

Creating Lifelike Characters in Toy Story

Tom Porter

Figure 1. Note the scratches on the skateboard wheels.

Introduction

As Visual Effects Supervisor on *Toy Story*, I led a technical group working on all the surface appearances in the film, along with certain visual effects outside the mainstream of Pixar's character animation process.

My enduring interest in computer

graphics has always been in pursuit of realism. I relished the *Toy Story* tasks of programming drips of rain on Andy's window and horizontal brush strokes and indentations on the baseboard of Andy's wall. I delighted in building libraries of dirt and smudges and scratches and stains.

The process of writing these appear-

ance "shaders" involved collecting lots of reference footage. Art director Ralph Eggleston filled numerous photo albums with dozens of candid shots of the undersides of tanker-trailers and the baseboards of old houses.

The process involved lots of clever programming by the shader writers. The RenderMan™ Shading Language

Those interested in making computers behave lifelike might benefit from a review of the principles employed in creating character animation for *Toy Story*. This paper will focus on how Pixar animators approached the problem of making Buzz and Woody lifelike. The underlying principles are somewhat counter-intuitive in their bias away from physical realism, though they are well accepted in the animation community. There are two lessons for the artificial intelligence community to absorb: "lifelike" is different from "realistic"; and the key to character animation is in depicting the thought behind the action.

Image courtesy Pixar Animations Studios. © Disney. All rights reserved.

provides the flexibility to apply lots of texture maps and lots of mathematics.

The process involved lots of iterations, as the technical staff sought creative approval. Every detail had to conform to the art director's taste and vision.

And therein lay the essential struggle in creating the surface appearances

for *Toy Story*. The collaboration between Science and Art brought together a technical staff, pushing for realism and armed with computer science and mathematics, along with a creative staff, pushing for believability and armed with an artistic sense.

The struggle was best exemplified by the shot in Figure 1. Among the hundreds of shaders that I wrote was the one for the wheels of the skateboard for this shot. Seeking reference material, I emailed fellow employees, and a skateboard appeared in my office. Armed with "the truth," I wrote a terrific shader for the wheel, matching the real scratches in length and color and frequency and coverage.

I confidently submitted an image for shader approval, and the art director rejected it quickly. When I protested that it looked exactly like a real skateboard, he excused himself, ran down the hallway, tore a thick plastic cap from a water jug, ran outside, rubbed it on the asphalt, and returned to show me what he wanted. "Yours may look like this skateboard, but *this* is what the American audience thinks a dirty skateboard wheel looks like!" I rewrote the shader (in a humble capitulation of Science to Art), and approval was easy.

I cite this parable here, not because shader writing has anything to do with lifelike characters, but rather to make the following point: movie-making at Pixar is a technical effort subject to creative control. The essence of *Toy Story* is in its lifelike characters; the characters are lifelike primarily because of creative control (the realm of Art), not technical prowess (the realm of Science).

Let us consider some of that creative control that Pixar employs to make its computer generated characters "lifelike."

Animation Principles from Disney to Pixar

There is nothing that Pixar is doing at the heart of character animation that Disney hasn't

done for decades. The problem is to breathe life into characters, whether hand-drawn or computer-generated. The trap that our community must remember is that *movement* in computer graphics is easy; animation is much more than just *movement*.

In 1987, having received an Oscar nomination for *Luxo Jr*, John Lasseter set out to educate the fledgling computer animation community. His 1987 SIGGRAPH paper [Lasseter 87] is as vital today as it was 10 years ago.

John presented the important technical aspects of animation, ideas that sprang up with Walt Disney and have supported most of the best animation over the past 75 years. These guidelines are interesting, because they point up the extent to which animators will depart from realism in an effort to be lifelike.

Here is a quick summary of 5 important principles: Squash and Stretch; Timing; Exaggeration; Anticipation; and Staging.

Squash and Stretch: Characters have no implicit physics.

