Forefront

COLLEGE OF ENGINEERING UNIVERSITY OF CALIFORNIA, BERKELEY fall 2006

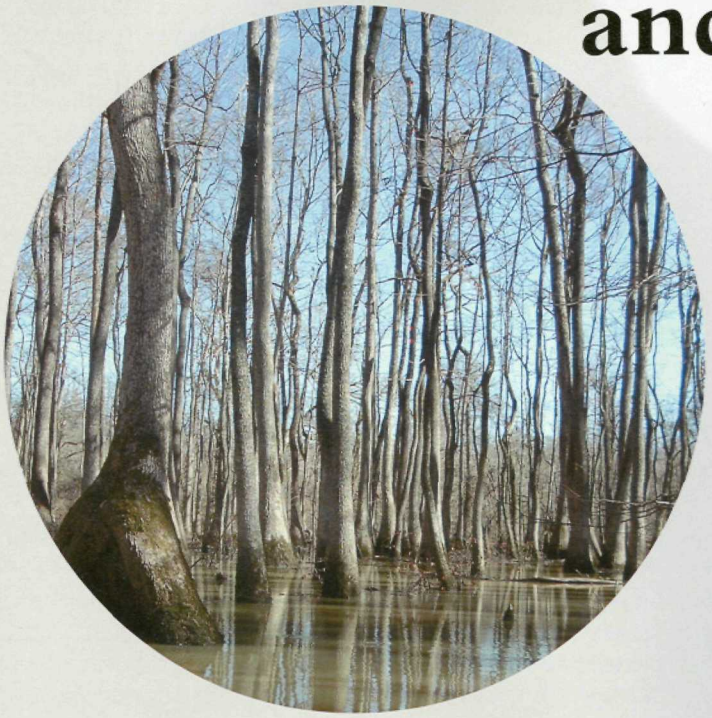
BIG GAME TICKET DRAWING!
See inside back cover.

Broken Levees: New Orleans to Sacramento

UC Berkeley engineers lead search for solutions

- New center puts Berkeley on the synthetic biology map
- Simulated quake rocks the house
- Can biofuels break our oil addiction?

The Ghost Bird and the Robot



BY DAVID PESCOVITZ | PHOTOS BY DEZHEN SONG

Somewhere in the swamps of eastern Arkansas, where mosquitoes reign supreme and thousand-year-old trees shroud the bayou below, the largest woodpecker in North America is hiding. Or not.

The ivory-billed woodpecker is thought to have been extinct for the last 60 years. However last year, researchers from Cornell University made headlines with their announcement that the elusive ivory-bill, also known as the "ghost bird" or "grail bird," had been not only spotted but also caught on a few seconds of video. If the species has indeed survived, it would justify decades of nature conservation efforts. To this day controversy rages about whether Cornell's blurry image flying off in the video is in fact the ivory-bill or a common look-alike, and whether the sighting reports are fact or figment.

So, even as this very human quest continues for the legendary ivory-bill, the first glamour shot—if the bird is indeed still flying over Arkansas—may actually be taken by a robot co-developed at Berkeley.

College of Engineering professor Ken Goldberg and collaborators from Texas A&M University and the Cornell Laboratory of Ornithology are developing an autonomous robotic camera that will maintain a constant vigil on the Arkansas skies above Bayou de View Wildlife Refuge. The aim is to get definitive video documentation of the "rediscovered" ivory-bill.

"Biologists spend a great deal of time observing and recording nature," says Goldberg, who holds a joint appointment in the Departments of Industrial Engineering and Operations Research and Electrical Engineering and Computer Sciences. "We're trying to help them bring the latest technology into the field."

