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Design of a Group Animation Production System Based on Artificial Intelligence Algorithms

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***Abstract*—With the growth of communication technology and hardware technology, animation production can only meet the needs of the times by continuous innovation. Aiming at the problems of traditional animation, such as single method, heavy task and low autonomy, the particle swarm optimization (PSO) algorithm is improved by using the convergence and divergence behavior in social learning mechanism. In order to improve the production method of group animation, this paper applies the modified PSO algorithm to the group animation production system driven by artificial intelligence, improves the influence mode of the "social" part of the standard PSO algorithm on particle motion, and selects the particle with the best fitness value in the particle field of view as the global extremum of the particle, so as to overcome the shortcoming that the original algorithm adopts the best individual among all particles as the global extremum and easily falls into the local optimum, thus simulating the group behavior more truly. The simulation results show that after the algorithm is iterated for a certain quantity of times, the particles tend to converge, but due to the limitation of the field of view, the quantity of connections between particles will remain in a relatively stable state, and the particles will not fall into the local optimum because of excessive aggregation, so it has the ability to continue exploration. PSO algorithm can truly simulate group behavior, which provides a basis for the design of group animation production system.**

Keywords—Artificial intelligence, Animation production, Group behaviour, Particle swarm optimization

I. INTRODUCTION

With the continuous progress of network technology and computer hardware technology, image production technology is becoming more and more efficient and low-cost, and image production projects are also beginning to develop digitally. At the same time, the image industry is also beginning to integrate different new technologies[1]. Based on the growth of digital technology, communication science and hardware technology, 3D animation techniques are facing technological innovation and begin to enter the era of real-time performance and rapid production. The production method of group animation has been continuously developed and improved, and the demand for film and television special effects is one of the important reasons to promote its development[2]. Because of the universal existence of group movements in the real world, it is becoming more and more important to simulate group movements in computer animation[3]. For example, using group animation technology to simulate disaster scenes can not only replace the performance of real actors, but also reduce the shooting cost, and the most important thing is to greatly improve the shooting safety. The simulation of group behavior is a very important part of animation, and it has been accepting new challenges. In the production process, if the quantity of individuals in the group is small, the animator can set the path and behavior of each individual, but if the quantity of individuals is large, it is very difficult to draw the movement trajectory of each individual manually, because not only the overall coordination of group movement is needed, but also each individual has a unique movement trajectory [4].

While the traditional computer animation creation technology is constantly improving, the creation of group animation is always a difficult problem in computer animation creation[5-6]. Due to the lack of autonomy, the traditional computer animation creation method based on key frames is extremely inefficient in the creation of group animation[7]. When the quantity of intelligent characters increases, the complexity of their creation will increase sharply accordingly. At the same time, the requirements for animators are very high and the labor intensity is also very high[8]. PSO algorithm is a population-based evolutionary algorithm, which draws lessons from the social behavior of birds or fish in the process of predation, and is an evolutionary computing technology different from genetic algorithm[9]. Based on the group intelligence of this algorithm, this paper applies it to the group animation production system, and improves the influence mode of the "society" part of the standard PSO algorithm on particle motion, so as to complete the group animation production more quickly.

II. METHODOLOGY

Group animation is a simulation of biological group behavior, and it is also an important research content of complex system simulation. In the process of group animation creation, it is not only required that each character has a unique trajectory, but also that the movement of the group is coordinated, which has the following two typical characteristics of a complex system. There are two main research directions of group animation: one is for the purpose of scientific research and experiment, and in this respect, group animation emphasizes the consistency between simulated group objects and statistical data. In the process of research, group individuals will ignore their individual geometric information and treat them as particles; One is for the purpose of digital entertainment games. In this respect, group animation emphasizes shocking emotional effects and realistic visual effects[10]. In addition, according to the different practical application types of groups, the simulation strategies needed are also different, such as military simulation in war and emergency escape from disasters in life.

