

Tricks to Animating Characters with a Computer

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Abstract

When I presented the first animation I had created with a computer, *The Adventures of André and Wally B.*, at SIGGRAPH 84, a number of people asked me what cool new software I had used to achieve such believable characters. I explained to them that the software was a keyframe animation system, not much different in theory than other systems that were around then. What was different was that I was using basic animation principles that I had learned as a traditional animator. It was not the software that gave life to the characters, it was these principles of animation, these tricks of the trade that animators had developed over 50 years ago. I was surprised at how few people in the computer animation community were aware of these principles.

Traditional animation is basically one trick after another. Whatever it takes to get it working right on the screen is fair game. It should be the same in computer animation. At Pixar, we constantly use tricks, old and new, to get what we need on the screen. In this talk, I will give away a few trade secrets that will be useful to anyone attempting to animate characters with computers, regardless of the software they are using.

Keyframes

Most commercially available computer animation systems are based on animating with keyframes. At first, this seems like the same thing as keyframes in traditional hand-drawn animation, but it is slightly different, and therefore, you should approach your animation differently. In hand-drawn animation, you work on the basic poses of the scene first, drawing poses of the entire character so the timing and acting can be worked out with a minimum of drawings created. Once the poses are finalized, then the in-between drawings are created to complete the action. With computer animation, keyframes are values at certain frames for the articulation controls of a model, which are usually set up in a hierarchy. The computer calculates the in-betweens values based on a spline curve connecting the keyframe values.

When I first began animating with a computer, I was used to hand-drawn animation and thought a keyframe in one medium was the same as the other. So I worked on

one complete pose, went ahead a few frames, then worked on the next pose. Well, the in-betweens produced by the computer were completely useless. I ended up having a keyframe at every frame to get the results I desired.

With computer animation, I learned to work down the hierarchy of the model, and as I went, created separate keyframes for the different controls at each level of the hierarchy. I found that controls at some levels needed only a few keyframes where some at other levels needed keyframes on practically every frame. I also found that I used far fewer keyframes overall and the in-between values that the computer would interpolate for me were far more useful. The important thing with this approach is to have a clear idea of the action you want to achieve before you start. Plan out the action with thumbnail sketches and plot timing ideas on an exposure sheet. Have these next to you as you block out the basic animation. You will find that you will always refer back to these.

2DVs. 3D

One of the biggest differences between hand-drawn animation and computer animation is the fact that computer animation is truly three dimensional. The first run cycle I ever animated on the computer looked great from the side view, but when I looked at it from the front, the arms were going through the body and the knees were bending the wrong way. From then on I always animated with two views of my character always showing, so that I could always tell if the animation was working from all sides.

Since computer animation is truly 3D, you can reuse the animation of a scene or parts of the animation and not tell that it is the exact same motion. Many times, if you simply look at a scene of animation from a different camera angle, it will look completely different. Sometimes, it may seem too similar, so just vary the timing of the motion or change the motion of an arm or head and it will cease to resemble the original. This is great for crowd shots, where the reuse of animation is an easy way to keep the crowd alive.

Weight & Size

The computer gives the ability to create images that look absolutely real. Especially with the latest techniques in rendering, texture mapping, ray tracing and radiosity, you can make an object look just like it's made of marble or rubber or whatever you wish. But to make it look like marble or rubber when it is in motion, has very little to do with the way the object is rendered. It has everything to do with the way the object is animated. It is

animation that gives an object its physical properties. More than anything else, the timing of the movement of an object defines the weight of that object.

Two objects, identical in size and shape, can appear to have two vastly different weights by manipulating timing alone. The heavier an object is, the greater its mass, and the more force that is required to change its motion. A heavy body is slower to accelerate than a light one. It takes a large force to get a bowling ball moving; but once moving, it tends to keep moving at the same speed and requires some force to stop it.

When dealing with heavy objects, one must allow plenty of time and force to start, stop or change their movements, in order to make their weight look convincing. Light objects have much less resistance to change of movement and thus require much less time to start moving. The flick of a finger is enough to make a balloon accelerate away. When moving, it has little momentum and even the friction of the air quickly slows it up.

The way an object behaves on the screen, the effect of weight that it gives, depend mostly on the spacing of the poses and less on the poses themselves. Again, no matter how well rendered a bowling ball may be, it does not look like a bowling ball if it doesn't behave like one when it is animated.

The proper timing of a motion can also contribute greatly to the feeling of size and scale of an object or character. A giant has much more weight, more mass, more inertia than a normal man; therefore he moves more slowly. Like a bowling ball, he takes more time to get started and once moving, takes more time to stop. Any changes of movement take place more slowly. Conversely, a tiny character has less inertia than normal, so his movements tend to be quicker.

