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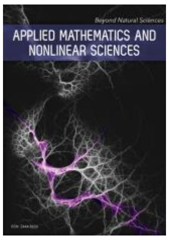

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Perceptual and cognitive infiltration of piano lessons for college students under the concept of digital health

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Abstract

In this paper, firstly, according to mental health education, the research on the perception penetration of the piano course is illustrated from the two directions of body perception and mind perception. Secondly, it researches the music feature extraction in the piano course, obtains the amplitude, wavelength and frequency of the music feature according to the piano string vibration equation, then applies the short-time Fourier analysis to identify the music feature and reconstructs the piano timbre by using the identification result, which provides technical support for the design and realization of the piano course teaching system. Then, the overall design direction of the piano course teaching system is determined according to the teaching needs of the piano course in colleges and universities, and then the core module of the piano course system is realized. At the same time, the teaching of piano courses is empirically analyzed through statistical analysis. The results show that there is a significant difference between piano course teaching and the degree of perception and cognition in piano course teaching ($F=4.194$, $p<0.05$), there is a significant difference between piano course teaching and the degree of cognition ($F=4.243$, $p<0.05$), and there is a significant difference between piano course teaching and interpersonal relationship ($F=5.391$, $p<0.05$). This study not only has a promoting effect on piano teaching in colleges and universities but also improves the guiding value of piano curriculum reform in colleges and universities.

Keywords: Vibration equation; Fourier analysis; Musical feature extraction; Piano teaching system; Perception; Cognition.
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1 Introduction

Online education at this stage is also more and more developed [1]. At this stage, Internet-enabled education has become an industry development trend [2-3]. In the field of education, many enterprises are also developing intelligent teaching products to help teachers improve their teaching efficiency and learning effect [4-6]. Music education is about the legacy of human culture, and piano education is particularly crucial [7].

Accepting good piano education can improve personal cultivation and cultural quality, cultivate sentiment and cultivate character, but it also can develop intelligence and cultivate coordination [8-10]. A variety of music teaching software competes in the public's field of vision but really meets the needs of the actual music classroom teaching application of the system software very little. The design and implementation of a music classroom teaching system to meet the actual needs of the practical teaching of the teaching system are of great practical significance [11-13].

This paper firstly realizes the inner music conception through practicing the piano and puts forward the suggestion of perceptual and cognitive penetration teaching in the piano course, and only by using the motivation drive scientifically can the students' piano playing level reach the perfect realm. Secondly, under the concept of digital health, the piano string vibration equation is determined from the piano course teaching, and then through the spectral analysis of the music signal, it can be seen that in the frequency domain of the fundamental wave to the fifth harmonic component of the energy ratio relationship and the harmonic frequency near the small range of frequency domain waveforms focus on the pitch, timbre, and the energy of the pitch and timbre of the performance information. Then, the piano course teaching system is constructed according to the music feature extraction and piano teaching needs, mainly including the analog piano template score editing module and score demonstration module, and the piano course teaching system is tested through simulation analysis and black box testing. Finally, we selected the School of Music of Huazhong Normal University, the School of Arts of Wuhan University, and the Department of Arts of Three Gorges University as the research objects and used the psychological statistical analysis software SPSS22.0 to statistically analyze the samples and draw the results of the research, which confirms that this paper's research has a guiding reference value for the development of piano teaching.

2 Relevant studies

Literature [14] in order to improve the quality of mental health of students in colleges and universities, on the basis of the intelligent fuzzy neural network, a music education-based fuzzy neural network is proposed, aiming at prompting the students to have healthy psychology, realizing the intelligent processing of nonlinear pressure signals output by the corresponding strain, and utilizing the music education to evaluate the students' mental health status. Literature [15] should study the psychological rescue function of music education in social crises as a response to distress in social crises. The results showed that improving the educational function of music education for mental health during social crises has largely solved the problem of people with psychological problems in society. Literature [16] explores the concept of manipulation as an important educational tool in music education.

Literature [17] suggests that the perception of music instruction is dependent on the normal functioning of the peripheral and central auditory systems and that older subjects without hearing loss have altered perceptions of music, including pitch and temporal characteristics. Literature [18] explored the importance of emotion in the instructional design of music lessons, and the study is relevant to teachers and practitioners because designing music instruction based on TPACK principles provides clear instructional design guidelines that address both cognitive and affective domains.

Literature [19] put forward the ability to combine music education and information fusion based on the “online and offline” spectrum of “online and offline” in the context of the 5g age.

3 Perceptual and Cognitive Infiltration of the Piano Program Based on Mental Health Studies

3.1 Piano program perceptual penetration

3.1.1 Teaching body perception in piano courses

The penetration of body perception in piano course teaching is shown in Figure 1. At the advanced stage of piano teaching, the use of body perception has three implications: (1) Body perception can simplify playing movements and reduce the fatigue of practicing. (2) Body perception can promote the playing state from rusty to mature. (3) The use of body perception can better interpret the music.

