International Journal for Housing Science and Its Applications
Publish August 10, 2025. Volume 46, Issue 4 Pages 3732-3743

https://doi.org/10.70517/ijhsa464497a

Spatially optimized layout of piano performance training in a housing environment and its mitigating effect on performance anxiety

Wenjie Zhu[1,*]
[1] Art Academy of Northeast Agricultural University, Harbin, Heilongjiang, 150030, China
Corresponding authors: (e-mail: zhuwenjie1117@neau.edu.cn).

Abstract This paper proposes a spatial optimization layout model of piano performance training environment based on Improved Whale Algorithm (IWAO) and BIM technology in response to the inability of traditional BIM technology to comprehensively reflect the optimized layout of piano performance training environment in housing. After determining the piano playing training environment, the alleviating effect of piano playing training on performance anxiety was explored, using questionnaires to obtain research data, and Pearson's correlation coefficient and multivariate linear regression model to explore the relationship between piano playing training and performance anxiety. Piano performance training occupies an area of 4.2 m², making the housing environment amenable to piano performance training activities. Performance anxiety mitigation = 0.347+0.313*Music reading training+0.459*Pedal training+0.487*Fingering training, and the VIF values of each variable are within the interval of 1~1.5, which satisfies the condition of 1<VIF<3, indicating that there is no multicollinearity in the believed regression analysis of piano playing training and performance anxiety mitigation, and that based on the linear quantitative form, the relationship between piano playing training on the performance anxiety alleviation.

Index Terms improved whale algorithm, spatial layout, multiple linear regression, housing, architecture design, Piano performance, performance anxiety

I. Introduction

As a widely spread musical instrument, the piano has unique charm and playing skills. Having good piano training habits can enhance the effect and quality of the performer's piano performance. In the training of piano performance, in addition to practicing the repertoire of the piano [1]-[4], it is also necessary to practice the correct seating posture and gestures, the flexibility and independence of the fingers, as well as the accuracy and consistency of the notes. The heavier practice also lies in the performer's mentality, and the performer's emotion and state will affect the overall effect of the piano performance [5]-[8]. One of the important ways to ease the performer's mindset is to optimize the spatial layout of the housing environment, which is of great significance in relieving performance anxiety [9], [10].

Anxiety is becoming more and more common in modern society, which brings serious impact on people's physical and mental health. In order to find effective psychological healing methods, people continue to explore and utilize various resources. As a psychological healing method, the optimization of the spatial layout of the housing environment has received more and more attention and research [11]-[14]. Spatial layout optimization of housing environment refers to the improvement of people's psychological state and emotional feelings through improving the spatial layout and environmental design of housing, so as to achieve the purpose of relieving anxiety [15]-[17]. Its main features include comfortable atmosphere, the use of natural elements, and the combination of sound and space. As a psychological healing method, space layout optimization has a significant healing effect on anxiety, mainly due to the stimulation of emotional regulation, distraction and diversion of attention, psychological suggestion and emotional release [18]-[21].

In this paper, BIM technology and improved whale algorithm are jointly applied to spatial optimization layout in housing environment, which is more innovative compared to the method alone. It is found that the WOA algorithm is easy to fall into the condition of local optimum in the late iteration, and after the introduction of inertia weights to improve the WOA algorithm, the WOA algorithm's ability to search locally in the mid- and late iteration is greatly improved to increase the convergence accuracy, and the Improved Whale Algorithm (IWAO) and the BIM technology are utilized to construct the model of spatial optimal layout in housing environments, and to determine the model's objective function, which is used for solving the optimal spatial layout of housing environments that makes it satisfy the piano playing training. The research object is selected, while the research hypotheses are proposed according to the research purpose, and the data are obtained through questionnaires. After that, the research data, Peel's selected correlation coefficient, and regression model were synthesized to jointly explore the interplay between piano playing training and performance anxiety.

II. Optimizing spatial layout in the housing environment

In this paper, we study the layout of indoor piano playing training environment with BIM as a platform, with the help of rich models and data in BIM, the layout objective function consists of layout constraint function and spatial quantization function of spatial syntax quantization, rule-based layout algorithm and spatial syntax based layout method, both methods are the object layout rules and layout space numerical optimization, traversal of the method of the time-consuming, the longer. Therefore an intelligent optimization algorithm is introduced for process optimization. Whale algorithm is a group-based natural heuristic algorithm, with faster convergence speed, the algorithm has both strong global search capability and good local search performance. Therefore, the whale algorithm is chosen to solve the objective function in this paper.

II. A.BIM Overview

The rapid development of information technology has provided new methods for the design of buildings and building structures. Nowadays, Building Information Modeling (BIM) has been widely used by the construction industry in building projects and has become the direction of the construction industry. The interior decoration industry, as part of the construction industry, has also started to approach and gradually apply Building Information Modeling as a means of designing, presenting, and delivering interior layout solutions.BIM is an innovative methodology used for building design, construction, and management, which helps in the coordination of information and the improvement of the quality of the project, and it is starting to play a role in the field of interior design as well.

