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SIMULATED BITE MARKS

By Pam Frost Gorder

FOR THE FIRST TIME IN 11,000 YEARS, THE FEARSOME SABER-TOOTHED TIGER'S CANINES WILL TEAR INTO FRESH MEAT—IF SCIENTISTS AT THE UNIVERSITY OF BUFFALO GET THEIR WAY.

Though real Sabertooth cats are long extinct, anatomist Frank Mendel and his team plan to build a scale model of the head and jaws of a 700-pound *Smilodon fatalis* to reproduce the predator's deadly bite. They want to measure the forces necessary for the teeth to penetrate the skin, muscle, and other tissues of a recently dead herbivore, and use the data in a new computer-aided design (CAD) program they're developing.

The CAD program, the Vertebrate Analyzer (VA), could do for muscle and bone what similar programs have done for bridges, buildings, and automobiles—let scientists probe the form and function of a complex object on the computer. Ultimately, it could shed light on human bone and muscle ailments, as well as the lives of long-gone exotic creatures.

Mendel wants to be careful not to oversell the technology. He and Kevin Hulme of the project's engineering team have only just begun to show the beta version of the VA at scientific conferences, and they've just applied for US$1 million of federal funding to develop it further. But everyone from paleontologists to orthopedists wants a finished product.

"Whenever I talk about the Vertebrate Analyzer, someone says, 'that sounds great, when can we have it?'" Mendel says.

Larry Witmer, an anatomist at Ohio University, echoes that sentiment. "The software sounds really exciting. It looks like they still have a ways to go before they have a really sophisticated tool, but they're on the right track," he says.

The Software

Witmer currently uses the 3D visualization program Amira from TGS to analyze computed tomography scans of fossil skulls—the same kind of data set that Mendel's team uses. Recently, Witmer changed the face of *Tyrannosaurus rex* by suggesting the dinosaur's nostrils rested lower on its snout than once thought; he's also reconstructed a Pterodactyl brain and inner ear. He wants a program like the VA, which promises to let users virtually apply tissue to bone quickly and easily.

With the VA, the 3D skull rotates and translates by using the arrow keys; two mouse clicks attach the ends of a muscle bundle. During jaw movement, the muscle glows green when it's relaxed, then yellow, and finally, red as it fully extends. The goal is for the virtual muscles to move like real ones. Users can hasten the simulation by lowering the resolution.

A supercomputer could speed things up, but Mendel wants the software to run on a PC.

What Mendel and Hulme hope will set the VA apart from similar software is what they plan to do with it. They want to maintain it as open-source code and create a publicly available online vertebrate anatomy library, comparable in scope to the National Center for Biotechnology Information's GenBank DNA database. Modeling *Smilodon* is the first step.

Toothy Test Case

When scientists study prehistoric animals, they don't often have the luxury of complete specimens. *Smilodon* is an exception, due to large clusters of remains such as the 2,000 cats preserved in California's La Brea Tar Pits. Those skeletons suggest that adults were about the size of an African lion, but with longer forelegs that were more powerful than its hind legs. The cat's infamous fangs—skinny and serrated like steak knives, and up to 7 inches long—prompted experts to debate whether they were used for hunting or for competition among males (see Figure 1).

For Mendel, that question is settled. "At La Brea, we can't tell males from females," he says. "They all have enlarged canines, even the kittens. This suggests that the teeth did something other than advertise age or gender."

But how *Smilodon* used those teeth is still a mystery. Did it clamp down on an animal's throat to suffocate it, as big cats do today, or simply tear the throat out and let its prey bleed to death? Maybe its strong front legs could have pinned down a suffocating Ice Age herbivore such as a deer, but could those relatively thin teeth, which lack a full coat

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Figure 1. Frank Mendel holding the Smilodon cast.

of the enamel that strengthens human teeth, have held on without breaking?

"We assume the teeth were used to kill, yet we have to account for the lack of heft and enamel, so it's a mechanical problem," Mendel explains. What's more, fossil skulls offer only the barest clues of the muscle architecture that made wielding such teeth possible.

He was considering this puzzle when news reports of Boeing's computer-designed 777 aircraft prompted him to contact engineers at his institution. "I thought, wouldn't it be great if we could bring CAD to bear on the things I want to look at? But modeling soft tissue is a complex problem. An airplane is great technology, but it pales in comparison to what humans do walking around every day."

Once they build a skull and replicate its bite on animal carcasses from a butcher shop, scientists might know more about *Smilodon*. But the real payoff could go beyond that.

Potential Value

One benefit would be a clearer picture of extinct animals' biomechanics. "If you just look at modern times, you're missing the diversity of most of the life that has existed on this planet," Witmer says. "Understanding animals from the past helps us better understand animals today."

Stuart Sumida, a functional morphologist at California State University, San Bernardino, who also works with the film industry, sees two other ways for this technology to reach people: movies and video games. Today, animators move virtual skeletons called rigs inside animated "skin" to create movement. "Using virtual muscles to pull on these rigs realistically is a kind of Holy Grail of special effects," Sumida says.

Medicine, too, could benefit, as doctors could use the software to study joint problems. For instance, the work on *Smilodon* could lend insight to temporomandibular joint disorder, which causes headaches and jaw pain in an estimated

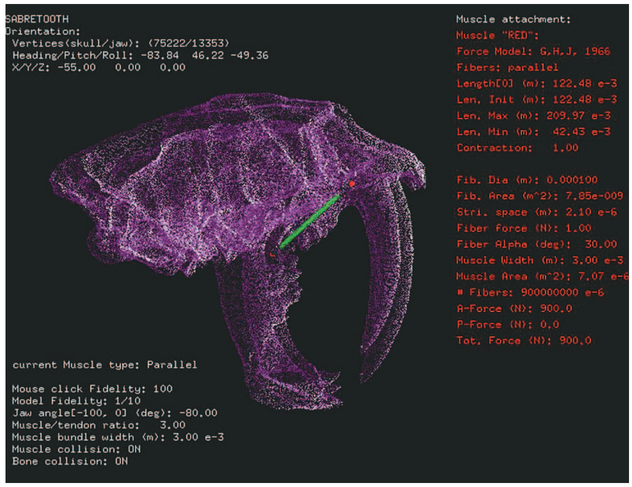

Figure 2. Vertex-based model of the Smilodon skull.

10,000 Americans (see Figure 2). Better artificial limbs could also result.

Mendel is staying patient. "If in three or four years we have a part of what I've been dreaming about, it'll be a great thing."

Pam Frost Gorder is a freelance science writer living in Columbus, Ohio.

BRIEF

New Cloud Animation Software On The Horizon

By Lissa E. Harris

A cirrus cloud wisp hovers on a brooding sky, glowing gold and vermilion with the last rays of the setting sun. But this cloud isn't made of dust and vapor—it's made of pixels. It's the product of Swell, a new software program that creates animated clouds with unprecedented speed.

Swell and Prime—two new programs that render animated, three-dimensional (3D) clouds—are the Purdue University Rendering and Perceptualization Lab's latest innovations. At the lab, directed by David Ebert, researchers are developing software that brings scientific and medical data sets to life as 3D models, computer-generated illustrations, and photorealistic images.

Swell

Swell isn't the first cloud-animation program to be developed, or the most realistic. But many simulators—like the software used to make virtual clouds for cinematic special effects—take hours or days to run. Those that function in real time, such as weather-predicting simulators that meteo-