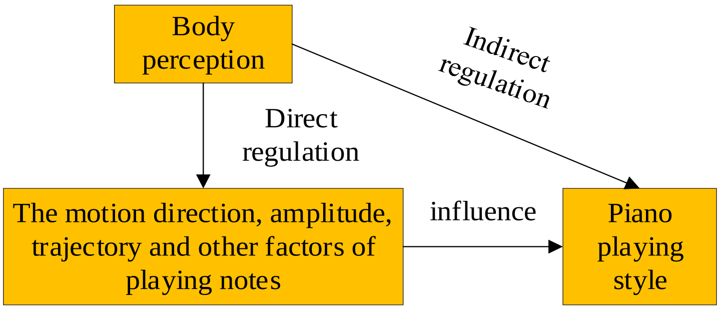

Figure 1. Body perception penetration in piano course teaching

3.1.2 Mindfulness in teaching piano lessons

As shown in Figure 2, if piano players want to improve their psychological perception, they must pay attention to learning the basic theoretical knowledge, understand the composer’s era background, emotional experience and creative style, etc., and deeply analyze how to deal with and use elements such as rhythms, modes, and harmonies in their performances, so as to deeply restore the author’s creative state of mind.

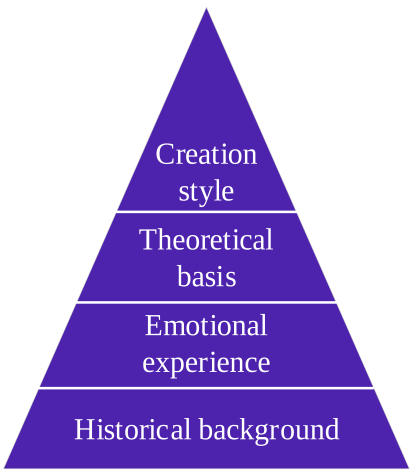

Figure 2. The path of spiritual perception enhancement in piano course teaching

3.2 Cognitive Infiltration in Piano Program

3.2.1 Psychological Cognitive Infiltration in Piano Programs

Cognitive psychology places a high value on the use of existing knowledge, which is why piano teaching must consider the integration and penetration of other disciplines. Piano learning requires students to master basic playing knowledge and repertoire appreciation ability, in essence, still belongs to the scope of the music discipline, so piano teaching in colleges and universities needs to pay attention first and foremost to the music discipline of integration and penetration. Students need to understand the background of the composition of the repertoire, performance style and expression of feelings, which requires students to have a certain basic knowledge of music appreciation and music history. In order for piano learning to be driven by music, teachers should first teach students the basics of music. Piano teaching also belongs to the branch of pedagogy; pedagogy, to a certain degree, and psychology have inseparable links, so teachers also need to use the advantages of pedagogy and psychology to change the teaching method and improve the teaching effect.

3.2.2 Health cognitive penetration of the piano program

There are three main modes of health cognitive drive: motivational drive, self-efficacy drive, and hypothetical future drive. Health cognitive motivation has the function of a self-regulatory motivational drive of life instincts, as shown in Figure 3. There are three factors involved in motivation: intrinsic causes, extrinsic triggers, and mediated regulation. In piano playing, “desire and emotion” are the intrinsic motivational factors. “Needs and satisfactions” are extrinsic motivational triggers. “Consciousness and will” are the intermediary driving force for self-regulation to realize the playing effect of perfect expression of musical ideas. The perfect motivational realm can only be achieved by the piano playing power through the scientific use of motivational drive.

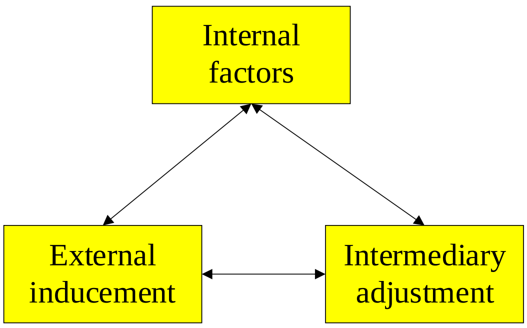

Figure 3. Healthy cognitive motivation self-regulates motivational drive function

4 Research on piano teaching under the concept of digital health

4.1 Music Feature Extraction in Piano Programs

4.1.1 Equation of piano string vibration

Assuming that the string is l long and is fastened to the rattle by tuning pegs at both ends, now strike the string with a cosine-shaped mallet of width 2δ . The interval of mallet strike is $\left(x_0-\delta\le x\le x_0+\delta\right)$. Let the striking point be $x=x_0$, the initial velocity of the string is v_0, the acceleration of the string vibration is a, and the vibration time of the string is t. Since it is a cosine convex mallet, the maximum velocity is obtained at point $x = x_0$ at the moment of striking, while at points $x = x_0 - \delta$ and $x = x_0 + \delta$ the velocity is zero, and the string is set to start vibrating freely thereafter, and the vibration of the string can be reduced to a fixed solution problem:

$$\begin{cases} \dfrac{\partial^2 u}{\partial t^2} = a^2 \dfrac{\partial^2 u}{\partial x^2} \\ u\big|_{x-0} = u\big|_{x-t} = 0 \\ u\big|_{t=0} = \varphi(x) = 0 \qquad\qquad (0 < x < l, t > 0) \\ \left.\dfrac{\partial u}{\partial t}\right|_{t=0} = \begin{cases} v_0 \cos \dfrac{x - x_0}{2\delta}\pi, & (x_0 - d \le x \le x_0 + d) \\ 0, & (0 \le x \le x_0 - d, x_0 + d \le x \le l) \end{cases} \end{cases} \tag{1}$$