II. B.Comprehensive Optimized Layout Based on Improved Whale Algorithm

II. B. 1) Whale of a Whale Algorithm (WOA)

The Whale Algorithm (WOA) is in reference to the foraging habits of a population of whales, the Whale Algorithm is shown in Fig. 1, in which it is assumed that the population size is N, the position of the i nd whale in the d-dimensional space is $X_i = \left(X_i^1, X_i^2, \ldots, X_i^d\right)_{i=1,2,\ldots,n}$, and the position of the objective corresponds to the global optimal solution of the problem [22]. In this paper the position of the whale corresponds to the layout position of the furniture, and the prey position X^* is the positional case of each furniture corresponding to the smallest sum of adaptations. Namely:

$$X_t = \begin{vmatrix} X_1^1, X_1^2, \ldots, X_I^d \\ X_2^1, X_2^2, \ldots, X_2^d \\ \ldots\ldots \\ \ldots\ldots \\ X_n^1, X_n^2, \ldots, X_n^d \end{vmatrix} \Rightarrow X^* = \begin{vmatrix} X_1^{*1}, X_1^{*2}, \ldots, X_1^{*d} \\ X_2^{*1}, X_2^{*2}, \ldots, X_2^{*d} \\ \ldots\ldots \\ \ldots\ldots \\ X_n^{*1}, X_n^{*2}, \ldots, X_n^{*d} \end{vmatrix} \tag{1}$$

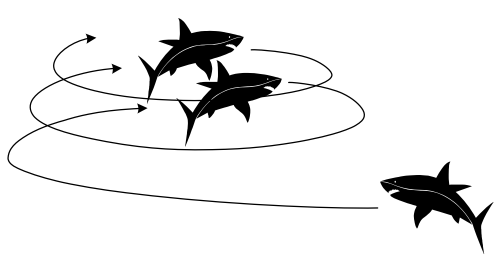

Figure 1: Whale algorithm

The WOA algorithm contains three different search methods, which simulate the contraction encircling mechanism of the whale population, the spiral predation mechanism and the individual independent search mechanism, respectively, and the encircling mechanism is shown in Figure 2. The first is to simulate the contraction encirclement mechanism of whales, i.e., the encirclement of the population to the optimal position.

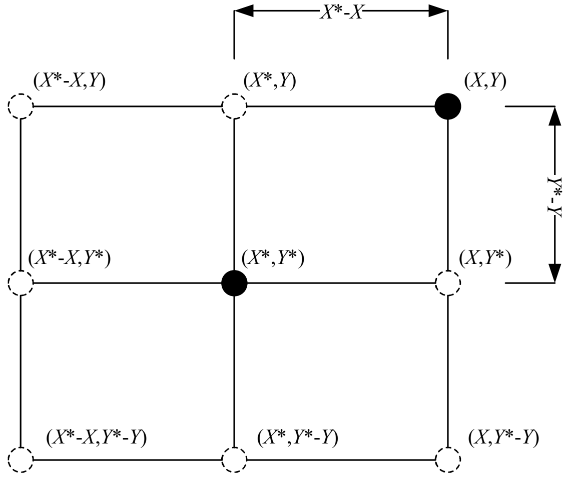

Figure 2: Enveloping mechanism

Update the population position according to equation (2). i.e:

$$X(t+1)=X^*(t)+A\left|C*X^*(t)-X(t)\right| \tag{2}$$

where t is the current number of iterations, $X^*(t)$ is the target position, $X^*(t)$ is the current optimal individual during the iteration, $A*\left|C*X^*(t)-X(t)\right|$ is the convergence margin, and A and C are defined as equations (3) and (4). That is:

$$A=2a*random_1[0,1]-a \tag{3}$$

$$C=2random_2[0,1] \tag{4}$$

$random_1$ and $random_2$ are random numbers on $[0,1]$, a is the convergence factor, and the relationship with t is equation (5). i.e:

$$a=2-\frac{2t}{t_{\max}} \tag{5}$$

where $t_{\max}$ is the maximum number of iterations.

The mathematical model of the spiral update position method for simulating whale spiral foraging is shown in equation (6):

$$X(t+1)=X^*(t)+D*e^{br}*\cos(2\pi r) \tag{6}$$

where $D=\left|X^*(t)-X(t)\right|$ denotes the distance between the i nd whale and the target, b is a constant that controls the magnitude of the spiral, and r is a random number on $[-1,1]$.

The process of encircling the prey and spiraling up when whales hunt are simultaneous, so both mechanisms are assumed to occur with a 50% probability. Given $\rho\in[0,1]$, the update of the whale's position is determined by equation (7). Namely:

$$X(t+1)=\begin{cases}X^*(t)+A*\left|C*X^*(t)-X(t)\right|, \rho\le 0.5\\ X^*(t)+D*e^{br}*\cos(2\pi r), \rho>0.5\end{cases} \tag{7}$$

In addition to the above two updating mechanisms, there is a simultaneous behavior of individual whales randomly searching for a target alone based on their position in the whale population, which is mathematically modeled as Eq. (8). That is:

$$X(t+1)=X_{ranstom}(t)-A*\left|C*X_{ranstom}(t)-X(t)\right| \tag{8}$$

where $X_{ranstom}(t)$ is the position of the individual whale that searches for the target alone.

In summary, the WOA algorithm flow is shown in Fig. 3.

