulation teaching undoubtedly plays a very important role in the quality and effectiveness of physical fitness training for teenagers.

RESEARCH OF MULTIMEDIA SIMULATION IN YOUTH PHYSICAL FITNESS TRAINING

Virtual reality technology enables teenagers to carry out physical training in person by creating realistic virtual scenes. For example, using virtual reality technology on a treadmill can make teenagers feel the fun of running in natural scenery or competitive scenes and enhance the attraction and effect of training (Hu, 2021). Some scholars have studied the application of virtual reality technology in physical education and explored how to use virtual reality technology to create realistic virtual scenes to simulate sports training and competitions and improve students' participation and learning effectiveness (Huang & Li, 2021).

The interactive multimedia learning environment provides teenagers with a learning experience of active participation and interactive feedback. By using technologies, such as sensors and motion tracking devices, students' movement status can be monitored and evaluated in real-time, helping them better master correct motor skills and training methods (Shi et al., 2021).

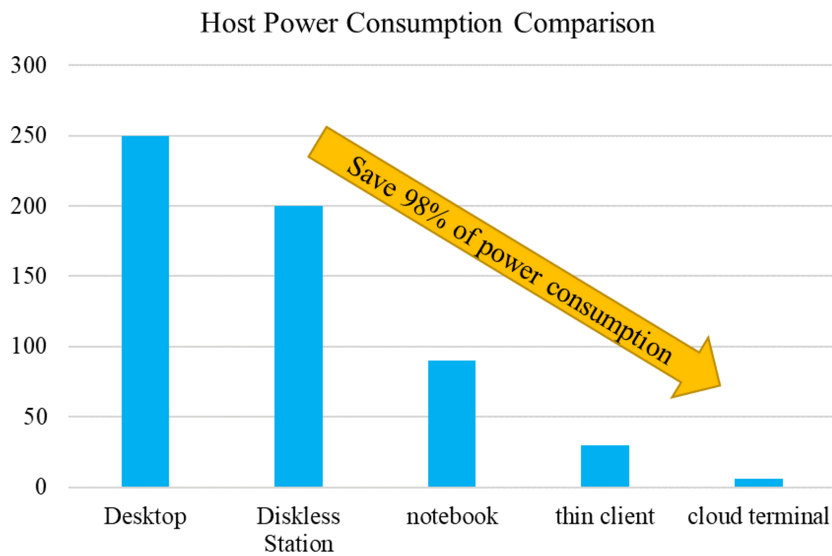
Teaching videos and online platforms provide convenience for teenagers to learn anytime, anywhere. Some researchers have studied the application of multimedia technology in middle school physical education classroom teaching. It explores how to utilize multimedia devices and instructional videos to provide rich learning resources and enhance students' interest and effectiveness in learning (Kurniawan et al., 2022). Some scholars have studied the application of virtual reality technology in youth sports training. It explores how to use virtual reality technology to create realistic training scenarios, provide personalized training support, and have an impact on students' motivation and mental health (Cheng, 2021).

APPLICATION OF MULTIMEDIA SIMULATION IN TEACHING

Media simulation teaching is a method of teaching that utilizes multimedia technology and virtual simulation environments. It combines visual, auditory, and interactive elements to simulate real scenes and situations, enabling students to learn and practice in a more intuitive and immersive manner. In multimedia simulation teaching, students can actively participate in the learning process, conduct experiments, simulation operations, decision-making, and other activities, and receive immediate feedback and evaluation (Ying & Jiaxuan, 2021). This interactivity helps to enhance learning motivation and depth. Figure 1 shows the proportion of multimedia resources in teaching statistics.

The characteristics of computer virtual simulation teaching are real and vivid, which can directly and dynamically reflect the production process. By placing students in a simulated environment,

Figure 1. Statistics on the proportion of multimedia resources in teaching



we can obtain timely feedback information through human-computer dialogue, actively adjust our learning progress and speed, and completely simulate teaching. The virtual simulation teaching can let students remember 70% of the content, while the traditional teaching mode of teachers' teaching and students' listening can only let students remember about 30% of the content (Zhu, 2021).