According to the boundary conditions, the eigenfunction is known to be $\sin\frac{n\pi a}{l}$, which can be expressed according to the general formula for string vibration:

$$u(x,t) = \sum_{n=1}^{\infty}\left(C_n \cos\frac{n\pi a}{l} t + D_n \sin\frac{n\pi a}{l} t \right)\sin\frac{n\pi}{l} x \tag{2}$$

Bringing Eq. (2) into the initial conditions to determine the coefficients C_n and D_n

$$\varphi(x) = \sum_{n=1}^{\infty} C_n \cdot \sin\frac{n\pi}{l} x = 00 < x < l \tag{3}$$

$$\psi(x) = \sum_{n=1}^{\infty} D_n \cdot \frac{n\pi a}{l} \cdot \sin\frac{n\pi}{l} x = \begin{cases} v_0 \cos\dfrac{x - x_0}{2\delta}\pi, & (x_0 - \delta < x < x_0 + \delta) \\ 0, & (0 < x < x_0 - \delta, x_0 + \delta < x < l) \end{cases} \tag{4}$$

The left side of Eqs. (3) and (4) are the Fourier series of that function on the right, from which the coefficients can be derived as follows:

$$C_n = \frac{2}{l}\int_0^l \psi(x)\sin\frac{n\pi x}{l} dx = 0 \tag{5}$$

$$\begin{aligned} D_n &= \frac{2}{n\pi a}\int_0^l \psi(x)\sin\frac{n\pi x}{l} dx \\ &= \frac{8v_0 d}{n^2\pi^2 a}\frac{1}{1-\frac{4d^2n^2}{l^2}}\sin\frac{n\pi x_0}{l}\cdot\cos\frac{n\pi d}{l} \end{aligned} \tag{6}$$

So the equation for the vibration of a piano string is:

$$u(x,t) = \frac{8v_0\delta}{\pi^2 a}\sum_{n=1}^{\infty}\frac{1}{n}\frac{1}{1-\frac{4\delta^2 n^2}{l^2}}\sin\frac{n\pi x_0}{l}\cdot\cos\frac{n\pi d}{l}\sin\frac{n\pi a t}{l}\sin\frac{n\pi x}{l} \tag{7}$$

4.1.2 Music feature recognition under short-time Fourier analysis

The process of sound perception is closely related to the fact that the human auditory system has a spectral analysis function. Therefore, spectral analysis of music signals is one of the effective means to recognize music signals and process audio signals. The short-time Fourier transform of signal $\{x(n)\}$ is defined as:

$$X_n\left(e^{j\omega}\right)=\sum_{m--\infty}^{\infty} x(m)\cdot\omega(n-m)\cdot e^{-j\omega} \tag{8}$$

Where $\{\omega(n)\}$ is a window sequence, it is clear that $X_n\left(e^{j\omega}\right)$ is a two-dimensional function, also known as the time-frequency function. Time-frequency function $X_n\left(e^{j\omega}\right)$ can be understood from two perspectives of physical significance: one interpretation is: when n is fixed, for example, $n=n_0$, then $X_n\left(e^{j\omega}\right)$ is the center of the window function to move to n_0 intercepted signals, and then do the Fourier transform and a spectral function, which is directly by the frequency axis of the direction of the formula (7) from the direction of the understanding of the frequency axis. The second interpretation is from the direction of the time axis to understand: when the frequency is fixed, for example, $\omega=\omega_k$, then $X\left(e^{j\omega_k}\right)$ can be seen as when the signal passes through a bandpass harmonizer with a center frequency of ω_k after the output. This is because the window sequence $\{\omega(n)\}$ in Eq. (7) typically has a low-pass frequency response, while $x(n)\cdot e^{jn\omega_k}$ has a Fourier transform of $X_n\left(e^{j\omega}\right)$, where the modulation of $x(n)$ by the exponential $e^{jn\omega_k}$ acts to shift its spectrum, i.e., to flatten the component of the $x(n)$ spectrum that corresponds to the frequency ω_k to the zero frequency. Thus, Fig. 4 shows the STFT bandpass harmonic action.

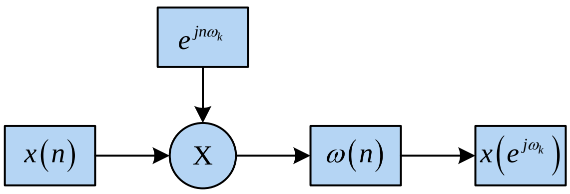

Figure 4. The band-pass filter of STFT

The square of the short-time Fourier transform amplitude $\left|X_n\left(e^{j\omega}\right)\right|^2$ is the spectral energy density function of the signal $x(n)$ at time n. When considering $x(n)$ as an energy finite signal, its spectral energy is continuously distributed in the frequency domain and can only be given as a density function. It is the Fourier transform of the short-time autocorrelation function of the signal $x(n)$, i.e.:

$$P_n(\omega)=\left|X_n\left(e^{j\omega}\right)\right|^2=\sum_{k=-\infty}^{\infty} R_n(k)e^{j\omega k} \tag{9}$$

Where the short-time autocorrelation function is defined as:

$$R_n(k) = \sum_{m=-\infty}^{\infty} x(m)\cdot\omega(n-m)\cdot x(m+k)\cdot\omega(n-m-k) \tag{10}$$

4.1.3 Reconstruction of piano timbre

Fourier analysis shows that the high-frequency component of a single tone played by a piano is an integral multiple of its fundamental frequency [20-21]. The human ear determines the height of the tone by determining its fundamental frequency, and the analysis of the measured performance data and its waveforms shows that the energy ratio of the fundamental to the fifth harmonic components in the frequency domain, as well as the waveforms in the frequency domain in a small range near the harmonic frequencies, concentrate on the pitch, timbre, and energy information of the tone being played. In the following experiments, a function is designed to simulate the waveforms of the corresponding tones from the fundamental frequency to the fifth harmonic frequency region under the condition of knowing the fundamental frequency of the given tone and the amplitude proportionality of the peaks from the first to the fifth harmonic frequency, the musical tone with piano timbre is successfully reconstructed as shown in Fig. 5.

