Chapter 4
Research on Behavior Control Method in 3D Virtual Animation Design Based on the Purpose of Improving the Effect of Overseas Dissemination

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Abstract In order to improve the overseas dissemination effect of 3D (Three-dimensional) animation, this paper starts from the perspective of animation character behavior control to improve the dynamic texture of animation and enhance the audience's visual experience. Moreover, this paper designs and verifies the behavior control system of mobile animation character model based on the mathematical model. In addition, the initial animated character model is used to collect and summarize the working data, and the targeted hierarchical behavior design method is formulated by analyzing and adjusting the target tasks of the moving animated character model, which can generate the real-time behavior track meeting the requirements, strengthen the motion control, pose data estimation and safety control of the behavior, and realize more efficient reaction control. Finally, the experimental results verify the effectiveness of this method, which has a certain effect on improving the overseas dissemination effect of animation.

4.1 Introduction

At present, the top three countries in the global animation industry are the United States, Japan, South Korea. Among them, there are eight animation companies in the United States. Moreover, advanced technology, sufficient funds, fully supported policies and excellent talents make its animation industry develop rapidly, which can be said to be the largest animation country in the world. Japan has a strong development

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momentum in recent years. With the strong support of its government, social recognition and excellent talents, it produces a large number of exquisite and high-quality animation works almost every year. Since the financial crisis, the government of South Korea also began to focus on the development of animation economy, and has now leapt to the third animation country. In addition, France, Britain, the Netherlands and other countries have strong creative and cultural industries.

From the perspective of animation companies, the transformation is difficult. Even though the country has gradually attached importance to the animation industry and provided strong policy support, there are significant shortcomings in China's animation companies themselves: firstly, there is a lack of original animation. Animation itself is a creative and cultural industry, and creativity occupies a large proportion, which can be said to be the soul of the entire industry. However, most animation companies in our country are processing companies and do not have a complete production chain, which leads to a situation where "skillful women cannot cook without rice", even with the best technology, it cannot be solved. Secondly, due to insufficient investment, animation works require a large amount of capital investment, which can directly lead to the production and quality of the works. According to international practice, the recovery of animation costs should account for 20 to 30% of production costs, and the return on investment in peripheral product development should be 70 to 80%. In China, the cost of playing original animated films is low, accounting for only 10% of the cost, making it difficult to recover production costs and continue operating, creating a vicious cycle. Once again, professional talents have withered, and the subject of animation education in China has just started. There is a shortage of animation talents, especially those who are skilled in creation and technology, which directly restricts the development of animation in China. Due to the inadequate development of animation companies, hard work and low wages, the temptation of the animation market demand is directly weakened. The cultivation of animation talents cannot be completed overnight and requires a short period of time. Finally, the domestic environment is chaotic, and vicious competition often occurs. Due to the increasing number of animation companies that draw well and cheaply, with an average cost of 5 yuan per animation, many people are willing to pay 2 or 3 yuan. Therefore, in order to compete for business, the industry has started vicious competition, forcing the entire industry's profit and income to decrease.

Technology is one of the important elements in the development of the animation industry, especially for some countries with relatively backward animation industry development, the advantages of technology are bound to become one of the shortcuts to accelerate industrial development. Currently, with the increasing use of computer technology in the field of animation, especially 3D and Flash technologies, significant breakthroughs have been made in the production of animation [1].

Traditional animation visual stimulation experiments play an important role in behavioral experiments, while other sensory stimulation experiments (such as hearing, smell, touch, etc.) are relatively less applied due to technical limitations [2]. Visual stimulation experiments are the largest and most diverse work to date, and commonly used visual stimuli can be divided into three different types: static stimuli, abstract stimuli, and video stimuli. Static stimuli are some of the earliest stimuli used in behavioral experiments. Stimulation often involves related animals, which are presented as a static object, such as animal models, images, etc. [3]. We used cardboard models of adult seagulls to simulate the begging behavior of seagull chicks. The chicks responded naturally to the model, just like begging for food from their parents. Reference [4] used a predator model to study the alarm behavior of animals. When the eagle's model moved above the cage, the chicken emitted an alarm sound. Scientists speculate that the test animals may view static models as real animals and react to them. The main advantage of reference [5] is that the same stimulus can be applied to different animals, and its visual characteristics can be modified between different experiments, which can control the time and frequency of stimulus transmission. The main limitation is that there is no interactive feedback between the stimulus and the tested individual, and over time, the individual becomes accustomed to the stimulus and stops responding to it [6].