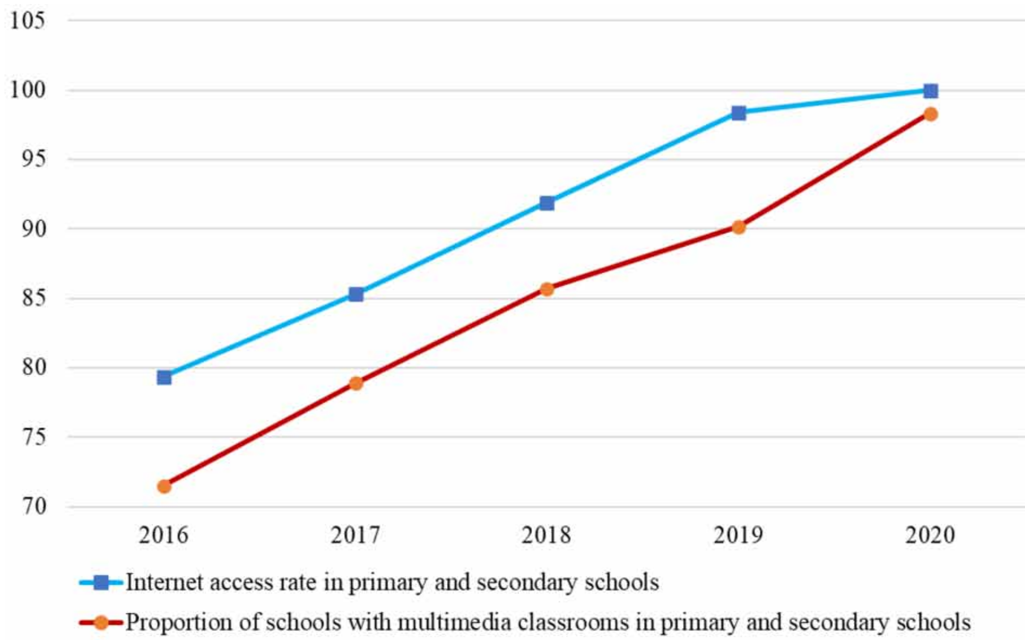
It also has the advantages of sharing teaching resources and assisting students in self-study content as courseware. Multimedia simulation is used to transform the various factors of the chemical production process, which have been represented in graphic form, into dynamic simulation courseware with the characteristics of image, vividness, and operability. Through the rich multimedia demonstration function, elements such as material flow are made dynamic. It not only facilitates teachers to complete teaching tasks but also helps students to understand and learn the content of the classroom, so as to achieve the purpose of quickly grasping the content of the course. Figure 2 shows the proportion of schools with multimedia classrooms from 2016 to 2020 (Juan & You, 2021).

RESEARCH METHODOLOGY

An artificial neural network is an extension of the physiological principles of the human brain and is a mathematical method that imitates the human brain based on the construction of neurons and the development and simulation of logical thinking processes in the human brain. The most crucial feature of artificial neural networks is their self-learning habits, adaptability, self-organization, and high fault-tolerance. They are suitable for analysing data in complex environments, finding patterns from historical data, and predicting unknown data under certain conditions. The structural prototype is the neural structure of the biological human brain. According to biological concepts, artificial neural networks can be intuitively understood as: neural network analysis is the abstraction of the logical thinking process of the human brain, which expresses the comprehensive analysis and thinking process of the brain in mathematical language and then uses computer programs to implement the commands and results of computational reasoning.

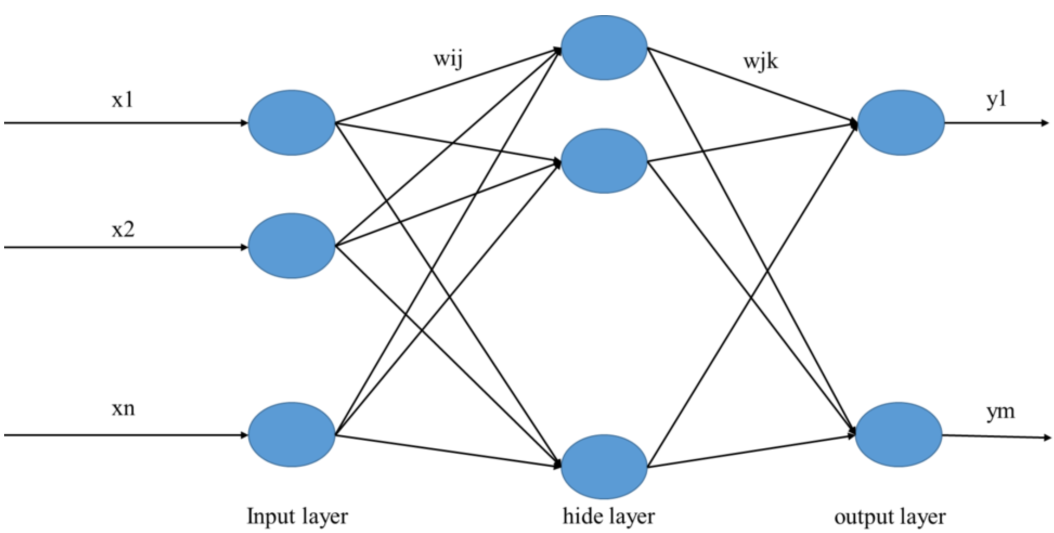
The artificial neural network consists of three parts: artificial neurons, network topology, and algorithms for training and learning, forming a complete artificial neural network. The main function of artificial neurons is to receive input signals and determine the signal strength to combine