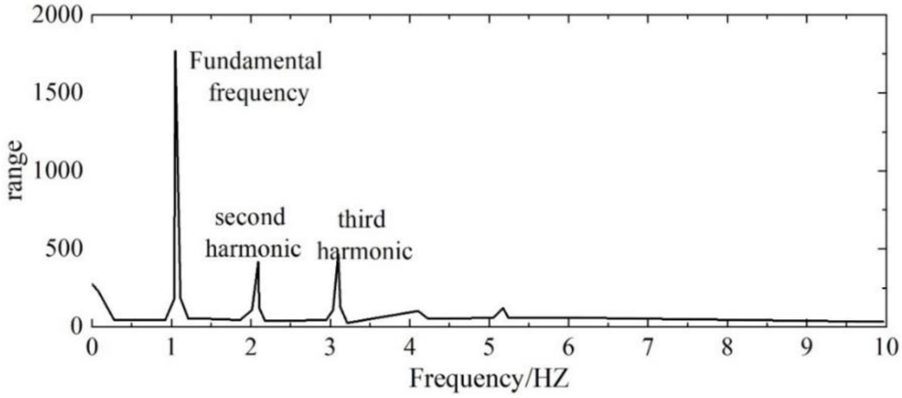

Figure 5. Music with a piano timbre

These functions are used to approximate the frequency domain waveforms of actual piano playing, where the weighted Cauchy function describes the information near the fundamental and octave frequencies, which is more apt to simulate the piano timbre. When the parameters are selected appropriately, the inverse Fourier transform is applied to the time domain, and a .wav file is constructed, whose playback effect is slightly different from the actual captured piano timbre, but the acoustic effect is already quite similar to that of the Grand Piano in the MIDI sound effects library.

In the experiment of approximating a frequency domain waveform using a weighted Cauchy function, let $Y(j\omega)$ be the discrete Fourier transform of the discrete time signal $y(n)$. Then $Y(j\omega)$ can be obtained using the following equation:

$$Y_i(j\omega) = S_i(j\omega) * F_i(j\omega) \tag{11}$$

$$S_i(j\omega) = \begin{cases} A_i \dfrac{\alpha_i}{\alpha_i^2 + (\omega-\omega_i)^2} \\ A_i \dfrac{2}{|\omega-\omega_i|} \end{cases} \tag{12}$$

$$Y(j\omega) = \sum_{i=1}^{n} Y_i(j\omega) \tag{13}$$

4.2 Piano Course Teaching System Design and Implementation

4.2.1 Overall Design of Piano Course Teaching System

As the digital piano course-based teaching system involves multiple modules containing multiple functions, this paper, in order to enable the smooth realization of the coordinated operation of the various modules within the system and to ensure the overall functionality while taking into account the stability and scalability of the system, carries out the overall design of the system, including the functional structure design and functional module design of the 2 parts. According to the actual needs of the digital music course teaching system, this paper divides the overall function of the system, which mainly includes the simulation of the piano template (also including the piano display control, piano playing, piano sound effect processing), the score editing module (including editing initialization, score editing, score displaying) and the score demonstration module (score playback control, score displaying control, demonstrating the sound effect processing) in 3 parts, and the system's overall The overall system structure is shown in Figure 6.