This paper combines the design technology of three-dimensional virtual animation design to improve the behavior control in animation design, improve the overall design quality of animation, and promote the overseas dissemination effect of animation.

4.2 Behavior Control Algorithm of 3D Animation

4.2.1 Mathematical Model of Behavior Control

Due to the limitation of technology, the control of some kinds of animation character behavior is still a single form of control, and the average control efficiency is low and the stability is poor. Traditional control instruction is relatively independent. Although it is a single control unit, but in the process of practical application, in the face of complex execution and processing environment, it will still produce certain errors and problems, resulting in more or less influence. In order to innovate the execution process, expand the control range of interactive instructions and form a more modular design idea, it is necessary to introduce the instructions of real-time data sharing area into the original initial control system, so as to create a more active, systematic and comprehensive execution environment, and use mathematical models to determine the task execution range of animation characters, and calculate the execution range through mathematical linear equations, as shown in the following formula (4.1) [7]:

$$\begin{cases} K = \frac{r}{3} + 6\varphi - \sqrt{2a+1} \\ P = 2\beta + 4\omega \end{cases} \tag{4.1}$$

In the formula, K represents the execution range, r represents the hierarchy ratio, φ represents the degree of shared control, a represents existing control errors, P represents the linear execution range, β represents the execution limit value, and ω represents the interaction coefficient. Through the above calculation, the actual execution range of animated characters can be finally obtained. Taking the obtained execution range as the actual processing range of the animation character behavior control system, on the basis of the above and combining with the actual control requirements, the limit edge control coefficient of the animation character is calculated, as shown in the following formula (4.2) [8]:

$$H = -\chi + 1.5 - \frac{e - 2\pi}{7} \tag{4.2}$$

In the formula, H represents the limit edge control coefficient, χ represents the value of edge distance, e represents the strain control ratio, and π represents the interaction area. Through the above calculation, the actual limit edge control coefficient can be finally obtained. According to the calculated value, the specific edge control range is set to form the limit internal control standard. It is set in the behavior control system processing model of moving animation characters, and according to the actual situation, the corresponding interactive control instructions are formed [9].

The control structure diagram of multi-behavior cooperative synthesis is shown in Fig. 4.1 [10].

After completing the design of interactive control instructions under the mathematical model, it is necessary to design the hierarchical module of the mathematical model of mutual class function. First of all, we need to build a linear mutual class environment according to the actual control requirements and execution conditions

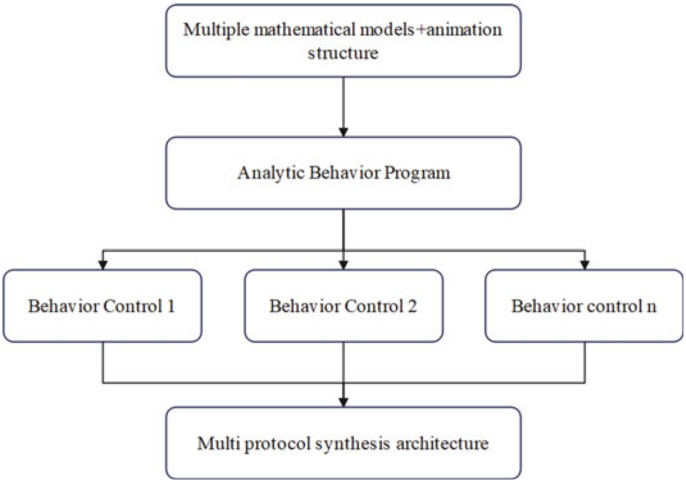


Fig. 4.1 Illustration of multi-behavior cooperative synthesis control structure

of animation characters [11]. In essence, this part delineates the instruction import area of animation characters under the mutual class mode, and associates the functional mathematical model with the related execution and processing instructions to form a more stable module control program. Therefore, we can first determine the cross-class control range and calculate the cross-class control ratio, as shown in the following formula (4.3) [12]:

$$G = (5\xi + 0.25) - \frac{1}{x} \tag{4.3}$$

In the formula, G represents the mutual class control ratio, ξ represents the coefficient of linear change, and x represents the controllable weight value. Through the above calculation, the actual cross-class control ratio can be finally obtained. According to the control ratio, the mathematical control model is created, and the mutual class function modules at different levels are designed. The mutual class function module is different from the common system execution module, and the mutual class module has stronger flexibility and can increase the connection between animation characters. It is necessary to first calculate the terminal deviation coefficient of the executive control section of the mutual class function module, as shown in the following formula (4.4):

$$O = \frac{Q}{2\varphi + 1} - 2\sqrt{3} + 7\varsigma \tag{4.4}$$

In the formula, O represents the terminal deviation coefficient, φ represents the number of interactive control sections, Q represents the actual behavior control range of animation characters, and ς represents the change protocol side.

