Computer-Aided Semi-Automatic Generation Method of Animation Image and Text Split Mirror

Xiaoyu Liu[1] and Deng Pan[2*]

[1]Tianjin Tuanbo Newcity Boxueyuan, Tianjin Ren'ai College, Tianjin 301636, China, liuxiaoyu62007@163.com
[2]Tianjin Tuanbo Newcity Boxueyuan, Tianjin Ren'ai College, Tianjin 301636, China, cgpanda@163.com

Corresponding author: Deng Pan, cgpanda@163.com

Abstract. This article establishes the basic framework of time and motion in animation, analyzes and defines the elements of virtual assembly animation in detail, gives the conceptual model of the assembly sub-shot script and the corresponding script information storage method, and uses the C++ programming platform to develop an assembly animation modeling system based on a split-shot script is developed. From the characteristics of the story text and the need to identify unregistered words in the plot extraction work, the paper proposes a classification-based extraction method of story elements and implements it. By studying the requirements of structured scripts in practical applications, a two-level script model is proposed, one for the internal representation of the system, and one for mapping the internal representation into a structured script. Then it developed assembly animation drive technology based on the conceptual model of the split-shot script, combined with the key issues of virtual assembly, they made a clear analysis of skeletal animation, collision detection and human-computer interaction, and realized the functions of virtual display, automatic assembly animation and interactive teaching assembly animation. Module construction provides technical support for the completion of virtual assembly animation. An open programming environment was used to integrate the system framework and functional modules, a user-friendly and flexible operation interface was designed, and a prototype of a virtual assembly animation system with a split-shot script as the core was constructed and realized. In addition, an example of the engine assembly model is used to illustrate the details of each function of the system prototype. The rapid and effective generation of the split-lens assembly animation solution supports the development of split-lens script modeling technology and corresponding animation-driven development ideas, and it proves the feasibility and practicality of the application of split-lens script technology in the field of virtual assembly technology.

Keywords: Computer aided; animation; image and text splitting; semi-automatic generation
DOI: https://doi.org/10.14733/cadaps.2022.S3.85-96

1 INTRODUCTION

With the rapid development of computer graphics and hardware technology, the application of computer technology to the production of cartoons, a large number of computer animation drawing aids have appeared, which greatly reduces the burden on painters and improves the production efficiency [1]. In the computer animation production auxiliary tool, the production staff first use the modeling tool to make the three-dimensional modeling of each character in the cartoon, and then give the key status and movement trajectory of the character, the trajectory of the camera and the shooting center, the position and brightness of the light source, etc. These parameters are finally calculated by the animation generating part to generate a continuous picture [2]. Therefore, artificial intelligence-based computer animation automatic generation technology has attracted more and more attention. It mainly starts from the animation design and production process, and studies the script written in natural language to the final animation realization process aiming to improve animation production and the degree of automation and intelligence. In the production process of traditional cartoons, the screenwriter first writes a literary script. After the director obtains the literary script, he analyzes and forms the director's idea. On this basis, he determines the role model and creates a sub-shot script. Then, the painter draws out the characters in the film, and breaks down each action according to the requirements of the sub-scene script, draws and shoots each frame one by one, and finally shows the animation we have seen in succession [3].

Aiming at the large workload of character action pose creation in traditional cartoon animation production, this paper proposes a computer-assisted cartoon character pose editing and interpolation method, and strives to provide animators with efficient creation tools. In this article, we propose two types of computer-aided methods: one is cartoon character manipulation. Using this type of method, the user only needs to simply drag the mouse to design the desired cartoon character's action posture. The other is the interpolation of the key posture of the cartoon character. This type of method can automatically establish the key action posture of the cartoon character. The feature correspondence relationship and interpolation generates smooth transition poses between adjacent key poses. Aiming at the problem that the result obtained by using the above operation method may be inconsistent with the geometric topology of the cartoon character, a cartoon character operation method considering the topology structure is proposed. This method retains the main advantages of the above method: the overall and local hardness is adjustable and real-time interaction, and effectively avoids the unnatural character operation results that the above method may produce. Its development can promote the further development of various related disciplines and research. It also makes outstanding contributions to the field of education, entertainment, and transaction processing.

