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Comparative Analysis of 3D Tools Suitable for the Rotoscoping Cell Animation Production Process

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Abstract

Recently, case presentations using AI functions such as ChatGPT are increasing in many industrial fields. As AI-based results emerge even in the areas of images and videos, traditional animation production tools are in need of significant changes. Unreal Engine is the tool that adapts most quickly to these changes, proposing a new animation production workflow by integrating tools such as Metahuman and Marvelous Designer. Working with realistic metahumans allows for the production of realistic and natural movements, such as those captured through motion capture data. Implementing this approach presents many challenges for production tools that adhere to traditional methods. In this study, we investigated the differences between the cell animation workflow and the computer graphics animation production workflow. We compared and analyzed whether these differences could be reduced by creating sample movements using character rigs in Maya and Cascadeur tools. Our results showed that a similar cell animation workflow could be constructed using the Cascadeur tool. To improve the accuracy of our conclusions, we created large, action-packed short animations to demonstrate and validate our findings.

Keywords: *Animation Production, Cascadeur, Maya, Unreal Engine, Character Animation*

1. Introduction

In the 1990s, a tool called Soft Image was mainly used to produce character animation or animation for movies. Later, Alias, headquartered in Canada, merged with a company called Wavefront and developed software that combined the strengths of Alias' 'PowerAnimator', Explore's 'Explore Professional', and Wavefront's 'Advanced Visualiser'. And 3D animation software ‘Maya’ was released in 1998 [1]. Afterwards, the number of ‘Maya’ users gradually expanded, and it became established as mainstream software in the 2000s. Starting with ‘Maya 7.0’, motion capture data processing became possible, and the Fullbody IK (Inverse Kinematic) function in the motion capture software called ‘MotionBuilder’ was applied. Over the next 15 years, it can be seen that the character animation process has been largely dependent on the capabilities of the worker rather than on functional changes that could bring about significant changes. On the other hand, the market is changing rapidly. First, post-production companies that require many employees are continuously decreasing

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in size, but the quality of results demanded by clients is relatively increasing. Second, media such as 'YouTube' and 'TikTok' require a production environment that can produce quickly. Third, production cases using markerless motion capture or AI are gradually emerging for the efficient production of digital actors.

In the industry, there are still many places that adopt Maya software as their mainstay in the field of character animation. In creating traditional keyframe animation, being able to create detailed animation movements using the graph editor window is the biggest advantage. Using animation layers and Fullbody IK, the Human-IK (HIK) window can easily modify motion capture data and accurately retarget characters of different sizes and shapes. However, from the perspective of teaching students, today's students want to achieve easier, faster, and higher results than students of the past. Maya's complex and difficult control-requiring processes are causing users to turn away and give up, so it appears that a more efficient process should be presented in the character animation production process.

While keyframe animation, a traditional production method, is a process of creating something from nothing, motion capture animating is a process of modifying data from captured data without creating every each pose. Because these two processes have opposite approaches, they have been difficult to integrate into the production process. However, in the case of cell animation, there have been situations in the past where the two processes coexist. This is a production method using rotoscoping. Rotoscoping animation, which started with the Fleischer brothers who produced animations such as Betty Boop, has been used in Disney's animation along with traditional exaggerated character animation created through the 12 principles of animation [2]. In cell animation, it is easy to modify or add pictures, so there is no major difficulty in fusing the two processes, but in 3D, factors such as gimbal lock when the character rotates or changes in the joint that serves as the axis of rotation. It is said that this is one of the reasons why it is difficult to use [4].

Figure 1 is a drawing of Disney's '101 Dalmatians'. Although it is cell animation, we can see that the character's poses were created using rotoscoping based on live action images (a). It was also possible to produce exaggerated animations using traditional methods (b). In order to easily work with computer graphics (CG) animations featuring realistic characters, a production process similar to cell animation is required, but most existing tools have not been able to do this easily.

