The Application Research of Artificial Intelligence Neural Network in the Posture Analysis of Six Joints of Piano Player and Arm

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Abstract: *With the development of society, people's living standards are getting higher and higher, and more and more people are learning to play piano. However, there are not many ways to put students on the right track. Most students give up learning halfway, mostly because the cooperation between hands and arm joints is not good enough. Many researchers have provided new ideas for the study of the use of the six joint postures of the piano player and arm. This paper is based on this as the research direction and research basis. This paper analyses the significance of piano performance and carries out academic research and summary on the use of the six joint posture of piano player and arm; Then the algorithm model is established, and relevant algorithms are proposed to provide theoretical basis for the application of artificial intelligence neural network in the analysis of the six joint posture of piano player and arm; Then it puts forward the application method of the six joint posture of piano player and arm; At the end of the article, the simulation experiment is carried out, and the experiment is summarized and discussed; According to the evaluation of the students' grades in the two classes, the number of students in Class A with grades of 70-90 is the largest, while the number of students in Class B with grades of more than 90 is the largest, and the excellent rate of Class A's grades is 20%, while the excellent rate of Class B's grades is 55%. At the same time, with the continuous popularity of piano performance, the use of the six joint postures of hand and arm is also facing new opportunities and challenges.*

Keywords: *Piano Performance, Arm Joints, Posture Application, Artificial Intelligence, BP Neural Network*

1. Introduction

Piano performance is the emotion and essence of piano works. It must be reflected in the performer's second creation to reach the psychological resonance with the audience. The piano performance perfectly combines technology and emotion to show the beauty of music itself. Through the analysis of the form of performance technology, it can provide technical and aesthetic guidance for the performance of musical instruments. Piano performance is a very free and open art form. This is not only the performer's personal piano performance skills, but also an expression of the performer's secondary creation of piano works, and also a pursuit of art. The joints of the arm are the key to connect the fingers and the arm. Only by adjusting all joints to the appropriate positions can all movements be smoothly carried out. Otherwise, there will be chaos, and the places that need to be relaxed will be stiff and unable to achieve the desired effect. Therefore, in the process of piano performance, how to give full play to the function of joints is a key link that piano novices need to understand and master.

The application research of piano artificial intelligence neural network in the posture analysis of piano player and six joints of arm. Farzana SF Mariyam found that the number of students studying piano is increasing, and piano players can play notes accurately similar to sports activities. Joint posture plays a vital role in piano. Because of the nature of music practice, improper joint posture and possibly harmful playing skills, musicians are vulnerable to injury. Most amateur players are vulnerable to injury. Amateur pianists can feel pain in their hands and fingers. The main purpose of the study is to strengthen the muscles of fingers and hands to reduce the degree of pain[1]. Blanco-Pineiro Patricia believes that objective bad posture will increase the risk of joint musculoskeletal disease of musicians. The research compares the posture quality required by different instruments or instrument series. The

method is that experts use a special posture observation instrument including 11 joint posture applications to evaluate the posture of 100 students in the conservatory of music [2]. Pappa Eleni found that although the importance of joint posture in piano performance is often emphasized, the role of experience is still unclear. The purpose of the study is to examine the use of joint posture of young piano students with different performance levels [3]. Qian Zhi believes that piano performance technology is reflected on the surface through the coordinated movement of the performer's fingers and other parts. Therefore, piano performance technology not only belongs to the category of music performance, but also belongs to the category of sports science. By effectively controlling the change of timbre and music, piano performance technology can be perfectly implemented [4].

The use of arms is very important in piano performance [5]. The application of science can improve the accuracy of performance and make it easier for players to break through technical barriers. Generally speaking, when playing, if you can't improve your playing speed, resulting in unclear playing sound, it will lead to unscientific use of the arm. Therefore, it is very necessary to actively strengthen the thinking of the arm on piano performance technology in piano performance technology [6].