Through the above calculation, the actual terminal deviation coefficient can ultimately be obtained. Construct a NAO processing program within the hierarchical module of the mathematical model, utilize the obtained data information, and combine it with choreography software to develop corresponding animation character behavior control instructions. This section is mainly divided into basic control commands, travel commands, jump commands, arm lift commands, etc. All commands are added to the control module to form a stable command control group. Under the influence of mathematical models, mathematical mobile programs are added to the instruction control group. The program is interconnected with instructions at each level and has a certain degree of adjustability. Changes can be made at any time according to actual needs. In the process of motion, control, and even inspection of animated characters, there are also different levels of mutual control commands. Similar to mathematical mobile programs, interclass control instructions execute tasks assigned by the system in a predetermined order, requiring fixed execution standards and levels to form initial functional modules, secondary functional modules, and top-level functional modules. Each functional module is independent of each other and has a certain degree of correlation, enhancing the stable operation of the system and ensuring clear execution goals, further improving the final design of the hierarchical module of the mathematical model for optimizing interclass functions.

4.2.2 Multi Behavior Collaborative Design

After completing the design of the hierarchical module of the mathematical model for mutual class functions, it is necessary to carry out the design of multi-behavior collaboration for mobile animation characters. Due to the fact that the animation characters designed in this article are multi-level control programs, supplemented by inter class control instructions, the control of animation character behavior also needs to be set to bidirectional or multiple to ensure the comprehensive control effect within the system.

Usually, when implementing behavior settings for animated characters, 3D technology is combined to establish a comprehensive coordinate system centered around themselves, using the animated character's abdomen as a preset reference to construct WDS (Wireless Distribution System) coordinates. W represents the horizontal axis for forward behavior control, *D* represents the vertical axis for backward behavior control of the animated character, and S represents the core axis for mid-range behavior control. When observing, the forward, backward, left, and right movements of animated characters are generally basic habits that can be completed in conjunction with mutual control commands. However, for jumping, forward, and other movements, joint coordination is required.

Generally, there are 30 joints in the animated character itself. By using bus association and timing control program, the joints are demarcated in the same control area, the timing access protocol is designed, and the specific number of timing protocol nodes is calculated, as shown in the following formula (4.5):

$$E = -j - \left(\sqrt[4]{g} + 2.5\right) - \frac{1}{b} \tag{4.5}$$

In the formula, E represents the number of timing protocol nodes, j represents the main control coefficient, g represents an access weighting value, and b represents the central control standard value. Through the above calculation, we can finally get the actual number of timing protocol nodes. Meanwhile, we set nodes in the main control area of the system according to the number. Combined with Choregraphe software animation character development software, we change the related index parameters and interface functions of animation character behavior control in the system, and adjust the running function and coverage control range of animation character ontology. Moreover, in the control system, the complex behavior of animation characters is also divided into several small behavior combinations, which can reduce the internal pressure of animation characters' behavior control to a certain extent. In addition, small behavior combinations consist of behavior units, so we can calculate unit behavior units first, as shown in the following formula (4.6).

$$N = \sqrt{5\gamma - \frac{\sqrt{2I}}{3} + R - o} \tag{4.6}$$

In the formula, N represents the unit of the unit line, γ represents the integration ratio, I represents the behavior synthesis ratio, R represents the standard value of behavior activation limit, and o represents the limit mathematical priority series. Through the above calculation, the actual unit behavior unit can be finally obtained. According to the above coordinate system, the behavior units are added to the hierarchical structure of the system and associated with the set mathematical model to form a multi-behavior cooperative synthesis control structure. The design of multi-behavior cooperative synthesis control structure can be completed. After completion, different behavior cooperation goals are set up in each control level, and different goals represent the corresponding behaviors of animation characters. So far, the multi-behavior cooperation construction is realized and the software design is completed.

4.2.3 Behavior Characteristic Selection

The quality of feature selection results directly affects the lightness and quality of the constructed human behavior recognition model. Excessive redundancy and irrelevant features are not only detrimental to the improvement of model generalization, but also easy to increase modeling difficulty and computational load This article proposes a feature selection technique based on Neighborhood Component Analysis (NCA) to perform high correlation feature selection on the original human behavior recognition feature set Therefore, from the perspective of correlation between behavioral features, this article uses NCA to select the highly correlated optimal feature subset from the human behavioral feature set, thereby improving the lightness of the behavior recognition model calculation process. NCA is a simple and efficient distance measurement algorithm. It selects the optimal feature subset for human behavior recognition models by maximizing the classification accuracy of the retention method.