The Thinking Character

When animating characters, every movement, every action must exist for a reason. If a character were to move about in a series of unrelated actions, it would seem obvious that the animator was moving it, not the character itself. All the movements and actions of a character are the result of its thought process. In creating a "thinking character," the animator gives life to the character by connecting its actions with a thought process. Walt Disney said, "In most instances, the driving forces behind the action is the mood, the personality, the attitude of the character — or all three. Therefore, the mind is the pilot. We think of things before the body does them."

To convey the idea that the thoughts of a character are driving its actions, a simple trick is in the anticipation; always lead with the

eyes or the head. If the character has eyes, the eyes should move first, locking the focus of its action a few frames before the head. The head should move next, followed a few frames later by his body and the main action. The eyes of a character are the windows to its thoughts; the character's thoughts are conveyed through the actions of its eyes.

If the character has no eyes, such as an inanimate object like a Luxo lamp, it is even more important to lead with the head. The number of frames to lead the eyes and head depends on how much thought precedes the main action. The animator must first understand a character's thought process for any given action. Consider a character wanting to snatch some cheese from a mouse trap; the eyes will lead the snatch by quite a bit because this is a big decision. The character needs time to think, "...Hmm...This looks tricky, is this cheese really worth it or is it just processed American cheese food?...Oh what the heck..." he decides, and snatches the cheese.

Conversely, if the action is a character ducking to miss a low flying sheep, the anticipation of the eyes leading the action should be just a couple of frames. "What the..." and the next thing, he is spitting wool out of his mouth.

The only time that the eyes or head would not lead the action would be when an external force is driving the character's movements, as opposed to his thought process. For example, if that character was hit in the back by the low flying sheep, the force of the impact would cause the body to move first, snapping the head back and dragging it behind the main action of the body.

Moving Holds

In hand-drawn animation, it is very common to animate an action, then slow into a pose and hold the drawing of that pose for several frames, then move into action again. Being two-dimensional animation, the action stays alive even with the use of held drawings. The same goes for puppet and clay animation. But in 3D computer animation, as soon as you go into a held pose, the action dies immediately. I've seen it happen with every animator that came out of traditional animation.

It must be the combination of the dimensional, realistic look and the smooth motion (usually on "ones") that makes a hold cause the motion to die. The eye picks it up immediately; it begins to look like robotic motion. To combat this, use a "moving hold." Instead of having every part of the character stop, have some part continue to move slightly in the same direction, like an arm, a head or even have the whole body.

Even the slightest movement will keep your character alive. Sometimes an action that feels believable in traditional animation, looks too cartoony in computer animation. Because

of the realistic look of computer animation, an animator needs to be aware of how far to push the motion. The motion should match the design of the character and the world. Animating very cartoony motion with lots of squash and stretch on a realistic looking object may not look believable, as would realistic motion on a caricatured object.

This is the pitfall of using motion capture devices to create final animation. Motion capture from human actors will always look realistic...for a human. But apply that motion to a chicken and it will look like a human in a chicken suit. You can use the motion capture data as a starting place, tweak the timing and poses to make it more caricatured, then apply it to the chicken and the motion will match the design of the character.

Emotion

The personality of a character is conveyed through emotion and emotion is the best indicator as to how fast an action should be. A character would not do a particular action the same way in two different emotional states. When a character is happy, the timing of his movements will be faster. Conversely, when sadness is upon the character, the movements will be slower. An example of this, in *Luxo Jr.*, is the action of Jr. hopping. When he is chasing the ball, he is very excited and happy with all his thoughts on the ball. His head is up looking at the ball, the timing of his hops are fast as there is very little time spent on the ground between hops because he can't wait to get to the ball.

After he pops the ball, however, his hop changes drastically, reflecting his sadness that the object of all his thoughts and energy just a moment ago is now dead. As he hops off, his head is down, the timing of each hop is slower; with much more time on the ground between hops. Before, he had a direction and a purpose to his hop. Now he is just hopping off to nowhere. [1]

To make a character's personality seem real to an audience, he must be different than the other characters on the screen. A simple way to distinguish the personalities of your characters is through contrast of movement. No two characters would do the same action in the same way. For example, in *Luxo Jr.*, both Dad and Jr. bat the ball with their heads. Yet Dad, who is larger and older, leans over the ball and uses only his shade to bat it. Jr., however, is smaller, younger and full of energy; he whacks the ball with his whole shade, putting his whole body into it. [1]

Readability of Actions

Proper timing is critical to making ideas readable. It is important to spend enough time (but no more) preparing the audience for the anticipation of an action; the action itself; and the reaction to the action (the follow

through). If too much time is spent on any of these, the audience's attention will wander. If too little time is spent, the movement may be finished before the audience notices it, thus wasting the idea.