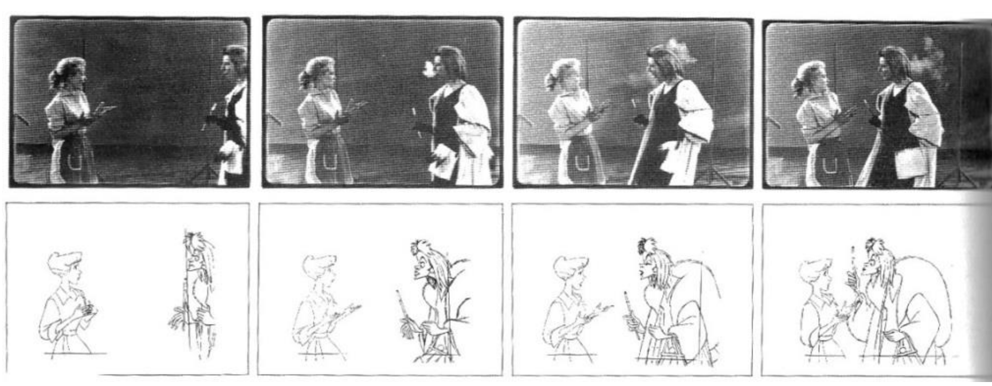


Figure 1. (a) Up: Live action, (b) Down: Drawing with Rotoscoping Technique [3]

Cascadeur software, launched in 2006, started with the advantage of being able to create movements and poses that can suggest appropriate movements for user-created characters using a functional engineering function called 'Auto Physics'. The fact that the rotation direction of the position can be easily modified due to the inserted motion is because the production method seems closer to cell animation than traditional 3D tools. With the advent of tools that enable new production processes, we attempted to find out the similarities with the cell animation production process compared to existing tools.

2. Experiments

Cell animation using the rotoscoping method can be said to be similar to the motion capture animation production method. In cell animation, keyframe and rotoscoping production methods have been easily used interchangeably as mentioned before, but this has not been the case in 3D animation. In existing CG character animation methods, keyframe animation and motion capture animation are still not commonly used together. The superficial reason is that the two types of animation have opposite approaches. Keyframe animation is a method of specifying key pose frames using a pose-to-pose method and specifying the timing of movements through time spacing, while motion capture animation involves modifying poses by adding an animation layer when keyframes are applied to all frames. It's a method. It can be said to be the opposite of the keyframe production method because the simpler the data, the more detailed movements disappear.

2.1 Comparison of rotation direction distortion of in-between poses

Keyframe animation sets poses at intervals of time. The computer automatically creates in-between poses between poses. As shown in the left picture of Table 1, in-between poses are created by using continuous curves to position the poses. The production process seems similar to cell animation at first, but differences soon become apparent. There are times when poses are added to In-Between, but movements appear completely different from what was intended. This mainly occurs when the character rotates, and when the curve exceeds 180, unintended movements occur. Maya provides various solutions to prevent this. A menu was created to allow the controller to use different rotation modes such as global, local, and parent gimbal, or to prevent the problem of changing the order of the rotation axis to xyz by considering the axis in the direction to be rotated. If gimbal lock occurs, we can correct it by converting the rotation value of the curve to Euler method in the graph editor, but if this does not work, we must correct it manually. In cell animation, if we draw and insert an in-between motion, the rotation direction appears to rotate in the desired direction, so the process is very easy, but in 3D animation, too much knowledge is required and a correction process is required. Table 1 shows the 360-degree rotation of Maya's HIK character. This is a movement that starts rotating from frame 0 and returns to its original position at frame 30. A total of 8 poses were created by rotating the character slightly counterclockwise. Looking at the eight poses created, it looks like the character rotates 360 degrees. However, in the graph editor window, the graph of rotate x does not appear to be rotated in one direction.