2 RELATED STUDIES

In terms of feature correspondence, Lee et al. [4] assumed that the edge of the shape is a steel wire with bending and stretching physical properties, and based on the shape's vertex angle and side length, it defined the stretch and bending of one steel wire to another steel wire. The work to be done and the vertices between the shapes are automatically corresponded through the dynamic programming method, so that the sum of the work required to stretch and bend the steel wire connected to the corresponding vertices is minimized. Lai et al. [5] define a triangle according to the two adjacent sides of each vertex of the shape, and automatically corresponds to the vertices of the source and target shapes based on the similarity between the triangles. The above methods only

establish the vertex correspondence between the source and target shapes based on the local geometric properties of the shape (such as side length, angle, triangle area, etc.), ignoring the characteristics of the shape, and it is often difficult to obtain satisfactory corresponding results. Therefore, they first detect the geometric protruding points on the shape (such as sharp points, inflection points, etc.), and divide the shape into multiple visually significant features; then we use principal component analysis technology to define the feature similarity measurement function to complete the feature correspondence between the shapes. Aiming at the possible ambiguity of the feature, Tenginakai et al. [6] proposed a more robust feature similarity measurement function to improve the accuracy of the corresponding algorithm. However, in practical applications, this type of method is greatly affected by the detected visual saliency points, and the corresponding results will be uncertain.

In response to the above-mentioned problems, this paper proposes an user-inspired semi-automatic feature correspondence method. In terms of path interpolation, simple linear interpolation methods tend to shrink and distort the shape. Bornik et al. [7] proposed an interpolation method based on the intrinsic properties of the corners, which can effectively reduce or avoid the shrinkage of the shape. However, it only considers the boundary of the shape, not the inside of the shape, and it is difficult to ensure that no distortion occurs in the shape during the interpolation process. Therefore, some scholars consider the interior of the input shape to perform isomorphic star convex decomposition, and interpolate the polar coordinates of the corresponding star convex shape to obtain the intermediate shape. This method can effectively maintain the area of the shape. Yang et al. [8] performed isomorphic triangular decomposition on the interior of the input shape to avoid the possible ambiguity of the isomorphic star convex decomposition within the shape, thereby improving the robustness of the algorithm. However, both isomorphic stellar convex decomposition and isomorphic triangulation decomposition require high computational consumption. In addition, the existing algorithms can only perform effective isomorphic star convex decomposition or isomorphic triangulation for simple non-self-intersecting closed polygons to extend it to general arbitrary shapes is still a challenging research topic.

In recent years, the shape interpolation method based on multi-resolution representation has attracted more attention from researchers. These methods decompose each shape into a basic shape and several layers of details, and respectively interpolate the corresponding base shape and each layer of details to reconstruct the intermediate shape. According to different application requirements, the shape interpolation method based on multi-resolution representation can achieve the best balance between interpolation efficiency and quality [9]. Similarly, Wang et al. [10] proposed a shape interpolation method based on hierarchical representation, decomposing the source shape and the target shape into a pair of frame polygons and several pairs of features. They use the approximate rigidity-preserving interpolation method and the linear interpolation method (or the corner interpolation method) to interpolate the corresponding frame polygons and features, respectively, which will produce the smooth shape transition sequence with the detail preservation [11]. However, in practical applications, the shape features are generally curved, and it is difficult to use a polygonal edge to express its local orientation. Therefore, this method is easy to produce visually unrealistic feature transition effects. The shape interpolation method based on the multi-level feature structure proposed in this paper uses a curved curve axis to represent the local orientation of each feature; by interpolating the corresponding curve axis, a visually true shape feature transition result is produced.

3 CONSTRUCTION OF SEMI-AUTOMATIC GENERATION MODEL BASED ON COMPUTER-AIDED ANIMATION IMAGE-TEXT SPLITTING

3.1 Computer-Aided Assembly Level

The pixel comparison method (also called template matching method) is to estimate the difference in brightness or chromaticity of corresponding pixels between two consecutive frames. The simplest

method is to calculate the sum of the absolute values of the differences between pixels and compare it with the threshold value. There are two ways to set the threshold. One is to manually select the best value after a large number of video material experiments, and the other is to add an automatic threshold estimation algorithm to the program to let the computer automatically set the value according to the video content. Figure 1 shows the computer-aided assembly hierarchy.