The original feature set of human behavior is $S = \left\{\left(\tilde{x}_i, \tilde{f}_i\right), i = 1, 2, ..., n\right\}$, where $\tilde{x}_i \in \mathbb{R}^m$ is the i-th behavior sample, $\tilde{f} \in \{1, 2, ..., c\}$ is the label of the i-th behavior sample, c is the number of categories and m represents the number of features. The Mahalanobis distance between behavior features $\tilde{x}_i$ and $\tilde{x}_j$ is:

$$d\left(\tilde{x}_i, \tilde{x}_j\right) = \sqrt{\left(A\tilde{x}_i - A\tilde{x}_j\right)^T \left(A\tilde{x}_i - A\tilde{x}_j\right)} \tag{4.7}$$

In the formula, A is the Mahalanobis distance transformation matrix, and T is the matrix transposition, and $j = 1, 2, ..., n$.

Using the method of leaving one to maximize the classification accuracy on the sample set of human behavior, the probability that the sample $\tilde{x}_i$ selects the sample $\tilde{x}_j$ as its reference point is as follows:

$$P_{ij} = \frac{\exp\left(-\left\| A\tilde{x}_i - A\tilde{x}_j \right\|^2\right)}{\sum_{q \neq i} \exp\left(-\left\| A\tilde{x}_i - A\tilde{x}_j \right\|^2\right)}, P_{ii} = 0 \tag{4.8}$$

In the formula, $q = 1, 2, ..., n$ represents the probability that the sample $\tilde{x}_i$ chooses the sample $\tilde{x}_j$ as its reference point. The probability that the sample $\tilde{x}_i$ is correctly classified is:

$$P_i = \sum_{i=1, j \neq 1} P_{ij} \tilde{f}_{ij} \tag{4.9}$$

Among them, $\tilde{f}_i \neq \tilde{f}_j$, $\tilde{f}_{ij} = 0$, and vice versa $\tilde{f}_{ij} = 1$.

The objective function is to maximize the number of correctly classified behavioral features, so it is defined as follows:

$$F(A) = \sum_i p_i \tag{4.10}$$

We use conjugate gradient method to solve A:

$$\frac{\partial F}{\partial A} = -2A \sum_i \sum_{j \in \tilde{f}_i} p_{ij} \left(\tilde{x}_{ij} \tilde{x}_{ij}^T - \sum\nolimits_q P_{iq} \tilde{x}_{ij} \tilde{x}_{ij}^T \right) \tag{4.11}$$

Among them, $\tilde{x}_{ij} = \tilde{x}_i - \tilde{x}_j$.

Using the optimized A, the feature subset after NCA selection is obtained

$$X = \tilde{X} \cdot A \tag{4.12}$$

In the formula, $\tilde{X} = \{\tilde{x}_1, \tilde{x}_2, ..., \tilde{x}_n\}$ and $X = \{x_1, x_2, ..., x_n\}$ represents the optimal feature subset selected by NCA.

4.3 Behavior Control Model of 3D Virtual Animation Design

When the three-dimensional virtual character external building is completed, it is necessary to adjust and control its movements to achieve the required authenticity. The control process is shown in Fig. 4.2. First of all, the action of the character material is captured, and the trajectory is copied by the method of physics, so that the 3D virtual animation can realize the movement and adjustment corresponding to the real character, thus realizing the fidelity of the three-dimensional virtual animation character. After that, through system feedback, the control parameters suitable