It is incumbent upon the animator to convey mass and flexibility. Anything composed of flesh should show considerable movement during an action. A bouncing ball should squash when it hits the ground and stretch as it bounces up. Such distortions should be done without changing the apparent volume of the object. This is employed not just to simulate the proper physics, but also strengthen timing and anticipation.

Timing: Characters have no implicit weight or musculature.

It is incumbent upon the animator to convey this. Timing specifies the force behind the movement. Timing is critical to making ideas readable. As John points out in his paper, no matter how well rendered a cannonball may be, it isn't a cannonball if it doesn't behave like a cannonball in motion.

Anticipation: It's not good enough just to portray action.

An animator must ensure that the



Figure 2. Woody considers his plan to overcome Buzz.

Image courtesy Pixar Animations Studios. © Disney. All rights reserved.

lifelike characters in a film like Toy Story is a more global idea. It permeates the story department as it develops the story idea and sketches the storyboards. The idea flows to the editing department as it assembles the story reel, starting with the storyboards and continually refining and inserting and recutting until the film is finished. And the idea dominates the animation department as individual animators create movement for a shot.

It is the simple idea that “lifelike” doesn’t mean “has movement”; “lifelike”

means “has a brain.” The underlying notion of Pixar and Disney animation is that action is driven by cognitive processes in the character, that there is intelligence and personality and emotion.

Remember that it is crucial that the audience understand the intelligence and personality and emotion. The continual challenge to the animator is in depicting in an unmistakable yet com-

audience understands the action. Animators think about the preparation for an action, the action itself, and the termination of the action. Cartoons have long portrayed exaggerated anticipation of any movement. Hands always reach far up before reaching down into a pocket. This is to preview the action, focus the audience’s attention, and heighten their enjoyment of the action.

Staging: Ideas must be conveyed in a clear and unmistakable way.

Actions must be understood, personalities must be identifiable, expressions must be recognizable. Animators, using camera and lighting and layout, will stage each shot to make it clear. Animators commonly convey only one idea at a time, and focus the viewer’s eye to the critical area of the screen.

Exaggeration: At any point, whether for the sake of Squash & Stretch, Timing, or Anticipation, or Staging, the animator will exaggerate. But exaggeration is not done haphazardly. It is done by cutting to the essence of an idea, understanding the reason for it, and enhancing it. This is done to augment the audience’s response to action, to character, or to mood. But it is mostly done subtly enough that the casual viewer will not

consciously note anything unrealistic. The bouncing ball is flattened when it hits the ground, and the animated cannonball explodes through a wall.

The Key to Lifelike Characters

These Animation Principles speak to the technical side of animation, the frame-by-frame techniques to enhance the lifelike nature of a character. But the key to depicting