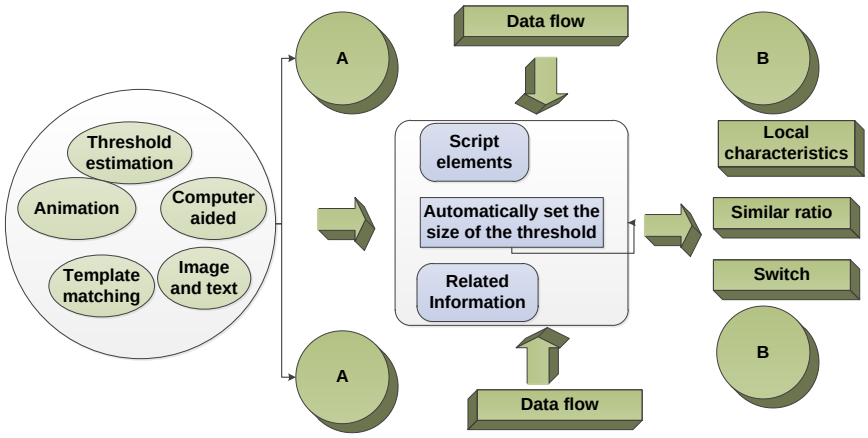

Figure 1: Computer-aided assembly hierarchy.

$$p=\{p1, p2,..., p-i\},(i=1,2,...,n) \tag{1}$$

The i and i+1 are two consecutive frames with the size of X*Y, Pi(x,y) is the brightness value of point (x,y), if the difference between the two frames D(i,i+1) is greater than the domain value. If T is large, it is assumed to be a lens switch. The main disadvantage of this method is that it cannot distinguish between large changes in a small area or small changes in a large area. Therefore, it is very sensitive to the movement of the object and the camera based on the simple comparison method.

$$\mathrm{u}(i,j)=\sum\sum|\, pi(x,y)-pj(x,y)\,|/x*y \tag{2}$$

Compared with the template matching method based on global image characteristics, the block-based comparison method uses local characteristics to improve the robustness to object and camera motion. The image is divided into a sequence of blocks, and the similarity ratios of the corresponding blocks of the i and i+1 frames are calculated.

$$t(k)=[m(i)+m(j)+(n(i)+n(j))\wedge 2]\wedge 2/m(i)*m(j) \tag{3}$$

Then find the number of blocks whose similarity ratio value is greater than the threshold value T. When the number of changed blocks is large enough, it is assumed that a switch occurs between the two frames. Compared with template matching, this method has a certain tolerance to the slow motion of small objects between two frames.

$$v(i)=\sum|\, u(i,t+1)-u(i,t)\,| \tag{4}$$

$$f(i)=\sum|\, u(i,t+1)-u(i,t)\,|\wedge 2/(u(i)+u(j)) \tag{5}$$

The global histogram comparison method is to compare the sum of the absolute value of the histogram difference of two consecutive frames. If it is greater than the threshold value T, it is assumed to be switched. The formula is as follows:

$$g(i)=\sum \min|u(i,t+1),u(i,t)|/\max|u(i,t+1),u(i,t)| \tag{6}$$

The t and t+1 are two consecutive frames of images, and j represents the j gray level. In order to enhance the difference between two consecutive frames when switching, a histogram variant detection method is called a2 detection method.

3.2 Animation Image and Text Splitting Algorithm

In the extraction of script elements, our goal is to obtain a series of text-related information through preprocessing, lexical and syntactic analysis of the story text, and use this information to filter out what we are interested in. Figure 2 shows the selection process of the animation image splitting algorithm. This screening process can essentially be regarded as a binary classification problem. The goal of classification is to judge whether a word or phrase is the script element we want to extract. Classification technology is a systematic method for establishing classification models based on input data. The assembly-related information of this module comes from the editing of the component elements of the assembly animation by the split-shot script modeling system, adding special effects such as light effects, sounds, and subtitles, and using algorithms such as collision detection, skeletal animation, and advanced shading language to drive this information to save and generate avi format video. The most commonly used methods include nearest neighbor classification, naive Bayes classification, decision tree classification, and support vector machines.

