

For the transformation scene in Vampire, Mack and other artists at Digital Domain modeled the before (straight) and after (curly) hair of the actress, adding texture maps created in Amazon 3D Paint (Interactive Effects; Irvine, CA) from paintings and pieces of the live-action plates. "It was an inordinate amount of work for one shot," Mack says. "But the curling made it custom."

However, when the hair or fur is being added to CG characters, animators can more easily use CG techniques that "grow" hair in particular shapes. Most of these systems use some variation of a painted surface to start from. "Seeds" or particles "planted" in the surface create the hair, with its length, color, density, transparency, direction, and overall shape controlled by a variety of techniques. In addition, most hair-growing systems include some physical characteristics to control movement, such as a parameter that increases or reduces the hair's springiness.

Alias/Wavefront's (Toronto) Comp U Hair uses what Duncan Brinsmead, a senior graphics programmer at Alias/Wavefront, calls a "volumetric particle-rendering method" to create hair. "It calculates soft volumetric tubes with self-shadows," he says. "The tube is a fuzzy volume, like a cloud with no surface, that is inherently soft at the edges. We intersect the tube with a ray." The Hair program also includes particle dynamics to give the hair bounce, and it works with spheres of influence provided by lights to control direction. The light forces can act, for example, as blow dryers.

Kelvin Lee, a 3D animator at Sony Pictures ImageWorks (Culver City, CA), used Alias' Comp U Hair to create a short piece titled "DragonMan" for SIGGRAPH '95 (see this issue's cover). The surface of his character emits particles constantly, a total of about 11 million particles per second. To control the length and stiffness of the hair, Lee used three different surfaces for the character's head, one for the torso, and others for each arm and leg.

Chris Landreth, an animator now working at Alias, used Comp U Hair for two characters in "The End," an animation most recently shown in the Electronic Theatre at SIGGRAPH '95 (see "Portfolio," September issue). The intent for the woman character was to give the hair a sort of phantasmagoric life of its own by using setting controls for air density and turbulence that would make the hair act as if it were underwater. "The hair stretches a lot," says Landreth. "It takes a while for it to catch up to the movement of the body." The other character in his animation has hair that is supposed to look realistic as the character goes through several transformations. "It took a little trial and error," says Landreth, "but I began to get a feel for how it would change." Version 7 of Alias/Wavefront's PowerAnimator includes a method for previewing the hair.

At Side Effects, the company's new Houdini software gives animators the ability to generate hair by using L-systems rather than particles. L-systems are more typically used to grow plants such as trees. To grow hair, Side Effects plants seeds inside spheres-in effect, thousands of little trees that don't branch.

Paul Simpson, an animator and director of a London-based production company called Hyperbolic, has been consulting with Side Effects on its Houdini software. "If I wanted to create a Mohican haircut," he says, "I'd paint a stripe onto the skull. That's read by the L-system. Hair grows within that stripe." Because he could include geometry at any point of growth, he could easily, for example, add beads to the hair as it grows--or cause the hair to sprout flowers.

As is the case with Comp U Hair, the hair is self-shadowing and can have specular highlighting. The self-shadowing mimics the quality of real hair, which is somewhat transparent and casts shadows on the hair beneath it.

The roots of lighting models for hair can usually be found in the papers written by Jim Kajiya, now a senior researcher at Microsoft (Redmond, WA), who published a method of lighting the anistropic surface of hair to correctly produce highlights that are wide across the hair and narrow in the direction of the hair. "Basically, the technique back then was very impractical," he says. "Now, it's practical."

One of the many companies using this technique is Taarna (Old Montreal, Quebec), in its custom, procedural hair software. Animators using this proprietary software "plant" guides to control the shape and length of a hair style, then set parameters such as the amount of "clumping" to control whether the hair looks dirty or clean, whether it has split ends, and how wavy it is. In addition, an option called "rare hair" adds a few strands of gray to a head of hair. Once the parameters are set, the hair is generated automatically and rendered via Photorealistic RenderMan.

Artists at PDI also use custom software to generate fur by placing cones on the surface of a model to set direction and control length. "If we used a painted look as a texture instead, you wouldn't see a correct silhouette at the edges," says Daniel Wexler, a member of the R&D staff at PDI.

At Vision Art (Santa Monica, CA), artists are creating custom fur for Santa Monica Pictures using a process that ties into Side Effects' Prisms software. "We use something we call a fur preparation material," says Rob Bredow, "that's like a skin you apply to a 3D model instead of a texture." Colors applied to this "material" control the langth of the fur. "If we were doing long, flowing hair, we would use a particle driven system," he adds. "But we're doing furry animals."

The most anticipated furry animals are also being created with custom software--the animals for the movie Jumanji. To grow hair and fur for these animals, ILM has created what Tom Williams, executive in charge of digital effects, calls a "hair primitive." "It's a new type of primitive that's limited to this one specific use," he says. "It's not a particle, not a polygon." Using this primitive cuts rendering time dramatically, since the renderer cares only about this "hair thing," and that, in turn, allows them to create millions of hairs.

Another way the ILM system differs from others is in its user interface. While most interfaces are paint-based, ILM has created an interface based more on the way hair is put on foam creatures in its model shop. Artists can cut hair to shape it, set different densities and color parameters, and adjust the way hair falls over shoulders. "We don't want the lion's mane sticking to its shoulders," Williams says.