At present, there are two ways to make role actions. One is that the animator comes to key frames, which requires a lot of animation, and 3D software is used to set key frames and key frames according to each shot. This method requires a large quantity of animators, and the animator's studio will be overloaded, and the requirements for animators are high, otherwise the action will have an average effect[11]. The other is to use dynamic capture to make actions. For this method, due to the mismatch between the actor and the model, it can not be fully applied to the model. When the action is given to the model, the model will be interspersed, because the actor is a real person and has physical physiological limits, and some exaggerated performance can not be completed. The behavior of roles or subjects in intelligent and adaptive complex systems follows certain rules, and adjusts their state and behavior according to "environment" and received information, and roles usually have the ability to adjust rules according to various information and produce new rules that have never been seen before. Through the relatively low intelligent behavior of the system subject, the system as a whole shows a higher level, more complex and more coordinated functional order. The PSO discriminator model is shown in Figure 1.

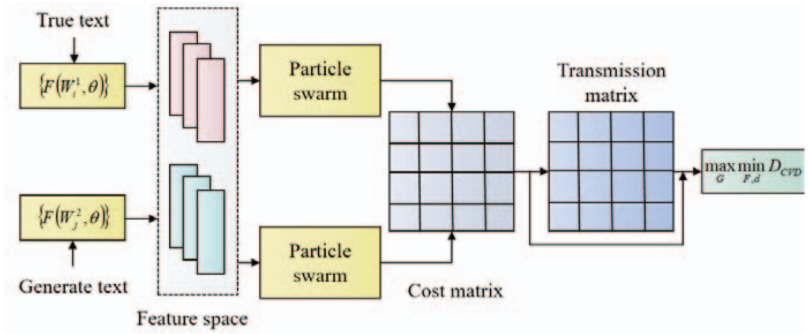

Figure 1. PSO discriminator model

Traditional 3D animation projects will spend a lot of rendering time, and animators will also spend a lot of energy and time making actions and expressions. The quantity of animators is very large, which will generate a lot of expenses and spend a lot of time. Although many virtual cameras are used now, real people hold virtual cameras to establish the camera trajectory, but it is very random. Once there is a problem, it will take more time to modify the camera trajectory later, and at the same time, we should pay attention to seamless docking with the original data, otherwise there will be frame skipping.

Planning the motion path for the characters in group animation is a very important work in the process of group animation simulation. Generating realistic motion paths plays a vital role in improving the simulation effect of group animation[12]. The embodiment function of solving group characteristics is mainly realized through the motion control of the intermediate control level or the middle and high control level of group motion simulation; Solving the control function of physical mechanics and the control function of group mechanical motion operation mainly depends on the motion control of low-level control level in group motion simulation. Animator's intention and role's response to environmental information and other role information. The reaction of dynamic characters to environmental information and other character information is mainly realized by collision detection and collision avoidance of characters.

The topological structure of PSO refers to the way that all particles in the whole population are connected with each other, while the neighborhood structure of PSO refers to how a single particle is connected with other particles[13]. The former is global and the latter is local, and the neighborhood structure determines the topological structure. Neighborhood structure is a very important factor to determine the effect of PSO algorithm, and the effect of PSO algorithm with different neighborhood structure will be very different. If there are 6 elements in the animation character, describe it as follows:

$$\mathrm{P} = \{\mathrm{X}, \mathrm{T}, \mathrm{J^c}, \mathrm{Re\,l}, \mathrm{S^o}, \mathrm{S_{tri}}\} \quad (1)$$

In the formula: X and T respectively represent different elements in the virtual environment and the relational operators between different elements. $\mathrm{J^c}$ and Rel respectively represent the conceptual hierarchy and non-clustering relationship between different elements. $\mathrm{S^o}$ and $\mathrm{S_{tri}}$ respectively represent the existing ontology prototype and the intrinsic correlation of the elements. Among them: $\mathrm{X_1, X_2, \ldots, X_n} \in \mathrm{X}$ describes all the elements in the animation character structure. The relational operator described by T can be expressed as:

$$\begin{cases} \text{attribute\_of } (\mathrm{X_1,X_2}) \\ \text{compose\_of } (\mathrm{X_1,X_2}) \\ \text{effect\_of } (\mathrm{X_1,X_2}) \end{cases} \quad (2)$$