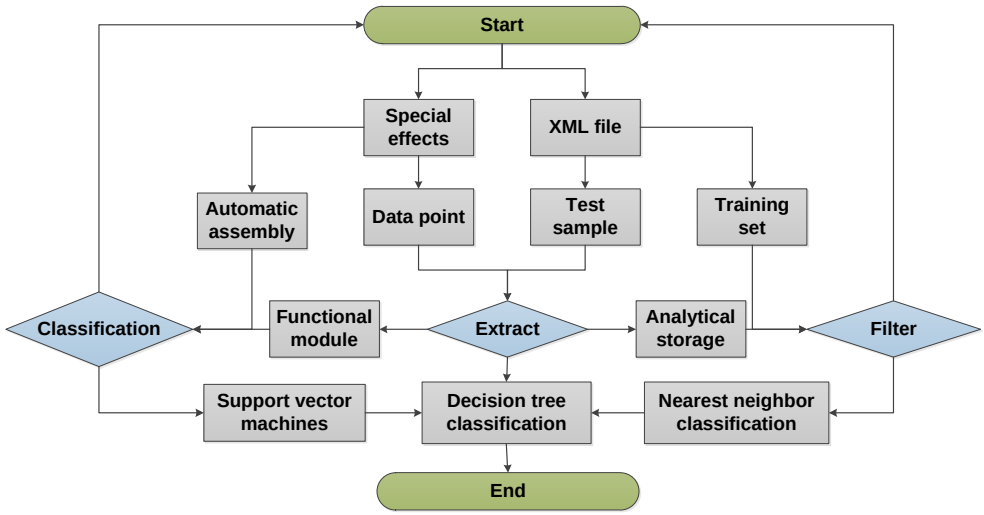

Figure 2: Animated image splitting algorithm flow.

The nearest neighbor classifier treats each example as a data point in a d-dimensional space, where d is the number of attributes. Given a test example, test the distance between the example and other data points in the training set. Select the k nearest data points to the given sample z.

$$y(x)=\int\int dist(x,u(x))dS \tag{7}$$

Once the nearest neighbor list is obtained, the test sample is classified according to the majority of the nearest neighbor classes and enters the automatic assembly module. The automatic assembly module is the most important functional module. The automatic assembly module realizes the automatic assembly animation of assembly parts in the XNA virtual environment by parsing the XML file that stores the sub-scene script information. This module uses majority voting to make each

neighbor have the same impact on classification, which makes the algorithm very sensitive to the choice of k. One way to reduce the influence of k is to weight it according to the distance between sample z and each nearest neighbor. As a result, training samples far away from sample z have a weaker impact on classification than training examples near z. we divide the data set into k disjoint data subsets with roughly the same size.

$$h(x) = \sum y(i) * t(i) / \sum t(i) \tag{8}$$

The learner performs k times of training and testing; each time the learner uses the remaining data except one subset as the training set, and the removed subsets are regarded as the test set to take the average of k times accuracy rate as the evaluation accuracy rate. This evaluation method makes full use of all data for learning, and is especially effective when the amount of data is insufficient.

3.3 Semi-Automatic Model Parameter Optimization

Most of the videos are compressed and stored in the MPEG format, so the video segmentation method based on the compression domain is becoming more and more important. Analyzing the compressed code stream of the video directly, and detecting the change of the lens has many advantages: first, there is no need to decompress, reduce computational complexity, and save decompression time and storage space after decompression; second, because of compressed video, the bit rate is lower than that of uncompressed video, so the processing speed is faster: third, the encoded video stream already contains a wealth of pre-calculated features, which are very suitable for video segmentation. The types of information used in lens change detection are roughly: DCI coefficients, DC component, macroblock coding methods and motion vectors, etc.

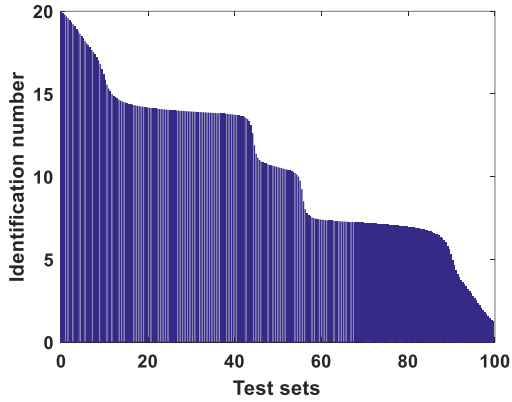

Figure 3: Animated text recognition histogram distribution under different test sets.