2. How to Use the Six Joint Posture of Piano Player and Arm

2.1. Analysis of Piano Performance Posture

The piano is an instrument with a keyboard and its playing position is fixed. Its timbre can be adjusted by the speed and strength of playing, and it can play a variety of different sounds. It has the characteristics of wide range and strong expressive ability. In the process of piano performance, the selection of touch keys is the most critical and basic link. Its different key modes will have a direct impact on the sound quality, timbre, performance effect and depth of performance [7]. The beautiful voice has a great relationship with the source of power, strength and the way of pressing keys of the fingers on the keyboard. Whether the use of keyboard tapping method is reasonable and scientific will directly affect the success and failure of playing, so accurate performance requires superb skills. If you can't grasp the keys correctly, no matter how difficult the music is, it will give you a feeling of chaos, and thus lose the unique aesthetic feeling in piano performance. Piano performance is an active and coordinated action of various parts of the body. Therefore, when performing key touch training, we should not only focus on the fingertip action but also ignore the impact of other parts on key technology. At the same time, when using the touch key technology, we should also take full account of the performer's own quality, performance style and other practical characteristics, and take different key methods according to different works.

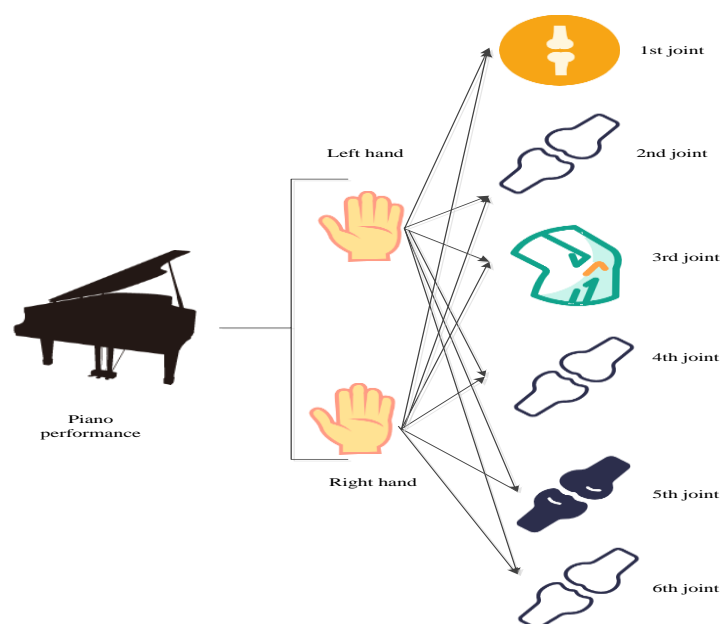### 2.2. Analysis of Posture Application of Six Joints of Arm

Figure 1: Use of the six joints of the arm.

First, separate the joints on the hand and arm. Apart from the thumb, it can be divided into six different joints [8]. The first joint is near the fingertip, and then the second joint is downward. The connection of the metacarpophalangeal root is called the third joint, the fourth joint is the wrist joint, the elbow joint is called the fifth joint, and the sixth joint is the connection between the arm and the shoulder. When playing the piano, the ten fingers of the human body, under the command of the human brain, move and coordinate step by step in order to play a wonderful piano song.

In this paper, the six joints of the arm are discussed in detail, and the posture of the six joints of the arm is shown in Figure 1:

The first joint is to hit the keys with your fingers to produce different sounds. In a strong performance, the soft part of the fingers tightly holds the keys perpendicular to the keys and closely cooperates with the second and third joints. The thumb is the center. Its supporting force allows the fingers to be independent. It transfers the strength of the arm to the fingertip to make the sound penetrating. At the same time, it can help fingers and wrists move left and right. It is a very critical supporting point in the piano playing technology and plays a decisive role in the playing process. Millions of notes in piano music are completed by its hinges. To accurately show the feeling of playing, we should focus on the keys of the fingers, so that the touch of the keyboard can match the result of imagination. Only in the correct way of pressing keys can the sound quality achieve a clear, bright and grainy effect. If the joint is not supported, the piano sound will become blurred [9].

The second joint works closely with the first and third joints at the moment when the fingertip touches the keys to keep the fingers in an arc. When holding the keys, it can help the fingers support and let the strength of the arm pass through the fingertip to the fingertip. If you change the bending of this joint, the finger will change when you press the key, so the sound will also change.

The third joint has good flexibility. It can use the movement ability of the palm and fingertip to quickly bounce off the fingers that need to be hit. The high finger is used to stretch the joints, and is used to the flexibility of tapping the keyboard and can maintain the independence of the fingers. At the same time of keystroke, it forms a natural arc with the first and second joints, which can better support the weight of the arm to the fingertip. When the fingers are independent and the arms are connected, the direction of the fingers can be transmitted to a farther place through the drive of the hands and arms, which is very helpful for the sound of playing.