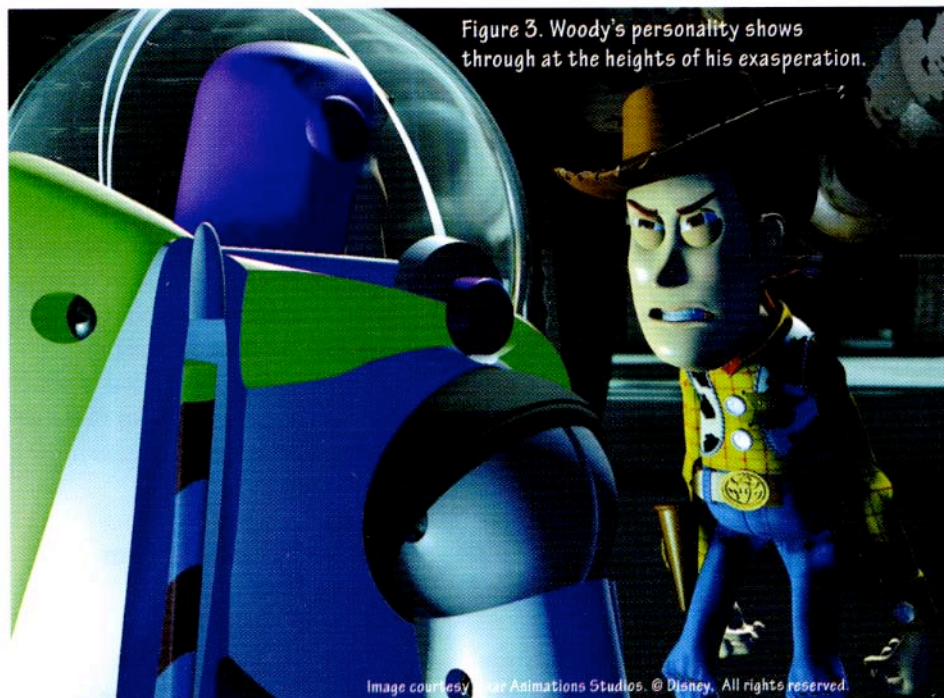


Figure 3. Woody’s personality shows through at the heights of his exasperation.

Image courtesy Pixar Animations Studios. © Disney. All rights reserved.

Animating a character

How does an animator prepare for a character? The *Toy Story* script called for Green Army Men to execute a mission. The army men are described as professionals: determined and efficient. The animator's challenge is to develop a style of movement that suits the required personality, given the physical limitations of the design.

Animation is acting. Pixar animators, shown in Figure 5, thus strapped boards to their feet, investigating the possible motions to fit the personality. That experiment led to a standard set of guidelines for the walk cycles and arm motions of the army man characters.

To some extent, the Army Man animation guidelines were set by the character's physical constraints, but to a larger extent, they were set by the need for the character to act determined and efficient.

Animating a Shot

How does an animator prepare for a shot? In the scene shown in Figure 6, Woody has been