Table 1. 360 Degree rotate pose in Maya

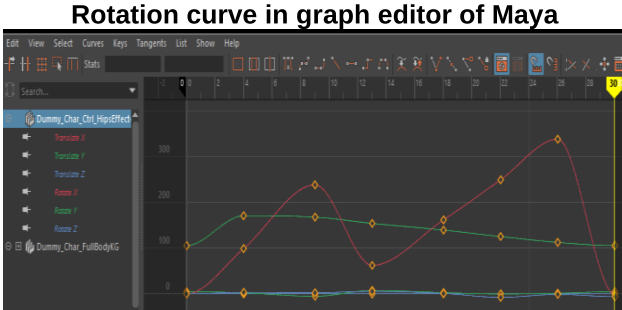
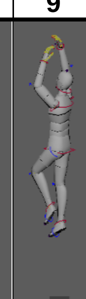
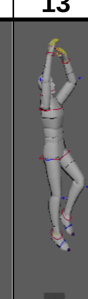
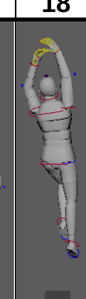
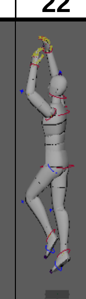
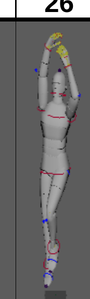
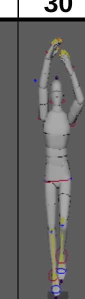
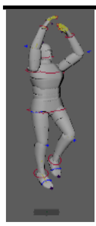
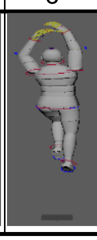
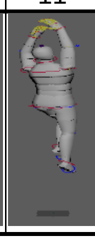
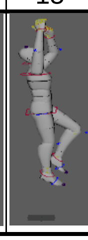
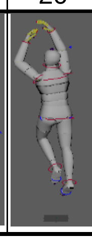
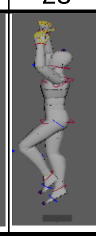
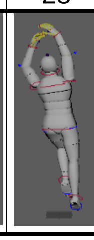
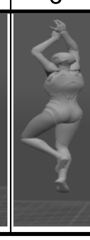
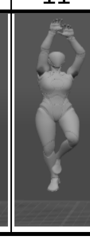
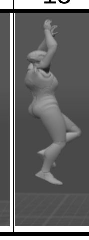
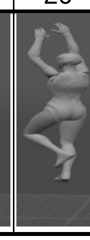
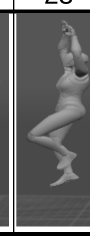
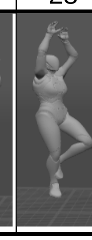
Rotation curve in graph editor of Maya	0	4	9	13	18	22	26	30
								

Table 2 shows the results of comparing the poses of each frame to see how the computer-generated intermediate movements appear in Maya and Cascadeur software. Two differences can be found. The first is that the poses of frames 11 and 28 are significantly different. In case of Maya, it was found to rotate in the opposite direction to the direction of X axis. Looking at the graph in Table 1, we can see that the X-axis rotation of the curve progressed in the opposite direction after frames 9 and 26. Even though the pose was clearly set by rotating the character slightly counterclockwise, the direction of progress changed as shown in the x-axis rotation curve in Table 1, and the in-between poses at frames 11 and 28 showed incorrect poses. In the case of Cascadeur, we can see that the poses of frames 11 and 28 were created exactly in the intermediate form between the front key pose and the back key pose.

Table 2. In between poses

In between frame pose in Maya							In between frame pose in Cascadeur						
1	6	11	15	20	23	28	2	6	11	15	20	23	28
													

The second difference is that the in-between poses shown in Maya are not upright but are slightly twisted. In the case of frame 28, it appeared to be tilted at an angle compared to the key pose at frame 30. In these cases, the rotation directions of the character were wrong due to the gimbal lock mentioned earlier. In this case, even if we create and insert additional poses, the in-between movements will not be resolved without solving the gimbal lock problem. On the other hand, looking at the in-between poses in the Cascadeur, we can see in Table 1 that the direction of the poses rotates in a counterclockwise direction. Cascadeur can be seen rotating in an unintended direction if there is too little rotation information in the in-between pose, but if there is a add pose that provides rotation direction information, it will rotate the character in the required direction. This is how it works. In cell animation, an intuitive work process is presented in the same way that a character progresses in the desired direction by additional drawings.