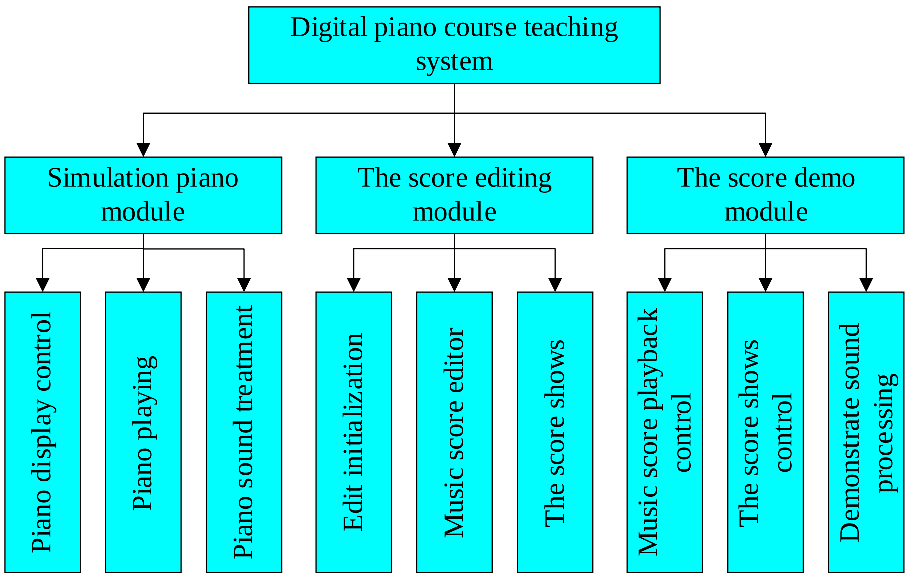

Figure 6. Overall design of the piano course teaching system

4.2.2 Implementation of the core module of the piano course system

1) Sequence flowchart of piano playing submodule

After the analog piano starts, it enters the piano display interface after initialization is finished and listens to the triggering or not of the playing event. After a playing event occurs, according to the actual different playing events to complete the corresponding processing, the end of the processing needs to be updated to the piano display interface so as to make the final presentation of the playing effect, the specific sequence of the realization of the flow shown in Figure 7.

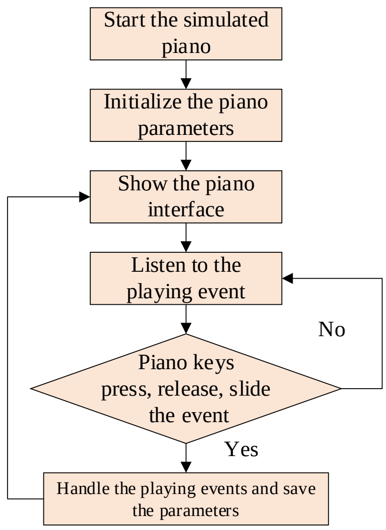

Figure 7. Flow chart of the piano playing submodule sequence

2) The realization of score editing sub-module

This module is mainly responsible for the editing process of sheet music, which mainly includes drag and drop modification of pentatonic clef, key number and beat number, addition or deletion of musical appendages, bars and notes, etc. The core module of sheet music editing involves many complex musical rules, and its accuracy and stability are dependent on the quality of its realization. Many complex musical rules are involved in the sheet music editing submodule as the core module of sheet music editing. The accuracy and stability of sheet music editing depend on the quality of its realization in order to further improve the effect of sheet music editing and presentation, this paper adopts piano feature extraction to complete the design of the module, the specific flow of the sheet music editing submodule is shown in Figure 8.

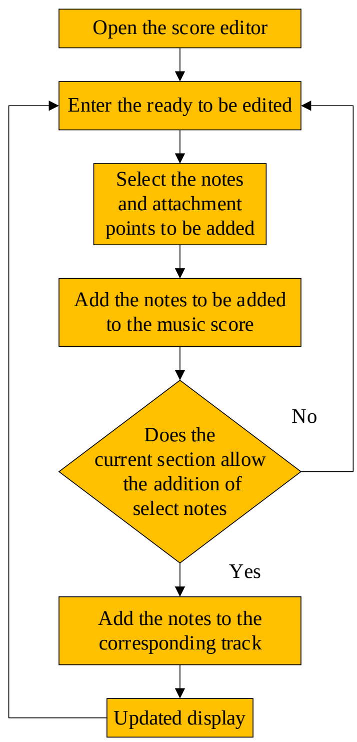

Figure 8. Specific process of the music editing submodule

3) The realization of sheet music display control sub-module

This module is mainly responsible for the control engineering of the display effect of the sheet music demonstration, which mainly includes zooming in/out of the sheet music, displaying or not the piano sheet music, and completing the switching of the position of the piano sheet music and so on. Through a variety of display effect settings, simplify the use of the process for teachers and students, making the demonstration effect more intuitive. This paper mainly uses the piano feature extraction to complete the design of the module. The specific flow of the sheet music display control sub-module is shown in Figure 9. In order to facilitate the teacher's classroom demonstration of the piano playing effect, the piano and sheet music position switching can be realized directly through the switching key and, at the same time, through the display of the pitch button on the display of the pitch or not to set directly, which facilitates the students' intuitive view of the piano keys and notes pitch.

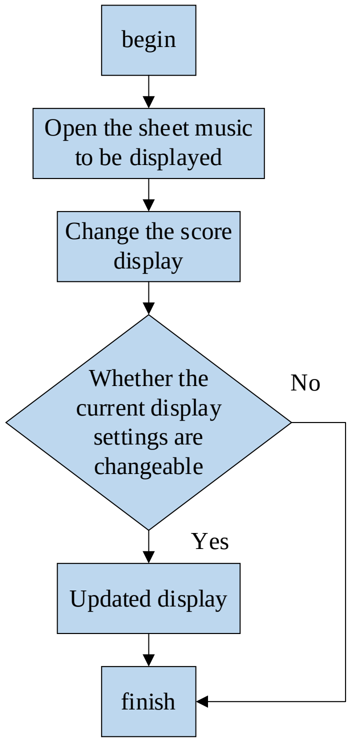

Figure 9. The music score shows the specific flow of the control submodule

4) The realization of the score sound processing sub-module

This sub-module is mainly responsible for improving the sound effects of sheet music, optimizing the sound effects of sheet music demonstrations, and improving professionalism. As an important module of the music demonstration, the music sound processing sub-module is responsible for realizing the difficulty and comprehensive factors. This paper adopts the open source soft source VST plug-in to complete the improvement of the purpose of the music sound effect, the sub-module of the specific process shown in Figure 10.