Figure 2. Proportion of schools with multimedia classrooms from 2016 to 2020



and output signals of limited amplitude. They are the most fundamental computing units in neural networks. As shown in Figure 3, the topology of an artificial neural network is a simulation of axon synapse dendrites, which connect neurons according to certain rules to form a network structure. Each neuron can have multiple input sources, and each input source corresponds to a connection weight. The connection weight changes according to specific rules of different learning parties to identify and learn input data. Each neuron only corresponds to one output, which is interconnected to the next layer of neurons.

Figure 3. Back propagation (BP) neural network structure diagram



An artificial neural network algorithm is a type of artificial intelligence algorithm. The application of an artificial neural network to construct models can analyse different models, such as pattern recognition models and expert system models. It is called intelligent algorithm because artificial neural networks can self-learn and train to simulate various mathematical algorithms. The sample data input network repeatedly learns the relationships between nodes using thresholds and training functions between neurons, updates weights based on errors, and iteratively identifies specific relationships between input and output data, which can be conveniently applied to model calculations.

Neural networks can also induce the characteristics of sample data and express the common features shared by data of the same category, thereby achieving data clustering. The use of neural networks can solve optimal problems and obtain global optimal solutions. Through learning and training, artificial neural networks have the ability to "absorb experience," similar to the intelligence of human brain thinking. The operation process is mainly divided into two stages: learning and work. During the learning phase, the parameters and functions are determined, and after repeated training, the weights of each layer connection are continuously modified and debugged. The second stage is the working stage. When the learning system is located in a relatively stable environment, guided learning can be used to learn the statistical features in the environment, and they can be remembered as experience by the neural network, as shown in Figure 4. When the learning system is in an unstable environment, the neural network can provide input values to the neural network based on its self-adaptability (unsupervised learning), as shown in Figure 5, allowing the network to explore patterns and patterns of data based on specific structures and training functions and automatically classify the same class of models, adjust connection weights autonomously, and make corresponding changes to the environment.

Previous studies have mostly used probability statistics and multiple regression analysis methods to establish mathematical models for the correlation between students' physical performance and physical fitness (Liu et al., 2022). However, these methods have certain limitations in prediction accuracy. This is because previous probability statistics and multiple regression methods were constrained by linear assumptions, multicollinearity, data distribution assumptions, and complexity when predicting the correlation between students' physical performance and physical fitness, resulting in limited prediction accuracy. In order to optimize the physical fitness assessment of teenagers, this article uses the BP neural network algorithm to solve this problem. Compared with traditional probability statistics and multiple regression analysis methods, the BP neural network algorithm can conduct nonlinear mapping through the hidden layer of the network to better capture the complex nonlinear relationship between variables. This is very beneficial for the possible nonlinear relationship between

Figure 4. Learning with mentors

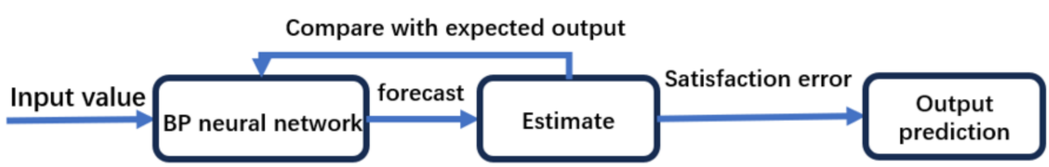


Figure 5. Unsupervised learning

physical performance and physical fitness. In addition, it can adaptively adjust network parameters, thereby improving the fitting ability and prediction accuracy of the model. Figure 3 shows the BP neural network structure diagram.

According to Figure 3, it can be seen that the BP neural network is composed of an input layer, hidden layer, and output layer. The processing units between layers are fully interconnected, and the processing units of the same layer are not connected. Its basic idea is that the information processing process consists of two processes: forward propagation and error backpropagation. During forward propagation, the input information is inputted from the input layer and outputted from the output layer after being processed by each hidden layer. If the output information of the output layer is inconsistent with the expected information, the output error will be transferred back from the output layer to the input layer in some form, and the error will be allocated to the processing units of each layer to gradually correct the calculated error.