2.2. Comparison of Rotation Axis Pivot Settings for Rotation

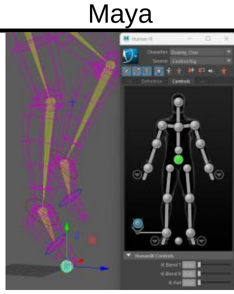
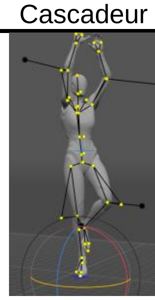
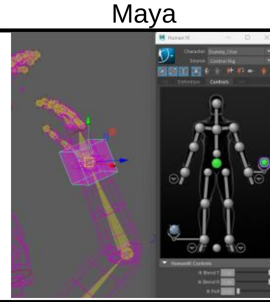
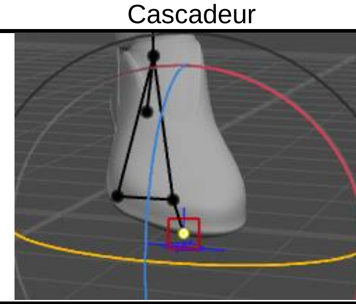
Maya software provides a HIK rigging and control window that allows easy modification and retargeting of motion capture data starting with Maya 7.0. The retargeting function that allows motion data to be applied to the shape of a custom character and the filter function that modifies mocap data still have advantages over other software. However, it does not show any attempts to deviate from the basic animation workflow.

In cell animation, to change the part on which the body's weight is carried from ankles to toes, simply draw as if the axis of rotation has been moved, so the operator only has to worry about the presentation. However, in 3D animation, difficult procedures are required to move the character's axis of rotation to areas such as the knees, elbows, and toes. In the case of Maya's HIK, we can create a Pivot effector by clicking RMB on the desired IK joint and moving the position of the rotation axis, as shown in the first image in Table 3. However, it only affects the parent joint of the pivot and is difficult to affect the entire body or the desired part. In other words, when the pivot is rotated, the ankle rotates around the pivot, but the entire body does not rotate. The second image in Table 3 shows changing the rotation axis in the Cascadeur. We can move the rotation axis to any IK joint in the body and easily set the area that requires rotation. If we select the desired body part and click RMB on the desired rotation axis joint, the rotation axis will be immediately moved, allowing we to move the rotation axis easily and intuitively.

2.3 Comparison of constraints for fixation

Depending on the situation, having a character's feet or hands fixed on the ground or an object is considered very important in expressing realism. Table 3 shows Maya supports constraint functions in several ways. If we look at the HIK Window, we can use IK joints for constrain, and also it provides a function to forcibly fix the joint by taking out an effector for each joint. On the other hand, looking at the Cascadeur character, it can be said to be very intuitive as it has no additional functions and all joints can be used to fix the joints simply and effectively.

Table 3. Comparison of rotation axis movement and constraint functions between tools

Rotation axis transformation of the tool		Tool's constraint function	
Maya	Cascadeur	Maya	Cascadeur
			

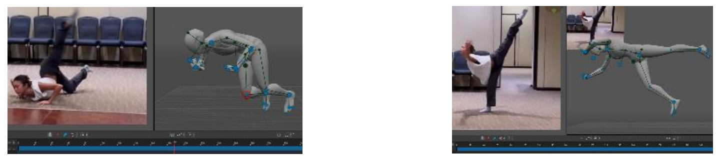
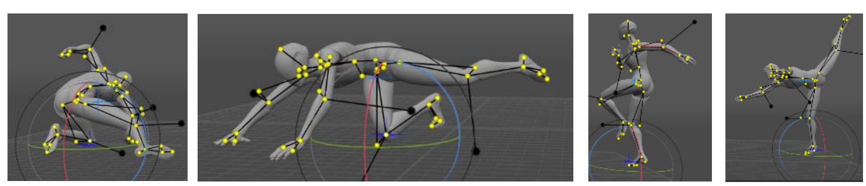
The existence of so many functions also means that it is not easy to control an object that must be repeatedly fixed and released. For example, in the case of HIK rigs, there is an advantage in fixing auxiliary effectors attached to the IK of the hand or foot. However, when using an auxiliary effector to fix joints such as elbows or knees, there may be a disadvantage in that the joints are not perfectly fixed. Additionally, when moving the animation clip of the control rig's animation data using an aux effector to FBX or a time editor window, the restraints may be released and the animation may change. In Cascadeur, simply select the desired joint and click the R key, as shown in the right image of Table 3. A red box is created, and we can easily fix and release the joint by turning it on/off. This is very simple, yet intuitive and shows easy and effective results.