The system, developed by Berkeley and Texas researchers, consists of two commercially available ultra-high-resolution video cameras and a computer processor mounted in a custom waterproof box. It will be mounted on a power line that cuts across the swamp. Pointed at opposite angles, the cameras will continuously capture video of the sky above. Most of that footage will be thrown out seconds after it's recorded. But if a bird flies through the frame, algorithms developed by Goldberg and former Berkeley Engineering student Dezhen Song (Ph.D.'04 IEOR), now an assistant professor at Texas A&M, will detect the motion and store the video for later analysis by Cornell's ornithologists.

"There's a long, romanticized history of field biologists trekking around in treacherous swamps," says Ron Rohrbaugh, project director for the Cornell search. "A camera might sound a little sterile, but it could cover the area of 10 people and probably do a better job. From a scientific perspective, that's terribly exciting to us."

Rohrbaugh's excitement has grown exponentially since Goldberg and Song first contacted him with their idea. His first reaction? "Skepticism," he says. Last year, the Cornell search cost nearly $1 million and involved nearly two dozen paid staff, many more volunteers and five field stations in the swamp. Most of the searching was conducted on foot or by canoe, with researchers looking for the bird, listening for its distinctly nasal "kent" calls and double raps and conducting transect surveys from tree to tree for possible nests and roosts in the half-million-acre Big Woods. The researchers had already deployed time-lapse cameras mounted to trees and remote microphones to listen for the telltale calls. In fact, Rohrbaugh had already investigated mounting a surveillance system along the same power line that Goldberg and Song identified as a strategic location for their system. The problem, Rohrbaugh says, was that the field of view he wanted to observe was so large and the camera resolution so low that even if the ivory-bill showed up for a screen test, it likely would be too small in the image to be positively identifiable.

"The system Ken and Dez are installing is much more sophisticated," Rohrbaugh says. "This robotic camera's ability to zoom in so you can identify what you're seeing from far away is just spectacular."

When it comes to the uncharted terrain of robotics in the wild, Goldberg and Song are trailblazers. For a dozen years, Goldberg has experimented with telerobotic cameras on the Internet. In 1994, he and his colleagues unveiled the Mercury Project, the first robot on the Internet that enabled anyone to interact remotely with the real world. Participants operated a telerobotic arm from their Web browsers to excavate artifacts in a terrarium in Goldberg's laboratory. Over the next 10 years, Goldberg experimented with myriad telerobotic systems, including the Telegarden, a physical garden that an online community tended using a robotic arm, and the Tele-Actor, a system he developed with Song and others where online users democratically "controlled" a human "robot" to explore remote spaces.

"After 9/11, there was a huge rise in the development of surveillance and security devices," Goldberg says. "In 2003, Panasonic came out with a low-cost, super-high-resolution controllable camera that greatly magnified the potential for invading personal privacy."

The result was Demonstrate, an art installation Goldberg and his students developed for the Whitney Museum of Art. In September 2004, they mounted a high-resolution robotic camera over Berkeley's Sproul Plaza, birthplace of the Free Speech Movement. Via the Internet, 4,000 people online participated in controlling the camera and recording activity on the Plaza. Demonstrate's state-of-the-art system raised compelling questions about personal liberty and personal privacy in public places.

"Afterward, we started thinking about how such cameras could be constructively installed in remote natural environments to help biologists observe endangered species," Goldberg says.

Bears, birds and other animals don't seem to mind a quiet camera nosing in on their business. Based on that assumption, Goldberg and Song obtained funding from the National Science Foundation last year and designed their first CONE (Collaborative Observatories for Natural Environment). The ultimate CONE is self-contained in a small, wheeled trunk that scientists leave behind at their research sites. Just open the lid, and the system automatically kicks into operation, seeking out a satellite connection for Internet access and charging its batteries via solar panels. Once the scientists return to the lab, they log onto the Internet to see what the

RIGHT: *This prototype camera will be replaced next month with a pair of ultra-high-resolution robotic video cameras developed by UC Berkeley and Texas A&M researchers.*

CENTER: *Berkeley professor Ken Goldberg (front of canoe) and Cornell ornithologist Ron Rohrbaugh in the Bayou de View Wildlife Refuge, Arkansas.*

FAR RIGHT: *One of America's most majestic birds, the ivory-billed woodpecker was believed to be extinct, but several sightings have been recently reported, prompting a massive search by experts and "ghost chasers."*

camera sees and collaboratively steer it to keep an eye on their animal subjects from afar.

