Keeping tabs on an expanse of land that spans a continent requires the lofty vantage point of a satellite. Both of the new studies—by remote-sensing specialist Stephen Prince and his colleagues at the University of Maryland, College Park, and by Nicholson and her remote-sensing colleagues—rely on images from a series of National Oceanic and Atmospheric Administration satellites carrying an Advanced Very High Resolution Radiometer (AVHRR).

Intended to map snow, ice, and clouds, the AVHRR is good at recording vegetation changes as well. A ratio of surface brightness in the red part of the spectrum, where chlorophyll absorbs light, versus brightness in the near infrared, where green leaves efficiently scatter light, provides a "greenness" index that can gauge surface properties—for example, the proportion of the surface covered by vegetation.

When Nicholson and her colleagues calculated the greenness index for the entire AVHRR record—1980 to 1995—they found the edge of the Sahara doing a frenetic tango paced by rainfall, rather than a steady march. In the western Sahel, the area covered by their study, the southern boundary of the Sahara advanced southward and then retreated at least three times, moving as much as 300 kilometers over several years. "There is no progressive 'march' of the desert over West Africa," they conclude.

The satellite record also does not reveal any long-term degradation of the vegetated land. The greenness index can be related to the amount of rainfall to produce a measure of rain-use efficiency—the amount of green plants produced per unit of water. If something other than drought (overgrazing or soil erosion, for example) lowered plant productivity, rain-use efficiency would drop. But it remains constant if productivity simply varies with rainfall. Neither Nicholson, looking at the western Sahel over 16 years, nor Prince and his colleagues, who considered the full breadth of the Sahel between 1982 and 1990, found any net change in rain-use efficiency.

"I would say the remote-sensing observations confirm what most ecologists believed in the mid-1980s," says ecologist Dean Graetz of Australia's Earth Observation Center, part of the Commonwealth Scientific and Industrial Research Organization in Canberra. "The deserts aren't advancing; the Sahara was never marching south. Policy-makers are still impressed by the word 'desertification.' It is hypnotic, but it's not appropriate." Land degradation is a better term, he says, reflecting the more localized effects of such activities as grazing and foraging for fuel. Ecologists working in the Sahel have shown that around villages and wells, for example, overgrazing by cattle can shift vegetation from grasses to equally green, but less palatable, shrubs.

And that kind of degradation can be reversible, says ecologist William Schlesinger of Duke University. "If humans cause degradation, humans have the power to remediate the damage. That's encouraging." Graetz, however, fears that drought and misuse of the land will keep taking a toll on the health of the Sahel, even if they don't threaten its existence. **–RICHARD A. KERR**

ADDITIONAL READING

S. E. Nicholson, C. J. Tucker, M. B. Ba, "Desertification, drought, and surface vegetation: An example from the West African Sahel," *Bull. Am. Met. Soc.* **79**, 815 (1998).

S. D. Prince, E. Brown De Colstoun, L. L. Kravitz, "Evidence from rain-use efficiencies does not indicate extensive Sahelian desertification," *Global Change Biology* **4**, 359 (1998).

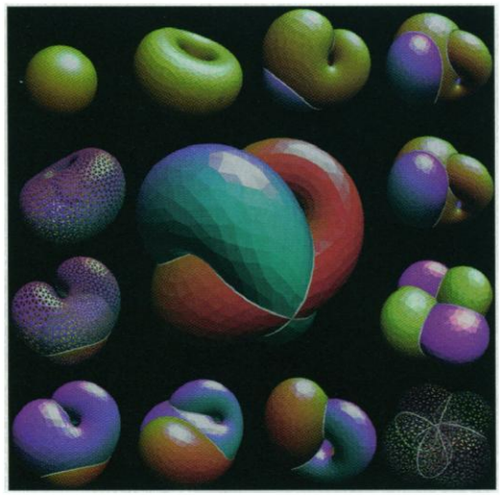
MATHEMATICS

Sphere Does Elegant Gymnastics in New Video

A tour de force of computer graphics gives the simplest solution yet to the venerable problem of turning a sphere inside out

More than 40 years ago, a University of Michigan graduate student named Stephen Smale laid down a challenge for future mathematicians. He proved an abstract theorem that had a startling corollary: An elastic sphere can be turned inside out, or "everted," without tearing or creasing it—providing the sphere can pass through itself, ghostlike. Smale did not give an explicit recipe for this sleight of hand, however. Since then, topologists have turned spheres inside out in media ranging from hand-drawn pictures to chicken-wire models to computer animations, but their solutions always seemed more complex than necessary.

Now, mathematicians George Francis and John Sullivan of the University of Illinois, Urbana-Champaign, have created a computer animation of a sphere eversion that is the simplest possible by several criteria. Demonstrated in a 6-1/2–minute video tour that will premiere next month at the International Congress of Mathematicians in Berlin and was shown in an abbreviated form at this month's Siggraph 98 convention in Orlando, Florida, their solution provides the most satisfying answer yet to Smale's challenge. It also shows how topologists are turning to computer graphics to solve some of their hardest problems. "In a real sense, the eversion question has become a benchmark for the use of computer technology in attacking problems of surfaces in three-dimensional space," says Thomas Banchoff of Brown University.



FRANCIS AND SULLIVAN

Sleight of computer. Animation turns a sphere inside out, using the least possible bending of the halfway point (center and bottom right).

A French mathematician, Bernard Morin, is generally credited with finding the first explicit eversion of the sphere in the early 1960s, and a computer-animated video called "Outside In," based on an idea by topologist William Thurston of the University of California, Davis, offers what may be the best-known example. Thurston's approach, however, is far from optimal. First, it allows the occurrence of many topological "events"—moments when two surfaces pass through one another, or when the curves of self-intersection abruptly change configuration. Second, it introduces an ornate pattern of corrugations to enable the sphere to twist around any potential kinks.

