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Influence of Outdoor Volleyball on Human Cardiopulmonary Function in Haze Environment

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Abstract
Smog has always been one of the initiators that affect human health. In a severe haze environment, all functions of the human body will decline or even fail. In this paper, the influence of outdoor volleyball on human cardiopulmonary function in severe haze environment is studied. Whether heart sounds and lung sounds are normal or not can directly reflect the health status of human heart and lungs. Therefore, based on DNN (Deep Neural Network), this paper realizes the detection, separation and detection algorithm of heart and lung sounds, and analyzes the influence of outdoor volleyball on human cardiopulmonary function in Haze environment. In this paper, a set of lung sound data acquisition paradigm and evaluation method is designed, and the collected lung sounds are preprocessed by band-pass filtering to suppress noise interference. And the original features of lung sounds are extracted by using Mel spectrogram. Experimental results show that this method has high separation accuracy and robustness, the average SNR (Signal to Noise Ratio) reaches 24,307, and the error is only 0.104. It effectively improves the accuracy and recognition rate of cardiopulmonary sound separation. This shows that the improved relationship modeling method can accurately reflect the influence of outdoor volleyball on cardiopulmonary system in severe haze environment, and provides an accurate theoretical basis for outdoor volleyball training in severe haze environment.
Keywords: Volleyball; Cardiopulmonary function; Deep neural network.

1. Introduction

With the development of heavy industries such as steel and chemical industry, domestic air pollution is becoming more and more serious, especially in North China. Because air pollution causes environmental deterioration, it has become one of the important meteorological disasters faced by most cities (Wang et al., 2012). Modern volleyball is not only a competitive sport and an industry, but also a kind of culture. In the process of vigorous development of modern volleyball, its diversified functions are particularly obvious. Volleyball has developed from simple games to competitive sports and then to a multi-functional body integrating politics, economy and culture, which all shows that volleyball has become a great wealth of human civilization in the world (Wagh et al., 2021). Volleyball requires very high air quality. If volleyball players train in Haze weather, their cardiopulmonary function will be affected to some extent. The development trend of modern volleyball is developing in the direction of "height, strength and speed", and the physical fitness training that is compatible with the development trend of volleyball also presents new features (Wang et al., 2020). When the human body obviously feels unwell, the disease has gone deep into the heart and lungs and other organs, making the treatment more difficult, and sudden heart and lung diseases often lead to the death of patients before they can be sent to hospital for treatment. If the disease can be found and treated in the early stage, then the patients can recover as soon as possible, thus reducing the occurrence of death.

Haze does great harm to human health and affects human production and lifestyle, which has become an urgent problem to be solved (Li et al., 2017). Heart sound, as its name implies, is the sound made by the beating of the heart. It is a biological signal that contains abundant physiological information of the heart and the whole blood circulation system. Lung sound, also known as respiratory sound, is the sound signal emitted by the respiratory system during gas exchange with the atmosphere. Lung sound signal contains a lot of physiological information of various organs in the respiratory system (Li et al., 2016). Therefore, smog is closely related to the morbidity and mortality of these diseases. The haze causes human health problems, so the cardiopulmonary function of human body in the haze environment is tested and analyzed. Heart-lung sound signal is a mixture of cardiopulmonary sound signals with various characteristics (Cai et al., 2017). Therefore, obtaining high-quality independent cardiopulmonary sound signals is an important link in the treatment of heart and lung system diseases, which helps to improve the treatment efficiency. In this paper, we put forward an algorithm of detection, separation and detection of cardiopulmonary sounds based on DNN. Based on this, we analyzed the influence of outdoor volleyball on human cardiopulmonary function in Haze environment, and put forward corresponding opinions and suggestions on this situation, so that volleyball

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players can keep healthy and improve the quality of volleyball training.

To improve the training methods of volleyball physical fitness, it is necessary to inherit the traditional barbell training methods and combine the new concept of core strength training. Improving all kinds of bouncing required by volleyball is the core of volleyball physical fitness (Li et al., 2018). This paper studies the content and characteristics of comprehensive training of physical fitness of modern high-level volleyball, so that we can further distinguish the four categories of volleyball physical fitness training methods, and make more scientific and rational use of various training means to improve the level of volleyball physical fitness training. High-quality and pure cardiopulmonary sound signals can improve the diagnostic accuracy of doctors, improve auscultation efficiency and bring good news to patients with heart and lung diseases. In this paper, an algorithm of cardiopulmonary sound detection separation and detection is proposed to analyze the influence of outdoor volleyball on human cardiopulmonary function in severe haze environment. The main innovations are as follows:

(1) This paper studies the content and characteristics of comprehensive training of physical fitness of modern high-level volleyball, and makes more scientific and reasonable use of various training means to improve the level of physical fitness training of volleyball.

(2) Based on DNN, this paper realizes the detection, separation and detection algorithm of heart and lung sounds, and analyzes the influence of outdoor volleyball on human cardiopulmonary function in severe haze weather.

(3) Analyzing the promoting effect of volleyball on cardiopulmonary function can provide an important theoretical basis for athletes' volleyball training, which has important practical significance.

The first section of the article introduces and analyzes the significance of the research on the influence of outdoor volleyball on human cardiopulmonary function in the Haze environment, and puts forward the research methods of this article. The second section is the related work, which expounds the research of related scholars on volleyball and human cardiopulmonary function; The third section is the method part, which constructs the model of cardiopulmonary sound detection separation and detection based on DNN. The fourth section is the result analysis, and the effectiveness of this method is verified by simulation experiments. The fifth section summarizes the methods and contributions of this paper, and puts forward the future research direction.

