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Creating Life in Animation

Research Assessment 2

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Porter, Tom, and Susman, Galyn. "Creating Lifelike Characters in Pixar Movies." *Communications of the ACM*, Jan. 2000, p. 25. *General OneFile*

To create lifelike animation animators must first have a strong understanding of the 12 principles of animation. These principles were created by Walt Disney and the "old men" of Disney Animation studios in the 1930's for the hand-drawn animation of the time. The 12 principles were used by Disney for decades to create beautiful hand-drawn animation and believable motion. (Porter and Susman 2) These principles were then published in *The Illusion of Life* a book by Ollie Johnston and Frank Thomas in 1981. However, these principles are just as applicable to modern computer animation and can be seen in all good animation.

The twelve principles of animation are squash and stretch, anticipation, staging, straight ahead action and pose to pose, follow through and overlapping action, slow in and slow out, arcs, secondary action, timing, exaggeration, solid drawing, and appeal. All of these principles can apply to modern day computer animation and are most often taught through animating a bouncing ball. Furthermore, in order to make an animation believable, all departments in the pipeline must portray what people perceive which is not necessarily complete realism and the

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twelve principle help this portrayal. (Porter and Susman 2) Thus the 12 principles of animation are the foundation of an animator's technique in animating any scene.

In animation showing the physics behind a character is very important because it makes an animation easy to understand. To show the physics of an object squash and stretch along with timing are very pivotal principles. Squash and stretch are used to show mass through distortion since characters and objects have no physics until they move. However, the distortions should not alter the object to the point that it is not recognizable to the audience. With this principle, a bouncing ball stretches before it impacts the ground and squashes when it impacts the ground. (Porter and Susman 5) Timing is another principle that is used primarily to convey the physics of a character's motion. It is used to show the force behind an action and is critical to an animation being readable to the audience. (Porter and Susman 5) Timing is also seen in the animation of a ball bounce particularly when it is falling to the ground and speeds up and when it is at the peak of the bounce and slows down slightly. These principles in conjunction are critical to creating the believable physicality of an animated object.

To increase readability and to show a character's thought process anticipation and staging are used. Anticipation is used to prior to most actions to make the action more readable to the audience. This principle shows the thought process of the characters and can often clue audiences into what is about to occur. (Porter and Susman 5) This is particularly effective when used in the comedic scenes of an animation. For example, when a character steps on a rake and it snaps up to hit them in the face the viewer will first see the foot stepping on the rake and then the rake hitting the character adding to the anticipation of the comedic peak. In conjunction with anticipation is the principle of staging can increase the comedy of some scenes. In the rake

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scenario, the camera may frame in on the foot then snap to the face when the rake hits the character. This can add to the comedy and interest of a scene through camera location and movement along with various props.

This in-depth information on the four principles of squash and stretch, timing, anticipation, and staging is very helpful. Even though I had learned about these principles in class reviewing them and applying them to examples on my own like the rake scenario was very informative. I think that analyzing the bouncing ball and rake scenario helped strengthen my fundamentals while applying the principles to a different situation. I believe that this understanding of other animation will allow me to improve my own work in class by thinking about the more complex application of the principles rather than simplistic application. My goal with this new information is to be able to apply it to my own work to improve the believability and quality of my animation.

Abstract:
Pixar's Toy Story and Toy Story 2 are computer generated animation films that use CAD and animation software to help characters come to life. This is a technical overview of what is done to do this.
Full Text:
Lifelike means convincing the audience an animated character has intelligence, personality, and emotion while inhabiting a physical world.

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Toy Story, the first full-length computer-generated animated feature film (released 1995) established itself as a visual benchmark for computer graphics hardware and software development. Soon after the film's debut, graphics chip makers wanted to know how they could compute Toy-Story-quality imagery on a PC; game developers wanted to know how they could deliver gay-Story-quality animation on game consoles; and robotics researchers wanted to know how they could build artificial intelligence into their machines to achieve Toy-Story-quality lifelike characters.