In Figure 3, the input and output variables of the BP neural network are:

$$X = (X_1, X_2, \ldots, X_n) \tag{1}$$

$$\mathrm{Y} = (Y_1, Y_2, \ldots, Y_n) \tag{2}$$

The BP neural network training process can be described in detail as:

Step 1: Determine the network structure, including the input layer, hidden layer, and output layer, and set initial connection weights and thresholds for them. In addition, it is also necessary to determine the learning rate η and the activation function f of the hidden layer. Standardize or normalize input data to ensure it is within the appropriate range:

$$X_{new} = La + \frac{x - x_{\min}}{x_{\max} - x_{\min}} \times (Lb - La) \tag{3}$$

Step 2: Starting from the input layer, multiply the input data with each connection weight and pass the result to the hidden layer. In the hidden layer, the input values are weighted and summed, and the activation function f is used for nonlinear conversion. The formulas are as follows:

$$H_j = f\left(\sum_{i=1}^{n} w_{ij} x_i - a_j\right), j = 1, 2, \ldots, l \tag{4}$$

$$f(x) = \frac{1}{(1 + e^{-x})} \tag{5}$$

Step 3: Transfer the input data of the training samples through the network to the output layer and calculate the output value of the network. Calculate the predicted value O of the BP neural network according to the output H of the hidden layer of the BP neural network, the connection weight *wjk* from the hidden layer to the neurons of the output layer, and the corresponding threshold *b* of the output layer:

$$O_k = f(\sum_{j=1}^{l} H_j w_{jk} - b_j), k = 1,2,\ldots,m \tag{6}$$

Step 4: Calculate the network error *e*. Compare the output value of the network with the actual label of the sample to calculate the error of the network. Mean squared error (MSE) or cross entropy is usually used as the error measure.

$$e = Y_k - O_k, k = 1,2,\ldots,m \tag{7}$$

Step 5: Update the weights. Update their values according to the error signal and learning rate calculated by the backpropagation, as well as the connection weight *w* between the hidden layer and the output layer and the threshold *b* of the output layer. The following update formula is usually used:

$$w_{ij} = w_{ij} + \eta H_j (1 - H_j) x(i) \sum_{k=1}^{m} w_{jk} e_k, i = 1,2,\ldots,n; j = 1,2,\ldots,l \tag{8}$$

$$w_{ij} = w_{ij} + \eta H_j (1 - H_j) e_k, j = 1,2,\ldots,l; k = 1,2,\ldots,m \tag{9}$$

Step 6: Update the threshold. According to the error signal and learning rate calculated by the backpropagation, the threshold of the hidden layer and the threshold of the output layer are updated. The following update formula is usually used:

$$a_j = a_j + \eta H_j (1 - H_j) x(i) \sum_{k=1}^{m} w_{jk} e_k, j = 1,2,\ldots,l \tag{10}$$

$$b_k = b_k + e_k, k = 1,2,\ldots,m \tag{11}$$

Step 7: Use different training samples for repeated training and determine whether to continue the iteration based on predetermined stopping conditions (such as reaching the maximum number of iterations or error less than the threshold). This can enable the network to continuously learn and gradually optimize the performance of the model.

The Gated Recurrent Unit (GRU) recurrent neural network adds update gates and reset gates on the basis of a traditional recurrent neural network, which not only retains the function of "memory" but also avoids the disadvantage of gradient explosion or disappearance in the process of Backpropagation Through Time(BPTT) for Long Short-Term Memory(LSTM). The function of the update gate and reset gate is to control the degree to which the state information of the previous moment is brought into the current state. The larger the value of the update gate, the more state information of the previous moment is brought in.

The reset gate is used to control the degree to which the state information of the previous moment is ignored before being ignored. The higher the value of the reset gate, the more likely it is to be ignored. The GRU should be trained through the gradient descent method, continuously updating parameters until convergence.

The recurrent neural network prediction model is used to study the prediction of students' physique. The overall framework is shown in Figure 6.