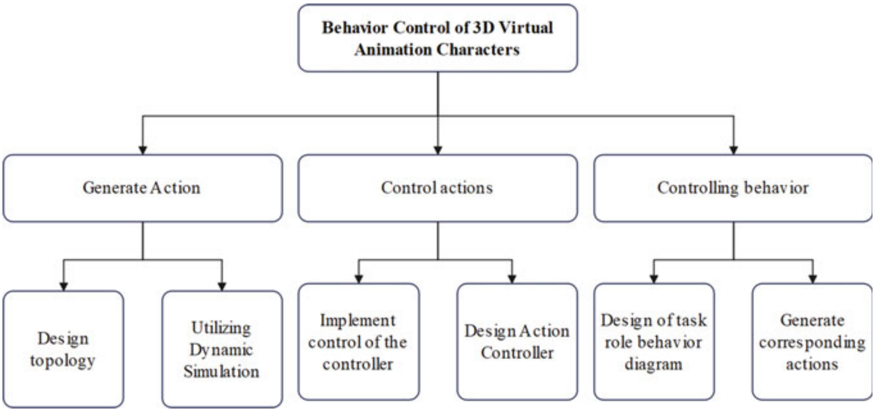


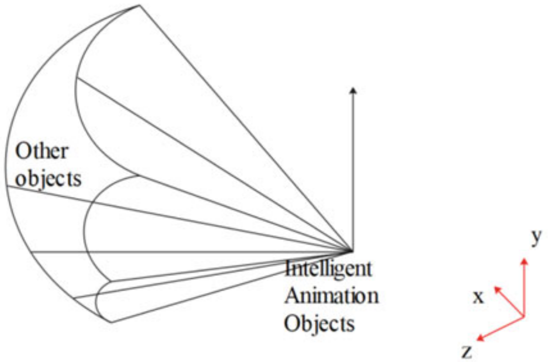
Fig. 4.2 Behavior control process of 3D simulation animation image

for 3D simulated character animation joints are set, which realizes the combination of external information and 3D virtual animation in proportion, avoids external interference as much as possible, realizes the conversion of relative data, increases the similarity between character image and real image, and satisfies the constraint control conditions for 3D virtual animation.

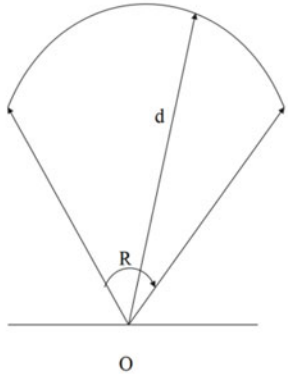
The visual perception model simulates the visual cone of real human eyes, and sets the appropriate visual field angle and range. Usually, the comfortable visual field of human eyes is within 30°, and only objects in the visual cone can be perceived by agents. Figure 4.3 is a visual perception model of intelligent characters. We assume P is a point on the object, O is the origin of the agent's line of sight, the distance between other objects and the agent character is d, and R represents the visual field a*ngl*e. If $\|O - P\| \leq d$ and the angle between the ray OP and the z axis (directly in front of the agent's line of sight) is less than $R/2$, the object is within the visual field of the agent character. In the virtual environment, it is necessary to judge whether the object is in the field of vision and whether the object is occluded. In this paper, point occlusion detection method is used for line-of-sight detection.

The auditory perception model of intelligent characters simulates the real auditory region through a spherical region, as shown in Fig. 4.4. If the agent can hear the sound, it makes behavior decision by the sound and makes appropriate behavior response. In order to increase the authenticity, we also need to consider the intensity range of sound.

Fig. 4.3 Visual perception model



(a) Visual stereoscopic images



(b) Planar decomposition image

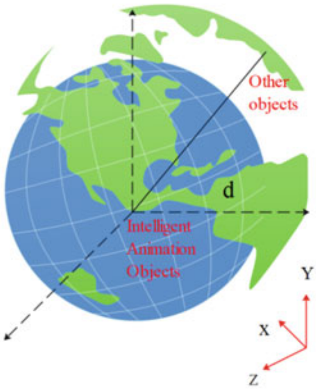
4.4 Model Validation

Currently, the operation of 3D virtual animation design is mostly based on MAYA software. Therefore, this article chooses MAYA software as the system software and combines the algorithm in the second part to improve 3D virtual animation design and automate the processing of intelligent characters.

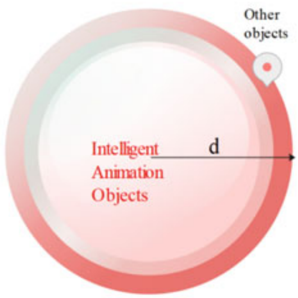
After constructing the above model, the effect of the model is verified. Firstly, the behavior control simulation analysis of domestic animation is carried out through the model constructed by the simulation system. The following Fig. 4.5 shows an example of simulation analysis through this model, and the case comes from the characters in domestic animation "Kuiba". With this method, the role reconstruction and behavior control analysis can be carried out from multiple angles, and behavior control can be carried out, and finally the following model is obtained.

After building the above model, we verify the effect of the model, and use multiple groups of simulation to verify the effect of this model in animation character behavior control, and finally get the verification results shown in Table 4.1 and Fig. 4.6.