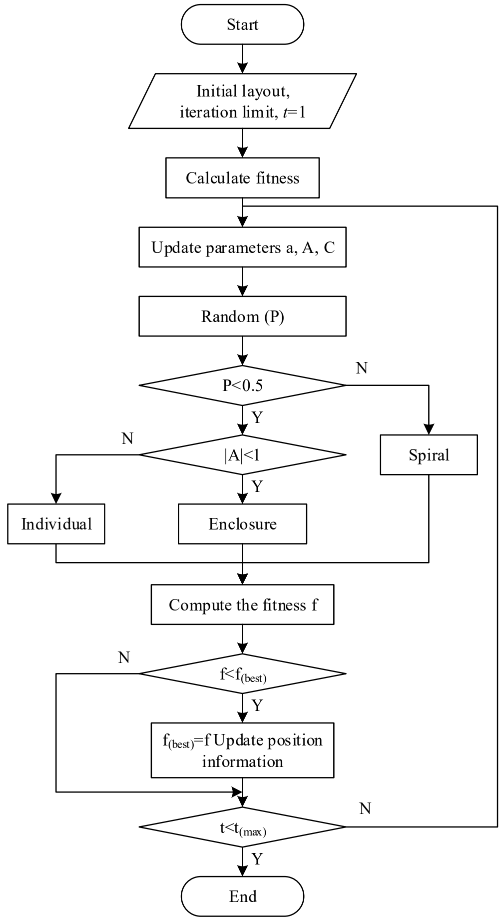

Figure 3: Algorithm flow chart

II. B. 2) Objective function

The rule-based layout algorithm focuses on the description of the specific relationship between furniture and space, furniture and furniture, and is less involved in the characteristics of the layout space itself: while the layout method based on spatial syntax starts from the layout space, focuses on analyzing the spatial relationship and social nature of the spatial level, and gives less consideration to the furniture. Combining the two methods, not only highlighting the layout characteristics of the layout space itself but also considering the interaction between furniture, is also a way to get a better layout effect. From a global perspective, the position of the furniture layout is mainly determined by the layout space itself, while the fine adjustment in the local scope depends on the constraint relationship. In other words, the quantized value of the layout space mainly affects the overall position, and the value of the layout constraint penalty function determines the specific layout position. This idea of layout is extremely similar to the whale algorithm in terms of optimization ideas. Therefore, the whale algorithm is chosen as the method to optimize the layout process, and the corresponding improvement is made to realize the optimization of the layout process by combining the actual situation of the layout problem. The objective function of the comprehensive layout algorithm contains two parts: the quantization function of the scheme and the layout constraint penalty function, as shown in equation (9):

$$f(Sen) = P(F) + S(Sen) \tag{9}$$

Type (9) needs to meet the furniture does not exceed the layout of the space (no touching with the wall that is): furniture does not overlap each other: furniture does not block doors and windows, etc..

II. B. 3) Improvement of the optimization algorithm

(1) Screening of the initial program

The initial scheme generated by the randomized method cannot effectively extract the useful information of the search space because of the lack of a priori knowledge, which to a certain extent affects the algorithm's solution accuracy and convergence speed. Pre-processing the initial scheme to screen out the scheme that is more in line with the actual layout requirements will effectively improve the layout efficiency the randomly generated initial scheme is processed to obtain a better initial population.

Multiple groups of initial schemes are first generated, and the more excellent ones are selected as the final initial schemes by calculating the initial objective function value and bequeathing the more excellent ones among them:

$$f(Sen)=\min\{f(Sen)\} \tag{10}$$

The final initial layout scheme is:

$$Sen=(F,x,y,f(Sen))\rightarrow Sen=(F',x',y',f'(Sen)) \tag{11}$$

(2) Improvement of convergence factor

Through the mathematical model of the algorithm, it is found that the convergence factor a determines the encircling step length, and in the original WOA algorithm, the value of the convergence factor $a=2-2t/t_{\max}$, a decreases linearly from 2 to 0, and the algorithm is prone to fall into a local optimal situation in the late iteration. The study of spatial quantization number mortgages reveals the existence of a large number of approximation regions in the peripheral region of the room. Therefore, in order to obtain the initial strong global search ability and faster convergence speed, and can maintain a certain search efficiency in the late iteration. The convergence factor a, as shown in Fig. 4, remains at a relatively high value for a period of time in the initial stage, then decreases rapidly to a low level and maintains a low value in the later stage of the iteration. Therefore, in this paper, a nonlinear convergence factor is designed with the expression shown in equation (12):

$$a=1.5+\frac{-1.2}{1+e^{\frac{-\zeta(2t-t_{\max})}{2t_{\max}}}} \tag{12}$$

where ζ is a moderator that affects the rate of change of the convergence factor a, which was experimentally ζ taken to be set at 20.