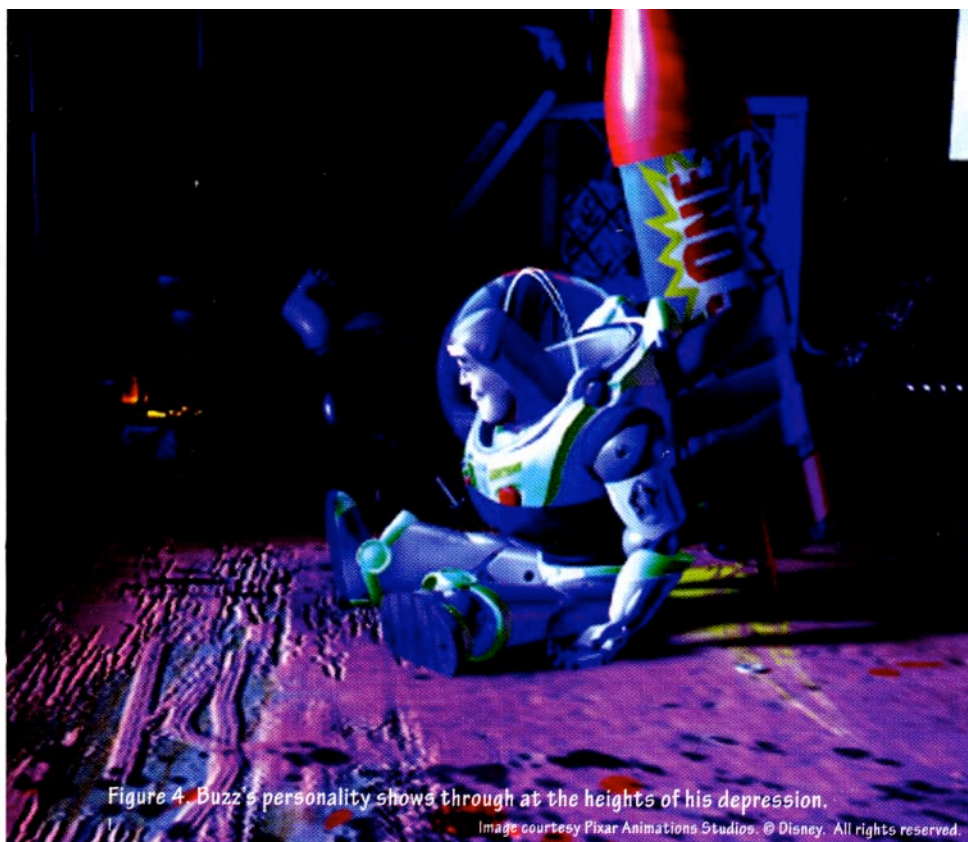


Figure 4. Buzz's personality shows through at the heights of his depression.

Image courtesy Pixar Animations Studios. © Disney. All rights reserved.

pellling way that the brain is driving the action.

When Woody overhears Andy saying that he will take only one toy to Pizza Planet, a series of shots such as the one in Figure 2 unveil Woody's plan to prevail. Woody's personality is depicted in these shots; reactions to events define the character. These shots are instructive in their use of camera and lighting to focus the audience's attention on what Woody is thinking.

The animation of Woody's eyes, the windows to his brain, is crucial to convincing the audience that there is thought behind his actions.

Later in the film, in the sequence under the truck at the gas station, Woody is exasperated at Buzz's delusion (Figure 3). Here again, the animators let Woody's personality flow through his actions and reactions. The exaggerated movement expresses the magnitude of the frustration. The movement is all motivated by the mental anguish.

And toward the end of the film, in the sequence on Sid's desk (Figure 4), Woody is trapped in the milk crate while Buzz is depressed about his place in life. Here, supported once again by the lighting and camera work, the ani-

matoms allow the volatile emotions to drive the acting. Buzz arises as Woody absorbs his gloom.

In each case, the key to making characters lifelike is to convince the audience they have brains: thoughts and personality and emotions drive the characters.



Figure 5. Pixar animators consider their options for animating the Army Men.

