

Virtual Emotional Experience System Based on Improved Genetic Algorithm

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Abstract: One of the most important reasons why ruin aesthetics has not become a system is "emotion". The "beauty of ruins" is not only a form of beauty, but also a space with historical and cultural value. This paper combines the virtual emotion technology to apply the beauty experience of the ruins to the virtual design to improve the immersion of the virtual emotion experience system. Moreover, this paper uses the improved genetic algorithm to estimate the model parameters, and combines the corresponding 3D software face generation technology to realize the control of virtual face expression. In addition, this paper establishes an emotional interaction system for virtual humans, and integrates the beauty of the ruins into the design. Finally, this paper combines experiments to verify that the system constructed in this paper meets the actual needs of system design.

Keywords: beauty of ruins; environmental design; virtuality; emotional experience; Improved Genetic Algorithm

1 INTRODUCTION

In terms of aesthetics, the emotional experience brought by the "beauty of ruins" is very profound. In the eyes of designers and artists, "beauty of ruins" is also an important source of creation. The public may not have developed relevant aesthetic habits. However, in industrialized societies, more and more ruins are produced, and people's understanding of ruined landscapes and buildings has increased accordingly.

As a symbol that often appears, it is also easier to arouse people's emotional resonance. On the basis of the theory of ruins landscape and ruins aesthetics, it is of practical significance for professionals and the general public in the industry to study the emotions triggered by it and the experience of users and the environment when interacting. In terms of design practice, the "beauty of ruins" does not only exist in the ruins, it has a large space to shape. Humans can make use of the sites, existing ruins landscapes and buildings that remain in ruins. This beauty can also be created by imitating the form of ruins, manufacturing and collecting waste materials [1].

The research on emotion and emotion in the field of psychology relies on a certain emotional modeling method to conduct qualitative or quantitative analysis of emotion. According to the way of emotion measurement, it is divided into discrete and continuous emotion models. The discrete emotion model attempts to classify all emotions completely and cover all possible emotions as much as possible [2] by using words that are well known and clearly defined to represent emotion types. The six-category emotion model established in literature [3] includes six basic emotions: pleasure, surprise, hate, sadness, fear and anger, and considers that the other types of emotions are composed of these six basic emotions; Literature [4] proposes to use eight basic emotions, and divides them into positive and negative groups. There are four pairs of opposite relationships between the two groups of basic emotions, including joy and sadness, anger and fear, trust and hate, surprise and expectation. Based on the color combination principle in self-painting, an emotion wheel similar to the color wheel is established, that is, according to the concept of color combination such as approximate color, contrast color, complementary color, etc, Use eight basic emotions to form a more complex emotion and form a complete ring. Many related researches in psychology have put forward their own discrete emotion models, but their core ideas are consistent with the six and eight classification emotion models.

The continuous emotion model divides all kinds of emotions into several orthogonal dimensions, projects emotions onto each dimension axis to form a set of values, and uses this set of values to represent the original emotion. The two-dimensional circular emotion model proposed in literature [5] takes arousal and pleasure as the two orthogonal axes, and places each emotion on the two-dimensional plane formed by the two axes according to the value of arousal and dominance. The distance between different emotions on the plane can reflect the approximate degree of the two.

Literature [6] proposes a three-dimensional emotional model, which forms a three-dimensional emotional space with three orthogonal dimensions of arousal, pleasure and dominance, and places different emotions in different positions of the space according to the value of the three dimensions. The two-dimensional emotional model in literature [7] actually uses two of the more important three dimensions for research. Affective-induced materials refer to materials used in psychological experiments or clinical applications to stimulate the specific senses of subjects or patients, so as to induce their emotions and achieve the purpose of diagnosis or treatment. According to the media of materials, they can be divided into text, pictures, audio and video. The pictures in the international emotional picture database will take into account the experience and feelings brought by the specific situation and its historical background, such as the use of war pictures to induce sad feelings. The disadvantage of this is that if the subjects or patients do not have relevant experience knowledge, it is difficult to be driven by such pictures [8].

Text, audio, audio and other types of emotion inducing materials also include the English Emotional Word Specification (ANEW), the International Audio Digital System (IADS), the China Audio Digital System (CADS), and the China Emotional Video Material Library (CEVS), which provide a comprehensive data base for psychological research [9]. Traditional psychological emotional elicitation materials have shortcomings such as poor elicitation effect, weak immersion, and easy to be disturbed by the environment. Moreover, due to the long history of early materials, some video clips or pictures with the characteristics of the times have been difficult to resonate, further leading to poor emotional elicitation effect. As a new type of multimedia material, virtual reality scene has the advantages of strong sense of reality, immersion and low environmental sensitivity, which can well make up for the shortcomings of the traditional emotion inducing material [10]. Literature [11] put forward the idea of using virtual reality scenes for emotion induction, and produced and launched the Emotional Induced Virtual Reality Scene Library (AVRS). In recent years, artificial emotion is a new research direction in the field of intelligent control. With the gradual maturity and improvement of virtual environment technology, virtual people have gradually entered the medical, health care, family, sports and service industries [12]. There is an urgent need to find new methods, and the emotion of entry into work provides a possibility for this. Artificial emotion is a research direction that attempts to simulate the emotional process of human beings, so as to obtain intelligence and autonomy that is difficult to achieve with rational thinking [13]. Emotion affects cognition and cognitive process. Positive mood leads to positive memory association and negative mood leads to negative cognition, which can affect people's work, learning memory, reasoning operation and problem-solving process; Cognition is the intermediary of emotional and behavioral reactions. Emotions and behaviors are not directly caused by events, but are generated by individual acceptance, evaluation and giving meaning to events [14]. Negative emotional experience is not equal to negative, sometimes negative experience can inspire people to fight; Similarly, positive or happy emotions are not always positive. Proper tension is conducive to work and learning, and the view that the best work efficiency can only be achieved when the body and mind are relaxed is unscientific [15].