The formula respectively describes the correlation between $\mathrm{X_1}$ and $\mathrm{X_2}$. For the sensitivity index, the characteristic elements in formula (2) can be described by formula (3):

$$\text{Sensitive}_{\text{time}} = \begin{Bmatrix} \text{attribute\_of } (\mathrm{X_1,X_2}), \\ \text{compose\_of}(\mathrm{X_1,X_2}), \\ \text{effect\_of}(\mathrm{X_1,X_2}) \end{Bmatrix} \quad (3)$$

According to the maximum mean square error, the threshold of the sensitivity index can be determined. The formula is described as:

$$\text{Threshold\_Sensitive}_{\text{time}} = \frac{1}{3\mathrm{E}}\left[\int_{\mathrm{t}=0}^{\mathrm{E}} \{\text{attribute\_of} \left(\mathrm{X_1(e),X_n(e)}\right)\mathrm{d(e)}\}\right] \quad (4)$$

Where E represents the playing time of video animation.

Due to the randomness of the initialization particle position, the distance between particles is random, and some particles are limited by their own field of vision, so the quantity of neighboring particles calculated is less than the specified value. The quantity of neighboring particles of other particles meets the specified value, and it can be used as the extreme value needed for iteration according to the information of the individual with the best fitness value in the neighboring particle set.

The idea of modeling can be based on the existing experience and knowledge, the data statistics and experimental results of dealing with problems, and the analysis of the regular characteristics and movement of the system itself, so as to abstract things in order to better understand them. Animator's modeling of individual characteristics, scene mode, movement trajectory, thoughts and emotions of characters in animation is animation modeling. Among them, the modeling of individual role characteristics, movement trajectory, thoughts and emotions is based on individuals in the group.

III. Result analysis and discussion

As the basis of getting real animation effect, computer virtual characters need to simulate the perception system of real life creatures. In computer animation, autonomous behavior is based on the agent's ability to perceive and act on the environment. The establishment of perception model is as important in autonomous behavior as perception is to animals. In this paper, the improved PSO algorithm is used in the group animation production system, and the influence of the "society" part of the standard PSO algorithm on particle motion is improved, so that the group animation can be made more quickly.

In a simulation cycle, the intelligent character will combine the action cycle of the intelligent character's reference coordinate system and the displacement of the world coordinate system to synthesize the overall motion animation of the intelligent character. The image classification accuracy of different animation algorithms is shown in Figure 2.

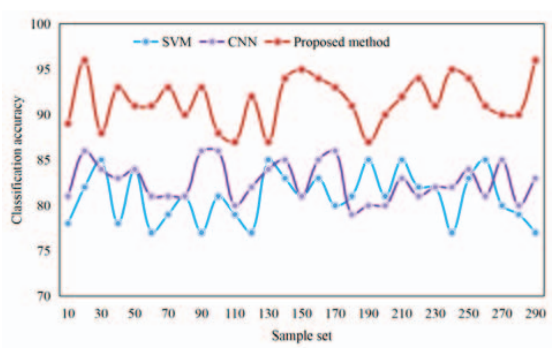

Figure 2. Image classification accuracy of different algorithms

As can be seen from Figure 2, the image classification accuracy of the proposed algorithm is more advantageous than that of the traditional algorithm. Compared with the traditional SVM algorithm, the improved PSO algorithm is closer to the known optimal value. And the average value of the results is lower than the average value of the standard PSO algorithm, which shows that the optimization ability of the improved PSO algorithm is greatly enhanced. At the same time, through the standard deviation of the improved PSO algorithm, it can be seen that the optimization results have not changed much every time in 30 experiments, and the optimization performance is relatively stable. In this paper, by adding unlabeled data to the training set, the performance of the algorithm is better than that of using labeled data alone, thus improving the accuracy of recognition.