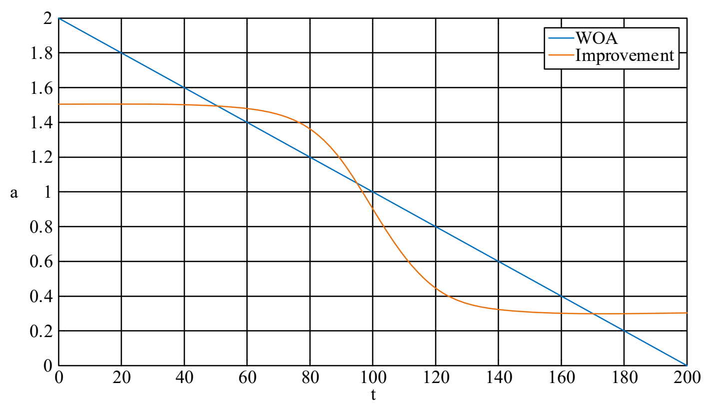

Figure 4: Convergent factor a

(3) Inertia weight of synergy α

Inertia weight w is an important parameter of particle swarm algorithm (PSO), which plays a great role in the convergence of the algorithm In PSO, the larger the value of w, the stronger the global search ability: conversely, the smaller the value of w, the stronger the local search ability, the weaker the global search ability. The inertia weight w of the PSO algorithm is introduced as a bootstrap weight to improve the convergence accuracy, and at the same time better regulate the global and local search ability of the algorithm. The value of inertia weight w of synergy a decreases with the number of iterations and is controlled by the convergence factor a so that the value of w is positively correlated with the value of a, as defined in Equation (13):

$$w=\frac{a}{(a_{\max}-a_{\min})}\left(w_{\max}-\frac{t(w_{\max}-w_{\min})}{t_{\max}}\right) \tag{13}$$

where, $a_{\max}$ is the maximum value of convergence factor a, $a_{\min}$ is the minimum value of convergence factor a: $w_{\max}$ is the maximum value of inertia weights, $w_{\min}$ is the minimum value of inertia weights: $t_{\max}$ is the maximum number of iterations.

After the introduction of inertia weights w to improve the algorithm, the three searches of WOA are changed to Eqs. (14), (15):

$$X(t+1)=\begin{cases} wX^*(t)+A*\left|C*X^*(t)-X(t)\right|\rho\le 0.5 \\ wX^*(t)+D*e^{br}*\cos(2\pi r),\rho>0.5 \end{cases} \tag{14}$$

$$X(t+1)=wX_{random}(t)-A*\left|C*X_{random}(t)-X(t)\right| \tag{15}$$

Overall, w decreases with the number of iterations, while w, which is controlled by a, also possesses nonlinear variations and is more adaptive. After the amplification of the coefficient of a, the algorithm has a stronger global search ability at the beginning of the iteration and improves the convergence speed: in the middle of the iteration, with the rapid decrease of a, w is reduced significantly at the same time, so that the algorithm has a greatly improved local search ability in the middle and late iteration and improves the convergence accuracy.

III. Effects of Piano Performance Training on Performance Anxiety

According to the previous description, the spatial optimization layout model of the housing environment based on the Improved Whale Algorithm (IWAO) and BIM technology is used to meet the requirements of piano performance training in the housing environment in order to carry out the following study on the effects of piano performance training on performance anxiety. Overall, the layout optimization in the housing environment is a mandatory requirement for piano performance training, based on which the effects of piano performance training on performance anxiety are explored with the help of multiple regression models and correlation coefficients.

III. A. Definition of relevant concepts

III. A. 1) Definition of Piano Performance Training

(1) Music Reading Training

Reading music belongs to the basic skill training of piano playing. When reading music, it is not only to memorize and express the notes, symbols and rhythms, but also to accurately grasp the thoughts, emotions and overall styles of the musical works, so as to express the profound connotations of the musical works. At this stage, some players do not pay attention to the memorization and understanding of musical symbols when reading music, but rather record and play mechanically, which is unable to express the profound connotations of the musical works. Therefore, when reading music, players need to enhance the training of reading music and pay attention to all kinds of markings in the music, so as to better show the content of the work. At the same time, in the process of reading music training, it is also necessary to develop a good habit of reading music, in order to incorporate emotions and express the emotions and connotations of the musical work.

(2) Pedal training

Pedal training is one of the important contents of piano playing skills training, most players only pay attention to the “stage” skills training, but lack of attention to the pedal training. The overall analysis of the piano performance shows that whether the piano player can standardize the use of the pedal has a very direct impact on the piano performance. In the specific training process of the pedal, emphasis should be placed on the degree of planning, and take it as a basic content of the training of piano playing skills. At the same time, piano players also need to master the type and role of the pedal, and through the performance of many types of repertoire, the important role of the pedal in the process of playing a full understanding, so that the actual performance process according to the rhythm of the work to be scientifically applied to the pedal.

(3) Fingering Training

In music performance, the role of fingering training can not be replaced by other training. At the same time, an important basic condition of piano performance is fingering training, only to master a certain fingering skills, to ensure the smooth progress of the subsequent performance. Therefore, in the process of carrying out fingering skill training, the player should first master the specific music and tones represented by different keys. If the player has no foundation, he should put 1 finger of the right hand on the center C and 2 fingers of the left hand on the B key, so as to ensure the standardized placement of the finger posture and enhance the sense of playing. In addition, during the training process, the player should also fully feel the pitch changes of different keys, so as to enhance the cooperation between the keys and the fingers. Secondly, the training form should be adjusted according to the style of the repertoire. It should not be overlooked that different players have very prominent individual differences, and in the process of training fingering, it is necessary to link the actual needs of different players to make reasonable adjustments and optimize the fingering training program.