When creating the hair for the human characters in the movie Toy Story, animators at Pixar also were concerned about production time as well as image quality. "Our basic constraints were that the hair looks good, requires minimal modeling, and is practical to render," says Darwyn Peachey, an animation scientist working on the movie (for more information, see "Toy Story: A Triumph of Animation," August issue). Peachey worked primarily on methods to create curly hair--that of the baby Molly, for example. "I used a procedural texture in a RenderMan shader to make solid pieces look like hair," he says. An artist can sit with a visual display of a head, move a control, and see the position, thickness, and number of curls.

For modeling Toy Story humans with straight hair, Eliot Smyrl used two methods. He started out using layers of geometry above the head--sort of smooth shells. Then, he'd sprinkle cylinders on top to break up the edges. Because the cylinders are like long, hair-sized tubes, they'd create the illusion of hair.

"I had thought that if I used too many cylinders, it would be an overwhelming rendering task," he says. But when he discovered that the buzz cut sported by Sid, the neighborhood bully, lent itself to simple geometry and fast rendering, he ended up using the spikes solely for Sid and, later, to create the hair for Andy, the little boy who owns the toys who star in the movie. For the lighting, he did "some fancy footwork in shaders."

"When you stick someone's head under a lightbulb in a dark room, which I did, you discover that specular highlights change color based on angle," he says. Thus, the RenderMan shader he wrote (about 300 lines of code) takes this into account when it takes painted textures, generates opacity, and adds color variations and specular sheen.

Even more concerned about production time is Joe Alter, vice president and director of production for Homer & Associates (Los Angeles), who's using his personal "creature shop" software at work to help create a CG host for a planned interactive television series. Within his software, he has procedural hair-growing tools that have put 400,000 hairs made of 80 segments each on one character's head. "I'm using the 'Chia Pet' approach, where you brush on seeds, then watch them grow," he says.

Equally important, he's working on speedy rendering. "Most people figure out whether each pixel is in shadow or not," he says, "but that doubles the render time." Instead, he uses two color maps that fake self-shadowing in half the render time with little tweaking.

As with Alias/Wavefront's software, Alter uses spheres of influence that act as magnets to help control hair direction. In addition, he provides a way for animators to sculpt the hair and comb it. "It interpolates from several hundred hairs and applies the grooming at render time to hundreds of thousands of hairs," Alter says.

"Our goal is to do long-format TV," he adds. "The rule of thumb is that renders have to be under a minute."

It's remarkable to think that only two or three years ago, people had about zero access to hair-creation tools. Now, animators are working to get the rendering time down to less than a minute for realistic-looking human hair.

"Then, we were worried about simpler things," says Bredow. "We never thought about the fur challenge. Things that were hard then are now easy."

So, having solved make-up and having nearly solved hair, it must be time to give digital actors their own costume designers. Maybe next year.



This image comes from an animation created by Becky Souder of Mind's Eye Graphics, a 3D animation and special-effects studio based in Richmond, Virginia. The data for the head itself was captured using a 3D digitizer, while the hair was modeled using the particle- based Comp U Hair module in Alias' PowerAnimator software and curled using volume light forces. Adobe Photoshop and Wavefront's Advanced Paint software were used to create the background.



Animator Chris Landreth created this image using Alias/Wavefront's PowerAnimator with Comp U Hair.



For this 3D actor, artists at Taarna used proprietary software to create hair for his head, eyelashes, and eyebrows. Guides planted on the 3D model control the shape and length of the hairs, which are procedurally generated and then rendered with Photorealistic RenderMan.



The head is a cyberscan of animator Chris Landreth.





The hair was created by Duncan Brinsmead using Comp U Hair from Alias/Wavefront. The first screen shot shows a preset hair pattern generated by a particle system that provides clumps of hairs with self-shadowing and transparency.



Animators can change the preset look with render parameters such as density, translucency, noise, blur, and color as well as with particle properties such as size, mass, elasticity, friction, and maximum hair length. The second shot shows changes to color, length, thickness, and curl.



In the third shot, the animator styled the hair using a volume light force that emits a directional wind within an ellipsoid volume, with the strongest wind in the center. "It's like using two blow dryers, one on either side of the head," says Brinsmead, who helped create Comp U Hair for Alias.--BR



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The hair-growing tools in Joe Alter's creature shop software are being used by Homer & Associates to visualize this character. The character, being created in association with U.S. West and Popular Arts Entertainment, will host an interactive television show scheduled for production this fall.



To avoid a "morph" look for a transformation scene in Interview With the Vampire, the artists at Digital Domain used 3D models, texture maps, and cross-dissolves to change the girl's straight human hair into this curly vampire hair. The 20-some curls started out as flattened cylinders that were curled procedurally with a math function, according to Kevin Mack. Then, more than 100 texture maps, most hand-painted, helped turn the geometry into reality.



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"The goal on this job was to make a realistic bee look cute," says Michael Necci, who worked on the visual effect at Pacific Data Images using that company's proprietary software. "Without the fur shader, the bees would have looked cartoonish."

Image courtesy of Pacific Data images



1995 Courtesy of Nintendo/Rare Ltd. Diddy Kong's hair created with Alias PowerAnimator Version 7.0.



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Paying particular attention to the challenge of making the fur look right on talking animals caused Vision Art to create its own fur-growing programs that tie into Side Effects' Prisms software. "We used a lot of smoothing algorithms and image processing techniques," says Rob Bredow, "to get the fur to fold correctly."



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With live-action film in mind as the final output, the artists at Rhythm & Hues used film whenever possible to help create the illusion of a talking pig in the movie Babe. With help from the rotospline feature in Parallax's Matador software (London), artists painted fur onto the pig's CG mouth, sometimes starting with digitized images, then composited the result with the live

action.

Barbara Robertson is CGW's West Coast Senior Editor. Computer Graphics World October, 1995



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