Story character names and prop names generally appear more frequently in the story text (here "higher" means more than once). Its distribution is divided into two situations: one is high frequency in the whole text, and the other is only high frequency in local areas. Based on this phenomenon, we adopted the characteristics of the recognition rate for screening. For the story text that has been segmented and annotated, we calculate the TF-IDF value of each word in the text and the recognition rate value in the paragraph where it is located. It can be seen from the definition that if a word appears in adjacent paragraphs, the recognition rate value of the word in these paragraphs is the same, and there is no need to repeat calculations. The experiment selects the appropriate threshold value by observing the calculation results. Figure 3 shows the calculation results, namely the columnar distribution of animated text recognition under different test sets. The data select words whose recognition rate value exceeds the specified threshold or the recognition rate value exceeds the specified threshold as candidate words. Since the plot of the children's story is relatively simple,

we use the reference resolution based on the recent precursor. According to the type of pronouns, it can be judged whether the object referred to is a person (role) or an object (props), whether the object's gender is male or female, and whether it is a group or an individual (singular and plural). Based on this information, we look for the characters in test sets that have appeared recently, singular, plural, gender, and other information in the previous article.

4 APPLICATION AND ANALYSIS OF SEMI-AUTOMATIC GENERATION MODEL OF ANIMATION GRAPHICS AND TEXT BASED ON COMPUTER AID

4.1 Model Information Preprocessing

Since the input of this system is a group of cartoon animation video sequences, the prerequisite for judging lens features is to perform accurate lens segmentation on the video sequence. After considering the comprehensive factors of detection efficiency and detection accuracy, the system mainly adopts the lens segmentation method based on histogram comparison, and has done a lot of experiments, and found a relatively stable similarity threshold. By finding the key frame of the sudden change of the shot, and then performing the shot segmentation, the main idea of the feature-based method is to extract the feature points of the adjacent key frames of the shots in the group, and establish the matching information of the corresponding feature points, and judge the motion mode of the shot through the vector information formed by the matching feature points. The key of the algorithm is the matching of feature points. We first realized the feature matching based on corner points. The experimental results show that this method can only accurately judge part of the lens movement, and the effect of the lens movement with push and pull is not very ideal.

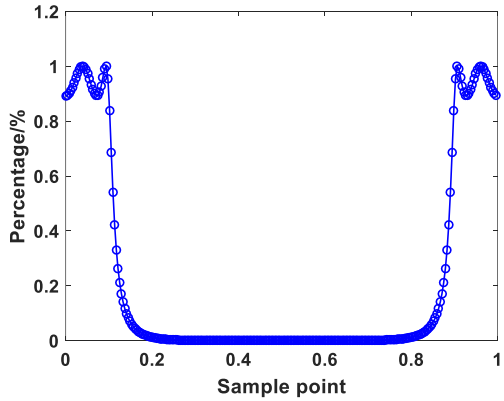

Figure 4: Matching rate curve of feature points of animated lens.

In the experiment, we adopted a cross-validation method to divide the data set into two parts, a training set and a test set, to calculate the matching rate of feature points. Figure 4 shows the matching rate curve of the feature points of the animated lens. Usually the training set contains two-thirds of the initial data set, and the remaining one-third are used as the test data set. The learner uses the training set data to construct a classifier, and then uses this classifier to classify the test set, and the error rate obtained is the evaluation error rate. The advantage of this method is that it is fast, but because it only uses the training set data to construct the classifier, it does not make full use of all the data for learning. If all the data are used, a more accurate classifier may be constructed. We divide the story into five subsets, four of which are 111 and one is 110. Each time 4 subsets are used as the training set, and the remaining one is used as the test set. The statistics of the experimental results are shown in the figure. By introducing local word frequency information, the recall rate of character name extraction is improved. However, there are some special cases where

local word frequency information can introduce noise: some children's stories are very short, with only one or two sentences per paragraph, which causes the recognition rate value of the translation candidates of these texts to be too high. The training has a certain impact. In the experiment, it was found that the story text contained a small number of prop names that appeared only once, and the word frequency method could not be used to extract these elements, resulting in a lower recall rate of prop name extraction. The syntactic structure information is helpful to identify the name of the item on page of this part, but at the same time it will greatly increase the time cost of the system, and introduce a large number of wrong extraction results, reducing the accuracy rate.