III. A. 2) Definition of performance anxiety

Anxiety is a complex emotional response to a current or perceived threat. Specifically, anxiety is a psychological state of nervousness and fear, which is mostly caused by the premonition of failure or the fear of failure [23], [24]. Anxiety is easy to cause the psychology of withdrawal, in the forward and backward mental contradiction in the performance, will inevitably lead to failure, and the shadow of failure exists in the player's heart, easy to create a psychological shadow and affect the next performance, the formation of a vicious circle. Piano players due to changes in the environment, changes in the audience, etc., will also produce anxiety, resulting in emotional control, resulting in a blank mind, thinking activities are disturbed. The ability to react to the outside world is reduced and the performance is out of order. All these problems are caused by stage psychological anxiety.

III. B. Study design

III. B. 1) Research Objectives

In order to investigate the impact of piano playing training on performance anxiety, this paper selects the target source of a university students, a total of 500 people, mainly in the age of 18 to 25 years old. Its research sample fully meets the standard requirements of the questionnaire, which facilitates the subsequent research work.

III. B. 2) Research hypotheses

Based on the definition of piano performance training and performance anxiety, the following two research hypotheses can be formulated:

Hypothesis 1: Score reading training, pedal training, and fingering training all have a significant positive relationship with performance anxiety reduction.

Hypothesis 2: There is a positive regression relationship between score reading training, pedal training, and fingering training and performance anxiety reduction.

III. B. 3) Questionnaire-based data acquisition

The data obtained from the statistical questionnaire of this study were divided into three main areas: first, the Piano Performance Training Scale was used as the independent variable to study performance anxiety. Second, the Performance Anxiety Mitigation Scale was used as the dependent variable to study performance anxiety mitigation. Third, demographic variables with significant differences in performance anxiety were used as control variables for multiple linear regression analyses. The designed questionnaire was tested for reliability and validity and was found to have excellent reliability performance (Cronbach's alpha > 0.9, KMO > 0.8). Beginning the formal distribution of 500 questionnaires, a total of 495 questionnaires were recovered, and its recovery rate was 0.99, excluding invalid questionnaires 8, and the final valid questionnaire was 487, and its validity rate was 0.974, and the data collected for the study fully met the requirements of the study.

IV. Analysis of research examples

IV. A. Analysis of the optimal spatial layout in the housing environment

IV. A. 1) Effective indoor space utilisation for activities

In this paper, the single flat housing environment is selected, and the layout of the indoor space in the single flat housing environment is shown in Figure 5 (dimensions in mm). The interior space consists of living space and living room. The living space is the main activity area of the members and has a flexible spatial layout, while the living room is used for piano playing training (not only has a large floor space, but also has a good sound insulation effect), and is less responsible for the activities of the members. Therefore, the optimisation of the interior space layout in a single flat housing environment is studied in the living space.

The total living space is 15.66m². The furniture covers a total area of 6.53m², of which the bed covers 3.51m², the desk 1.87m², the wardrobe 1.008m², and the piano is placed in the living room, which covers 4.8m², taking into account that the piano is too large for the training sessions and the soundproofing effect. The vertices of the furniture not leaning against the wall were selected, and the housing space was sequentially divided into six subspaces by orthogonal straight-line connections: C1, C2, C3, C4, C5, and C6. The footprints of the subspaces C1, C2, C3, C4, C5, and C6 were 3.43 m², approximately 3.48 m², 1.47 m², 0.247 m², 0.36 m², and 0.202 m², respectively.

Since sub-spaces C4, C5 and C6 all have a footprint of less than 0.8 m², the area of S2 is 1.24 m². The area of effective indoor activity space in the housing is 8.355 m² (cyan area in the figure). The utilisation rate of effective indoor activity space in housing is about 51.96%. Based on the above analysis, it can be seen:

(1) The housing has a good utilisation rate of effective indoor activity space, and the layout of indoor space can meet the needs of piano performance training.

(2) The spatial layout of the housing tends to be flat, and the vertical height space is not fully utilised.

(3) The placement of furniture in the housing is easy to interfere with the activities of the personnel, and it is impossible to form a relatively independent personal privacy space.

The optimisation of the indoor space layout of the housing can significantly improve the utilisation of effective activity space.