"To our knowledge, there is no serious robotics research to develop tools for the scientific study of natural environments," Song says. "That's unbelievable to me, but for a researcher, it's a gold mine of opportunity."

The researchers tested their first CONE at the Marin County, California, home of Berkeley professor Eric Brewer, whose balcony overlooks a bird preserve. They kept the camera running for three months. Coincidentally, that's when Goldberg first read about the quest for the ivory-bill.

"That story struck me because it had all the ingredients we were talking about," he says. "The ivory-bill search is a really hard problem requiring a lot of remote fieldwork. Bird watching is all about vigilance. But a lot of that sitting and waiting is drudgery. Fortunately, robots are great at drudgery."

After speaking by telephone with Cornell Laboratory of Ornithology head John Fitzpatrick, Song and Goldberg took a February field trip to Brinkley, Arkansas, hometown of the ivory-bill search. "We were riding in the back of these pickup trucks, where it's extremely cold and damp," Goldberg says. "Then we get into canoes and paddle through this serene swampland. They took us to the place where the sightings had occurred in the bayou."

A power line that cuts right across the bayou provides a swath of sky 50 feet wide by 900 feet long. It's the perfect spot for a CONE for several reasons, Goldberg explains. First, there aren't any trees in the line of sight. That's essential because the camera is triggered by movement. The sway of a tree would yield a false positive. And if the bird is out foraging in the area, it would likely pass over this region at some point. Finally, the power line can provide endless juice to keep the camera running day and night. The one thing lacking in the middle of the swamp, though, is a wireless network.

"We're doing the ultimate in old-fashioned networking," Goldberg says. "A student will row a boat out there every two weeks, pull out the hard drive and put in a new one. The student will then go to a local lab to upload the images for remote analysis."

Those brave souls are students of David Luneau, the avid birdwatcher who shot the highly scrutinized 2004 video that's still the best evidence that at least one ivory-bill was alive and well in Arkansas. Luneau, who is a professor of electronics and computers at the University of Arkansas at Little Rock, recently joined the CONE team to create a database of the gigabytes of video that the camera will capture each week.

Meanwhile, Song and his students are collecting clips from several cameras on the roof of his lab to ensure that the system captures the resolution necessary to satisfy Cornell's critical eye. This easy-access deployment also serves as a testbed to hone the computer-vision algorithms that recognize when a bird flies across the background. Just defining that background isn't easy, Goldberg explains. For example, the system must be smart enough to know that clouds or rain or even changes in lighting shouldn't be treated as objects of interest.

Next fall, the team will row back into the swamp to install its CONE system. That's just before mosquito season starts and things get really ugly out there, Goldberg says.

For Rohrbaugh, the robotic camera isn't the only method his team will use in their continued search. It's in his best interest, he says, not to put all his eggs in one basket. "There are techniques we're onto now that offer real optimism." And cautious optimism, Goldberg agrees, is the name of this game.

"I'm hopeful but not overconfident," Goldberg says. "We're willing to run this camera for years, and we're prepared to accept it if we never see the bird. We always assume the null hypothesis. But if this persistent robot out on the bayou manages to capture verifiable high-resolution images of the legendary ivory-bill, it would be a major discovery for scientists, for conservationists and for more than 45 million American birdwatchers."

For more on the project, go to **www.c-o-n-e.org/acone.**

DAVID PESCOVITZ (david@pesco.net) writes *Lab Notes*, the College of Engineering's online research digest. He is also co-editor of *BoingBoing.net* and editor-at-large of *MAKE: Magazine*.

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