4.2 Split Shot Animation Simulation

This article first preprocesses the product model information for the virtual environment. Using the Pro/Engineer secondary development tool Pro/toolkit to realize the extraction of basic information of the model and the extraction of assembly information. Through the transformation of the three-dimensional model surface, the information bridge between the CAD system and the virtual environment system is established, which is the next scenario for the scenes. Modeling and assembly animation generation has laid the data foundation. The script element extraction is mainly divided into three steps: text preprocessing, candidate selection and script element identification. First, we use the introduced unregistered word recognition method and ICTCLAS2009 word segmentation tool to preprocess the story text, then use the word frequency and other information to extract candidates from the word segmentation results, and finally use the classifier combined with the rule method to identify the candidates, and finally get the script element set.

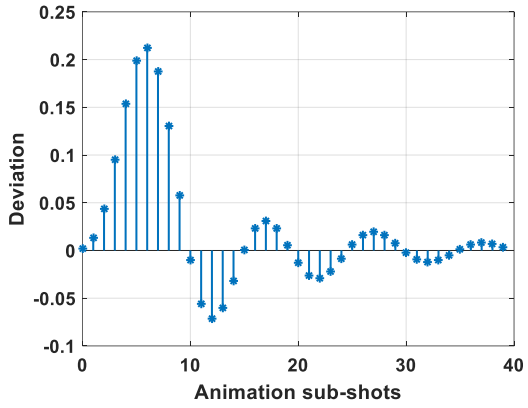

Figure 5: Statistics of image pixel gray difference deviation.

The first step of the feature-based method is to extract some feature points on the video screen. We can get different feature points by definition without asking, such as points with sufficiently high curvature on the image boundary, and points with obvious curvature changes on the image boundary. They are the points where the direction of the image boundary changes discontinuously and the points where the gradient value and the gradient change rate are very high in the image, and so on. From the perspective of calculation, the number of feature points is better. After experiments, it is found that the reference corner extraction algorithm has the characteristics of simple implementation, relatively accurate feature location, strong anti-noise ability, and the number of corner extractions is moderate. Figure 5 shows the statistics of image pixel gray difference deviation. It can be seen from this that each effective motion vector is compared with the unit vectors in eight directions, and the number of motion vectors in each direction j is calculated.

The basic idea of the method based on the optical flow field is to establish the optical flow field for two key frames in the lens, and then determine the specific motion mode of the lens through the

optical flow field information graph. If the number of motion vectors calculated in a certain direction is the largest, and the number in the second multi-direction is more than twice as large, this frame represents movement in this direction. Through the statistics of the motion vector, the motion lens of the camera can be distinguished to avoid misjudgment. We scan the input image with a W*W template, compare the gray value of each pixel in the template with the center pixel, and give a threshold to judge whether the pixel belongs to use the template to move on the image. If the difference between the gray level of the pixel in the template and the gray level of the center pixel of the template is less than a certain threshold, it is considered that the point and the nucleus have the same or similar gray level.

4.3 Example Application and Analysis

We conducted an experiment of extracting unregistered words from 174 Chinese children's story texts, including 160 of "Andersen's Fairy Tales". The length of these stories is between a few hundred to tens of thousands of words, and there are big differences in terms and writing habits. In the experiment, considering the length of the story text and other factors, the threshold of the high-frequency string is set to 2 in the experiment to ensure the recall rate; through statistical observation of the experimental results, the threshold of the internal combination of the string based on mutual information is finally set to 4.9. The extraction results obtained 143 unregistered words, of which 131 were correct, and the correct rate was 91.7%. Given the small size of children's stories and insufficient information, this result has been very satisfactory. Some sampling results are listed in the figure.

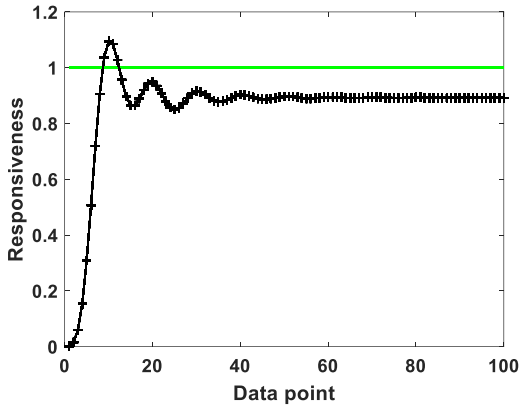

Figure 6: Animated text response fitting curve of different sample points.