In the process of interacting with the environment, natural organisms show certain adaptive and self-learning ability, which provides a useful reference for the construction of intelligent agents. An agent must have some evaluation mechanism to judge whether a certain behavior can bring greater value to itself, which is one of the bases for the intelligent system to realize unsupervised learning. Psychological research has confirmed that emotion is an evaluation system. Literature [16] classifies emotion theory into five categories, namely, feeling, physiology, behavior, evaluation and cognition; "Emotion is the subject's evaluation of the state" is the main point of view of the research on the evaluation mechanism of emotion at present; the evaluation-based theory proposed in the literature [17] represents the mainstream of psychological research on emotion at this stage. On the whole, the psychological circle has said that "emotion is the evaluation of the subject's own state, environment and behavior" The theory of has basically reached consensus. The development of psychological research has also laid a foundation for the study of artificial emotion.

This paper combines the virtual emotion technology to apply the experience of the beauty of the ruins to the virtual design, improve the immersion of the virtual emotion experience system, and promote the scientific nature of modern art environment design.

2 VIRTUAL EMOTIONAL EXPERIENCE MODEL

2.1 Learning algorithm for parameter estimation of emotional models

The establishment of emotion model can make the computer have the basic ability of emotion recognition and expression, and has a wide range of applications in harmonious human-computer interaction. In this paper, the human emotion is analyzed, and on this basis, an emotion model based on Hidden Markov Process is proposed. In order to express the evolution process of human emotion model more accurately, an improved genetic algorithm is proposed to estimate the model parameters. In order to overcome the shortcoming that the evolutionary process of real coded genetic algorithm is easy to stagnate, a new improved crossover operator-heuristic weighted crossover operator is proposed in this paper by combining the advantages of the individual and the average fitness of the population. The simulation test results show that the emotion model estimated by the algorithm conforms to the basic laws of human emotions.

In order to better explain the problem, an example is used to explain the evolution of the decision system. The overall structure of the decision system is shown in Figure 1.

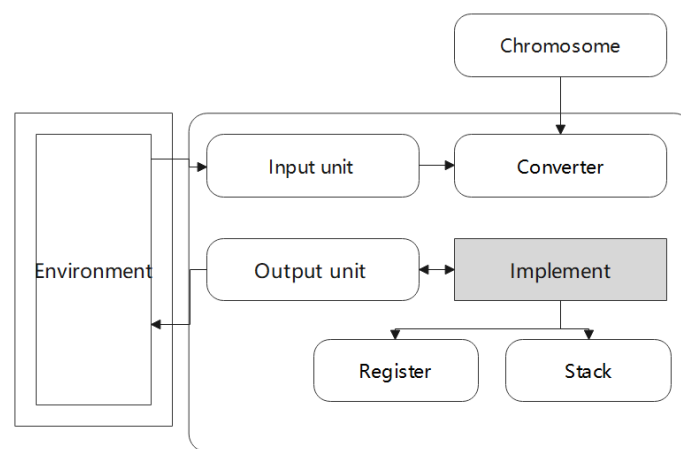


Figure 1 Decision system

The evolution of the aforementioned emotional system provides a certain basis for the estimation algorithm of emotional model parameters below. Figure 2 is the whole process of emotional model training and emoji output.

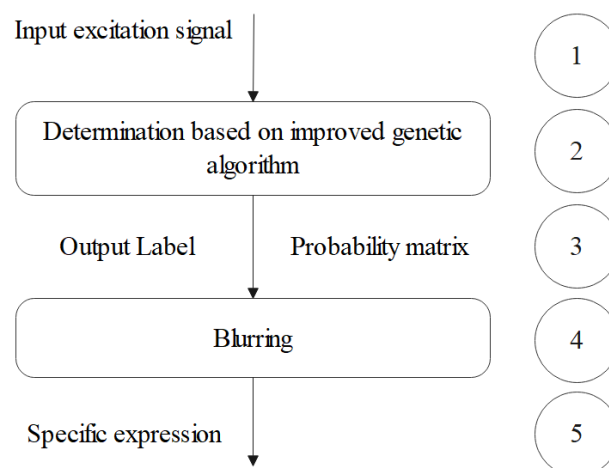


Figure 2 The training and expression output process of emotional model

In the figure, ① is the input excitation signal sequence, and the excitation signal is defined as t . When $t=0$, it means that the incentive is criticism, and when $t=1$, it means that the incentive is praise. For the same virtual person, different stimulations can be given to him continuously, so that different excitation signal sequences can be obtained. ② is the process of determining the parameters of the HMM model. The establishment process of

the HMM emotional model has been introduced in detail in the previous chapter. Here, the improved genetic algorithm is used to determine the parameters. ③ is the process that different stimulus signal sequences enter the emotional model, and the output expression probability matrix is calculated through the trained model, and the output result is a fuzzy value. ④ is the process of defuzzification, that is, to determine the emotions that are finally expressed through clear calculations.