In order to enrich the features to make the model more accurate, a two-dimensional vector of n (time series) $\times$ s (features per time series) is used as input. The 2018 and 2019 students' physical fitness evaluation scores and the data of the survey questionnaire were concatenated, respectively, and then the concatenated data of the 2 years of high requirements for data standardization, so all input data are subject to min-max normalization. Through normalization, it ensures comparability and consistency between students' physical fitness evaluation scores and survey questionnaire data in the data processing and analysis process and also helps to obtain more accurate and interpretable analysis results. The students' physical fitness evaluation scores in the third year:

$$loss = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \widehat{Y}_i)^2 \tag{12}$$

Optimizing the loss function using a gradient descent algorithm enables the LSTM network to learn how to predict student fitness scores one year into the future. In the prediction process of the LSTM network, the three-year physical fitness evaluation results of the students are expressed as a time series [xt-1, xt, xt+1], and [xt, xt+1] in this time series is used, namely, 2019 and 2020. Years of data are used as input to predict the physical fitness training scores in 2021.

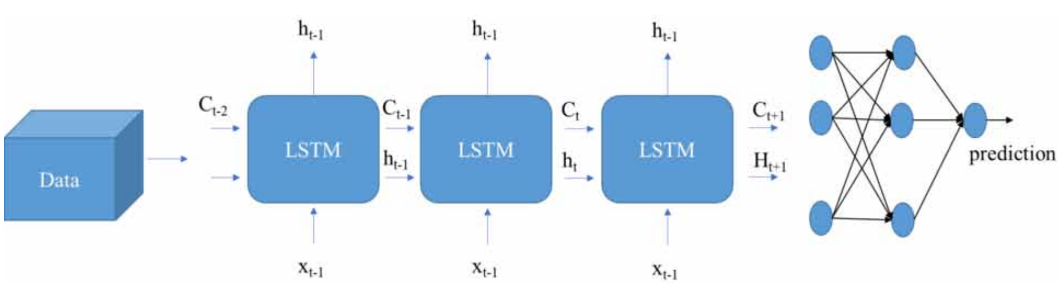
Using the sensitivity and other algorithms' accuracy evaluation indicators:

$$\text{ACC} = \frac{TP + TN}{TP + FP + FN + TN} \tag{13}$$

$$Specificity = \frac{TN}{FP + TN} \tag{14}$$

$$\text{Sensitivity} = \frac{TP}{TP + FN} \tag{15}$$

Figure 6. Recurrent neural network prediction model framework



True positives (TPs): the number of cases correctly classified as positive cases, that is, the number of cases actually classified as positive cases by the classifier; 2) false positives (FPs): the number of cases wrongly classified as positive cases, that is, the number of cases actually classified as negative cases but classified as positive cases by the classifier; 3) false negatives (FNs): the number of cases wrongly classified as negative cases, that is, the number of instances that are actually positive cases but classified as negative cases by the classifier; and 4) true negatives (TNs): the number of instances that are correctly classified as negative cases, that is, the number of instances that are actually negative cases and classified as negative cases by the classifier.

RESULT AND DISCUSSION

Experimental Data and Environment

In order to achieve the process of predicting youth physical fitness, this article associates the BP neural network algorithm with specific data in the multimedia intelligent teaching system and designs and implements simulation experimental algorithms. The basic process of training is mainly three steps: data set introduction, training and parameter setting, and verification and feedback, and to begin, one would introduce the body fat percentage, step test, and grip strength to establish a new evaluation. The data collection and simulation experiments in multimedia intelligent teaching systems can provide the necessary data support for a physical fitness assessment. The price index system uses a multiple linear regression model and least square method to fit the relationship between the teenagers' physical training and total test scores and obtains a mathematical model. In the collection process of the sample data of the multimedia intelligent teaching system, the average sampling rate of the test sample set was $fs = 10\ kHz$, and the training sample length of the specific data in the multimedia intelligent teaching system was 1,024. The number of visits was 189,283 times, the adaptive iteration step parameter $u = 0.0002$, the interference of other data in the teaching system was $n(k) = nr(k) + jni(k)$, and the global iteration number was 500 times. The number of discrete samples of interfering data information was 990. The data information model in the multimedia teaching system was constructed through the above data collection results, and the bandwidth of the specific data sampling in the multimedia intelligent teaching system was obtained. According to the above simulation environment, the frequency domain diagram of data training sample collection in the multimedia intelligent teaching system was obtained, as shown in Figure 7.

Experimental Results and Analysis

First, the BP neural network was trained with training data. It was found that there was a trend of decreasing first and then increasing. The optimal number of hidden nodes of a BP neural network was determined as 7.

According to the performance analysis of the BP neural network in Figure 8, the algorithm proposed in this paper is suitable for multimedia simulation of youth physical fitness training, greatly improving the quality and efficiency of classroom teaching and more in line with effective teaching laws.