The shortest responsivity, the longest responsivity and the average responsivity of a pair of shape features are respectively counted. Using the completely manual interaction method, they are 0.73, 0.207, and 0.142, respectively; while using the user-inspired semi-automatic feature correspondence method, they are 0.20, 0.53, and 0.41, respectively. Figure 6 shows the animated text responsivity fit curve for different sample points. The results show that the method in this paper effectively reduces the user's interaction time. In addition, through experimental feedback, every tester thinks that the method in this paper is more intuitive and simple to use, and the test strongly proves its efficiency and practicability. The shape gradient algorithm based on the multi-level feature structure produces a shape gradient result comparable to the rigidity-preserving interpolation method. However, the rigidity-preserving interpolation method considers the interior of the shape through the i-angle grid, and requires the source and target shapes to be isomorphic i cornerization, so it is only suitable for simple non-self-intersecting closed polygons, but this method has no such limitation. In addition, the efficiency of this method is much higher than the rigidity-preserving

interpolation method. For example, the rigidity-preserving interpolation method takes an extra 2086 ms for isomorphic triangulation, and the interpolation frame rate is 156 frames/s (the method in this paper is 568 frames/s).

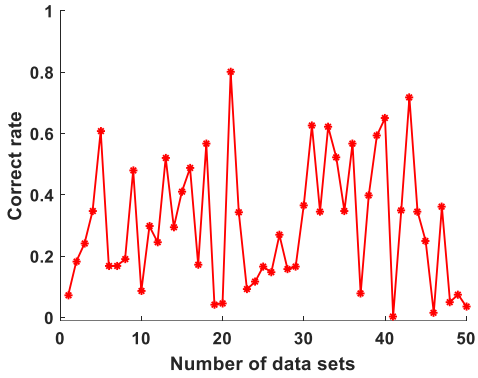

Figure 7: The test line chart of the animated image after interpolation processing.

In addition, through the analysis of experimental results, it is found that the use of mutual information-based spam string filtering enables some low-frequency unregistered words to get higher correct rate, which is of great help in solving the problem of data sparseness caused by the length of the story. However, it also caused some high-frequency unregistered words to have low correct rate, which could not reflect the reference role of word frequency in screening. Figure 7 shows the test line chart after the interpolation processing of the animated image. Each experimental result figure shows the test situation of the key frame image and its corner points connected by the smallest path after the image interpolation processing, and the vector scene established by the corresponding corner points of the two frames is marked on the last picture.

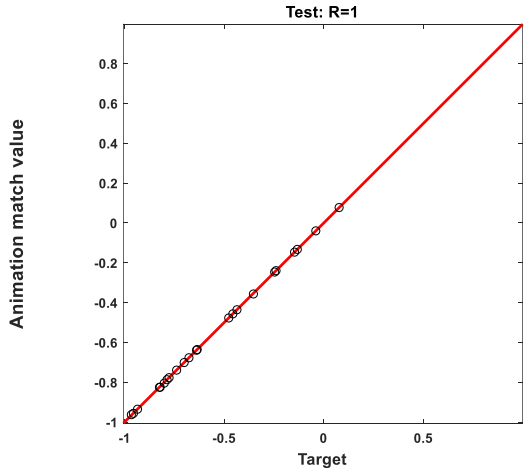

Figure 8: Data fitting situation of animated lens displacement vector.

Among them, the black circle displayed on the cross coordinates of each group of pictures represents the weighted average vector of the vector established by all matching corners, which can reflect the motion information of the lens. Figure 8 shows the data fitting of the animated lens displacement

vector. For example, when the lens is shifted, the weighted average vector should coincide with the horizontal axis of the coordinate. When the lens is tilted, the weighted average vector should coincide with the vertical axis of the coordinate. When the lens is tilted, the weighted average vector is a vector that is consistent with the direction of lens movement. When the lens is pushed or pulled, the size of the weighted average vector should be 0, that is, it is located at the origin of the coordinate. Among them, the two-frame matching picture has a small lens movement, only a few pixels, so the corresponding vector size in the cross coordinate is also small.