This paper analyzes the traditional intermediate reorganization methods and two improved crossing operators. Based on this, a new crossing operator is proposed, so that the algorithm has greatly improved both in terms of convergence and correctness.

(1) Crossing operator of intermediate reorganization

Any two parent individuals used for crossing are:

$$\begin{aligned}x(t) &= [x_1(t), x_2(t), \dots, x_n(t)] \\y(t) &= [y_1(t), y_2(t), \dots, y_n(t)]\end{aligned}\quad (1)$$

The two offspring individuals after crossover are:

$$\begin{aligned}x(t+1) &= [x_1(t+1), x_2(t+1), \dots, x_n(t+1)] \\y(t+1) &= [y_1(t+1), y_2(t+1), \dots, y_n(t+1)]\end{aligned}\quad (2)$$

Among them, $x_i(t), y_i(t)$ is the corresponding i -th dimension variable in the parent solution vector, that is, the i -th parameter to be optimized, and $x_i(t+1), y_i(t+1)$ are the corresponding i -th dimension variables in the offspring solution vector. The equation for cross mutation from parent to offspring is:

$$\begin{aligned}x_i(t+1) &= \alpha x_i(t) + (1-\alpha)y_i(t) = y_i(t) + \alpha[x_i(t) - y_i(t)] \\y_i(t+1) &= \beta y_i(t) + (1-\beta)x_i(t) = x_i(t) + \beta[y_i(t) - x_i(t)]\end{aligned}\quad (3)$$

Among them, $\alpha, \beta \in \text{rand}(0,1)$.

When the crossover operation of intermediate recombination is adopted, the average fitness of the parent and offspring will hardly change, and the individuals in the population will tend to be the same, which will stagnate the evolution process.

(2) Uniform arithmetic crossover operator and heuristic crossover operator

Because the effect of real-coded genetic algorithm using intermediate recombination crossover operation is not very good, many papers have proposed improved algorithms.

The literature proposes a uniform arithmetic crossing operator. The operator is described as:

The parent individuals are:

$$\begin{aligned}x(t) &= [x_1(t), x_2(t), \dots, x_n(t)] \\y(t) &= [y_1(t), y_2(t), \dots, y_n(t)]\end{aligned}\quad (4)$$

Among them, the adaptation value $f(x)$ of individual $X(t)$ is considered to be larger, that is, the individual $X(t)$ is better.

Then, the cross-operator calculation equation of the i -th dimension variable in offspring individuals is:

$$x_i(t+1) = y_i(t+1) = \alpha x_i(t) + (1-\alpha)y_i(t)\quad (5)$$

Among them, $\alpha = \frac{f(x)}{f(x)+f(y)} \in [0,1]$.

It can be considered that the equation (5) is a weighted operation. The essence is a greater weight to the individual with a large adaptation, which makes the offspring individuals be produced near the parent individuals with a high degree of adaptation. The advantages of such crossing operators are not unreasonable individuals, but the disadvantages are also produced. That is, it can only be searched in the interval formed by the parent individuals, and it cannot be searched for better solutions outside the interval.

The assumptions for individual and individual fitness remain the same as above, and the equation for the i -th

dimensional variable in the two offspring individuals is changed to:

$$\begin{aligned}x_i(t+1) &= x_i(t) + |\alpha|[x_i(t) - y_i(t)] \\y_i(t+1) &= x_i(t) - |\alpha|[x_i(t) - y_i(t)]\end{aligned}\quad (6)$$

Among them, $\alpha \sim N(0, 1/3)$.

The new solution generated by using heuristic crossover operator is around the parent individuals $x(t)$ with large adaptation, which is searched for all around, so it is more realistic. However, since the generated new solutions may be beyond the allowed range, the susceptibility to incomprehension is its drawback. Although it can be re-generated according to $\alpha \sim N(0, 1/3)$, the probability of still being an unreasonable individual remains high. In particular, the probability is higher when there are more constraints on the solution. When doing simulation experiments with MATLAB, the program often falls into a dead loop, which leads to an inability to estimate the total merit-seeking time.

Based on the above two improved crossover operators, a new crossover operator, the heuristic weighted crossover operator, is proposed. For the individuals and the assumption conditions of individual fitness remain the same as above, the i -th dimensional variable in two offspring individuals is calculated as:

$$x_i(t+1) = \alpha x_i(t) + (1 - \alpha)y_i(t) \quad (7)$$

$$y_i(t+1) = \alpha x_i(t) - (1 - \alpha)y_i(t) \quad (8)$$

Among them, $\alpha = \left[\frac{f(x)}{f(x) + f(y)} \right]^{(n-1)}$, $\gamma \in (0, 1)$, $n = 1, 2, \dots$

n is the number of times to use equation (7) or equation (8), that is, in the calculation of $x_i(t+1)$ used in equation (7), this is the first time to use equation (7), so $n = 1$. Since $x_i(t+1)$ must be a feasible solution, n is used only up to $n = 1$. In the calculation of $y_i(t+1)$, equation (8) is used for the first time, so $n=1$. When the calculated $y_i(t+1)$ is a feasible solution, it is the same as above, and n is used only for $n=1$. However, when $y_i(t+1)$ exceeds the allowed range, it needs to be calculated again according to equation (8). At this point, equation (8) is used for the 2nd time, so $n = 2$, and so on, and the algorithm ends until $y_i(t+1)$ is a feasible solution.