As we at Pixar tried to answer, we also sought to create scenes even more complex, images more wondrous, and characters more fluid. For A Bug's Life (released 1998), we extended our lighting and shading methodology to depict the transparency and back-lighting of an insect world. We developed new methods for modeling and animating large crowds of characters. And we embraced the use of subdivision surfaces to provide more flexible and organic characters. Toy Story 2 (released November 1999) leveraged these developments, depicting the gay Story world with far more detailed sets, visually richer texturing, and more sophisticated design and animation of human characters.

Comment [1]: To create natural looking characters and organic forms subdivisions are used

But any claim that the answers to these questions lie in more processing power, bandwidth, and memory obscures the more interesting truth. That's why we focus here on how--and why--Pixar animators have made Buzz, Woody, Flik, and many other characters so lifelike.

As supervisor of shading and visual effects on the original Toy Story, Tom Porter led a group of technical artists working on all surface appearances in the film, along with certain visual effects outside the mainstream of Pixar's character-animation process. Back in 1995, Pixar used single-processor 150Mhz SGI Indigo2 machines with 64Mb of memory for each animator and technical director, along with 100 dual-processor Sun Microsystems Sparc 20 machines in the company "renderfarm." Final rendering involved 77 minutes of images, or the entire length of the film. (Rendering was at 24 frames per second at 1536 x 922 pixel resolution.)

Galyn Susman was supervising technical director of Toy Story 2, leading the people responsible for modeling, shading, lighting, special effects, and rendering the entire length of the film. For Toy Story 2, Pixar had dual-processor 195Mhz-to-300Mhz SGI Octanes, with from 640MB to 1GB of memory on each desktop machine, along with a 1,400-processor Sun renderfarm. This improved processing power was fully utilized for creating the film, applying hundreds of gigabytes of textures to models, computing complex deformations of facial muscles and clothing, and calculating hundreds of light and atmospheric effects. But all of this advanced computing power is neither the whole story nor the most interesting aspect of movie-making at Pixar.

The technologies and the artists using them have to be guided carefully so every detail conforms to the movie director's taste and vision. The movie-making collaboration between science and art involves a

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technical staff pushing for visual complexity and realism--in the service of the story and ultimately the believability of the characters and the environments used to tell that story. This struggle is exemplified by the shot in Figure 1. Among the hundreds of shaders Porter wrote for Toy Story was the one for the wheels of the skateboard shown here. Seeking reference material, he emailed fellow Pixar employees and a skateboard appeared in his office. Then, armed with reality, he wrote a terrific shader for the wheels, matching the real scratches in length, color, frequency, and coverage.

[Figure 1 ILLUSTRATION OMITTED]

Porter confidently submitted an image for shader approval, but the Toy Story art director rejected it. When Porter protested that it looked exactly like a real skateboard, the art director excused himself, ran down the hall, tore a thick plastic cap from a water jug, ran outside, rubbed it on parking lot asphalt, and returned to show what he wanted. "Yours may look like this skateboard, but this is what the U.S. audience thinks a dirty skateboard wheel looks like." Porter rewrote the shader--in a humble capitulation of science to art--and approval was easy.

This parable is worth noting, not because shading in and of itself makes a character lifelike, but to make the point that movie-making at Pixar is a technical effort subject to creative control. The essence of these films is their lifelike characters, who are lifelike primarily because of creative control (the realm of art), and only secondarily because of technical prowess (the realm of science).

Animation Principles: Disney to Pixar

There is nothing Pixar is doing at the heart of character animation that Walt Disney Studios hasn't done for decades. The problem is how to breathe life into characters, whether hand-drawn or computer-generated. The folly that the computer-based animation community has had to anticipate is that movement in computer graphics is easy, but animation is much more than just movement.

Just after his Academy Award nomination for the 1986 Pixar short film, Luxo Jr., John Lasseter (later the director of Toy Story, A Bug's Life, and Toy Story 2) wrote his seminal paper "Principles of Traditional Animation" for SIGGRAPH 1987 [1]. He presented the important technical aspects of animation, based on ideas developed by Walt Disney himself, that have supported most of the best animation over the past 75 years (see the sidebar). What makes Lasseter's guidelines so interesting is that they point out the extent to which animators depart from realism in order to appear lifelike.