Using multiple linear regression models and least squares methods to fit the relationship between youth physical fitness training and total test scores, a mathematical model was obtained. The results show that the fitting accuracy of the BP neural network model was higher than that of the multiple linear regression model, that is, the BP neural network model better reflected the functional relationship between students' physical fitness training indicators and test scores, providing a more reasonable mathematical model for predicting youth physical fitness training.

In short, multimedia simulation teaching has a great auxiliary effect on youth physical fitness training. In youth physical fitness training, the coaches' understanding, and application ability of multimedia teaching is crucial. It is necessary to strengthen the training of coaches in the application

Figure 7. Frequency domain diagram of data training sample collection in the teaching system by multimedia simulation technology

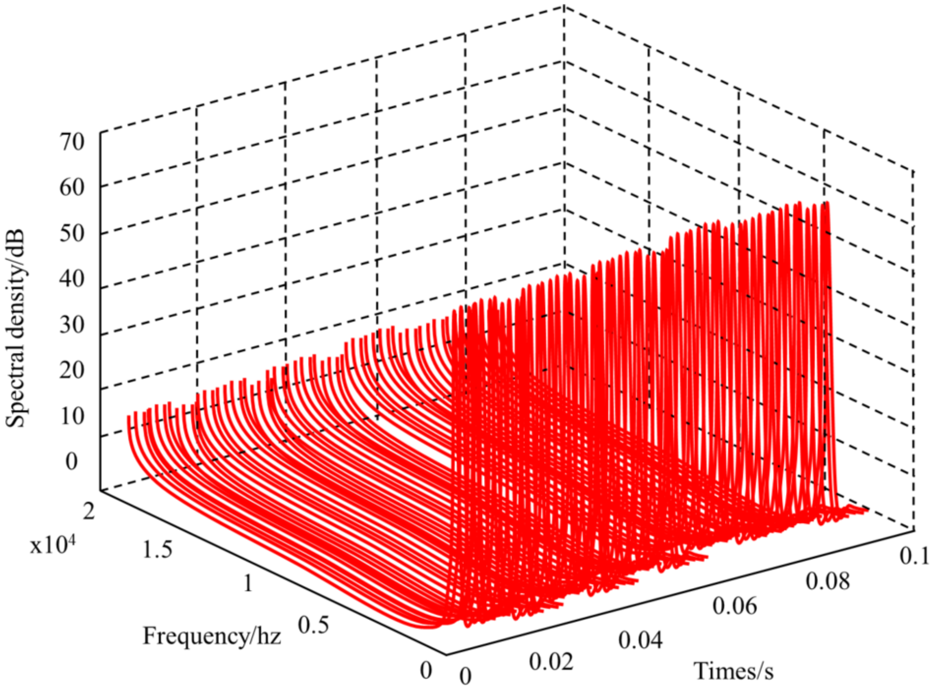
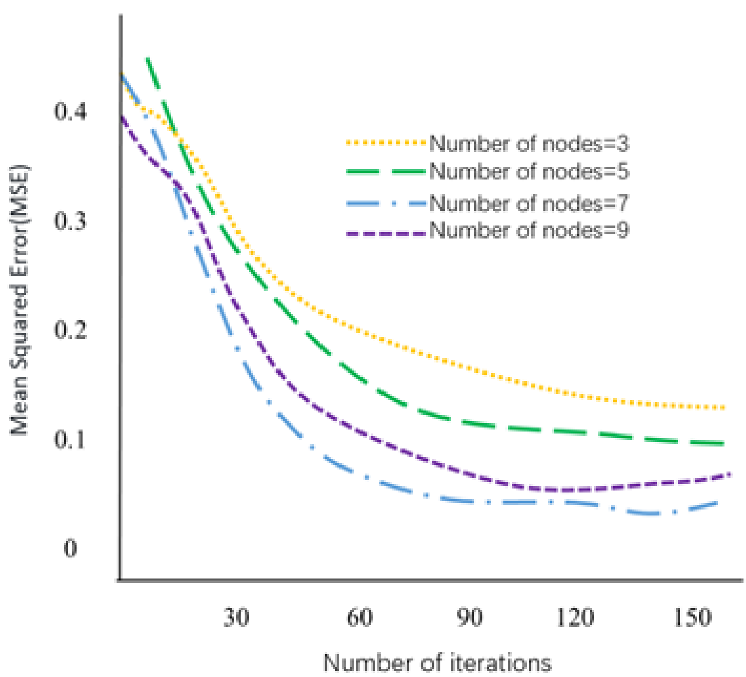


Figure 8. Performance analysis of BP neural network



of multimedia skills. A practical and feasible sports training plan supplemented by multimedia resources needs to be developed. In addition, the training characteristics and methods of skill-oriented and physical fitness-oriented sports projects are different. Therefore, it is necessary to combine the inherent characteristics and requirements of each sports project and use multimedia simulation technology in a targeted and reasonable manner.