The analysis of equation (7) is the same as the previous analysis of equation (5), the range of offspring individuals still does not exceed the range of parent individuals, which are points within the parent composition interval. Therefore, it will not be an unreasonable individual. When the variation of equation (8) is applied, the algorithm obtains $y_i(t+1) = \alpha[x_i(t) + y_i(t)] - y_i(t)$, which is the point outside the composition interval of the parent. It is possible that its range is beyond the allowed range, but by varying n , the distance to the better individual is gradually reduced going in a finite number of steps to obtain a feasible solution, which ensures the continuous operation of the program.

In summary, this inspiration of weighted crossing operators integrates the advantages of the above two improvements. It not only has a large weight for individuals with high adaptation, but also uses inspirational strategies to search only around individuals with large adaptation. Therefore, the convergence speed is faster than the above two methods, it is not easy to fall into a local optimal solution, and the program is susceptible to a dead cycle when using an inspiration method.

Based on the above proposed improved genetic algorithm, it is used for the parameter estimation operation of the sentiment model in the following steps.

1) Encoding: In the state transfer probability matrix of mood and the conditional probability matrix of expression, the elements of each row are probabilities, which should satisfy the non-negativity and normalization of the probability definition. Therefore, the elements of the matrix are initialized on $[0, 1]$ and the sum of the elements of each row is 1. The real number is encoded and the population size is 100.

2) Adaptation degree calculation: this paper takes the adaptation degree function as:

$$f = C_{max} \text{ where } C_{max}.$$

Among them, ERROR represents the error between the results calculated and the results of the experience definition.

3) Replication: The selection method of roulette is adopted in the replication process, and the fitness function value f_i of each individual is calculated, so the probability that the individual in the population is selected in the next generation is: $P_{slec} = \frac{f_i}{\sum f_i}$.

4) Crossover: This paper adopts a new crossover operator—heuristic weighted crossover operator. Any two parent individuals are:

$$\begin{aligned}x(t) &= [x_1(t), x_2(t), \dots, x_n(t)] \\y(t) &= [y_1(t), y_2(t), \dots, y_n(t)]\end{aligned}$$

Among them, it is considered that the fitness value $f(x)$ of the individual $x(t)$ is larger, that is, the individual $x(t)$ is better. The calculation equation of the i -th dimension variable in two offspring individuals is:

$$x_i(t+1) = \alpha x_i(t) + (1-\alpha)y_i(t) \quad (9)$$

$$y_i(t+1) = \alpha x_i(t) - (1-\alpha)y_i(t) \quad (10)$$

Among them, $\alpha = \left[\frac{f(x)}{f(x)+f(y)} \right]^{(n-1)}$, $\gamma \in (0,1)$, $n = 1, 2, \dots$

n is the number of times of equation (9) or equation (10), that is, equation (9) is used when calculating $x_i(t+1)$, and it is the first time that equation (9) is used, so $n=1$. Because $x_i(t+1)$ must be a feasible solution, so n only uses $n=1$. When calculating $y_i(t+1)$, equation (10) is used for the first time, so $n=1$. When the calculated $y_i(t+1)$ is a feasible solution, it is the same as above, and only $n=1$ is used for n in this paper. However, when $y_i(t+1)$ exceeds the allowable range, it is necessary to recalculate according to equation (10), which is the second time to use equation (10), so $n=2$, and so on, and the algorithm until $y_i(t+1)$ is a feasible solution. For equation (9), the range of offspring individuals does not exceed the range of parent individuals, which are the points within the composition interval of the parents, so they will not be unreasonable individuals. After the variation of equation (10), the algorithm obtains $y_i(t+1) = \alpha[x_i(t) + y_i(t)] - y_i(t)$, which is a point outside the composition interval of the parent generation, whose range may be beyond the allowed range. However, by varying n , the distance to the better individual is gradually reduced so that the feasible solution can be obtained in a finite number of steps, which ensures the continuous operation of the program.

5) Variance: The variance operator used for the variance operator is: $x' = x \pm 0.5L\Delta.5$.

Among them, $\Delta = \sum_{i=0}^m \frac{a(i)}{2^i}$, $a(i)$ takes the value of 1 with probability $1/m$, and takes the value of 0 with $1-1/m$, and usually $m=20$. L is the value range of the variable, x is the value of the variable before the mutation, and x' is the value of the variable after the mutation value.

The crossover probability P_c and the variance probability P_m are adjusted adaptively, and the adjustment strategy is:

$$P_c = \begin{cases} P_{c1} - \frac{(P_{c1}-P_{c2})(f'-f_{avg})}{f_{avgmax} - f_{avg}} & f' < f_{avg} \\ P_{c1} & f' \geq f_{avg} \end{cases} \quad (11)$$

$$P_m = \begin{cases} P_{m1} - \frac{(P_{m1}-P_{m2})(f_{max}-f')}{f_{max} - f_{avg}} & f \geq f_{avg} \\ P_{m1} & f < f_{avg} \end{cases} \quad (12)$$

6) The algorithm determines whether the condition is satisfied, and the number of evolutionary generations is used as the condition in this paper. When the number of evolutionary generations meets the requirement, the genetic algorithm ends and the algorithm returns four matrices.