The principles in the sidebar speak to the technical side of animation, the frame-by-frame techniques needed to enhance the lifelike nature of a character. Animators use them to convey their characters intelligence and personality. They understand that "lifelike" does not mean "has movement"; lifelike means "has a brain." The underlying notion of Pixar and Disney animation is that action is driven by the

Comment [2]: Shows that animation has to show what people think they see not purely realism

Comment [3]: To make a high quality and believable animation the principles of animation must be taken into account.

Comment [4]: Pure realism is not always what people understand and see in the world.

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character's cognitive processes--that it reflects intelligence, personality, and emotion. The animator is constantly challenged to depict in an unmistakable yet compelling way that the brain is driving the action. In Toy Story 2, Woody faces an immediate crisis when his arm is partly ripped off in play, and Andy stores him on a shelf instead of taking him to Cowboy Camp. Woody's dejection is seen clearly as he settles onto the shelf (see Figure 2). His languid motion, posture, strain in his brows and mouth, and most important, his downcast eyes all convey his tremendous disappointment. The animation of Woody's eyes--the windows to his brain--is crucial to convincing the audience that there is thought behind his actions. The scene's content is emphasized by the shelf's dusty details, making the location seem a forgotten and secluded place, while the relatively flat lighting leaves Woody in a world without vibrancy.

[Figure 2 ILLUSTRATION OMITTED]

As the film progresses, Woody is introduced to the Round-Up Gang and learns his personal toy history through them. His time in this environment fills him with conflict over his loyalty to Andy and his fear of the end of his useful toy life. His newfound family of toys offers him immortality while giving him a tremendous emotional lift. All of this inner turmoil is presaged by the awe he feels as he discovers "who he is" (see Figure 3). Woody's personality flows through his actions--and in this case his reactions as well.

[Figure 3 ILLUSTRATION OMITTED]

In the end, Woody's loyalty to Andy wins out. Woody and the audience are surprised by the strength of that loyalty and its power to override the desire for immortality. In this single shot, Woody feels confusion, revelation, and determination; the audience is right there with him, feeling each of these emotions. Believability is in the realm of art, not purely the result of CPU power and memory bandwidth.

Animating a Character

How does an animator prepare for a character? For example, the Toy Story and Toy Story 2 scripts both called for green plastic army men--described as "professionals," determined and efficient--to execute a reconnaissance mission. The animator had to develop a consistent style of movement suiting the required personality and given the design's physical limitations. Animation is acting; so Pixar animators strapped boards to their feet to investigate the range of physical motion available for them to depict the army men personalities. That experiment led to a standard set of guidelines for the walk cycles and arm motions of these characters.

How does an animator prepare for a shot? In a particular scene in Toy Story 2 (see Figure 4), Woody has just been shown the Woody's Round Up toy collection, an experience that turns out to be a crucial moment in his life. How he reacts to discovering he is a rare collectible and that he has the opportunity to

Comment [5]: To make animation look believable the audience has to believe there is thought behind the characters action.

Comment [6]: Animators must maintain consistency in style through a movie so that the viewer can understand the movement

Comment [7]: In order to maintain consistency walk cycle similar patterns should be standardized

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achieve immortality is the key to the audience believing he would turn from life with Andy to a pampered though less-nurturing existence in a museum.

[Figure 4 ILLUSTRATION OMITTED]

Using the story reel and the storyboards, the story department conveyed several key notions to the animators creating the movements in the shot. The animators then had to ask themselves, What's really going on in the story? Here, it's that Woody is finding his long-lost past. What is Woody thinking? Wow, I have a past and value I never before imagined. What is Woody's central emotion the animators have to use to involve the audience? An overwhelming sense of awe.

Successful animators stay aware of their characters' motivations as they create their movements. Here, the animator had Woody rubbing his face and the back of his neck, showing his surprise and overwhelming need to calm himself and focus his thoughts. Nothing in the script specified that Woody touch his own face. Yet the time given for this motion was critical to the shot. The animator succeeded in giving us a glimpse into Woody's mind and that he was absorbing a new identity; the audience was convinced that Woody was lifelike.