The improvement of neighborhood structure is a very important aspect of PSO algorithm research. When multiple particles run on the function to be optimized, each particle is detecting the value of the function at each step of the iteration, and this information is passed between different particles. The particles share the global information about the function to be optimized, so that each particle can adjust their search direction and amplitude according to this information in the next iteration. Figure 3 shows the variation curve of the optimal solution of particle swarm optimization.

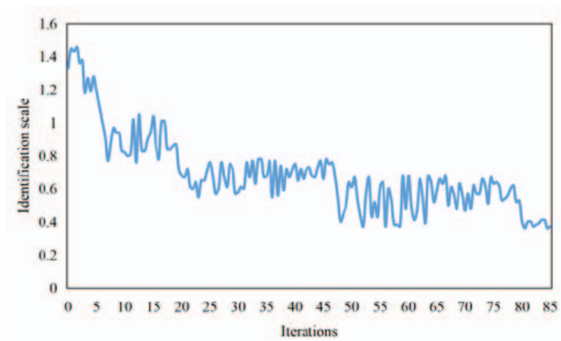

Figure 3. Variation curve of optimal solution of particle swarm optimization

It can be seen from Figure 3 that the whole layout optimization solution process is smooth and rapid, and it can quickly approach the optimal solution. This shows that PSO algorithm can solve the problem of group animation production well.

Neighborhood structure determines the way information is transmitted between different particles, including that particles can directly get the information transmitted by other particles in each iteration, the speed and intensity of these information transmitted between particles and so on. If the information is transmitted between particles too fast, it is easy to make the whole system premature, that is, the particles will quickly gather at a local extreme point. On the other hand, if the information transmission is too slow, it is difficult for a single particle to get the information of the particles that are far away quickly, which makes the convergence speed of the algorithm slow down and affects the calculation efficiency. Figure 4 shows the MAE comparison of different algorithms on the test set. Figure 5 shows the response time comparison of different algorithms.

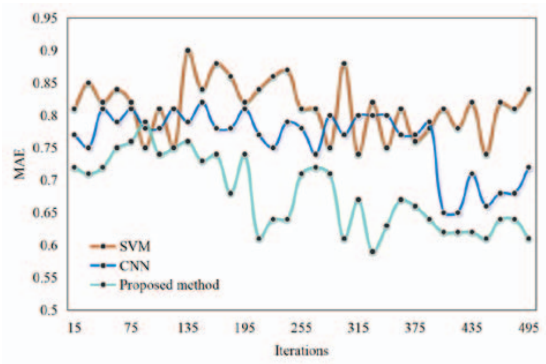

Figure 4. Error of different algorithms on training set

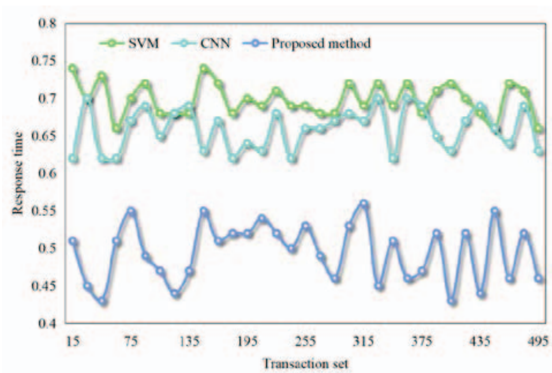

Figure 5. Response time of different algorithms

It can be seen that the MAE of this algorithm is obviously improved compared with the traditional CNN and SVM algorithms on the test set, and the response time of the algorithm is obviously reduced. In the improved algorithm, the information of the particle with the optimal fitness value in all particles is used as the required extreme value of iteration, which actually adopts a highly connected topological structure to make the particle converge as soon as possible and increase the probability of finding the optimal solution. When the algorithm iterates for a certain quantity of times, the particles tend to converge, but due to the limitation of the field of view, the quantity of connections between particles will remain relatively stable, and the particles will not fall into the local optimum because of excessive aggregation, so it has the ability to continue exploration.