CONCLUSION

The multimedia simulation teaching mode introduces students into virtual scenes for learning. Whether it is to enhance students' interest in learning or enhance their physical fitness, it is a new teaching mode. This article explores the application of multimedia simulation teaching in youth physical fitness training, establishes a BP neural network model to study the prediction of students' physical fitness, and conducts experiments on youth physical fitness prediction and evaluation. The results show that the fitting accuracy of the BP neural network model is higher than that of the multiple linear regression model, that is, the BP neural network model better reflects the functional relationship between various indicators of students' physical fitness and the total test score, providing a more reasonable mathematical model for evaluating youth physical fitness. However, the data set used in this study has certain limitations, such as insufficient sample size, which may affect the generalization performance and applicability of the model. Secondly, although BP neural network models perform well in fitting accuracy, they may also have high complexity. This may lead to overfitting issues, especially when the sample size is small. More complex models may also require more data for effective training.

Therefore, in order to improve the quality and applicability of research, it is possible to consider addressing these limitations in future research and conducting more extensive and in-depth data collection and analysis. In addition, interdisciplinary cooperation and the comprehensive use of multiple research methods can also enhance the credibility and practicality of research.

CONFLICTS OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

FUNDING STATEMENT

The authors received no financial support for the research, authorship, and publication of this article.

ACKNOWLEDGMENT

The authors would like to show sincere thanks to those techniques who have contributed to this research.

REFERENCES

Bishop, D. J., & Girard, O. (2013). Determinants of team-sport performance: Implications for altitude training by team-sport athletes. *British Journal of Sports Medicine*, *47*(Suppl 1), i17–i21. doi:10.1136/bjsports-2013-092950 PMID:24282200

Cheng, J. (2021). Evaluation of physical education teaching based on web embedded system and virtual reality. *Microprocessors and Microsystems*, *83*, 103980. doi:10.1016/j.micpro.2021.103980

Guerra, L. A., Dos Santos, L. R. A., Pereira, P. E., Lauria, V. T., De Lima, C., Evangelista, A. L., Rica, R. L., Bocalini, D. S., Messias, C. B., & Teixeira, C. V. L. S. (2019). A low-cost and time-efficient calisthenics strength training program improves fitness performance of children. *Journal of Physical Education and Sport*, *19*(1), 58–64. doi:10.7752/jpes.2019.s1009

Han, Y. (2015). Application of multimedia CAI technology in physical education. *The Open Cybernetics & Systemics Journal*, *9*(1), 1814–1819. doi:10.2174/1874110X01509011814

Hu, N. (2021, August 19–20). *Research on the application of VR technology in clothing design teaching* [Conference session]. The Sixth International Conference on Information Management and Technology, Jakarta, Indonesia. https://doi.org/ doi:10.1145/3465631.3465910

Huang, J., & Li, S. (2021). Research on the application of digital VR technology in snow and ice landscape teaching. *Journal of Physics: Conference Series*, *1992*(2), 022122. doi:10.1088/1742-6596/1992/2/022122

Juan, C., & You, Q. (2021). Research on the application of computer multimedia technology in English education and teaching. *Journal of Physics: Conference Series*, *1915*(3), 032018. doi:10.1088/1742-6596/1915/3/032018

Kurniawan, A. W., Wiguno, L. T. H., & Maimunah, I. A. (2022). Application-based walking and running materials for middle school physical education. *Journal of Physical Education and Sport*, *22*(12), 2965–2973. https://pesquisa.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/resource/pt/covidwho-2203259

Lin, Y. (2022). The application of multimedia technology and situational teaching method in English classroom of grade 6 in primary schools—Taking the teaching design of unit 1, volume 2 of grade 6 in Oxford Shanghai Edition as an example. *OAlib*, *9*(2), 1–12. doi:10.4236/oalib.1108387

Liu, D., & Pu, B. (2021). Research on physical education and training based on the theoretical teaching of computer three-dimensional animation technology. *Journal of Physics: Conference Series*, *1744*(3), 032052. doi:10.1088/1742-6596/1744/3/032052