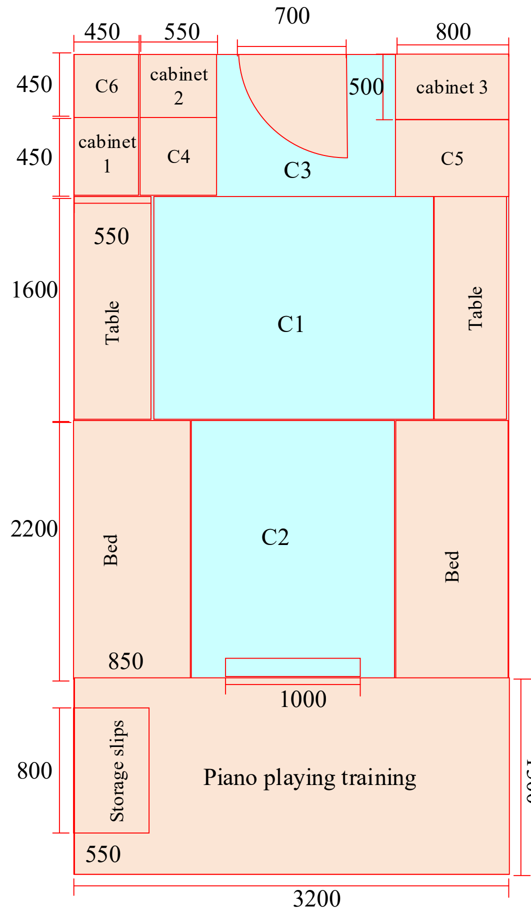

Figure 5: The interior space layout of a university housing environment

IV. A. 2) Space layout optimisation programme

In Matlab environment, based on the improved whale algorithm pass algorithm for indoor space layout optimisation solution, the results of the optimised layout parameters are shown in Table 1 and Table 2, and the space layout optimisation scheme is shown in Figure 6. The total area of living space is 16.08 m. Floor space: the desk, bookcase and wardrobe are all located around the bed, which overlap with the floor area corresponding to the bed, so the furniture floor space only needs to calculate the floor area corresponding to the bed. Therefore, S2 is 7.2m². In the optimization scheme, the area of subspace C1, C2 and C3 is 2.8m², 2.59m² and 3.05m² respectively, all of which are greater than 0.753m², and the piano performance training covers an area of 4.2m² (the piano itself covers an area of 0.912m², considering the corresponding training aids, it is set to 3500mm*1200mm=4.2m², which can well meet the needs of the piano performance training environment). The area of indoor effective activity space is 8.68m² (cyan area in the figure), and the utilization rate of indoor effective activity space is about 55.22%. It can be seen that using the improved whale algorithm to optimise the spatial layout of the indoor usage rate of housing can significantly improve the effective activity space utilisation rate, which can well meet the user's requirements for the piano playing training environment.

Table 1: Optimization of layout parameters results 1

ID	Name	Length /mm	Width /mm	Layout optimization results.	
				x/mm	y/mm
1	Bunk bed 1	2200	700	420	1500
2	Bunk bed 2	2200	700	2550	1500
3	Bunk bed 3	2200	700	2550	4000
4	Bunk bed 4	2200	700	420	3800
5	Piano playing training	3800	1500	3500	1200

Table 2: Optimization of layout parameters 2

ID	Name	Length /mm	Width /mm	Layout optimization results.	
				x/mm	y/mm
1	Bookcase 1	1530	800	300	500
2	Desk 1	800	700	400	1000
3	Wardrobe 1	700	750	300	1000

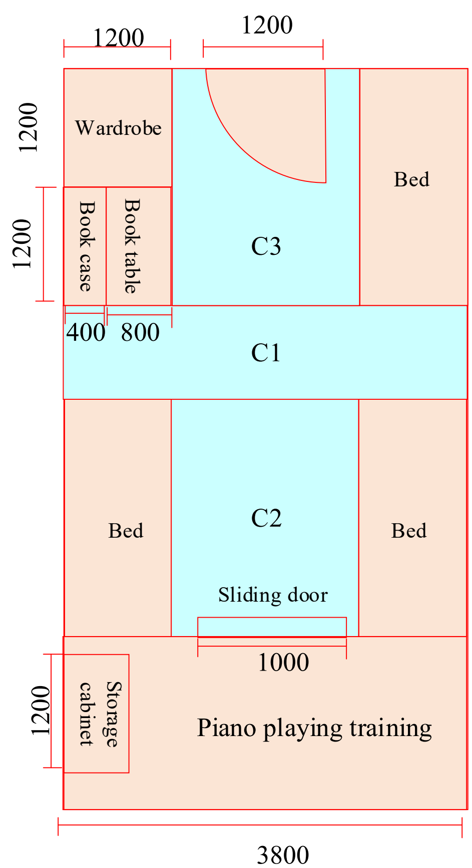

Figure 6: Spatial layout optimization scheme

IV. B. Effects of Piano Performance Training on Performance Anxiety

IV. B. 1) Descriptive statistical analyses

In this section, the data results of the scales were analysed descriptively and the results of the statistical data for each variable are shown in the table below. All the scales in this study used a 5-point scale with a median value of 3.0, and the results of the descriptive statistical analysis are shown in Table 3. Based on the data in the table, it can be seen that there is the presence of reading training (3.39±0.87) < pedalling training (3.65±0.79) < fingering training (3.84±0.77) < performance anxiety mitigation (3.87±0.89), i.e., the variables are at a high level of quantification.

Table 3: Descriptive statistical analysis

Variable type	Variable name	Mean	Standard deviation
Independent variable	Music reading training	3.39	0.87
	Pedal training	3.65	0.79
	Fingering training	3.84	0.77
Dependent variable	Performance anxiety reduction	3.87	0.89

IV. B. 2) Demographic analysis

The questionnaires of this study were centrally collected 495, but during the collection process, the questionnaires that did not meet the criteria of the study, i.e., invalid questionnaires, were excluded, and the validity of the questionnaires was statistically determined to be 97.40%. The results of demographic analysis are shown in Table 4. Firstly, the basic analysis of the sample of subjects was carried out, and 55.65% of the subject students were males and 44.35% were females, which was a relatively even distribution. Freshmen to seniors accounted for 98, 207, 119 and 72 students respectively, with each grade accounting for 18.28%, 42.51%, 24.44% and 14.78% of the total sample. Regarding the different school types, the majority of the subject college students were enrolled in general institutions, while 17.86 per cent were in 985 institutions, 28.54 per cent belonged to 211 institutions, and 53.59 per cent were in general institutions. With regard to the types of majors, the number of university students majoring in humanities and social sciences accounted for 22.18 per cent of the total, the total number of university students majoring in natural sciences accounted for 7.39 per cent of the total, and science and technology majors had the highest number of students, which was as high as 70.43 per cent.