IV. Conclusions

Computer 3D animation is an important field of computer application at present. In recent years, the simulation of virtual character group movement has gradually become a hot research topic, a hot spot in computer graphics, and always a difficult problem in computer animation creation. Because of the universal existence of group movements in the real world, it is becoming more and more important to simulate group movements in computer animation. For example, using group animation technology to simulate disaster scenes can not only replace the performance of real actors, but also reduce the shooting cost, and the most important thing is to greatly improve the shooting safety. In this paper, PSO algorithm is applied to group animation, and the particle with the best fitness value in the particle field of view is selected as the global extremum of this iteration, and the problems that may be encountered in real environment such as obstacle avoidance and collision avoidance are also considered, thus simulating group animation more truly. In the improved algorithm, the information of the particle with the optimal fitness value in all particles is used as the required extreme value of iteration, which actually adopts a highly connected topological structure to make the particle converge as soon as possible and increase the probability of finding the optimal solution.

References

[1] Ma B. Animation Production Teaching Model based on Design-Oriented Learning. International Journal of Emerging Technologies in Learning (iJET), vol. 13, no. 8, pp. 172, 2018.

[2] Ni N. Application of intelligent optimization algorithm on group animation design. Revista de la Facultad de Ingenieria, vol. 32, no. 8, pp. 694-699, 2017.

[3] Sun J, Lu D, Liu L, et al. A Visual Disparity Adjustment Method for Stereoscopic 3D Animation Production. Journal of Computer-Aided Design and Computer Graphics, vol. 29, no. 7, pp. 1245-1255, 2017.

[4] Braga P, Silveira I F. SLAP: Storyboard Language for Animation Programming. IEEE Latin America Transactions, vol. 14, no. 12, pp. 4821-4826, 2017.

[5] Yang J, Yang S. Application of 3D Reality Technology Combined with CAD in Animation Modeling Design. Computer-Aided Design and Applications, vol. 18, no. 3, pp. 164-175, 2020.

[6] Wang Q, Ji X. Research on the 3d animation design and model simulation optimization based on multimedia technology. Boletin Tecnico/Technical Bulletin, vol. 55, no. 6, pp. 541-547, 2017.

[7] Zhu S, Wang J. Computer-aided 3D ethnic art animation design and based on maya software. Boletin Tecnico/Technical Bulletin, vol. 55, no. 4, pp. 500-506, 2017.

[8] Tian Y, Li Y, Pan L, et al. Research on group animation design technology based on artificial fish swarm algorithm. Journal of Intelligent and Fuzzy Systems, vol. 38, no. 2, pp. 1-9, 2019.

[9] Yin L. Design and implementation of digital ink animation based on decorative style. Paper Asia, vol. 2, no. 2, pp. 6-12, 2019.

[10] Chen H. Research on the application of digital media art in animation control based on Maya MEL language. Acta Technica CSAV (Ceskoslovensk Akademie Ved), vol. 62, no. 1, pp. 499-507, 2017.

[11] Cui X, Diao J, Liu Y. Study on the three dimensional animation creation based on digital technology and multimedia simulation. Revista de la Facultad de Ingenieria, vol. 32, no. 3, pp. 65-72, 2017.

[12] Teng M. Research on the application of computer digital technology in 2D animation design. Revista de la Facultad de Ingenieria, vol. 32, no. 5, pp. 714-722, 2017.

[13] Abdrashitov R, Jacobson A, Singh K. A System for Efficient 3D Printed Stop-motion Face Animation. ACM Transactions on Graphics, vol. 39, no. 1, pp. 1-11, 2019.