2.4 Create animation clips

The easier the three functions mentioned above are applied, the closer we can get to the cell animation production process. To obtain more accurate results, we created a short movement. Using Cascadeur, an animation was created using rotoscoping using dance video clips with large rotations and poses, and the video was uploaded to YouTube [11].

The production process is the same as the workflow shown in Table 4. Using the reference video, we first extracted the approximate pose and timing using Cascadeur's 2D mocap function. When the character rotates, 2D mocap extraction has pose accuracy of less than 40% of the data. However, because we can find accurate timing in the data, we can reduce production time by finding keyframe timing in 2D mocap data and removing in-between frames. In the next step, modify the key poses and change the curve properties of the in-between section to Bezier clamp to check continuous in-between operation. And depending on the movement of the character's feet and hands, the mode of the in-between section is designated as IK or Forward Kinematic (FK).

Table 4. Character animation workflow using Cascadeur

Workflow	image
1.Import reference sequences and 2D mocap	
2. Key pose marking and in-between pose removal	
3. Modify key pose 4. In-between curve mode change and additional keyframe creation	
5.Detail production: Rotation axis and parts curve modification	

Due to the nature of the operation, there is a lot of rapid rotation, but when information between key frames is insufficient, the in-between operation often moves in the opposite direction as shown in Table 2. However, when a key frame is added to the in-between section, it responds intuitively and rotates in the desired direction. This was judged to be very similar to the cell animation production process. And, looking at number 5 in Table 4, there were many cases where the character's axis of rotation had to be changed during the dance process. Starting from the left image, there are cases where the character rotates around the left knee, right knee, right ball, and right toe.

3. Results

While producing a character animation with a lot of rotation, we compared the processes of representative tools. When creating animations, Cascadeur had no trouble creating all the action using only the character rig and timeline window. Just as we can create cell animation with just paper and pen, we can skip the complex processes that Maya brings.

The items mentioned in Table 5 were important and time-consuming processes in character animation work. Cascadeur makes solving this problem easier and simpler than Maya. One drawback is that it is not easy to express the anterior and posterior rotation of the spine. Bending back and forth requires movement of the chest and pelvis controllers, and excessive expression will cause the pelvic region to rotate excessively when transmitting data to other characters. To prevent the spine from becoming out of shape, we must move the chest and pelvis controllers up and down to prevent excessive rotation of the spine.

Table 5. Characteristic differences between software

process	Maya software	Cascadeur software
In-Between Pose rotation	A situation occurs where the direction of rotation is reversed.	The direction of rotation is determined depending on the pose we add.
Pivot	Can be used as a Pivot Effector. Affects only the affected joint	Pivot setting that can affect all selected joints just by selecting body joints without additional functions
Constrain	Can be used as an Aux Effector It is not easy to fix joints in the knee or elbow	All joints can be easily fixed and released
Excessive joint rotation	In a Dummy character, it is difficult to check for excessive rotation of the knee, elbow, or shoulder joints.	Excessive rotation of joints can be easily checked by applying Shift-Z in 'Auto position' mode.
Spine rotation	Various spine rotation expressions possible	It is not easy to express spine rotation forward and backward
Applying data to Metahuman	Additional steps are required for retargeting in Unreal Engine	When creating a UE sample character, we can easily retarget to the Metahuman Rig

4. Conclusion

Until now, creating character animations that required large movements using 3D animation tools was very complicated and took a long time to produce. Controlling the character required more technical knowledge than necessary. In this situation, through several tests using the Cascadeur tool, which shows a workflow closer to the production method of cel animation, we found that animation could be produced much more intuitively than with the existing Maya tool. The fact that distorted poses between keyframe poses can be easily modified even without technical knowledge of rigging proves that it is possible to create a workflow that is very close to the production method of cel animation. Although the accuracy is still low, the 2D mocap function can determine the timing and pose of the entire movement, so it can be judged to provide a shape or temporal rotoscoping function. This is very helpful in shortening production time and was proven by producing a sample video. However, it is not easy to express small but detailed actions such as emotional expressions, so we plan to conduct additional research in this area.

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