Only 2 joints of the thumb can move up and down like other fingers. Through its internal support as a key, the left and right freely movable fulcrums enable both hands to smoothly walk and run horizontally on the keyboard. Its flexible fingers can complete extremely fast vibrato decoration in a very short time. The speed of its movement plays a decisive role in performance. Therefore. An important aspect of practicing playing technique is to consciously exercise its basic independence and flexibility.

Section 4 refers to the wrist. It is composed of eight irregular small bones, and the surrounding muscles and ligaments are very flexible. The wrist joint is loose and flexible, which is very beneficial for the speed and strength of pressing keys. As long as the wrist turns back and forth on the keyboard like opening the door, the scale and arpeggio can be switched up and down.

The fifth joint is the elbow. It is combined with the following joints to support the strength of the arm when touching the key. Use wrist coordination to complete the rotation action in piano music to achieve accurate playing effect.

The sixth joint is the most flexible one on the shoulder. Let every joint of the body cooperate with the fingers to make a strong sound. The flexible use of the hands and ankles is a prerequisite for playing the piano. The weight transfer of the shoulders and the overlap of the independent finger support can make the sound sink to the bottom to achieve full and firm effect. It can freely start and cooperate with the elbow and wrist to complete the staccato, chord and octave swing. At the moment when the finger is pressed, it can play a positive and negative effect with the hand and arm joints.

2.3. Joint Posture Application under Artificial Intelligence Neural Network

BP (back propagation) neural network is a multi-layer feedforward neural network, which is a multi-level feedforward network trained according to the error back propagation algorithm. In the input layer, there are 6 neurons corresponding to 6 joints of the arm, while in the hidden layer, there is 1 neuron responsible for processing and transmitting information, and in the output layer, there are 6 neurons, which are nodes of each input layer [10].

It can be calculated by empirical formula, namely:

$$n = \sqrt{i + o} + m \tag{1}$$

Here, i is an input node, o is an output node, and m is a constant between 1-10. The BP network model is shown in Figure 2.
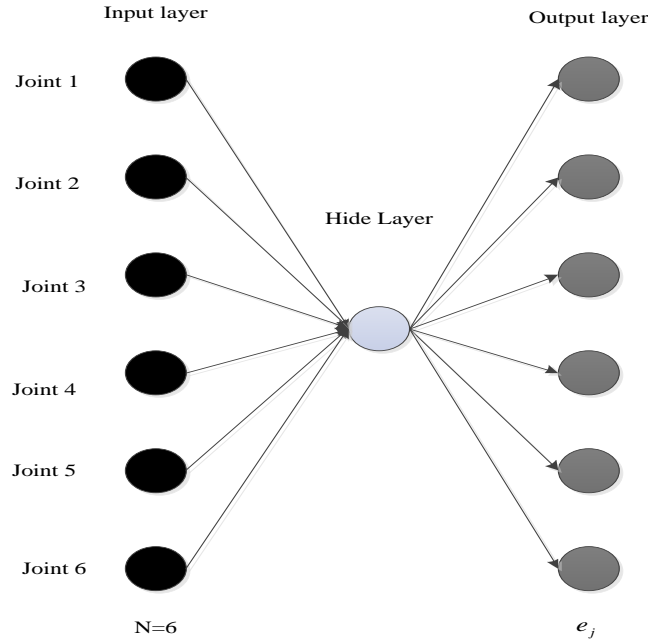

Figure 2: The BP network model.

First, calculate the total error of the network from input to output as follows:

$$e(n) = \frac{1}{2} \sum_{j=1}^{2} e_j^2(n) \tag{2}$$

Then, reverse transmission of error signals is used to adjust the network in the weight adjustment stage [11-12]. First, the weights of hidden layer and output layer are adjusted. According to the fastest descent method, the gradient between error and w_{ij} should be calculated first, and then reverse adjustment should be made in this direction:

$$\Delta w_{ij}(n) = -\frac{\partial e(n)}{\partial w_{ij}(n)} \tag{3}$$

$$w_{ij}(n+1) = \Delta w_{ij} + w_{ij} \tag{4}$$

After repeated training, the weight adjustment principle between hidden layers is similar to the above.