Fig. 4.4 Auditory perception model



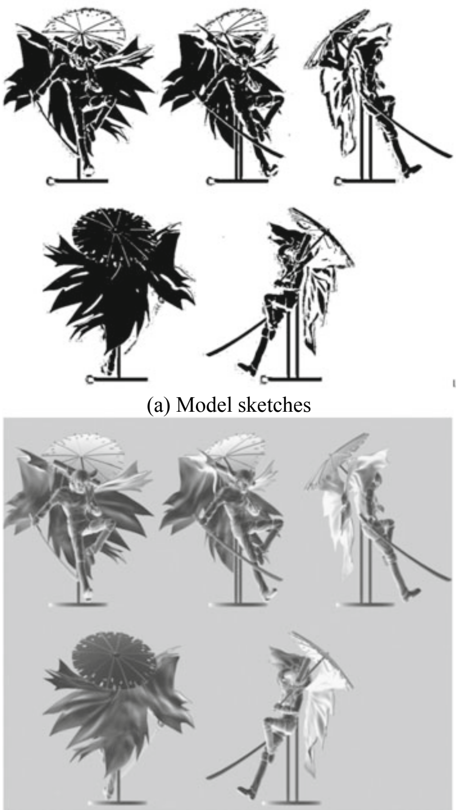
(a) Auditory stereogram



(b) Horizontal exploded view

From the above analysis results, we can see that the behavior control method in 3D virtual animation design proposed in this paper has a good effect on the behavior control of animation characters, so it can promote the look and feel of animation and have a certain positive effect on promoting the overseas dissemination effect of animation.

Fig. 4.5 Example of behavior control model



(a) Model sketches

(b) Behavior control model

Table 4.1 Simulation analysis of behavior control

Simulation serial number	Behavioral control	Simulation serial number	Behavioral control	Simulation serial number	Behavioral control
1	79.83	13	83.54	25	83.60
2	81.71	14	88.56	26	80.90
3	79.14	15	86.90	27	85.09
4	78.03	16	86.12	28	84.60
5	86.32	17	82.80	29	81.66
6	86.19	18	79.96	30	79.64
7	80.51	19	83.08	31	81.88
8	78.98	20	82.63	32	88.75
9	78.74	21	82.80	33	80.27
10	86.49	22	79.06	34	81.32
11	87.99	23	87.69	35	82.22
12	88.84	24	78.51		

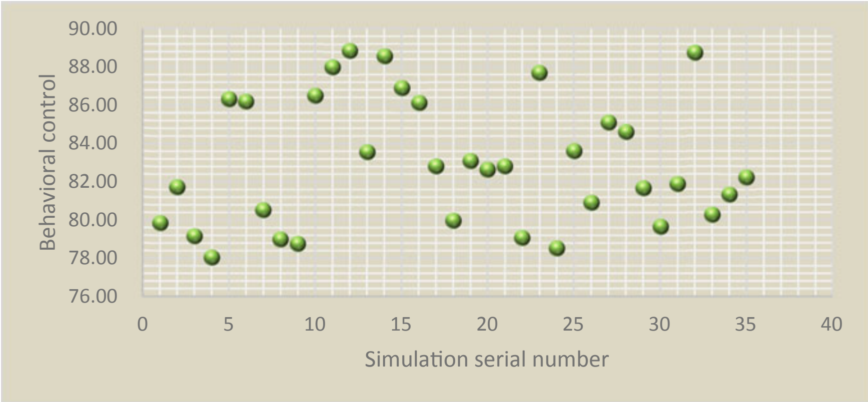


Fig. 4.6 Statistical diagram of behavior control simulation data

4.5 Conclusion

This paper combines with 3D virtual animation design technology to improve the behavior control in animation design to improve the overall design quality of animation and promote the effect of animation overseas dissemination. Moreover, this paper designs and verifies the behavior control system of mobile animation character model based on the mathematical model. Under the aided design of the mathematical model, the behavior control program of animation character model is innovated, and the initial animation character model is used to collect and summarize the working data. Moreover, by analyzing and adjusting the objectives and tasks of moving animation character model, a targeted hierarchical behavior design method is formulated, which can generate real-time behavior trajectory meeting the requirements, strengthen the motion control, pose data estimation and safety control of behavior, and realize more efficient reaction control. From the analysis results, we can see that the behavior control method in 3D virtual animation design proposed in this paper is very good for improving the effect of animation character behavior control, which is helpful to promote the overseas dissemination effect of animation.

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