## A HISTORY OF NO OWNERSHIP

**The case of Washington University v. Catalona et al., is the latest example of courts not lending much credence to the concept of people owning their excised tissues. In two major cases, *Moore v. Regents of the University of California* (1990) and *Greenberg et al. v. Miami Children's Hospital Research Institute, Inc., et al.* (2003), patients had sued researchers for patenting a cell line or gene isolated from samples without the donors' knowledge. In both cases, courts ruled that patients had no property rights to the tissues or what was derived from them.**

gal correctness. "Maintaining public trust in research is critically important. What will affect medical research is if people think they're being taken advantage of," says Ellen Wright Clayton of Vanderbilt University, who testified on behalf of Catalona's patients. "I think we need a larger discussion about control over the use of stored tissue samples for research."

The degree of control that people want over their donated samples seems to be low in most cases, but not all. In one 2005 study, investigators found that 87.1 percent of tissue donors who filled out consent forms at the National Institutes of Health granted unlimited further use of their biological specimens, largely irrespective of the signers' age, race, residence or possibility of benefiting from research. Only 6.7 percent refused any ongoing use of their tissues, suggesting that a simple all-or-nothing consent form may be enough, the authors concluded. But if given the additional choice of being recontacted for approval of future research, a substantial minority, 26.2 percent, selected that option.

There are signs that research institutions perceive a need to maintain the public's trust. The nonprofit Coriell Institute for Medical Research in Camden, N.J., which houses the samples collected by the International HapMap Consortium, requires investigators to consult with the communities providing specimens if they reside in the U.S. Perhaps researchers are coming to believe that, just as with tissue, lost trust is hard to get back.

*JR Minkel is a frequent contributor (of words, not cells).*

SOFTWARE

# Inpaint by Numbers

## AN ALGORITHM TO AUTOMATE THE REPAIR OF MOVING IMAGES

**BY BRIE FINEGOLD**

**Astute moviegoers may** have noticed a traveling car and its trail of exhaust in a scene from Peter Jackson's *The Lord of the Rings: The Fellowship of the Ring*. Current tools, such as Adobe System's After Effects "healing brush," can readily camouflage, or inpaint, small blemishes. To fix larger gaffes, though, the user must tirelessly cut small patches of image and paste them over the unwanted object. The effort typically yields mediocre results for all but the smallest repairs: on the DVD version of *Fellowship*, a blurry spot is visible where the car was.

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But new software using advanced mathematics may soon enable video editors to automatically inpaint a moving object quickly and seamlessly. It can even massage away large moving objects that hide other action, according to the software's principal developer, computer scientist Guillermo Sapiro of the University of Minnesota.

Sapiro's knowledge of video inpainting builds on his prior experience with still photographs. In 1998 Sapiro and three colleagues observed inpainting techniques of traditional restoration artists in Paris, who started from the edges of the damage, extended the basic structure inward and then colored according to image intensity (lightness or darkness). Focusing first on grayscale images, the researchers translated the artists' techniques into mathematics (specifically, partial differential equations) that described how the intensity changed throughout the photograph in every direction.

In the case of a photograph of a bridge missing a circular patch, the program, like the artist, fills in the patch from the boundary of the circle inward. The mathematics encodes a process for simultaneously extending a special set of curves, called isophotes, along which the image intensity remains constant. The inpainting is complet-

ed when tones of gray flow along these curves from the exterior of the circle inward. "Propagating boundaries from the outside in is the common denominator among all recent inpainting techniques," Sapiro explains. For color images, the researchers calculated and then later combined the intensities of three basic colors (red, green and blue).

Extending these breakthroughs to video would seem simple—just repair each frame. Despite being straightforward, this strategy might produce a choppy video or simply not work. Taking as input a frame in which the logo on a T-shirt is completely obscured, a photographinpainting program would yield a perfectly fine T-shirt with no logo. But a program exploiting the temporal aspects of video could restore the logo by overlaying it with nearby frames where it was not obscured.