In the above improved genetic algorithm, the parameters in the equation were chosen as follows: population size

Popsize=100, upper limit of crossover probability $P_{c1} = 0.8$, lower limit of crossover probability $P_{c2} = 0.1$, upper limit of variation probability $P_{m1} = 0.4$, lower limit of variation probability $P_{m2} = 0.01$, and the number of iterations $gen=150$.

For each input, the expression of the system output must be uniquely determined, so it is necessary to convert the fuzzy quantity into a clear quantity. The function of clarification is to transform the control quantity (fuzzy quantity) obtained by peer-to-peer inference into the actual clear quantity used for control.

For clarity calculation, there are maximum affiliation method, median method and weighted average method. In this paper, the maximum affiliation method is used. The reason is that the maximum affiliation method is more in line with the objective and practical laws.

Maximum affiliation method: If the affiliation function $\mu_{c'}(z)$ of the output fuzzy set c' has only one peak $\mu_{c'}(z_0)$, the maximum value of the affiliation function is taken as the clear value, that is:

$$\mu_c(z_0) \geq \mu_c(z) \quad z \in Z \quad (13)$$

Where, z_0 denotes the clear value and Z denotes the domain. If the affiliation function of the output quantity has more than one extreme value, the average of these extreme values is taken as the clear value.

In order to verify the correctness of this method to estimate the model parameters, we select some actual results calculated by the model as a comparison, and the calculation process of the virtual human output expression probability is shown in Figure 3.

Only 3 cases are listed in Figure 3, and there are 14 cases in total, and other calculations are similar and omitted here.

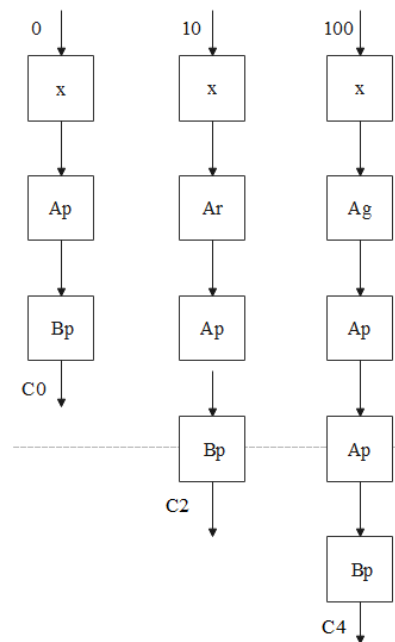


Figure 3 Probability calculation of model output expression

In order to verify the correctness of the model parameter estimation, the error functions are defined here as $ERROR_1$ mean square error and $ERROR_2$ absolute error, respectively, where

$$ERROR_1 = \|C_0 - C\|^2 + \|C_1 - C\|^2 + \dots + \|C_{13} - C\|^2$$

$$ERROR_2 = |C_0 - C| + |C_1 - C| + \dots + |C_{13} - C|$$

The error functions are substituted into the fitness function f , respectively, and the MATLAB simulation results are shown in Figure 4.

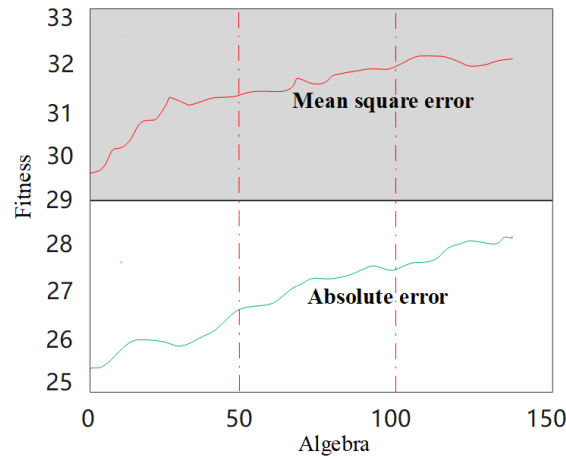


Figure 4 Adaptability function curve

The curve change of the fitness function in the figure is getting higher and higher. Its indicates that the expression output probability calculated from the model parameters estimated by the algorithm is getting closer to the empirically defined expression output probability.

The parameter estimation of the developed sentiment model by the above improved genetic algorithm finally yields four matrices, namely,

$$A_R = \begin{bmatrix} 0.26 & 0.72 & 0.02 \\ 0.10 & 0.89 & 0.01 \\ 0.38 & 0.46 & 0.16 \end{bmatrix} B_R = \begin{bmatrix} 0.29 & 0.58 & 0.13 \\ 0.169 & 0.83 & 0.001 \\ 0.649 & 0.18 & 0.171 \end{bmatrix} \quad (14)$$

$$A_P = \begin{bmatrix} 0.26 & 0.02 & 0.72 \\ 0.38 & 0.16 & 0.46 \\ 0.10 & 0.01 & 0.89 \end{bmatrix} B_P = \begin{bmatrix} 0.29 & 0.13 & 0.58 \\ 0.649 & 0.171 & 0.18 \\ 0.169 & 0.001 & 0.83 \end{bmatrix} \quad (15)$$

2.2 Implementation of emotional interaction system for emotional virtual human

Human-computer interaction technology refers to the technology to realize the dialogue between human and computer in an effective way through computer input and output devices. It includes the machine providing a lot of relevant information and prompting instructions to the human through the output or display device, the human inputting relevant information and prompting instructions to the machine through the input device, and the human inputting relevant information and answering questions to the machine through the input device. Human-computer interaction technology is one of the important elements in computer user interface design, which is closely related to cognitive science, ergonomics, psychology and other subject areas.

