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Meet Geri
The New Face of Animation



Meet Geri

The New Face of Animation

BY BARBARA ROBERTSON

The marriage of technology and art is not always an easy alliance. Taken to its extreme, the partnership pits left brain versus right brain, logic versus feeling, cold versus warm. Yet out of this conflict, a kind of creativity can emerge that neither side could produce alone. In the history of computer graphics, there are numerous beautiful examples of this creativity—and some of the most brilliant have been produced at Pixar Animation Studios.

The most recent blending of Pixar's state-of-the-art graphics technology with story-telling and animation, is *Geri's Game*, a 4-1/2-minute animated short film that premiered in Los Angeles last November, in the nick of time for Academy Award Nominations. Academy Award honors are not new at Pixar: John Lasseter received a nomination in 1986 for *Luxo, Jr.* and an Oscar in 1988 for *Tin Toy*. What's new is that this film marks the debut of a new director at Pixar, Jan Pinkava, and that Pinkava's film is the first short animation to be produced by Pixar in eight years. Whether or not *Geri's Game* joins its predecessors at Pixar by receiving an Oscar nomination this year, the film is likely to have as much impact on computer graphics animation as Pixar's earlier shorts did—in terms of both art

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Pixar's new short film advances the art and science of character animation

and technology. In fact, Pixar has already applied for patents on the innovative technology used in the film to create surfaces and to animate cloth.

Written and directed by Pinkava and produced by Karen Dufilho, the film opens as an old man, Geri, begins setting up a chess board on a small table in a park on a sunny autumn morning. The colors, the look of Geri and the cut of his jacket all have a European flavor. Geri himself is a sweet, kindly old man—kindly, that is, until he walks around to the other side of the table and begins playing chess against himself. The Geri on this side of the table suddenly transforms into the old man's faster, younger, more aggressive alter ego. The stakes are high: Geri has bet his false teeth on the game. As play continues, the nasty Geri makes all the right moves and humiliates the sweet old Geri. But just when it looks like the bad side is going to win, the nice side of Geri, in a brilliant burst of creative energy, pulls an outrageous stunt and wins the teeth—by cheating. There is no dialog in the film; it's done entirely with mime.

Few studios in the world have been able to blend computer graphics technology and animation into as a fine an art as has Pixar, and *Geri's Game* continues that tradition. Hidden beneath the artistic success in *Geri's Game* is a research project, a project designed specifically to develop and hone new in-house technology for producing humans and clothing and to test that technology within a production environment.

As Pinkava tells the story, Ed Catmull, Pixar founder and chief technology officer, wanted to start up the short film group again to do R&D within a production environment and to give animators a chance to develop their skills. For the first film out of the newly resurrected shorts group, the R&D target would be humans and cloth simulation, two areas Pixar wanted to improve. "Ed said to me, 'Maybe, Jan, you can do a short film, if you can come up with a human char-



The two sides of Geri begin to emerge as each contemplates his next move. Notice that the trees behind the "nasty" Geri on the left have red leaves, while the trees behind the "nice" Geri on the right have yellow foliage.

acter,'" Pinkava remembers. Pinkava, who has directed award-winning commercials at Pixar, had loads of ideas for short films, but none had human characters.

"At Pixar, usually we're thinking about bringing alive things not normally alive," he says. But when he thought about the films they'd done and remembered the baby in *Tin Toy*, he decided to create a human character at the other end of life, one with realistic clothes. Then, as he thought about doing an old character, he remembered watching his grandfather playing chess. "I like to take a simple situation, like an old guy in a park playing chess, and let the story grow from that," he says. "Also, I like the idea of concentrating on one character." But one aspect of drama is conflict, as Pinkava points out, so to create conflict with a single character, he decided Geri needed an alter ego, and that led to the story of *Geri's Game*.

The decision to base the film on one character was a plus for the technical side as well as the artistic: Geri may have two personalities, but he has just one head, one body, and one jacket.

To create Geri, Pinkava began by sculpting the old man's hands and face, the difficult organic parts, he explains. Organic, but not exactly realistic. "I imagine Geri as a super stop-motion puppet, only better because he has more expression than a puppet," Pinkava says. "He has a style of his own with his big nose and big head. I really like the fact that he's not real.

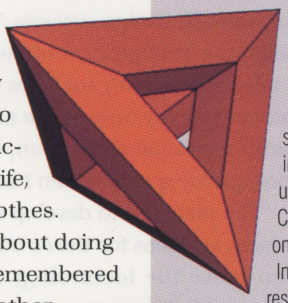
"People have been creating stylized characters in sculptures for thousands of years," Pinkava adds. "We don't think about it in terms of computer graphics very much, but it's an incredibly rich tradition."