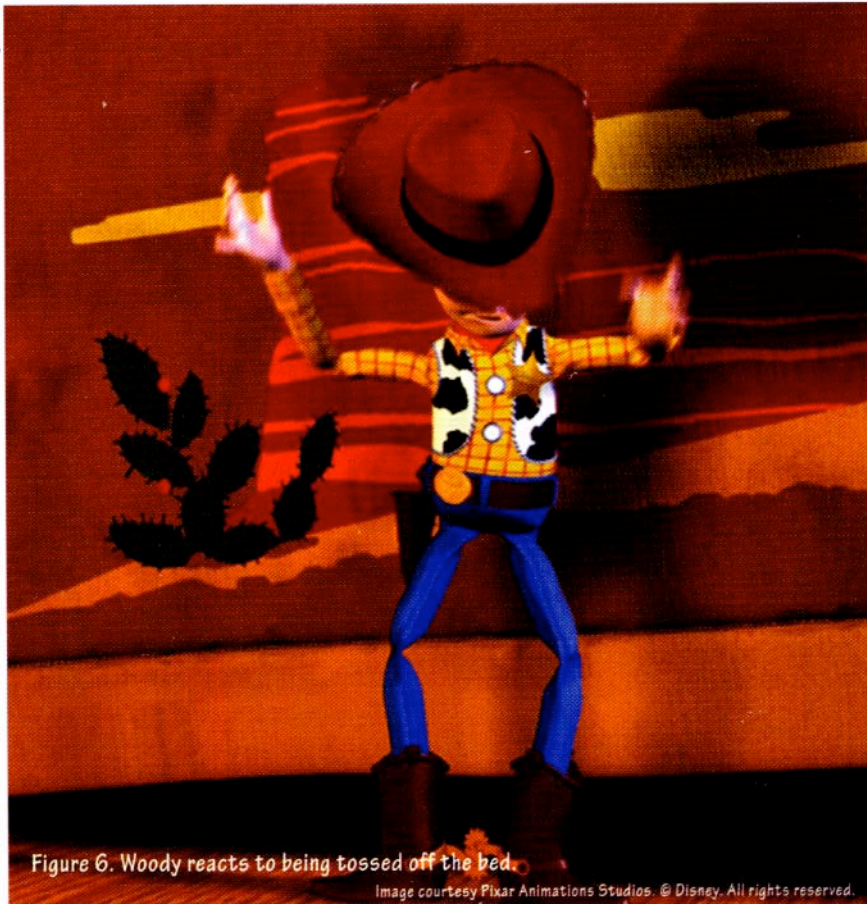


Figure 6. Woody reacts to being tossed off the bed.

Image courtesy Pixar Animations Studios. © Disney. All rights reserved.

surprisingly tossed off the bed by Andy and in front of all the other toys. This turns out actually to be a fairly crucial moment in Woody's life. How he reacts to being ousted is key to defining his personality.

Dialog for a shot has all been recorded before animation begins. With the story reel and the storyboards, the story department is able to convey several key notions to the animator in charge of creating the movement for the shot. Here are principal questions that the animator considers:

What's going on in the story? Woody has been ousted.

What is the character arc? Woody must reassert his honor.

What is the controlling idea? Woody denies that he's been ousted.

What is the central emotion with which to involve the audience? Jealousy.

Successful animators stay very conscious of the character's motivation as they create movement. Here Woody dusts himself off and adjusts his hat to show that he remains in control.

There is nothing in the script which

specifies that Woody adjusts his hat. And yet the time taken to adjust the hat is critical to the shot. A perfunctory rise to his feet would exhibit no clues to Woody's personality or current state of mind. The animator succeeds in giving us a glimpse into his mind, and we are convinced that Woody is lifelike.

Conclusion

As a final example, let us consider dialog animation. Because dialog is recorded before animation begins, this seems to indicate that automatic lip synching methods could produce the needed facial animation. Pixar animators do not use such methods, not because automatic lip synching cannot accurately produce mouth motions, but because it cannot capture the proper emotion. The lesson in dialog animation is the same as the lesson outlined above: *dialog animation is not about talking; it's about thinking.*

So whether it's wheels on a skateboard or the curl of Woody's lip, the

creative staff has something other than strict realism as the goal. The art director wants believability, and pure physical realism does not ensure believability. The animation director wants lifelike characters; that's done by depicting brain function, not just movement.

Acknowledgments

This paper was adapted from lectures given at the Lifelike Computer Characters '96 and Agents97 Conferences. The ideas here are taken from conversations with *Toy Story* Animation Supervisors Pete Docter and Rich Quade, Art Director Ralph Eggleston, and Technical Director Ronen Barzel.

References

Lasseter, John, "Principles of Traditional Animation Applied to Computer Animation," *Computer Graphics* 21(4), July 1987, pp. 35-44. ■

Tom Porter has been working in 3-D computer graphics since 1975.

He has won two Academy Awards, in 1993 for his solution to motion blur in rendering computer-generated images, and in 1996 for his pioneering work in digital image compositing.

Tom is currently the Supervising Technical Director of Pixar's third feature film. He can be reached at tom@pixar.com.

PERMISSION TO COPY WITHOUT FEE, ALL OR PART OF THIS MATERIAL IS GRANTED PROVIDED THAT THE COPIES ARE NOT MADE OR DISTRIBUTED FOR COMMERCIAL ADVANTAGE, THE ACM COPYRIGHT NOTICE AND THE TITLE OF THE PUBLICATION AND ITS DATE APPEAR, AND NOTICE IS GIVEN THAT COPYING IS BY PERMISSION OF THE ASSOCIATION FOR COMPUTING MACHINERY. TO COPY OTHERWISE, OR PUBLISH, REQUIRES A FEE AND/OR SPECIFIC PERMISSION. ©ACM 0153-4830/97/0100 \$3.50