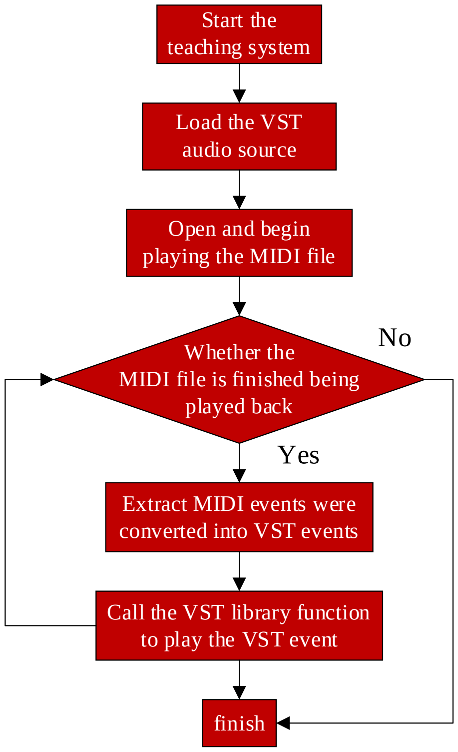

Figure 10. Flow chart of music score and sound processing submodule

5 Empirical analysis of digital piano course teaching system under the concept of digital health

5.1 Piano Music Feature Extraction Recognition Analysis

5.1.1 Data sets

In the computerized recognition of piano performance completed in this paper, the short-time Fourier analysis with higher efficiency and higher correctness rate is chosen as the core idea to extract the information related to the pitch of the fundamental tone, the triggering moment, the duration of articulation and the ending moment of the audio signal. The function module of pitch time value can better deal with independent monotone, monotone melody and simple diatonic, and the detailed results of feature extraction are expressed in the time as the horizontal axis and the keyboard serial number as the vertical axis. The datasets trans.dat, trans_tone.dat, and trans_key.dat are simplified tables of three tables, listing only the ranges of commonly used piano music f-c3 is used to enable the normalization of the extracted frequencies, adjusting them to the key numbers that the player can understand, and the relevant frequency cross-references used in extracting the fundamental frequencies are shown in Table 1. On the piano, the grouping of fundamental levels from left to right is in order:

Large character group 2: A2, B2;

Large character group 1: C1, D1, E1, F1, G1, A1, B1.

Large character groups: c, d, e, f, g, a, b.

Small character groups: c, d, e, f, g, a, b.

Small character group 1: c1, d1, e1, f1, g1, a1, b1.

Small word group 2: c2, d2, e2, f2, g2, a2, b2.

Small word group 3: c3, d3, e3, f3, g3, a3, b3.

Small word group 4: c4, d4, e4, f4, g4, a4, b4;

Small print group 5: c5.

Table 1. The control table of first partial picking-up

Order number	Musical alphabet/Hz	Calculated rate/Hz	The starting point frequency/Hz	Termination frequency/Hz	High pitch/Hz
37	a	219.9	213	225	220
38	#a	233.07	226	239	233
39	b	246.93	240	253	247
40	c1	261.62	254	268	262
41	#c1	277.17	269	284	276
42	d1	293.65	285	301	293
43	#d1	311.12	302	319	312
44	e1	328.62	320	338	331
45	f1	348.22	339	358	348
46	#f1	369.98	359	379	371
47	g1	392.01	380	402	391
48	#g1	415.29	403	426	414
49	a1	439.9	427	452	441
50	#a1	466.15	453	479	465
51	b1	493.87	480	507	493
52	c2	523.25	508	537	522
53	#c2	554.35	538	569	553
54	d2	587.31	570	603	553
55	#d2	622.25	604	639	621
56	e2	659.25	640	677	659
57	f2	698.45	678	718	697
58	#f2	739.97	719	760	741

5.1.2 Results and analysis

Let's take a look at the results of pitch-time value extraction for monophonic tones first. The recognition results of the frequency of the mid-range scales (c^1-c^2) using the above musical tone recognition method are shown in Table 2. For the pitch-time value extraction results of monophonic melodies, the experimental data are 100 pieces of musical themes or main melody fragments, including different styles of Chinese and foreign classical and modern. Piano learners played the fragments, and the length of the fragments did not exceed 30 bars, i.e., not more than one minute. The difficulty level of the pieces used in the experiment ranged from introductory to amateur piano playing grade 10 (but only monophonic melodic parts were played). All notes were correctly recognized, and the score was completed with the combination of adjusted timings.

Table 2. Recognition result

Identify notes	Standard frequency /Hz	Identification frequency / Hz	Error rate
c^1	261.63	261.2985	0.1270%
d^1	293.66	293.9221	0.0890%
e^1	329.63	329.7346	0.0320%
f^1	349.23	350.1726	0.2700%
g^1	392.00	392.8633	0.2200%
a^1	440.00	439.244	0.1720%
b^1	493.88	494.791	0.1840%
c^2	523.26	524.4255	0.2230%

Table 3 shows the frequency, tone name and time value of the musical note "City in the Sky" after endpoint detection and note recognition. The system correctly recognizes the names of all the notes in the music. For the time value, its actual meaning is to determine the delay of the music, which is to distinguish between whole notes, half notes, quarter notes, etc. The time value of the quarter note is the same as that of the quarter note, which is the same as that of the quarter note. The quarter note time value is 555.55ms, and the eighth note time value is 277.77ms, at which speed the time value recognition error is calculated. In general, since the time interval of standard note timings is large, the difference between whole note and half note timings is 1111.12 ms, the difference between half note and quarter note timings is 555.55 ms, and the difference between quarter note and eighth note timings is 277.78 ms, in terms of error, as long as the tolerance range is set to (-25.5%, +23.42%), all the timings can be adjusted correctly. So, in terms of error, by setting the tolerance range to (-25.5%, +23.42%), you can correctly adjust all the timings.