The automatic face expression recognition technology is developing rapidly under the impetus of various applications, and the system mainly includes the following links: acquisition of face expression images, face detection, face expression feature extraction and face expression recognition, and its structure diagram is shown in Figure 5.

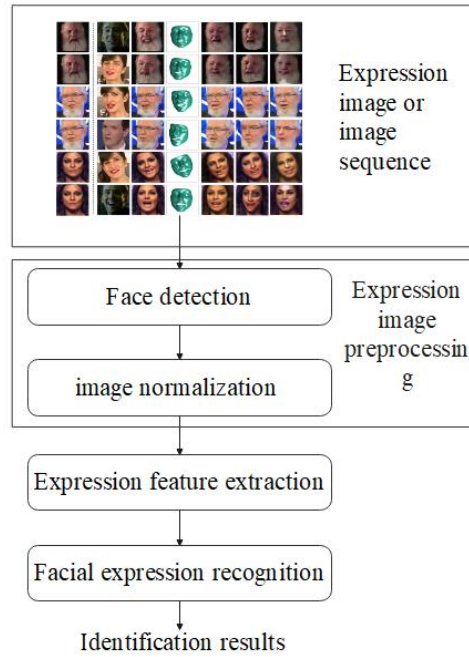


Figure 5 Structure diagram of automatic facial expression recognition

In this paper, 2DPCA is used to extract the expression features. Firstly, the overall scatter matrix of the training sample set is calculated, then its eigenvalues and eigenvectors are calculated, and the matrix consisting of the eigenvectors corresponding to the larger eigenvalues is selected as the projection space, and then the image is projected into the projection space to extract the feature matrix. According to the classical Ekman classification, the expressions are classified into 7 major classes (angry, disgusted, fearful, happy, neutral, sad, and surprised), denoted as $e_1, e_2, e_3, e_4, e_5, e_6, e_7$. The number of training sample images of the i -th class is n_i , denoted as $A_{i1}, A_{i2}, A_{i3}, \dots, A_{in_i}$. The total number of training samples is $M = \sum_{i=1}^7 n_i$, and each sample image is represented as a matrix of $m \times n$. The mean value of the training samples can be expressed as:

$$\bar{A} = \frac{1}{M} \sum_{i=1}^7 \sum_{j=1}^{n_i} A_{ij} \quad (16)$$

The difference of each image for the mean image is:

$$\psi_k = A_{ij} - \bar{A} (i = 1, 2, \dots, 7; j = 1, 2, \dots, n_i) \quad (17)$$

In equation (17), $k = n_1 + n_2 + \dots + n_7$.

If the matrix is $H = [\psi_1^T, \psi_2^T, \psi_3^T, \dots, \psi_k^T]^T$, then the overall scatter matrix of the training samples can be estimated by the following equation.

$$\Sigma = \frac{1}{M} H^T H \quad (18)$$

In equation (18), the dimension of Σ is $D \times D$.

According to the theorem, the set of optimal projection vectors $u_1, u_2, \dots, u_d$ is the standard orthogonal eigenvectors corresponding to the d largest eigenvalues ($\lambda_1 \geq \lambda_2 \geq \dots \geq \lambda_d$) of Σ . The projection of the expression image in this direction maximizes the overall dispersion of the image and is called the optimal projection axis. The set of vectors in the optimal direction forms the projection matrix $[u_1, u_2, \dots, u_d]$, which is the projection feature space. Then, the image matrix A_{ij} is projected into the space to obtain the overall projection feature matrix of the image A_{ij} , namely:

$$\begin{bmatrix} p_{11} & p_{12} & \dots & p_{1d} \\ p_{21} & p_{22} & \dots & p_{2d} \\ \dots & \dots & \dots & \dots \\ p_{m1} & p_{m2} & \dots & p_{md} \end{bmatrix} = A_{ij} [u_1, u_2, u_3, \dots, u_d] \quad (19)$$

This projection matrix is the expression feature matrix to be extracted, which is used for the next expression classification calculation.

Currently, the methods used for expression classification can be divided into two categories: spatio-temporal class methods and spatial class methods. The spatio-temporal class methods include Hidden Markov Model methods (HMM), Recurrent neural networks, spatio-temporal motion energy template methods, etc. Spatial class methods include neural network methods, rule-based inference methods, subspace methods, support vector machine methods, etc. In this paper, Manhattan distance classifier is used to the classification of expressions.

The Manhattan distance is calculated for the feature matrix extracted by equation (19) as follows.

$$d_M = |p_{11} - p_{11}'| + |p_{12} - p_{12}'| + \dots + |p_{md} - p_{md}'| \quad (20)$$

The Manhattan distance enables even smaller values to hold some weight, and is more capable of distinguishing different expressions in expression classification.