2. Related Work

Bartels et al. dynamically observed changes in people's cardiovascular function, respiratory function and aerobic work capacity during long-term exercise, and explored the impact of long-term regular exercise on people's cardiopulmonary function (Bartels et al., 2011). In order to establish a correct cardiopulmonary function model, Nagashima et al. proposed an analysis model considering the abnormal interactive changes of cardiopulmonary parameters, and applied it to the analysis of the promotion of cardiopulmonary function by exercise (Nagashima et al., 2010). Chae et al. adopted an adaptive noise reduction method based on the fourth-order statistic of the signal to eliminate the noise and interference in the lung sound signal (Chae, 2012). This method does not require pure noise as a reference, and the entire spectrum of the signal can be preserved through adaptive filtering. Giordano proposed a matrix algebraic eigendecomposition method based on higher-order statistics and transformed the blind source separation problem into a linear algebraic eigenvalue problem (Corrà et al., 2012). Wei et al. proposed a heart sound segmentation algorithm (Hu et al., 2013). The algorithm utilizes the approximate and detailed intensity envelopes of the original heart sound signal generated by discrete wavelet decomposition and reconstruction. The db6 wavelet signal is used to decompose the heart sound signal first, and then the de-noised signal is de-noised and feature extraction is performed on the decomposed signal, and finally the de-noised heart sound signal is reconstructed. Rong et al. proposed a method to automatically identify heart sound signals (Zhu et al., 2020). The method firstly extracts the Mel-frequency cepstral coefficients from the collected heart sound signals as its characteristic parameters; secondly, it selects the support vector machine as the classifier; finally, the characteristic parameters are input into the classifier for classification and recognition, and the average recognition rate is higher. Marco et al. used multiple sensors to collect lung sounds and surrounding environmental noise, which can improve the performance of adaptive noise cancellation to a certain extent, but this method is obviously not suitable for single-channel signal separation (Di Marco et al., 2010). Datta et al. studied the instantaneous cycle frequency of heart sound signal and its application (Datta et al., 2015). Based on the cyclostationary signal theory, the instantaneous cyclic frequency and calculation method of the heart sound signal are proposed, which reflect the instantaneous repetition frequency of the mechanical vibration of the heart. Krol et al. used the mel spectrograms generated by lung sounds as features, and implemented anomaly detection of lung sounds using support vector machines, GoogleNet, ResNet, and a VGGNet-based subdivision discriminant model (Krol et al., 2019). Lin et al. proposed a method based on auditory scene analysis to remove noise interference (Lin et al., 2019). The heart and lung sound signals are collected through two channels, and the intensity difference between the two channels is extracted by imitating the human ear, and the noise is masked by the acoustic masking effect, which realizes the enhancement of the heart and lung

sound signals and achieves the purpose of eliminating noise interference. Lim et al. proposed to input the power spectral density time-frequency distribution as a heart sound feature into NN (Neural Network) for heart sound classification (Lim & Yoon, 2017). Tancredi et al. provided a new blind source separation method for cardiopulmonary sound mixed acoustic signals (Tancredi et al., 2011). The method utilizes non-negative matrix factorization, cluster analysis and time-frequency masking techniques, and successfully separates the aliased clinical auscultation acoustic signals into two independent acoustic signals, cardiopulmonary sound.

The traditional cardiopulmonary parameter analysis model must require the parameters to be stable or the parameters to change regularly. Once the parameters change irregularly, the model will quickly fall into non-convergence, and the modeling process cannot be effectively completed. Based on DNN, this paper realizes the detection, separation and detection algorithm of heart and lung sounds, and analyzes the influence of outdoor volleyball on human cardiopulmonary function in severe haze environment. In this paper, a set of lung sound data acquisition paradigm and evaluation method is designed, and the collected lung sounds are preprocessed by band-pass filtering to suppress noise interference. And the original features of lung sounds are extracted by using Mel spectrogram. It effectively improves the accuracy and recognition rate of cardiopulmonary sound separation.

3 Methodology

3.1 Related theoretical and technical basis

In cities, toxic particles mainly come from the following aspects: (1) Automobile exhaust. (2) Exhaust gas generated by heating in winter. (3) Gases emitted in industrial production. (4) Dust generated by construction site and road traffic. At present, the phenomena of high energy consumption, high emission and heavy pollution are emerging one after another. Volleyball is an exercise that can effectively regulate the function of every part of human body. Volleyball has an outstanding exercise effect on human cardiopulmonary function, muscle strength and endurance, and flexibility (Kelsey et al., 2014). This paper studies the influence of volleyball on human cardiopulmonary function in severe haze weather environment, and provides a basis for improving human cardiopulmonary function. Healthy people's heart sound signals are mainly divided into the following four parts: first heart sound, second heart sound, systolic phase and diastolic phase. These four parts just constitute a heart sound cycle produced by a heartbeat. Lung sounds, like heart sounds, belong to non-stationary periodic signals. Generally speaking, the frequency range of lung sounds is between 50 and 50~3000Hz. Auscultation is a commonly used means to obtain heart sounds and respiratory sounds, because it has the advantages of non-invasion and low cost. However, in reality, the heart sound or lung sound signals obtained by auscultation interfere with each other, exist at the same time, and influence each other, so the heart sound signals obtained by auscultation are mixed in time domain, which greatly interferes with the accuracy of auscultation. In addition, environmental noise also has some influence on auscultation. In addition, the traditional stethoscope has great limitations and can only be used by medical staff. The diagnosis result of this auscultation depends on the professional experience of doctors. Different doctors may have different diagnosis results, which may lead to misdiagnosis to a certain extent.