In the new eversion, Francis and Sullivan minimized bending by assigning their elastic surface an "energy" that increases when it is bent more tightly. At all stages of their eversion, the surface automatically keeps the lowest possible energy. And thanks to work done more than 10 years ago by Robert Kusner, a mathematician at the University of Massachusetts, Amherst, they already had an optimal configuration for the halfway point in the eversion, where the bending energy reaches a maximum.

Topologists had shown that at some stage in any sphere eversion, four sheets of surface

must pass through the same point. They knew that a surface with such a "quadruple point" must have a bending energy of 16 π, expressed in a dimensionless unit. (By comparison, the starting energy of any sphere, regardless of size, is 4 π.) In 1983, Kusner had found a surface with exactly that energy—a surface that looks very much like the halfway surface in Morin's eversion.

Kusner proposed that one could give this surface a little push, as one might push a chair that is precariously balanced on two legs, and let nature take its course. A nudge in one direction, he proposed, would cause it to collapse into a sphere; a nudge in the opposite direction would cause it to collapse into an inside-out sphere. Then, by running one sequence backward and the other forward, one could create a complete eversion, in which the original sphere evolved into Kusner's surface and then into its inside-out alter ego.

But there were doubts. Kusner's surface might not be as unstable as the chair on two legs: Given a small push, it might just return to the balance point. Or it might indeed collapse to a sphere when pushed one way, and to the same sphere (not an inside-out one) when pushed the other way. Finally, in its quest to minimize energy, the surface might pinch off into two separate spheres. The animation by Francis and Sullivan shows, however, that the eversion works according to plan.

To create it, the two researchers enlisted software tools that had not existed when Kusner did his work. Each frame of their video uses between 1000 and 2000 triangles to approximate the elastic surface. Both the number of triangles and the way they are connected change during the animation, making it nearly impossible to describe the intermediate surfaces by standard mathematical techniques. Instead of computing the movement of the surface as a whole, the software had to follow each piece separately.

When Francis and Sullivan ran the computation, they found that their energy-minimizing approach offered a bonus. Not only did it minimize bending, but it turned out to have the smallest possible number of topological events as well. To Banchoff, a member of the jury for the VideoMath section of the International Congress of Mathematicians, the video by Francis and Sullivan "represents a new level of elegance." Now, Sullivan hopes to apply the energy-minimizing approach to other classical topology problems, such as smoothly deforming a torus (an inner-tube shape) so that a stripe painted around the central hole changes places with a perpendicular band, running around a "meridian" of the inner tube.

–DANA MACKENZIE

Dana Mackenzie is a mathematics and science writer in Santa Cruz, California.

U.S. SCIENCE POLICY

Physicist-Turned-Politician Seeks Middle Ground

Representative Vern Ehlers, a former professor, is completing one of his biggest assignments: setting out a course for U.S. science in the next century

When House Speaker Newt Gingrich (R–GA) called for a sweeping review of science policy last summer, he said it was time for a dramatic new vision for science and technology after the Cold War and on the brink of the millennium. He gave the job of pulling together that vision to Representative Vern Ehlers (R–MI), the number two Republican on the House Science Committee.

Now, on the eve of unveiling his report, Ehlers knows he faces a tough sell. The more detailed the recommendations, the more critics it will attract, including those who may reject it as a partisan document serving the man who requested it. But a failure to take a stand on the important issues facing the community could turn the report into a political bookend, unread and ignored.

SAM KITTNER

"The science community has to develop a new constituency and stop bemoaning the loss of the old one."

—Vern Ehlers

Finding a middle ground is no easy task, even for a man recently named one of the three brainiest U.S. House members by *Washingtonian* magazine. For example, although Ehlers suggests that consolidating research agencies may be a good idea, he hastens to add that there are "many different options." The report, he says, "will not make any recommendations" on the matter or lay out detailed options. "We will simply point out the problem."

Ehlers's background—he calls himself the first research physicist to serve in Congress—may disarm some potential critics. He has a reputation as a moderate Republican and environmentalist. He also holds a Ph.D. in nuclear physics from the University of California, Berkeley, did research at Lawrence Berkeley National Laboratory, and taught for 17 years at his undergraduate alma mater, Calvin College in Grand Rapids, Michigan. And, despite a 23-year career in politics, he retains the serious, self-effacing, and soft-spoken quality of a small-college professor.

"I didn't fit the typical mold," he says, recalling his first try at public office. "Scientists don't generally run. And people who get elected have hair." But the voters didn't seem to mind, electing him as county commissioner, and later state legislator, before sending him to the U.S. House of Representatives in 1995.

The science policy study is proving to be one of the biggest challenges of his political career. "The most frustrating part is the lack of time to do the kind of job I would like to do," he told *Science*. "I don't want to put the kiss of death on the report, but it was a very complex and time-consuming task, and it comes on top of my regular duties, which take 80 hours a week."

Time is not his only challenge. Neither House Democrats nor the White House has shown much enthusiasm for the review, and a series of hearings held to gather input on a host of science-related issues played to half-empty hearing rooms. But Ehlers, a devout Christian who has rankled some researchers with his opposition to human cloning, is hoping that his scientific colleagues will ultimately embrace his project as a well-intentioned attempt to stir debate on an enormously complicated and important subject. "Nothing would sink it faster than them saying, 'Oh, this is just another study,' " he says.

What follows is an edited transcript of a