When you see Geri, one thing that strikes you right away is the quality of his skin. It's smooth, malleable—as if it might have been made of soft clay. The flexible skin is a direct result of new surface modeling technology developed at Pixar called "subdivision surfaces." With this technology, Geri's whole face and head were created with one surface, one skin. Tony DeRose, who has written three patents for Pixar as a result of his work on *Geri's Game*, has been working on subdivision surfaces for years, primarily during ten years as a professor of computer science at the University of Washington. While there, he tried to interest CAD vendors in the technology, but wasn't able to wean them from NURBS. At Pixar, he found a more receptive audience, and this brought the technology full circle: The first subdivision surfaces were created by Pixar's own Ed Catmull along with Jim Clark (founder of Silicon Graphics, Inc., and of Netscape) when they were students together at the University of Utah 20 years ago. With NURBS, or B-splines, models are created with

Subdivision Surfaces

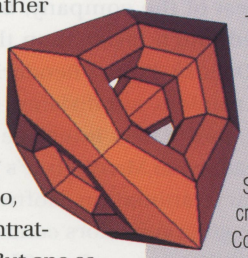
A standard way to model complex smooth surfaces is by using a patchwork of trimmed B-splines. But this approach has two disadvantages: trimming is expensive and prone to numerical error, and it is difficult to maintain smoothness of the patchwork as the model is animated.

Subdivision surfaces overcome both of these problems. They do not require trimming, and smoothness of the model is automatic, even as the model is animated. A subdivision surface is animated by moving the points of the control mesh. No matter where they are positioned, the final surface is guaranteed to be smooth.



The first image (left) shows the points and facets (collectively called the control mesh) used to create a subdivision surface.

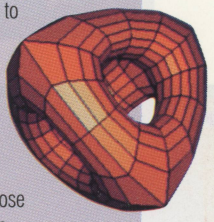
The second image (bottom left) shows the control mesh after one subdivision step. Each of the 24 facets of the control mesh has been split into 4 facets (for a total of 96 facets), and the points have been repositioned using a carefully constructed averaging process that Ed Catmull and Jim Clark created 20 years ago. (See "Recursively Generated B-spline Surfaces on Arbitrary Topological Meshes." *Computer Aided Design*, 10(6), 1978.)



In the third image (right) the mesh has been split and averaged once again, resulting in more facets.

The fourth image (bottom right) shows a final subdivision surface.

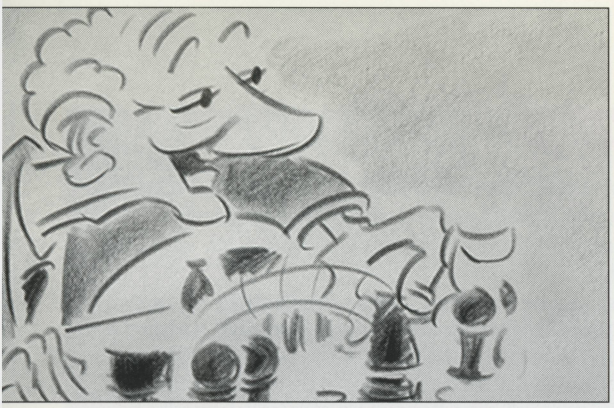
The magic that guarantees that the final surface is smooth is tied up in the averaging process; most averaging methods create infinitely bumpy "fractal" surfaces. Recently, a rigorous mathematical proof of smoothness of the surface was constructed by Ulrich Reif (See "A Unified Approach to Subdivision Algorithm," Technical Report A-92-16. Universtat Stuttgart, 1992). As the math has become better, the software for creating smooth animated surfaces has become simpler.