The faster the movement, the more critical it is to make sure the audience can follow what is happening. The action must not be so fast that the audience cannot read it and understand the meaning of it. [4]

To make sure an idea or action is unmistakably clear, the audience's eye must be led to exactly where it needs to be at the right moment; they must not miss the idea or action. Timing, as well as staging and anticipation are all integral to directing the audience's eye. A well-staged anticipation will be wasted if it is not timed properly. [1]

It is important that only one idea is seen by the audience at a time. If a lot of action is happening at once, the eye does not know where to look and the main idea will be overlooked. The object of interest should be significantly contrasted against the rest of the scene. In a still scene, the eye will be attracted to movement. In a very busy scene, the eye will be attracted to something that is still. Each idea or action must be timed and staged in the strongest and simplest way before going on to the next idea or action. The animator is saying, in effect, "Look at this, now look at this and now look at this." [3]

In most cases, an action should not be brought to a complete stop before starting another action; the second action should overlap the first. This slight overlapping maintains a flow and continuity between whole phrases of actions.

In *Luxo Jr.*, it was very important that the audience was looking in the right place at the right time, because the story, acting and emotion was being put across with movement alone, in pantomime, and sometimes the movement was very subtle. If the audience missed an action, an emotion would be missed, and the story would suffer. So the action had to be timed and paced so that only Dad or Jr. was doing an important action at any one time, never both. In the beginning of the film, Dad is on-screen alone and your eye is on him. But as soon as Jr. hops on-screen, he is moving faster than Dad; therefore the audience's eye immediately goes to him and stays there.

Most of the time Jr. is on-screen, Dad's actions are timed to be very subtle, so the attention of the audience is always on Jr. where most of the story was being told. If Dad's actions were important, Jr.'s actions were toned down and Dad's movements were emphasized; then the attention of the audience would transfer to Dad. For example, when Jr. looks up to Dad after he's popped the ball and Dad shakes his head, all eyes are on Jr. [1]

A Story Trick

In storytelling, the timing of ideas and actions is important to the audience's understanding of the story at any point in time. It is important that the animation be timed to stay either slightly ahead of the audience's understanding of what's going on with the story, or slightly behind. It makes the story much more interesting than staying even with the audience. If the animation is too far ahead, the audience will be confused; if the animation is too far behind, the audience will get bored; in either case, their attention will wander.

Action timed to be slightly ahead of the audience adds an element of suspense and surprise; it keeps them guessing about what will happen next. An example of this is at the beginning of *Luxo Jr.* Dad is on-screen, alone and still; the audience believes they are looking at a plain inanimate lamp. Unexpectedly, a ball comes rolling in from off-screen. At this point, both Dad and the audience are confused. The audience's interest is in what is to come next.

When the action is timed to be slightly behind the audience, a story point is revealed to the audience before it is known to the character. The entertainment comes in seeing the character discover what the audience already knows. Another application of this is with a dim-witted character who is always behind; the audience figures it out before he does.

Many of these tricks can be used in concert in any given scene in order to achieve the strongest impact on an audience. At the end of the dream sequence in *Red's Dream*, Red juggles three balls and catches them with a big finish; the crowd explodes into wild applause, and Red takes his bows. Slowly the circus ring dissolves to the interior of the bike shop, the sound of the applause fades into the sound of rain, and Red, unaware, continues to take his bows. At this point, the audience has not caught on to what is happening because the timing of the action is slightly ahead of the audience. As the room appears, so does the large "50% OFF" tag hanging from Red's seat. The animation of the tag is timed to be light in weight; it flops around more actively than anything else in the scene. This contrast of action directs the audience's attention to the tag which is a subtle reminder that Red is still in the bike shop. The audience is now ahead of the character and watches Red discover where he really is. Red's actions were timed to be slow, accentuating his sad emotion. Timing made the story points clear, the emotion stronger and the character's actions were a result of his thought process; thus, the scene has a strong impact on the audience.

Ask Why

In every step of the production of your animation, the story, the design, the staging, the animation, the editing, the lighting, the sound, etc., ask yourself why? Why is this here? Does it further the story? Does it support the whole? To create successful animation, you must understand why an object moves before you can figure out how it should move. Character animation isn't the fact that an object looks like a character or has a face or hands. Character animation is when an object moves like it is alive, when it looks like it is thinking and all of its movements are generated by its own thought process. It is the change of shape that shows that a character is thinking. It is the thinking that gives the illusion of life. It is the life that gives meaning to the expression. [3] As Saint-Exupéry wrote, "It's not the eyes, but the glance - not the lips, but the smile..." [2]

Every single movement of your character should be there for a purpose, to support the story and the personality of your character. It is animation after all and any kind of motion is possible, and in the world of your story any kind of rules can exist. But there must be rules for your world to be believable. For example, if a character in your story can't fly and then all of a sudden he can fly for no reason, your world and story will lose credibility with your audience. The movement of your character and the world of your story should feel perfectly natural to the audience. As soon as something looks wrong or out of place, your audience will pop out of your story and think about how weird that looked and you've lost them. The goal is to create a personality of a character and a storyline that will suck your audience in and keep them entertained for the length of your film. When a film achieves this goal, the audience will lose track of time and forget about all their worldly cares. For all that any audience truly wants is to be entertained.

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