5 CONCLUSION

This paper first proposes a planar polygon feature correspondence algorithm, which can automatically complete the feature matching between two polygons efficiently and robustly. Based on this, we can semi-automatically establish the feature correspondence between two key poses with complex geometric structures. We propose a fast two-level hierarchical path interpolation method to interpolate the key poses of cartoon characters. This method is not only suitable for the key poses of characters represented by polygons, but also for the key poses of complex characters described by multiple closed or open curves that are separated, connected or covered with each other. In the interpolation process, this method can effectively maintain the feature details on key poses and the relative position relationship between features. We use the related content of artificial intelligence to assist the animation director to complete the production of a simple animation, which involves some planning of the routine animation production process, such as scene planning and photography planning (including cameras and lights). We will qualitatively quantify the specific information of each sub-shot we need through the user's settings for the animation (mainly the scene and the description of the sub-shot plot), and then generate the script code through the sub-shot planning (Maya C++ combination), and finally call a series of classes (weather, camera...) written by API in Maya to produce animation effects. The algorithm constructs a multi-level feature structure of the source and target shapes, then interpolates the feature information at different levels respectively, and reconstructs the final intermediate shape. Compared with the existing interpolation methods, the method in this paper is simple and efficient. Effectively it avoids the internal distortion of the shape. The local characteristics of the shape are maintained, and a smooth, natural and visually realistic shape gradual change sequence is produced.

Xiaoyu Liu, https://orcid.org/0000-0001-7629-4955
Deng Pan, https://orcid.org/0000-0003-1917-8784

REFERENCES

[1] Juan, C.-N.; Bodenheimer, B.: Re-using traditional animation: methods for semi-automatic segmentation and inbetweening, Eurographics symposium on Computer animation, 12, 2020, 223-232. https://doi.org/10.1145/1218064.1218095
[2] Yu, J.; Tao, D.; Wang, M.: Semi-automatic cartoon generation by motion planning, Multimedia systems, 17(5), 2018, 409-419. https://doi.org//10.1007/s00530-010-0225-6
[3] Huijsmans, D.-P.; Lamers, W.-H.; Los, J.-A.: Toward computerized morphometric facilities: A review of 58 software packages for computer - aided three - dimensional reconstruction, quantification, and picture generation from parallel serial sections, The Anatomical Record, 216(4), 2019, 449-470. https://doi.org/10.1002/ar.1092160402
[4] Lee, Y.-S.; Shamir, A.: Mesh scissoring with minima rule and part salience, Computer Aided Geometric Design, 22(5), 2019, 444-465. https://doi.org/10.1016/j.cagd.2005.04.002
[5] Lai, Y.-K.; Hu, S.-M.; Martin, R.-R.: Automatic and topology-preserving gradient mesh generation for image vectorization, ACM Transactions on Graphics (TOG), 28(3), 2019, 1-8. https://doi.org/10.1145/1531326.1531391

[6] Tenginakai, S.-J.; Machiraju, R.: Salient iso-surface detection with model-independent statistical signatures, Proceedings Visualization, 2, 2020, 231-238. https://doi.org/10.1109/VISUAL.2001.964516
[7] Bornik, A.; Urschler, M.; Schmalstieg, D.: Integrated computer-aided forensic case analysis, presentation, and documentation based on multimodal 3D data, Forensic science international, 287, 2018, 12-24. https://doi.org/10.1016/j.forsciint.2018.03.031
[8] Yang, W.: Context-aware computer aided inbetweening, IEEE transactions on visualization and computer graphics, 24(2), 2017, 1049-1062. https://doi.org/10.1109/TVCG.2017.2657511
[9] Madeira, J.-S.; Stork, A.: An approach to computer-supported cartooning, The Visual Computer, 12(1), 2019, 1-17. https://doi.org/10.1007/BF01782215
[10] Wang, C.-L.; Wang, Y.: Feature based 3D garment design through 2D sketches, Computer-Aided Design, 35(7), 2020, 659-672. https://doi.org/10.1016/S0010-4485(02)00091-X
[11] Min, J.; Chen, Y.-L; Chai, J.: Interactive generation of human animation with deformable motion models, ACM Transactions on Graphics (TOG), 29(1), 2019, 1-12. https://doi.org/10.1145/1640443.16404529-329