Liu, X., Khadidos, A. O., & Keir, M. Y. A. (2022). Research on predictive control of students' performance in PE classes based on the mathematical model of multiple linear regression equation. *Applied Mathematics and Nonlinear Sciences, 7*(2), 297–306. https://sciendo.com/article/10.2478/amns.2021.2.00058

Papadakis, S., Zourmpakis, A. I., & Kalogiannakis, M. (2023). Analyzing the impact of a gamification approach on primary students' motivation and learning in science education. In *Learning in the age of digital and green transition: Proceedings of the 25th International Conference on Interactive Collaborative Learning (ICL2022)* (Vol. 1, pp. 701–711). Springer International Publishing. doi:10.1007/978-3-031-26876-2_66

Parissi, M., Komis, V., Dumouchel, G., Lavidas, K., & Papadakis, S. (2023). How does students' knowledge about information-seeking improve their behavior in solving information problems? *Educational Process: International Journal, 12*(1), 113–137. https://files.eric.ed.gov/fulltext/EJ1384866.pdf

Ren, X., & Cui, J. (2020). The development and application of multimedia technology in college gymnastics teaching. *Journal of Testing and Evaluation*, *49*(4), 2262–2270. https://www.astm.org/jte20200196.html

Shi, X., Li, X., & Wu, Y. (2021). The application of computer-aided teaching and mobile Internet terminal in college physical education. *Computer-Aided Design and Applications*, *18*(23), 163–174. doi:10.14733/cadaps.2021.S4.163-174

Song, R. (2021). Research on the application of computer multimedia music system in college music teaching. *Journal of Physics: Conference Series*, *1744*(3), 032214. doi:10.1088/1742-6596/1744/3/032214

Tian, C. (2021). The application of multimedia and network technology in practical writing teaching of higher vocational education. *Journal of Physics: Conference Series*, *1881*(4), 042039. doi:10.1088/1742-6596/1881/4/042039

Tzanetakos, N., Papastergiou, M., Vernadakis, N., & Antoniou, P. (2017). Utilizing physically interactive videogames for the balance training of adolescents with deafness within a physical education course. *Journal of Physical Education and Sport*, *17*(2), 614–623. doi:10.7752/jpes.2017.02093

Varghese, M., Ruparell, S., & LaBella, C. (2022). Youth athlete development models: A narrative review. *Sports Health*, *14*(1), 20–29. doi:10.1177/19417381211055396 PMID:34758649

Xiao, X., Xiao, Z., & Liu, X. (2021). Research on the application of computer virtual simulation teaching platform in the training of medical examiners. *Journal of Physics: Conference Series*, *1915*(3), 032069. doi:10.1088/1742-6596/1915/3/032069

Yao, Y., Wang, P., Xia, X., Li, X., & Song, C. (2021). The application of multimedia technology in teaching innovation. *Journal of Testing and Evaluation*, *49*(4), 2295–2303. doi:10.1520/JTE20200232

Ying, L., & Jiaxuan, L. (2021). Study on the application and teaching strategy of multimedia technology in music teaching in colleges and universities. *Journal of Intelligent & Fuzzy Systems,* (Preprint), 1–8. 10.3233/JIFS-219119

Zhao, J., & Ying, F. (2021). Research on the construction of virtual simulation experiment teaching center based on computer-aided civil engineering in colleges and universities. *Journal of Physics: Conference Series*, *1744*(3), 032115. doi:10.1088/1742-6596/1744/3/032115

Zhou, J. (2021). Virtual reality sports auxiliary training system based on embedded system and computer technology. *Microprocessors and Microsystems*, *82*, 103944. doi:10.1016/j.micpro.2021.103944

Zhu, Y. (2021). Research on the application of multimedia technology in French listening teaching. *Journal of Physics: Conference Series*, *1915*(4), 042004. doi:10.1088/1742-6596/1915/4/042004

Zourmpakis, A. I., Kalogiannakis, M., & Papadakis, S. (2023). A review of the literature for designing and developing a framework for adaptive gamification in physics education. In M. F. Tasar & P. R. L. Heron (Eds.), *The international handbook of physics education research: Teaching physics* (pp. 5-1–5-26). AIP Publishing. doi:10.1063/9780735425712_005

Zourmpakis, A. I., Papadakis, S., & Kalogiannakis, M. (2022). Education of preschool and elementary teachers on the use of adaptive gamification in science education. *International Journal of Technology Enhanced Learning*, *14*(1), 1–16. doi:10.1504/IJTEL.2022.120556