Among various classification algorithms for machine learning, NN algorithm is the one with the widest application range and deeper research depth. NN runs without a central controller, and it relies on the cooperation and mutual restriction of neurons to achieve the purpose of solution. It is characterized by the distributed storage and parallel processing of information, which can analyze a large number of complex data, imitate the information processing, storage and retrieval functions of the human brain to varying degrees, and complete extremely complex pattern extraction and trend analysis [21].

The multilayer perceptron in NN is composed of input and output layers plus one or more hidden layers. Multi-layer perceptron has strong fitting and modeling ability in nonlinear problems. When dealing with simple classification problems, single-layer perceptron can handle them better, but when facing complex problems, it needs to rely on more complex network models. Error back propagation is applied to the training of multi-layer perceptron, and the obtained network is BPNN (Back Propagation Neural Network). BPNN finds out the internal relationship between output and learning, so as to get the solution of the problem, instead of relying on the prior knowledge and rules of the problem. Therefore, it has an adaptive function, which is very beneficial to reduce the influence of human interference factors in the weight determination process. BPNN is a relatively mature network structure in the field of NN at present, in which the idea of BPNN error back propagation training network is used for reference by many subsequent NNs. As NN, which can accurately fit complex nonlinear mapping relations, BPNN has the advantages of low computational complexity, high robustness and parallel processing. NN has a self-learning process before classification detection, and its learning methods are generally divided into supervised learning and unsupervised learning. Gradient descent method iterates in the opposite direction of gradient vector in the hope that it can find the maximum point of the function, but it is difficult to find the maximum point, just find the extreme point near the maximum point.

DNN training is completed through two stages.
(1) The unsupervised layer-by-layer training method is adopted to train each network level, layer by layer. Then the initial values of each layer and the overall network parameters are obtained.
(2) Using the supervised training method to adjust the parameters of the network, the characteristics of the network can be described more accurately through continuous learning, thus achieving a high level of recognition and prediction. Generally speaking, DNN has more powerful nonlinear fitting ability than the traditional artificial design method, and has made proud achievements in various application fields. The structure of DNN is shown in Figure 1.