Dialog animation is another key to a creating lifelike characters. Because dialog is recorded before animation begins, this technique would seem 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 produce accurate mouth motions, but because it cannot capture the proper emotion. The lesson in dialog animation is the same as the lesson in overall character animation: The goal is not about talking but about thinking.

Comment [8]: In order to show a characters thought process and emotions in any given scene.

Creative Choices

Whether it's wheels on a skateboard or the crinkle of Woody's brow, Pixar pursues something other than strict realism in its films. The goal is believability, but pure physical realism does not ensure a character's or a scene's believability. Most important, we aim to tell a compelling story, with characters that elicit a response and connect with the audience. That connection is accomplished only through lifelike behavior. We have had increasingly more powerful technology at our disposal creating Toy Story, A Bug's Life, and most recently Toy Story 2. We moved to dual-processor SGI Octanes on every desktop. We upgraded to 14-processor Sun UltraSparc E4500 machines in a renderfarm that has perhaps 20 times the performance of its 1995 Toy Story counterpart. We use Alias|Wavefront modeling software, along with Pixar's own proprietary modeling language, to describe the shape and articulation of characters and objects. We also enhanced our RenderMan software in many ways to manage greater scene complexity, including more objects, more textures, more lights, and more shading computations.

Comment [9]: Animators must create what people people perceive not necessarily true realism.

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The galloping environment of computer graphics hardware and software has even brought some of this technological performance to average desktop machines. But such power alone will never deliver Toy Story 2 on a PC. Only intelligent (and sometimes non realistic) creative choices ensure that the story makes sense, the characters are appealing, and the images are stunning.

[Figure 5 ILLUSTRATION OMITTED]

REFERENCES

[1.] Lasseter, J. Principles of traditional animation applied to computer animation. Comput. Graph. 21, 4 (July 1987), 35-44.

RELATED ARTICLES: Five Key Principles of Cartoon Character Animation

The following five animation principles were first articulated by Lasseter in 1987 and have since been employed regularly in Pixar's movies.

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 and flexibility 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. Squash and stretch is employed not just to simulate the proper physics but to simultaneously strengthen timing and anticipation.

Comment [10]: To show an objects mass and physical realism squash and stretch is heavily used.

Comment [11]: Object still has to look like what it is. It should not distort the object to the point it is not recognizable.

Timing. Characters have no implicit weight or musculature. It is incumbent upon the animator to convey body characteristics. Timing specifies the force behind the movement. Timing is critical to making ideas readable. As Lasseter pointed out, no matter how well rendered a cannonball is, it isn't a cannonball if it doesn't behave like a cannonball in motion.

Comment [12]: To show why an action occurs and o give meaning to an action

Anticipation, It's not good enough just to portray action. An animator has to ensure that the 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 exaggerated movement is to preview the action and focus the audience's attention and heighten its enjoyment of the action.

Comment [13]: Specifically in comedic cartoons a character always shows a lot of anticipation. This is done to clue the audience into the joke prior to the character knowing.

Staging. Ideas should be conveyed clearly and unmistakably. Actions have to be understood, personalities identifiable, and expressions recognizable. Animators, in conjunction with camera, lighting, and layout, stage each shot to make it clear. They usually convey only one idea at a time, focusing the viewer's eye on the critical area of the screen.

Comment [14]: This is similar to live action in that staging must be clear to convey ideas to the audience

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Exaggeration. At any point, whether for the sake of squash and stretch, timing, anticipation, or staging, the animator might exaggerate. But exaggeration is not haphazard. It is done by cutting to the essence of an idea, understanding the reason for it, and enhancing it. Exaggeration should augment the audience's response to action, character, or mood. But it should be done with such subtlety that the casual viewer does not consciously note that anything is unrealistic.

Comment [15]: Exaggeration must not look unrealistic. It should only enhance an idea and make it easy to understand..

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