3 SYSTEM DESIGN AND EXPERIMENTAL ANALYSIS

3.1 Virtual emotional experience system integrating the "beauty of ruins" environmental design concept

An emotional avatar is a virtual intelligence that is capable of autonomous emotional thinking and emotional expression. The emotional decision mechanism of the emotional avatar is determined by the emotional decision model of the avatar. The most distinctive feature of an emotional avatar is the ability to interact emotionally with the machine. The prerequisite for emotional interaction is the ability to intelligently recognize emotions, make decisions about emotions, and express emotions. Therefore, the working mechanism of the emotional avatar is a very important process. It describes a process by which the avatar simulates human thinking and decision making about emotions.

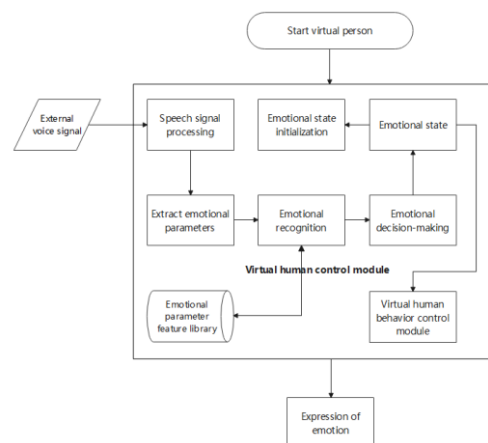


Figure 6 The working mechanism model of virtual human

Figure 6 is the model of the working mechanism of the emotional avatar. The model details the process and mechanism of the avatar's work. The design of the system key technology is shown in Figure 7, each part relies on the result output of the previous step. The third part includes the basic 3D scene, emotional positive feedback interaction events and virtual realization, and the construction of the basic 3D scene relies on the Unity3D game development engine.

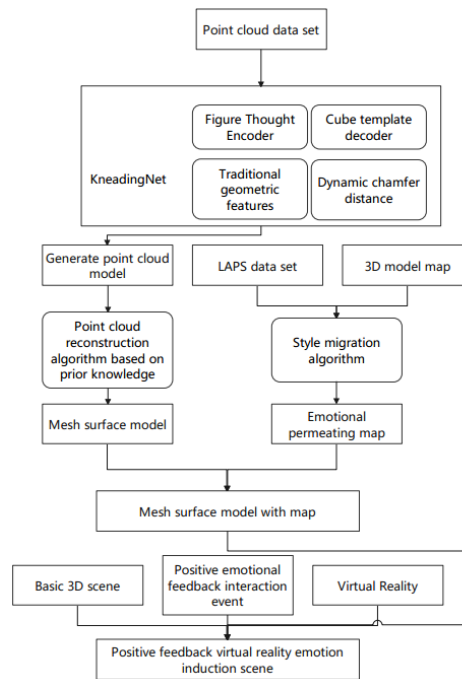
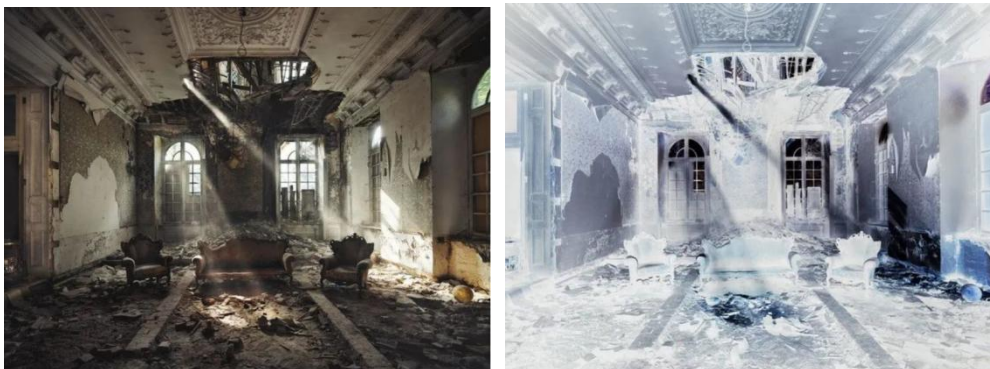
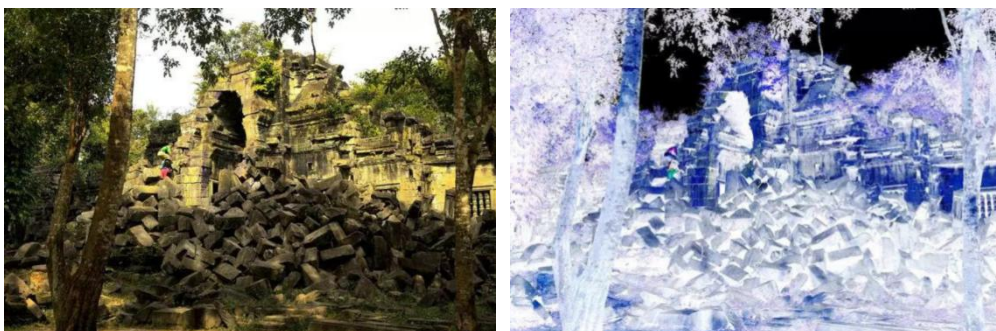


Figure 7 Design framework diagram of the key technologies of the system

Figure 8 shows an example of the environment design incorporating the beauty of ruins designed by the system in this paper. From the figure, it can be seen that the ruins designed in this paper have a certain virtual emotional experience effect.