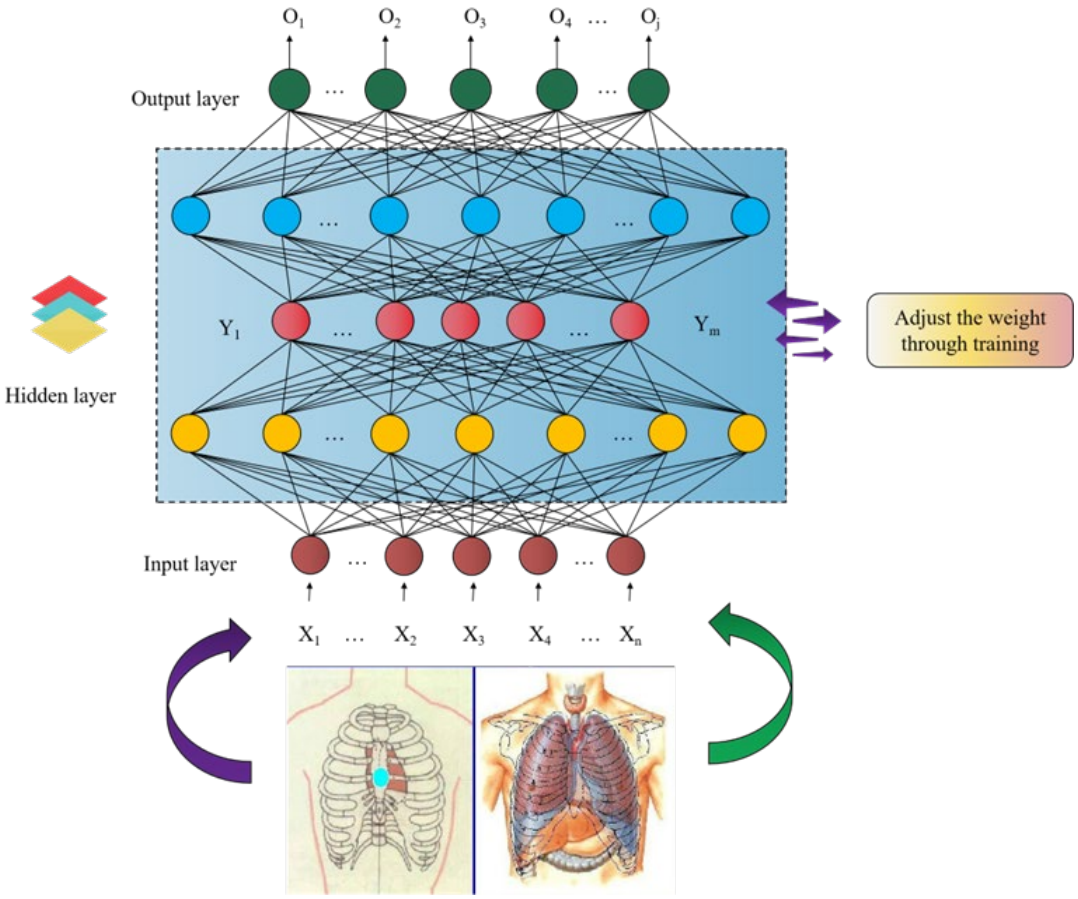

Figure 1 DNN structure diagram

Compared with the lung sound signal, the heart sound signal is similar to the stationary signal in a short period of time, so it can be said that the heart sound signal is stationary for a short time. But in the whole-time domain, cardiopulmonary sound signals are typical non-stationary signals, and their distribution parameters or laws change with time. Therefore, the audio signal can be cut into multiple segments in the unit of window length, and then further processed. Cardiopulmonary sound detection is a process of signal detection, analysis, recognition and classification. The processing process is as follows: firstly, preprocess the heart-lung audio signal; Secondly, extracting the characteristic parameters representing the effective information from the preprocessed cardiopulmonary sound data; Finally, an appropriate classifier is selected according to the cardiopulmonary sound data, and the extracted feature data is divided into training data and test data.
The training data is used to train the classifier to generate the optimal classification model, so that it has the performance of classifying heart and lung sounds. The test data is used to test the classification effect of the model and realize the classification and recognition of cardiopulmonary audio signals. Blind source separation, also known as blind signal separation, refers to the process of how to separate each independent source signal from the aliasing signal with little prior knowledge or no prior knowledge at all.
Blind source separation is common in the field of signal processing. Heart-lung sound separation based on blind source separation technology is also an effective separation method. In the separation of heart and lung sounds, first of all, appropriate signal features should be adopted to prepare for the next separation algorithm. For time-series audio signals, some researchers use linear prediction cepstrum coefficient as the signal feature, or use another cepstrum coefficient feature-Mel cepstrum coefficient. In this paper, the signal feature used in heart-lung sound separation is short-time Fourier transform time spectrum.

3.2 Modeling the relationship between volleyball and cardiopulmonary function

The modeling of the relationship between various physiological indexes and sports of outdoor volleyball players in Haze environment is mainly accomplished by setting physiological parameters and measuring physiological parameters through sports in specific environment. In the process of analyzing the cardiopulmonary function of outdoor volleyball in Haze environment, the cardiopulmonary function parameters need to be established. In the algorithm, the time-frequency spectrum of heart-lung sound mixture obtained by short-time.

Fourier transform of heart-lung sound time-series mixture signal is processed, and two masks of heart and lung sound are obtained respectively, and then the two masks are calculated with the time-frequency spectrum of mixture, and finally the corresponding estimated time-frequency spectrum is reconstructed.

Cardiopulmonary sound is both time-varying non-stationary signals, so it is necessary to process the heart-lung sound signals into stationary signals before using feature extraction algorithm to extract features. Using the short-term stability of audio signal, the collected heart and lung sounds are processed in a short time, that is, divided into frames, and the signal can be considered as stable within one frame. Next, the heart sounds and lung sounds are included. Then, this paper assumes that the heart-lung sound mixture signal is sufficiently sparse, and gives the corresponding time-frequency mask method to reconstruct the cardiopulmonary sound from the mixture signal. Finally, inverse short-time Fourier transform is performed on heart sounds and lung sounds in time domain, so as to obtain the sum of heart sounds and lung sounds in time domain. In addition, there are voices in the data set used in this paper, but the distribution is not balanced. In order to improve the adaptability of the model to the voice, increase the robustness of the model, and thus alleviate the over-fitting problem. In this paper, a data enhancement method is designed, in which random speech is added to lung sound data at a certain SNR. The source data set is merged with the data set added with certain SNR to form the data set added with speech. The flow chart of heart-lung sound separation method is shown in Figure 2.