Table 3. Sky City Note Recognition Results

No	Frequency /Hz	Identify the sound name	The detection value	Accurate value	Error%
1	261.565	c^1	616.77	555.55	+11.01
2	293.288	d^1	565.98	555.55	-1.87
3	330.755	c^1	431.74	555.55	-22.28
4	349.255	f^1	700.22	555.55	+26
5	391.593	g^1	588.71	555.55	-5.96
6	391.053	g^1	602.26	555.55	+8.42
7	393.448	g^1	275.73	277.77	-8.42
8	350.895	f^1	282.98	277.77	-0.72
9	330.193	c^1	413.5	555.55	-25.5
10	348.832	f^1	685.72	555.55	+23.42
11	348.402	f^1	595.02	555.55	-7.11
12	348.452	f^1	326.52	277.77	+17.54
13	329.351	c^1	312.01	277.77	+12.32
14	291.393	d^1	562.34	555.55	-1.21
15	261.046	c^1	573.25	555.55	-3.17
16	330.383	c^1	631.3	555.55	+13.62
17	392.011	g^1	44.46.72	555.55	+19.6

5.2 Piano Program Teaching System Test

5.2.1 Test environment

The system uses three types of servers. The first step is to deploy the system's front-end and back-end code on a web server. The second is a database server, using MySQL relational database to store the different objects of the system and their relationships; the third is a resource storage server. The system's images, music scores, audio recordings, and a variety of algorithmic files are stored on the resource server. The Nginx running in the web server is responsible for request forwarding, and the requests routed by the back-end arrive at Laravel's index.php through php-fpm, and the requests routed by the front-end are forwarded to the folder where the front-end code is deployed to get the static resources. The testing of the system mainly includes functional testing and performance testing. Table 4 displays the testing environment.

Table 4. System testing environment

Host type	Software hardware parameters	Explain
Server	The web server operating system version	Centos release 6.10(Final)
	The Web Server hardware version	Intel(R) Xeon(R) CPU E5-2682 v4 @ 2.00GHz
	Back-end language	PHP 7.0.33 Zend Egine v3.0.0
	HTTP server	Nginx/1.14.2
	Application server	MySQL 5.6
	Resource server	Aliyun OSS
Browser	Google browser	72.0.3626.121
	Firefox browser	66.0.1 (64-bit)
Client	Client version	iPad pro 11 iOS Version 12.1.5
	Type	v0.99
We chat	The web server operating system version	iPhone xs max iOS Version 12.1.5
	The Web Server hardware version	Version 7.0.4

5.2.2 Functional testing

Functional testing involves three common approaches: black box testing, white box testing, and gray box testing. Black-box testing refers to treating the system as a "black box" and testing the system only through its external functionality. White-box testing refers to testing the system not through the external performance of the system but through the internal methods of the system. Gray box testing is in between black box testing and white box testing. Black box testing is used for functional testing of this system. We will test the functionality of each functional module from the client side in the following. The playing module mainly needs to test whether the functions of viewing exercises, assigning homework, and completing exercises are normal or not, and the specific test results are shown in Table 5.

Table 5. Piano performance function test

Test item	Expected result	Bear fruit
Check out the exercises	Users can click on the card on the right side of the welcome page to enter the page to view the practice, for seven days of practice	Pass through
To give an assignment	Xi shows it in the form of cards in reverse order of time, and the cover of the card is the insertion of the score	Pass through
Complete the practice	Graph. Other exercises follow the book card, click the book card to see this	Pass through
View the demonstration	Cards for all the exercises in this book.	Pass through
Switch the left hand spectrum, right hand spectrum and both hand spectrum	Click the assignment button to enter the interface of selecting the textbook, which presents the current use	Pass through

5.2.3 System performance testing

The performance of the system is tested in this paper. At this moment, we have chosen the score upload interface for stress testing. The interface HTTP method is POST, and the server will receive the Music XML file, and the illustration file of the score will be uploaded to the AliCloud OSS server, but also to write the database. At this time, it is necessary to write Lua scripts to test. The system performance test under a long connection is shown in Table 6. It can be observed that the system's ability to write is considerably inferior to its ability to read. This is because it takes more time for MySQL to write data than to read it, and the server has much overhead for uploading files to AliCloud's OSS server. In practice, the system receives far more GET requests than POST requests, so the system's current write capacity should also be able to support the workload of the piano course at this stage.