(a) Ruins example 1



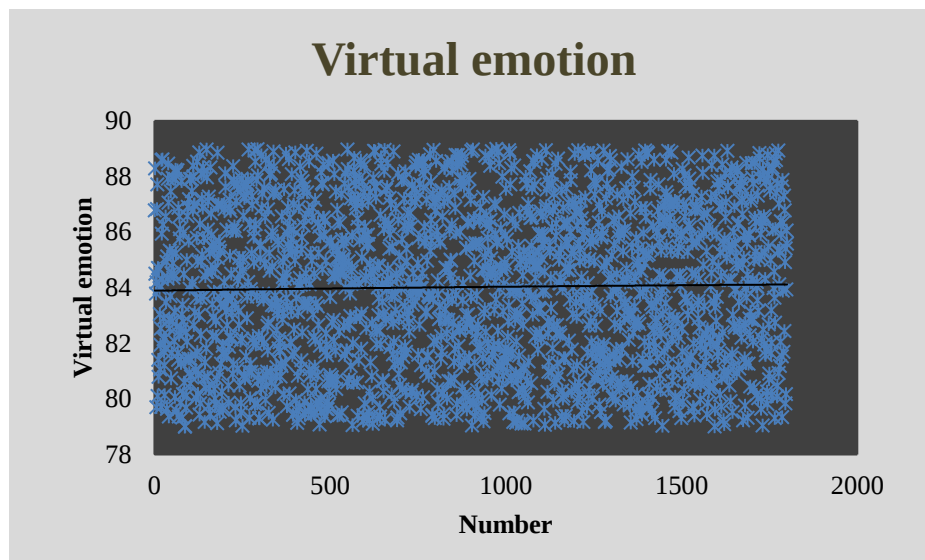
(b) Ruins example 2



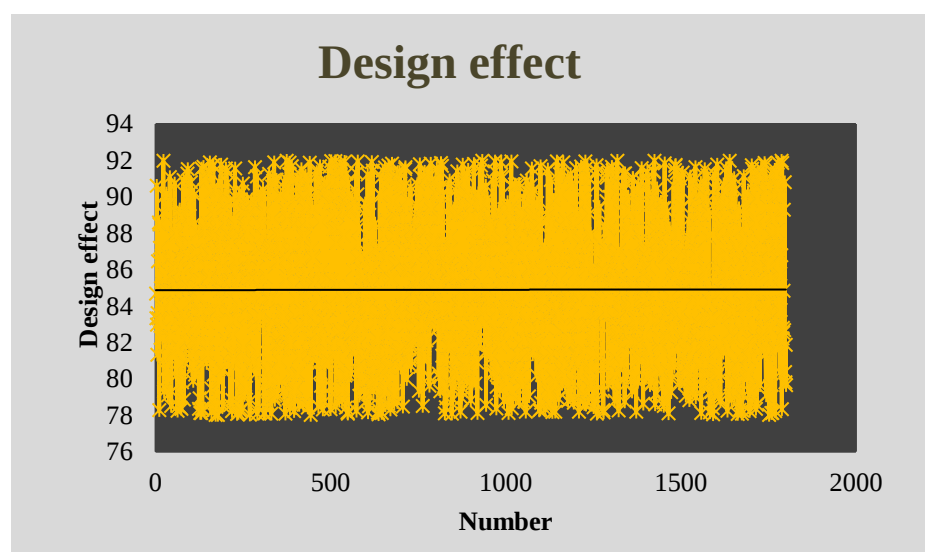
(c) Ruins example 3

Figure 8 Virtual design of the beauty of ruins

In this paper, the simulation analysis is conducted by multiple sets of data, and the virtual emotional experience effect of the system proposed in this paper and the design effect of the beauty of ruins are statistically analyzed, and the results shown in Figure 9 are obtained.



(a) Experimental data of virtual emotional experiences



(b) Experimental data of the design effects of the beauty of ruins

Figure 9 Experimental research results

It can be seen from Figure 9 that the virtual emotional experience system that integrates the "beauty of ruins" environmental design in this paper can effectively improve the experience effect of virtual emotion, and at the same time, the beauty of the ruins can be effectively integrated into the environmental design.

4 CONCLUSION

Emotional experience is a key part of the "beauty of ruins". Only by experiencing their emotions can we appreciate the beauty of ruins, otherwise the ruins will always be meaningless or just "relics" that need to be put away. Of course, humans will always need emotions to experience something important. However, the peculiarity of ruins is that if people don't have emotions, it can be "worthless" and unattractive. The "beauty of ruins" in environmental design is only a small node, and there are many ways to express similar and identical emotions, but this does not obscure the particularity of the "beauty of ruins". This paper combines virtual emotion technology to apply the beauty of ruins experience to virtual design, improve the immersion of virtual emotion experience system, and promote the science of modern art environment design. According to the experimental analysis, the virtual emotion experience system proposed in this paper can effectively enhance the virtual emotion experience effect and effectively integrate the beauty of ruins into the environment design.

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