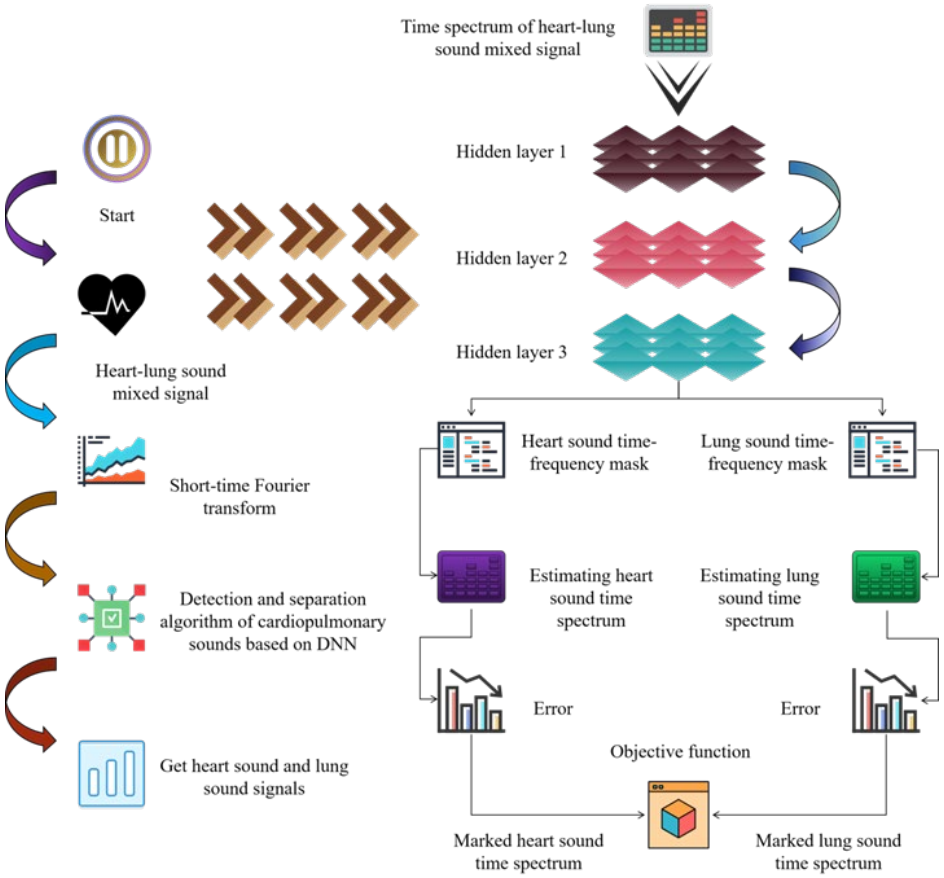

Figure 2 Flow chart of heart-lung sound separation method

The mathematical model of mixed source signal is that the source signal obtained by auscultation is a mixture of heart sound, lung sound and noise signal. In this paper, the mathematical model of mixed source signal is established. See the following formula:

$$X = AS + N \quad (1)$$

Among them, X represents the source signal of

cardiopulmonary sound mixed with other noises; S is the cardiopulmonary sound source signal; A is the amplitude of the source signal; N represents white Gaussian noise. In this way, formula (1) constitutes a mathematical model of the mixed source signal of heart and lung sounds and noise.

Since the collected audio data has sharp high-frequency noise, pre-emphasis can increase the high-frequency noise components in the cardiopulmonary audio data to distinguish them from the low-frequency signal frequency components of the cardiopulmonary audio, and then filter them out through a filter. Assuming that the sampling value corresponding to the cardiopulmonary audio signal at the sampling point n is $x(n)$, the output signal $y(n)$ after pre-emphasis is shown by the following formula:

$$y(n) = x(n) - ax(n-1) \tag{2}$$

In the formula, a is the pre-emphasis coefficient, this paper takes a=0.94; n is the signal sampling point.

The traditional analysis method based on Fourier transform and its inverse transform can well analyze the information of signals in time domain or time domain. This is enough for a stationary signal. However, for the non-stationary signal of cardiopulmonary sound, the analysis method based on Fourier transform and its inverse transform seems pale and powerless. Therefore, a short-time Fourier transform, a technology for transforming time-domain signals into transform domains with both time-domain and frequency-domain characteristics, came into being. Short-time Fourier transform is simple, intuitive and efficient. The formula of short-time Fourier transform is shown in the following formula:

$$S(t,\omega) = \int_{-\infty}^{\infty} s(\tau)\omega(t-\tau)e^{-j\omega\tau} \tag{3}$$

Among them, $\omega(t-\tau)$ represents a window function with time-frequency domain characteristics, sliding along the time axis to intercept the $s(\tau)$ signal, and performing Fourier transform on each intercepted part. After short-time Fourier transform, the mixed source signal of heart and lung sound changes from time domain signal to time-frequency domain signal. As shown in the following formula:

$$X(t,\omega) = \sum a_i S_i(t,\omega) + N(t,\omega) \tag{4}$$

$$X(t,\omega) = AB(t,\omega) + N(t,\omega) \tag{5}$$

$$A = \sum_i \sum_k a_k,\ B(t,\omega) = \sum_i S_i(t,\omega) - \sum_i \sum_k b_k \tag{6}$$

Equation (4) can be rewritten in the form of Equation (5). Among them, b_k and a_k respectively represent the k-th component of the source signal and its amplitude. In this way, the mixed signal of heart and lung sounds can be regarded as a two-dimensional matrix in the time-frequency domain. There are three main types of indicators to measure cardiopulmonary function, namely, cardiopulmonary oxygen uptake V_{O2}; CO_2 emission V_{CO2}; and heart rate HR. Other parameters include unit time ventilation V_E, oxygen pulse O_2P, and respiratory entropy derived from these three types of indicators. First, the maximum oxygen uptake of the heart and lungs can be calculated using the following formula:

$$V_{O2\max} = HR_{\max} \times MSV \times OPD \tag{7}$$

The characteristics of oxygen intake of athletes during training in Haze environment were extracted. The oxygen pulse of athletes can be calculated by the following formula:

$$V_{O2} = HR \times SV \times OPD \tag{8}$$

Among them, HR is used to describe the athlete's heart rate; SV is used to describe the output of each pulse; OPD is used to describe the difference between arterial and venous oxygen content. According to the above formula, the calculation formula of oxygen pulse can be obtained as follows:

$$O_2P = SV \times OPD \tag{9}$$

Using the oxygen pulse index can measure the function of the left ventricle of the athlete during volleyball. The heart rate HR of a volleyball player can be calculated using the following formula:

$$HR_{\max} = 220 - Age \tag{10}$$

The factor that affects the maximum heart rate is the age of athletes. The following formula can be used to calculate the respiratory entropy of athletes during exercise in Haze environment:

$$RQ = \frac{V_{O2}}{V_{CO2}} \tag{11}$$

Respiratory entropy can describe the exchange rate of oxygen during respiration. Adding white Gaussian noise at a certain SNR is a common method of audio data enhancement. It can increase the robustness of the model, enhance the adaptability of the model to electronic noise, and alleviate the problem of over-fitting. In this paper, the source data set and the data set with white Gaussian noise are merged to form a data set with white noise data. SNR is used to evaluate the separation performance by calculating the ratio of the

original signal energy to the noise energy and then taking logarithm. The separation performance is directly proportional to the SNR value. The larger the value, the closer the separated signal is to the original mark signal. The SNR formula is as follows:

$$SNR = 10\log_{10}\left(\frac{\sum_{i=1}^{n} X_i^2(t)}{\sum_{i=1}^{n}\left[X_i(t)-\hat{X}_i(t)\right]^2}\right) \quad (12)$$

In heart-lung sound separation, if the original marker signal corresponds to the actual heart sound timing signal, the noise is the difference between the estimated heart sound timing signal and the actual heart sound timing signal. In general, there are some components with strong energy in the sample data, and the objective function will be dominated by these components, thus affecting the reconstruction of other signals with weak energy. To avoid this situation, divide the energy of each error in the objective function by the energy of the marker signal, and you can get:

$$\min J_{DT}(\Omega) = \frac{1}{N}\sum_{i=1}^{N}\sum_{S\in(H,L)}\left(\lambda\frac{\left\|\hat{X}_s^i - X_s^i\right\|^2}{\left\|X_s^i\right\|^2} - (1-\lambda)\frac{\left\|\hat{X}_s^i - X_{s'}^i\right\|^2}{\left\|X_{s'}^i\right\|^2}\right) \quad (13)$$

In the formula, $\left\|X_s^i\right\|^2$ and $\left\|X_{s'}^i\right\|^2$ are the energy of the labeled heart sound of the corresponding item, and Equation (13) is the objective function used in the discriminative training of DNN in this paper.

According to the different domains in which the characteristic parameters are located, the characteristic parameters of cardiopulmonary sound audio signals are generally extracted from time domain, frequency domain and cepstrum domain, and the characteristic parameters in different domains represent different physiological and pathological information. The time domain characteristics of heart-lung sound signal can be directly extracted from the time domain waveform of heart-lung audio signal, which has the advantages of intuitive processing and less computation.

Many signals in reality have non-negative characteristics, such as spectrum signal, energy signal and image signal. However, the speech signal is characterized by wave pattern in time domain, with both positive and negative values, so it is not suitable for non'-negative matrix decomposition. However, the speech signal after short-time Fourier transform is a spectrum signal in time-frequency domain, which has non-negative characteristics and can be analyzed by using non-negative matrix decomposition technology. By calculating the correlation coefficient between each column vector in the base matrix containing cardiopulmonary sound information and the reference base matrix of cardiopulmonary sound, two correlation coefficient matrices can be obtained. Specifically, the correlation coefficients of the columns of the base matrix and the reference base matrix of heart sounds are calculated and combined into the correlation coefficient matrix of heart sounds. Similarly, the correlation coefficient is calculated with the reference matrix of lung sounds, and the correlation coefficient matrix of lung sounds is combined. In this paper, there is too much noise in the data, and the first second and the last second of the data are mostly useless data. Therefore, in this paper, the collected data is bandpass filtered, and the first second and the last second of the data are removed, so that the time length of all samples is 10 seconds.

4. Result analysis and discussion

Traditional methods only use the related physiological parameters such as heart rate, arterial blood pressure, respiration, etc. obtained by exercise to analyze the degree of influence of exercise on the physiological mechanism of cardiopulmonary function in Haze environment, and can't establish an effective model. Therefore, an analysis model of the influence of outdoor volleyball on cardiopulmonary function in Haze environment considering the abnormal changes of cardiopulmonary interaction is proposed. In order to accurately analyze the influence of volleyball on cardiopulmonary function in Haze environment, 200 volleyball players were taken as test samples to perform volleyball in Haze environment, and their cardiopulmonary function changes were tested according to this method. Analyze the test results. The athletes are all male, healthy, with no history of respiratory and circulatory diseases and no habit of smoking. The basic physical characteristics of athletes are shown in Table 1.

Table 1 *Basic physical characteristics of athletes*

Index	Volleyball team in Haze environment	Normal environment control group
Age/years	35.42±4.3	26.35±2.2
Height /cm	174.5±6.0	174.0±3.8
Weight /kg	67.5±9.5	66.5±6.5

It is not difficult to see that there is no significant difference in the age, height, weight, BMI and other parameters of the subjects. Firstly, the experiment of this algorithm is carried out. The experimental data of this algorithm is collected from the public data of the Internet, and realized on the Matlab platform. The experimental data set is a mixed signal of 6000 heart and lung sounds generated by the free combination of 120 heart sounds and 50 lung sounds. In this paper, all the audio files are processed in a unified way, and all the audio files of heart sounds and lung sounds are in a unified. wav format, with a duration of 6s. By down sampling, the audio sampling rate is 2KHz. Figure 3 shows the time domain waveform of one of the mixed signals of heart and lung sounds.