To incorporate time into their inpainting algorithm, the researchers viewed it as a third dimension. A circle of missing image data smoothly wandering around the film could be imagined as the result of a worm taking a wiggly path as it eats through a stack of frames. The length of the worm is the circle's duration on the film. Once these spacetime boundaries have been identified, the program inpaints the 3-D shape carved by the worm, simultaneously inpainting the 2-D circle on each frame to create a smooth result. Luckily, the user need only identify the circle in one frame, and the program will extract the entire worm by sorting static from moving parts.

Sapiro's algorithm has yet to appear in commercial software; in any case, he and his colleagues are still refining it. With Kedar Patwardhan of the University of Minnesota and Marcel Bertalmio of Universitat Pompeu Fabra in Barcelona, Sapiro describes in a paper under review a faster algorithm that allows for some camera motion. Still, no software exists to remove an expanding or contracting object, such as that which occurs when a camera zooms out or in on a subject. Nor are there algorithms for completing erratic motions. As computer scientists overcome these challenges, they might even wipe away Web sites such as movie-mistakes.com, where *Titanic* is listed as having 140 filming errors.

### INPAINTING AS FLUID FLOW

**The mathematics underlying video inpainting resembles the extensively studied Navier-Stokes equations, which model the motion of fluids. Color, like liquid, flows into holes (missing circular patches on a photograph) and diffuses around obstacles (well-defined image outlines). This analogy with liquid led computer scientist Guillermo Sapiro of the University of Minnesota and his colleagues to automate inpainting using techniques similar to those employed to predict fluid flow. NASA used their program to restore images of Venus (www.iua.upf.es/~mbertalmio/venus/index.html).**

**Examples of Sapiro's video inpainting are at www.tc.umn.edu/~patw0007/video-inpainting**

**Examples of the colorization of grayscale images, a kind of video inpainting, are at http://mountains.ece.umn.edu/~liron/colorization/**

PROBIOTICS

# Digestive Decoys

BACTERIA MADE TO TAKE THE TOXIC BULLETS AIMED AT HUMAN CELLS **BY CHRISTIN E SOARES**

**Travelers to the tropics** usually try to avoid consuming the local microscopic flora responsible for "Montezuma's revenge" and other, more life-threatening intestinal illnesses. But an Australian research team thinks the best way to protect against those harmful gut bacteria may be to swig more bacteria: specifically, a benign strain of *Escherichia coli* genetically engineered to absorb other bacteria's toxins.

James C. Paton and his colleagues at the University of Adelaide modified a harmless strain of *E. coli* so that it sports human-looking docking sites on the surface of its cell membrane. The idea is for bacterial toxins to bind to the decoy cells instead of to cells lining the human gut. The group's latest version mimics the human cell receptors for cholera toxin, and each bug is able to soak up 5 percent of its own weight in poison. In a test tube, the decoy bacteria neutralize 99.95 percent of the toxin's ability to kill human cells. When a dozen baby mice were given the modified bacteria and then infected with *Vibrio cholerae*, eight mice survived, whereas all 12 cholera-infected control mice died. Three quarters of the test mice survived even when researchers waited four hours after infection to treat them.

Paton has also engineered *E. coli* to bind toxins produced by more aggressive strains of its own family, including the bacterium that produces Shiga toxin and the one that often causes travelers' misery as well as lethal diarrhea among children in the developing world. He hopes his designer "probiotic" will

### TOO CLOSE FOR COMFORT?

**Concern that bacteria engineered to mimic human cells might provoke autoimmunity is based on a rare phenomenon seen after natural infections. Guillain-Barré syndrome, a condition in which antibodies attack peripheral nerves, causes muscle weakness and has been linked to bacteria. A quarter of syndrome sufferers show signs of previous infection by *Campylobacter jejuni,* which bears a surface receptor similar to one present in the myelin sheath covering human nerve fibers. Thus, antibodies developed in response to *C. jejuni* might be turning against the host's own myelin. The**

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