Table 4: Demographic analysis

Variable	Category	Frequency	Percent
Sex	Male	271	55.65%
	Female	216	44.35%
Grade	Freshman year	89	18.28%
	Sophomore	207	42.51%
	Junior	119	24.44%
	Senior year	72	14.78%
School category	985 academy	87	17.86%
	211 academy	139	28.54%
	General school	261	53.59%
Professional category	Social sciences	108	22.18%
	Natural sciences	36	7.39%
	Technologists	343	70.43%

IV. B. 3) Correlation analysis

Setting score reading training, pedal training and fingering training as independent variables and performance anxiety reduction as dependent variable, the correlation analysis between piano performance training and performance anxiety reduction was carried out with the help of the Pearson's formula mentioned above, and the results of the correlation analysis are shown in Table 5. According to the data in the table, the Pearson's correlation coefficients of score reading training, pedal training, fingering training and performance anxiety reduction are 0.447 (0.004), 0.201 (0.008), 0.218 (0.006), respectively, which satisfy the condition of Sig<0.05, indicating that there is a positive and significant correlation between score reading training, pedal training, fingering training and performance anxiety reduction, which confirms that the hypothesis 1 (score reading training, pedal training, fingering training and performance anxiety reduction) proposed by the above formula is not a positive one. Hypothesis 1 (Score reading training, pedal training, and fingering training are all significantly and positively correlated with performance anxiety reduction).

Table 5: Correlation analysis result

Name		Music reading training	Pedal training	Fingering training	Performance anxiety reduction
Music reading training	Pearson	1	0.396	0.323	0.447
	Sig		0.006	0.009	0.004
	N	487	487	487	487
Pedal training	Pearson	0.396	1	0.469	0.201
	Sig	0.006		0.007	0.008
	N	487	487	487	487
Fingering training	Pearson	0.323	0.469	1	0.218
	Sig	0.009	0.007		0.006
	N	487	487	487	487
Performance anxiety reduction	Pearson	0.447	0.201	0.218	1

	Sig	0.004	0.008	0.006	
	N	487	487	487	487

IV. B. 4) Regression analysis

In order to investigate the linear relationship between piano performance training and performance anxiety mitigation, a stepwise regression analysis was done with performance anxiety mitigation as the dependent variable, the three dimensions of piano performance training (score reading training, pedal training, fingering training) as the independent variables, and the demographics of gender, grade, type of school, and major as the control variables, and the results of the regression analysis are shown in Table 6. The data in the table shows that Performance Anxiety Mitigation = 0.347 + 0.313*Reading Training + 0.459*Pedal Training + 0.487*Fingerstyle Training, and the coefficient of determination of its regression equation is 0.751, which means that the explanatory power of the independent variable for the dependent variable is 75.10 per cent. The VIF value of each variable is within the interval of 1~1.5, which satisfies the condition of $1<VIF<3$, indicating that there is no multicollinearity in the believing regression analysis of piano playing training and performance anxiety reduction, and in addition, it also confirms Hypothesis 2 mentioned above (music reading training, pedal training, fingering training all have positive regression effect relationship with performance anxiety reduction).

Table 6: Results of regression analysis

Variable	Unnormalized coefficient		Standardization coefficient	T-Value	P-Value	VIF
	B	Standard error	Beta			
Constants	0.347	0.034		2.658	0.009	1.117
Gender	0.453	0.036	0.449	4.232	0.008	1.062
Grade	0.244	0.031	0.242	3.403	0.007	1.008
School type	0.348	0.037	0.343	3.182	0.008	1.212
Majors	0.227	0.048	0.227	1.977	0.003	1.103
Music reading training	0.313	0.027	0.308	2.007	0.006	1.453
Pedal training	0.459	0.003	0.454	4.399	0.004	1.129
Fingering training	0.487	0.032	0.483	1.962	0.006	1.403
R^2	0.753					
Adjust R^2	0.751					

V. Conclusion

This paper first integrates BIM technology and Improved Whale Algorithm (IWOA) to construct a housing space optimisation layout model, gives the objective function of the optimisation model, and solves the objective function to derive the housing space optimisation scheme. Then we use a mixture of questionnaires and mathematical and statistical theories to explore the role of piano playing training on performance anxiety relief. The floor space of space C1, C2 and C3 is 2.8m^2, 2.59m^2 and 3.05m^2 respectively, all of which are larger than 0.753m^2, and the floor space of piano performance training is 4.2m^2, which can fully meet the requirements of piano performance training. The regression equation oriented towards piano performance training and performance anxiety reduction is, performance anxiety reduction = 0.347 + 0.313* music reading training + 0.459* pedal training + 0.487* fingering training, which interprets the alleviating effect of piano performance training on performance anxiety through linear quantification.