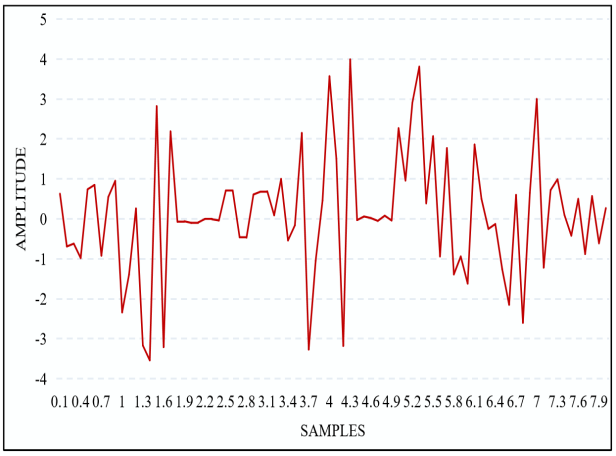

Figure 3: The waveform of the mixed signal of heart and lung sounds

When calculating SNR and correlation coefficient, we compare the correlation coefficient and SNR between the cardiopulmonary sound generated by the function and the separated cardiopulmonary sound. The relationship between circulating blood volume and intrathoracic pressure can be described by Figure 4. According to this model, the relationship between cardiorespiratory reflex and heart rate related to volleyball breathing is shown in Figure 5 below.

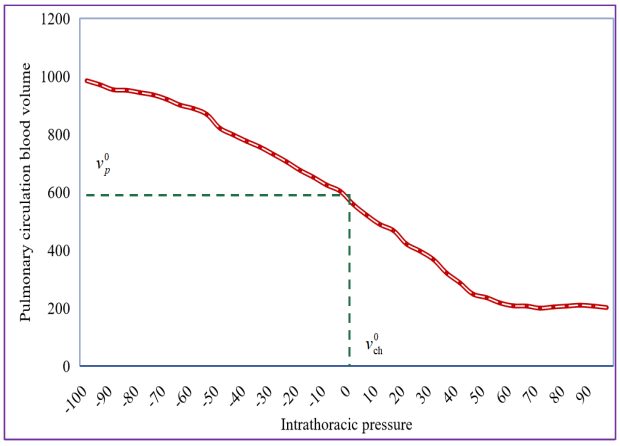

Figure 4: Relationship between pulmonary blood volume and intrathoracic pressure

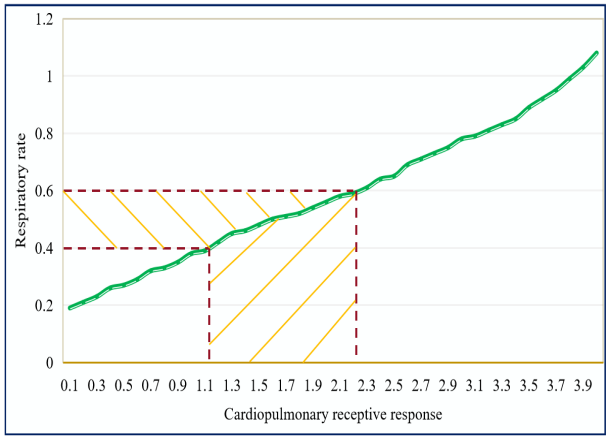

Figure 5 The relationship between cardiopulmonary receptive response and respiratory heart rate

When the time-frequency spectrum of mixed heart-lung sounds is obtained by short-time Fourier transform, Hanning window is used as the window function, and the corresponding window length and frame shift are 128 and 64 respectively. Time frames of time-frequency spectrum are input into DNN network one by one. The network has three hidden layers, and the number of neurons in each layer is 300, and the activation function of each layer is ReLU. SNR evaluation of separation effects of different methods is shown in Figure 6.

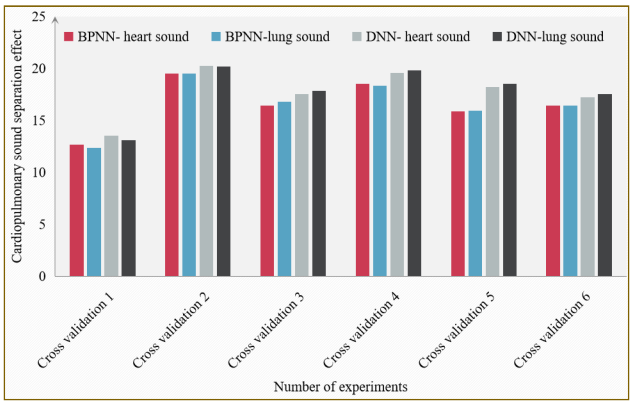

Figure 6 Separation effect of different methods

As can be seen from the figure, the DNN model of differentiated training in this paper is better than the general BPNN model. Compared with the general BPNN model, the DNN model of discriminative training can not only distinguish a certain feature from a certain class, but also distinguish that the feature does not belong to a certain class, thus increasing the separation performance of heart and lung sounds and achieving a better separation effect. Figure 7 shows the error of the algorithm.