3. Piano Player and Arm Six Joint Posture Application Experiment

According to the above research on the application of artificial intelligence neural network in the analysis of the posture of the piano player and the six joints of the arm, this part proposes the simulation experiment analysis [13-14]. The students' performance of two piano instrument classes A and B is evaluated. Class A uses the traditional method to teach the use of the six joint posture of hand and arm when playing piano, while Class B uses the method under the BP neural network model established above to use the six joint posture of hand and arm when playing piano. Table 1 shows the statistics of the number of global piano beginners and the growth of piano sales in 2018-2022:

Table 1: Scale of global piano beginners and growth rate of piano sales in 2018-2022.

	2018	2019	2020	2021	2022
Number of people (ten thousand)	5000	5344	5821	6143	6598
Growth rate (%)	/	6.9	8.9	5.5	7.4
Piano sales (10000 sets)	53	59	62	71	79

First of all, grade segmentation is carried out, in which the score is greater than 90 points for excellent, 70-90 points for good, 60-70 points for passing and less than 60 points for failing. It is known that there are 20 students in Class A and Class B, and for the sake of fairness, each student has one piece of music, which will be evaluated by the class teacher after playing, as shown in Figure 3:
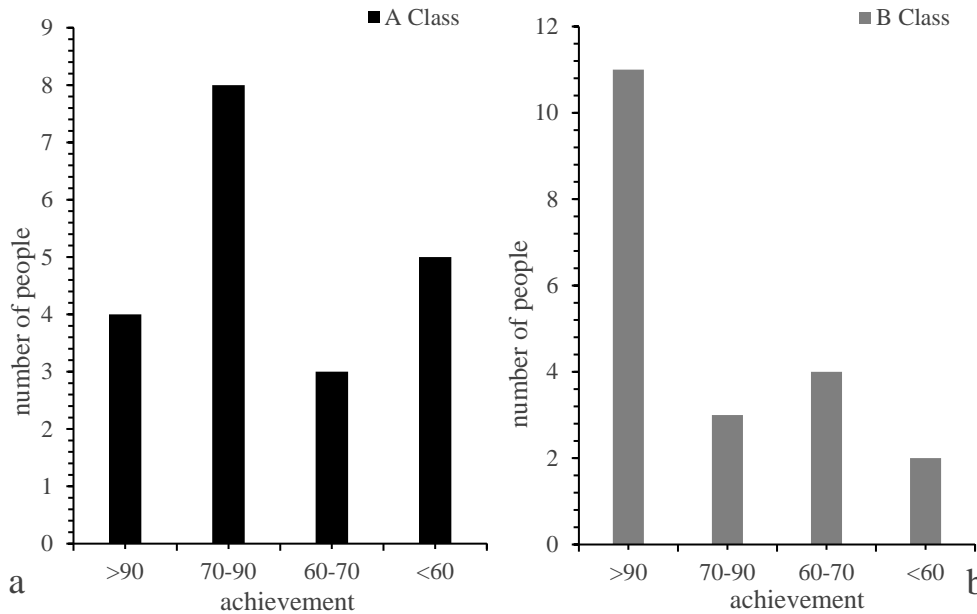

Figure 3 a: The number of students in each section of class.
Figure 3 b: The number of students in each section of class.

Figure 3: Number of students in each class.

Figure 3a shows the number of students in each grade segment of Class A, and Figure 3b shows the number of students in each grade segment of Class B. It can be seen from Figure 3 that the number of students in Class A with grades of 70-90 is the largest, while the number of students in Class B with grades of more than 90 is the largest, and the excellent rate of Class A's grades is 20%, while the excellent rate of Class B's grades is 55%. Among them, the number of students in Class B with grades of more than 90 is 7 more than that of Class A, the number of students in Class B with grades of 70-90 is 5 less than that of Class A, and the number of students in Class B with grades of 60-70 is 1 more than that of Class A The number of students in Class B with grades less than 60 is 3 less than that in Class A. It can be seen from this that the effect of using the traditional method to teach the six joint posture of hand and arm during piano performance is not as good as that of using the method under the BP neural network model established by Class B to teach the six joint posture of hand and arm during piano performance.

4. Conclusion

Everyone is a whole but is composed of different parts. So is piano performance. It looks like a whole but is actually completed by many different links. They also have relatively independent sports ability. Therefore, when performing, it is necessary to ensure the coordination of various parts, clarify their role and strengthen their role, Let them give full play to their role so as to improve the piano playing skills.

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