Table 6. System performance test under the long connection

Thread number	Linker number	Average number of requests per second	Average processing time (ms)	Mission success rate(%)
10	20	3046.12	20.04	100
10	50	4879.05	23.71	100
10	200	563.95	26.38	100
10	500	5185.57	36.23	100
10	1000	4001.29	38.07	100

5.3 Statistical Analysis of Perception and Cognition in Teaching Piano Courses

5.3.1 Research Objects

In this paper, some second- to fourth-year undergraduates of the School of Music of Central China Normal University, the School of Art of Wuhan University, and the Department of Art of Three Gorges University and some first- to third-year graduate students of the first two schools are taken as the objects of the survey, which are divided into piano majors and non-piano majors who are studying the piano. The age distribution of the research subjects is between 19-26 years old. The psychological development of this age group has tended to be mature, and they have an independent way of judging the view and understanding of things, and they also have certain experience in the study of the profession. The college mandates a piano course for non-piano majors during the undergraduate stage. After a year of piano study, technology and skills will also have a certain foundation and enhancement, so the research object selection from the second year of sampling will be more accurate.

Undergraduate and graduate students majoring in piano have been trained for a long time, so these students will gradually form their learning styles and have a certain degree of stability in their undergraduate and graduate studies. So, the research object of this paper only involves the second year of undergraduate students to the third year of graduate students in the School of Music.

5.3.2 Research methodology

In this paper, the questionnaire method of the survey method was used to conduct a relevant study on some piano majors and students who majored in a piano elective in the art department of Huazhong Normal University School of Music, Wuhan University College of Arts and Three Gorges University, through which the author obtained a first-hand sample, and used the psychological statistical analysis software SPSS22.0 to count and analyze the sample and draw the results of the study. The questionnaire data were analyzed using analysis of means, independent samples t-test and one-way ANOVA to summarize whether there were any significant differences in the specifics of enabling perceptual, cognitive and interpersonal intelligence in piano sight-reading.

5.3.3 Data analysis

The results of one-way ANOVA (F-test) for piano course instruction are shown in Table 7, which shows that there is a significant difference between piano course instruction and perception ($F=4.194$, $p<0.05$), piano course instruction and cognition ($F=4.243$, $p<0.05$), and piano course instruction and interpersonal relationships ($F=5.391$, $p< 0.05$). Only through the guidance of scientific training methods and persistent and extensive practice can we continuously improve our piano-playing ability.

Table 7. One-way variance analysis for piano course teaching

Project	Quadratic sum	Free degree	Mean square	F-Value	Significance P-values
Piano course teaching and perception degree	26.837	6	4.472	4.194	.000
Piano course teaching and cognitive degree	22.202	6	3.699	4.243	.000
Piano course teaching and interpersonal relationship	33.358	6	5.559	5.391	.000

The results of the one-factor correlation analysis of piano course teaching are shown in Table 8, and Pearson correlation analysis was used. By analyzing the correlation coefficients of perception, cognition, and interpersonal relationship in piano course teaching, the degree of closeness of the relationship between the three is compared. It can be seen that there is a significant positive correlation between the two of perception, cognition and interpersonal relationship in piano course teaching. The correlation between perception and interpersonal relationships was greater than the correlation between perception and cognition ($r=0.652>r=0.626$). “The correlation between cognition and interpersonal relationships” is greater than “the correlation between cognition and perception” ($r=0.732>r=0.626$). “The correlation between interpersonal relationships and cognition” was greater than “the correlation between interpersonal relationships and perception” ($r=0.732>r=0.652$). If you want to achieve a high level of piano playing, you can’t do it without the aid of systematic teaching materials, the establishment of perception and cognition, and, even more so, the accumulation of interpersonal relationships.

Table 8. Analysis of single-factor correlation in piano course teaching

Project		Piano course teaching and perception	Piano course teaching and cognition	Piano course teaching and interpersonal relationship
Piano course teaching and perception	Pearson coefficient	1	.626**	.652**
	Sig		.000	.000
	Quantity	334	334	334
Piano course teaching and cognition	Pearson coefficient	.626**	1	.732**
	Sig	.000		.000
	Quantity	334	334	334
Piano course teaching and interpersonal relationship	Pearson coefficient	.652**	.732**	1
	Sig	.000	.000	
	Quantity	334	334	334

6 Conclusion

With the increase in popularity of personal computers, it would be beneficial to develop a system that scientifically and objectively judges the performance of piano players using music feature extraction technology. This paper proposes a piano course teaching system that uses musical feature extraction to improve students' piano playing in the context of digital health. The following conclusions can be drawn:

1) There is a difference of 555.55 ms between half note and quarter note timings and a difference of 277.78 ms between quarter note and eighth note timings, so as far as the error is concerned, all the timings can be correctly adjusted as long as the error tolerance range is set to (-25.5%, +23.42%). The feasibility of music feature recognition under short-time Fourier transform analysis is fully demonstrated, and technical support is provided for the design and implementation of the piano course teaching system.

2) Through the testing of each module of the piano course teaching system, the final test results verify the specific implementation process of all the functions of the system and ensure the stable operation of each functional module in the system. The functions of the core modules, including the piano playing submodule, the score editing submodule, the score preview and saving submodule, the score display control submodule, and the score sound processing submodule, have also been realized, providing technical support for music classroom teaching.

3) There is a significant positive correlation between perception, cognition, and interpersonal relationship in piano curriculum teaching, in which the correlation between cognition and interpersonal relationship is the highest, the correlation between perception and interpersonal relationship is medium, and the correlation between perception and cognition is the lowest. In this way, we can explore the methods and approaches to improve piano sight-reading with a theoretical basis and further provide some theoretical reference basis for the reform of piano sight-reading teaching materials.

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