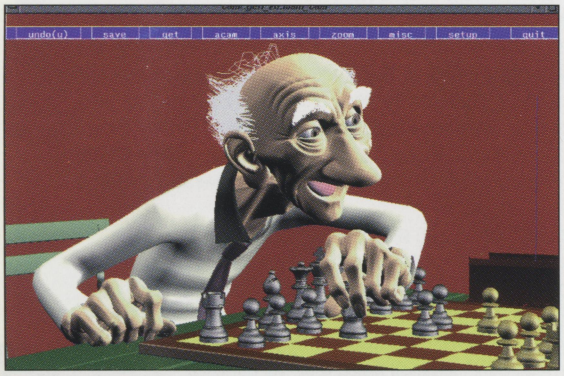


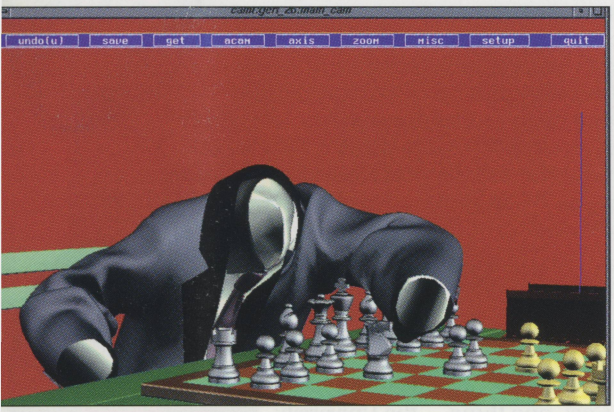
Conceptually, the final surface is the infinitely faceted model that results if subdivision is repeated forever. Of course, in practice one cannot subdivide forever, so we've developed methods that allow highly accurate images to be created after just a few subdivision steps. Some of those methods are in a technical paper published in the SIGGRAPH 93 Conference Proceedings: "Efficient, Fair Interpolation Using Catmull-Clark Surfaces," by Mark Halstead, Michael Kass, Tony DeRose. The new technology we've developed at Pixar since then is in the patents we've filed.



Tony DeRose, senior scientist, Pixar Animation Studios









From storyboard to chessboard, Geri moves from drawing, to 3D animated model, through the wardrobe department, and into his final rendered self.

patches and as a model is animated, the patches often tear apart at the seams. Subdivision surfaces solve that problem and a second problem as well: With NURBS, adding detail in one place in a model often produces additional detail elsewhere. That doesn't happen with subdivision surfaces. This meant the animators could work in a facile way with surfaces that had complexity only in the areas useful for facial animation. The word quickly spread within Pixar.

"The plan was to develop subdivision surfaces for *Geri's Game*, then move the technology into the rest of the company, but it moved much faster than that," says DeRose. Pixar's RenderMan now renders subdivision surfaces, and a new interface has been added to MenV, Pixar's proprietary animation software, which gives animators control of the subdivision surface. The interface is largely the work of Paul Aichele, one of the technical directors for *Geri's Game*.

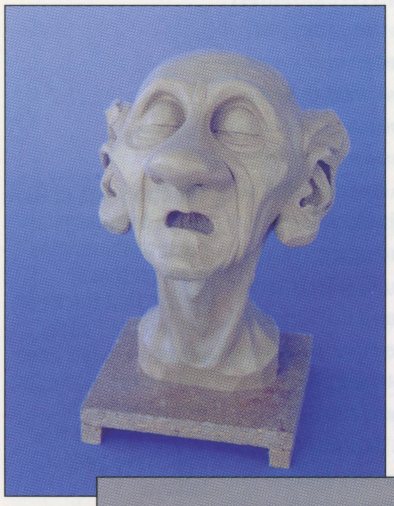
In *Geri's Game*, everything that moves has been created with subdivision surfaces, including the jacket. "If we had used NURBS, we would have had to construct the jacket out of pieces connected along trim curves," explains Michael Kass who created the cloth simulator that animated Geri's jacket. "Now we never have to worry about trim curves, and we can have different levels of detail in different regions."

He also had to solve computational problems to make the cloth look and act like cotton and to keep it from intersecting with itself and with other objects. "There are thousands of vertices in the subdivision surface that makes up the jacket, each of which could have millions of interactions, so we have to use clever techniques to avoid a computational nightmare," he says. Kass's goal was to create a cotton jacket that was neither too rubbery nor too silky. The interactions of the vertices determine the material properties—how stretchy or stiff the cloth is. "As soon as cotton is stretched to its maximum length, it doesn't stretch any more, which makes the equations unstable and unreliable, so the material itself was a problem, " he says. Moreover, the material had to be stiffer in the places where jackets are typically reinforced so they needed to invent "virtual starch" as well.

The first time they ran the cloth simulator, it looked like Geri was wearing a T-shirt, says Kass, and they pulled their hair out trying to figure out what was wrong. It turned out that the initial model of the jacket was wrong. "We had to learn the obvious fact that if you want it to move like a real jacket, it has to be tailored like a real jacket."