References

[1] stün, Emre|Ozer, Burcu. (2020). Effects of piano accompaniment on instrument training habits and performance self-efficacy belief in flute education. Cypriot Journal of Educational Sciences, 15.

[2] Payeur, P. , Nascimento, G. M. G. , Beacon, J. , Comeau, G. , & Charpentier, M. A. . (2014). Human gesture quantification: An evaluation tool for somatic training and piano performance. IEEE International Symposium on Haptic. IEEE.

[3] Hua, J. . (2024). Interaction of motor practice and memory training in expressive piano performance: expanding the possibilities of improvisation. Psychological Research, 88(5), 1426-1436.

[4] Chen, L. . (2019). Development of the indoor piano performance training in the piano teaching design of colleges and universities. Basic & clinical pharmacology & toxicology.(S2), 125.

[5] Jennifer, A., Bugos, Simran, Kochar, & Nathan, et al. (2016). Intense piano training on self-efficacy and physiological stress in aging. Psychology of Music.

[6] Bugos, J. , & Kochar, S. . (2017). Efficacy of a short-term intense piano training program for cognitive aging: a pilot study. Musicae Scientiae, 21(2), 137-150.

[7] Peng, L. . (2023). Piano players' intonation and training using deep learning and mobilenet architecture. Mobile Networks and Applications.

[8] Marin, M. M. , & Bhattacharya, J. . (2013). Getting into the musical zone: trait emotional intelligence and amount of practice predict flow in pianists. Frontiers in Psychology, 4(1), 853.

[9] Xiao, H. , Cai, H. , & Li, X. . (2020). Non-visual effects of indoor light environment on humans: a review. Physiology & Behavior, 228, 113195.

[10] Brid, Sona, Erik, Dietl, Anna, & Steidle. (2018). Recovery in sensory-enriched break environments: integrating vision, sound and scent into simulated indoor and outdoor environments. Ergonomics.

[11] Cai, H. , Lin, Q. , Liu, H. , Li, X. , & Xiao, H. . (2024). Recognition of human mood, alertness and comfort under the influence of indoor lighting using physiological features. Biomedical signal processing and control(Mar.), 89.

[12] Tabatabaian, M. , & Tamannaee, M. . (2013). Investigation the effect of built environments on psychological health. armanshahr architecture & urban development.

[13] Sroykham, W. , Wongsathikun, J. , & Wongsawat, Y. . (2014). The effects of perceiving color in living environment on qeeg, oxygen saturation, pulse rate, and emotion regulation in humans. IEEE.

[14] Kong, Z. , Liu, Q. , Li, X. , Hou, K. , & Xing, Q. . (2022). Indoor lighting effects on subjective impressions and mood states: a critical review. Building and environment.

[15] Takahashi, H. , Kato, S. , Higuchi, M. , Ishiguro, T. , Amano, K. , & Tani, H. . (2010). F-10 indoor odor exposure effects on psycho-physiological states during intellectual tasks and rest. Techinical Papers of Annual Meeting the Society of Heating,Air-conditioning and Sanitary Engineers of Japan, 453-456.

[16] Rautio, N. , Filatova, S. , Lehtiniemi, H. , & Miettunen, J. . (2018). Living environment and its relationship to depressive mood: a systematic review. International Journal of Social Psychiatry, 64(1), 92-103.

[17] Lan, L. , Hadji, S. , Xia, L. , & Lian, Z. . (2020). The effects of light illuminance and correlated color temperature on mood and creativity. Building Simulation(3).

[18] Yingying, Z. , Minqi, Y. , Ying, Y. , Xiao, X. , Guofu, Z. , & Psychology, S. O. . (2017). Effects of indoor illuminance on cognitive performance: the mediating role of subjective mood and alertness. Journal of Psychological Science.

[19] Ibrahim, A. , Ali, H. , Zghoul, A. , & Jaradat, S. . (2021). Mood state and human evaluation of the thermal environment using virtual settings:. Indoor and Built Environment, 30(1), 70-86.

[20] Yu, C. , & Yoon, H. . (2010). The role of colour in 'health and wellbeing' of the built environment. Indoor & Built Environment, 19(4), 403-404.

[21] Spence, C. . (2020). Using ambient scent to enhance well-being in the multisensory built environment. Frontiers in Psychology, 11, 598859.

[22] Chenyang Gao,Yahua He & Yuelin Gao. (2024). A Multi-Strategy Enhanced Hybrid Ant–Whale Algorithm and Its Applications in Machine Learning. Mathematics(18),2848-2848.

[23] Beatrice Tosti,Stefano Corrado,Stefania Mancone,Tommaso Di Libero,Chiara Carissimo,Gianni Cerro... & Pierluigi Diotaiuti. (2024). Neurofeedback Training Protocols in Sports: A Systematic Review of Recent Advances in Performance, Anxiety, and Emotional Regulation. Brain Sciences(10),1036-1036.

[24] Aline Ananias de Lima,Rosana Christine Cavalcanti Ximenes & Sandra Lopes de Souza. (2024). Factors associated with music performance anxiety in adolescents: A systematic review. Children and Youth Services Review107860-107860.