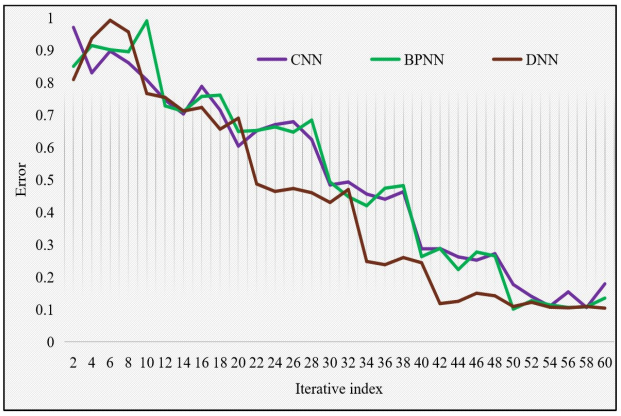

Figure 7 Error situation of algorithm

Body composition is the general name of different components that make up human tissues and organs. According to the difference of physiological functions of different components, body weight is usually divided into lean body weight and fat body weight. Body composition is closely related to people's health. The influence of volleyball on body composition in severe haze weather is shown in Table 2.

Table 2: *Effects of volleyball on body composition in severe haze weather*

Index	Volleyball team in Haze environment	Normal environment control group
Fat content /kg	22.55±5.30	22.12±5.60
Muscle content /kg	41.31±5.85	41.15±6.95
Lean body weight /kg	45.86±10.52	45.20±10.10
Body fat percentage/%	33.52±10.23	36.78±6.21
Body mass index	23.45±4.54	23.19±6.15

Analysis of Table 2 shows that the indexes of body composition of heavily polluted volleyball group are significantly lower than those of normal environment control group.

When playing volleyball, the oxygen demand of human body doubles. Table 3 shows the results of cardiopulmonary sound separation by different methods.

Table 3 *Results of cardiopulmonary sound separation by different methods*

Cardiopulmonary sound separation method	Average SNR of heart sounds	Robustness	Operating speed
The method in reference [12]	22.519	Good	Common
The method in reference [15]	18.536	Poor	Fast
The method in reference [19]	21.054	Better	Common
Methods of this paper	24,307	Good	Fast

In this paper, one of the obtained basis matrices is taken as the basis vector of heart sound reference signal, and the other is taken as the basis vector of lung sound reference. The mixed basis matrix is clustered, and the cardiopulmonary sound are reconstructed to realize the separation of heart and lung sound. The experimental results show that this method has high separation accuracy and robustness, and the average SNR reaches 24,307. Table 4 describes the effect of volleyball on cardiovascular function in severe haze weather.

Table 4: *Effects of volleyball on heart rate, blood pressure, pulse pressure and cardiac function index in severe haze weather*

Index	Volleyball team in Haze environment	Normal environment control group
Resting heart rate/(b· min-1)	67.96±4. 10	72.71±64.65
Systolic pressure /mmHg	136.92±7.94	139.62±7.12
Diastolic pressure /mmHg	71.82±6.04	72.95±6.85
Pulse pressure /mmHg	17.12±6.05	51.56±3.57
Heart index	139.75±9.18	148.35±9.10

It is not difficult to see that the quiet heart rate, systolic blood pressure, diastolic blood pressure, pulse pressure and cardiac work of the heavily polluted exercise group are higher than those of the control group. And there were significant differences in quiet heart rate, pulse pressure and cardiac work index between the two groups ($P < 0.05$).Fine particulate matter in the air of smog is an important factor that aggravates the hospitalization rate and mortality rate of chronic obstructive diseases. Volleyball is mostly played outdoors, and there are more volleyball lovers in cities with developed industries. Therefore, the Haze environment makes volleyball players have to absorb high concentration of PM2.5 for a long time, which leads to the extremely high incidence and mortality of lung cancer.

Volleyball is a sport that improves energy through anaerobic respiration and aerobic respiration, and aerobic exercise is the main sport, supplemented by anaerobic exercise. Long-term aerobic exercise plays an important role in human heart function. First, it can improve the change of heart rate and make the human body in a quiet state, which is bradycardia; second, it can increase the strength of heart muscle contraction. At the same time, it can obviously improve the endurance sports quality of volleyball players. In order to realize the essential function of volleyball, it is necessary to effectively improve the haze environment. However, the improvement process needs time to be realized. During this period, volleyball players need to take protective measures to avoid damage to cardiopulmonary function.

5 Conclusions

At present, the situation of air pollution is very serious, so it is necessary to prevent and control air pollution while facing urgent tasks such as urban industrialization. Controlling smog is an arduous and long-term task. The existing scientific evidence can confirm that smog will bring great harm to human body, especially in volleyball, which will cause more direct and serious damage to human cardiopulmonary function.

In this paper, the influence of outdoor volleyball on human cardiopulmonary function in severe haze environment is studied. In this paper, a set of lung sound data acquisition paradigm and evaluation

method is designed, and the collected lung sounds are preprocessed by band-pass filtering to suppress noise interference. And the original features of lung sounds are extracted by using Mel spectrogram. At the same time, the objective function of DNN network is improved by using the technique of distinguishing training. On the basis of the original objective function, the improved objective function can not only train the model to distinguish the category of features, but also train the model to have the ability to distinguish features that do not belong to other categories, thus improving the separation performance of the network and achieving better separation effect. Experimental results show that this method has high separation accuracy and robustness, and the average SNR reaches 24,307, with an error of only 0.104. It effectively improves the accuracy and recognition rate of cardiopulmonary sound separation. This paper studies the influence of volleyball on human cardiopulmonary function in severe haze weather environment, and provides a basis for improving human cardiopulmonary function. However, because the characteristics of heart sound signals and lung sound signals are quite different, how to effectively detect and analyze the common characteristics of heart sound signals and realize more accurate diagnosis of heart and lung diseases needs further research and experiments.

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