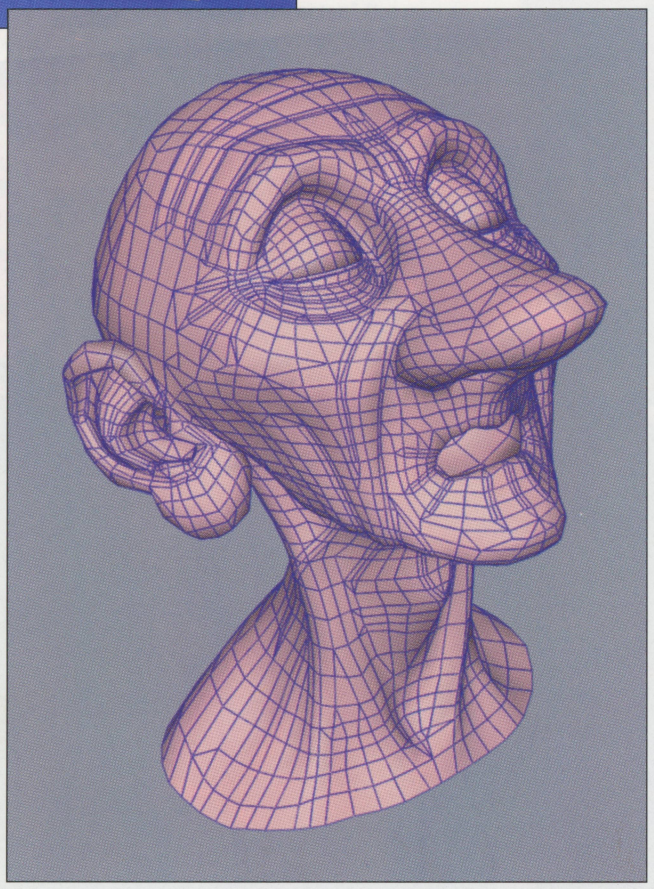
A second computational problem Kass needed to solve was getting the cloth to move like cotton. "It's easy to do rubbery or silky cloth," Kass says, "but it took a while to develop energy functions that would make it move like cotton material." The energy functions in the simulator describe the resistance to various kinds of deformations. For example, energy functions describe stretching on the warp and the weft of a piece of cloth. The energy functions in the cloth simulator are now so sophisticated that the cloth moves differently depending on whether a garment is cut on the bias or not.

"It is a thankless task," says Pinkava of providing a simulator



Jan Pinkava, writer and director of *Geri's Game*, sculpted several shelves full of Geri heads and bodies before settling on this one, which was then digitized and used as a basis for creating the 3D model.

sophisticated enough to animate the jacket well enough to pass an animator's scrutiny. "When Michael succeeds, no one notices the jacket." By all accounts, the cloth simulator has succeeded: the simulator ran on all 89 shots in *Geri's Game*. Using it, however, required several adjustments by the animators and in the animation process. For example, because Geri has to always be in the same, known position to start the simulation, each shot was actually animated 30 frames before the beginning. Second, animators could no longer "cheat" by ignoring body parts hidden from the camera's view. The camera may not see Geri's arm, for example, but the simulator will still use it to calculate the way the cloth gets tugged around. And third, the animation process itself needed to change. "We had to add an extra step in the process for the jacket simulation," explains Dave Haumann, lead technical director. Instead of sending their animations directly to the renderer, Geri's animators had to first send the animated body to the simulator. The simulator, in effect, put the jacket on Geri and animated it to match the body animation.



Was all this cumbersome to the 18 animators who worked on Geri? Not to animator Karen Prell, who worked on 14 shots in *Geri's Game*. "I thought, 'Thank goodness, I wouldn't have to animate the jacket,'" says Prell, who was a real time puppeteer with the Muppets and with her own company in England before joining Pixar last April.

For her, the hardest work on *Geri's Game* was learning how to do a performance one frame at a time. "It's like performing while doing your tax return," Prell says. She starts by animating body language and head attitudes, working on the pacing of those movements. "I get as far as I can before getting into facial expressions, and then once I get to the face, the eyes are what I have to get right." She explains that usually the eyes lead the action and the body follows, just as internal thoughts lead to external movements.

Prell, like most animators at Pixar, has a mirror in her cubicle. "I act things out in front of the mirror to see how each part of the body moves, what motivates the movement, what makes the movement work," she says. "When I was in Pixar's boot camp, I would videotape myself then watch the movement frame by frame looking at which part is moving and which parts are holding still."

"It was so much fun getting into Geri," Prell says. "If you think of him as a 3D puppet, he's so amazingly expressive. He's fun and feisty and still a kid at heart. There's a lot of Jan in Geri, and that's one reason why he's so delightful."

"What the simulation gives you is this very complex behavior that would be prohibitive to do by hand, but the actual real control still has to be with the animator because that's the part people care about, the acting and the performance. I think we found a good mix on Geri. Michael [Kass] did a good job of freeing the animators from technical constraints on the acting part."

"The marriage of simulation and animation is difficult," Pinkava adds. "People interested in simulation are typically from the academic community and know how to do multiple differential equations. But if you're an animator, you're interested in performance and acting and story, the right-brain kind of stuff. Those are two different cultures. Bringing them together is what Pixar does, and that's what Pixar is about. [The cultures] kind of clash in the middle, and in the conflict, good things happen."

As with Pixar's other short films in the past, one of those good things is *Geri's Game*. CGW

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