IN THIS ISSUE

News from
THE CENTER FOR INFORMATION TECHNOLOGY RESEARCH IN THE INTEREST OF SOCIETY

THE CITRIS SIGNAL

FEB/MARCH
2014 ISSUE

SUPERCHARGING OUR WATER-RELATED PROJECTS

Dear Friends of CITRIS,

It is hard to enjoy the clear warm weather in Berkeley this winter; never far from our minds is the drought that threatens to wreak havoc on the state. We use water to generate power, to grow half of the nation's fruits, nuts, and vegetables, to preserve our environment, to prevent wildfires, to make silicon chips, and, among so many other things, to keep ourselves alive and hydrated. With the Sierra snowpack at only about 17 percent of its average for this time of year, with two dry years preceding this one, and with no significant precipitation in sight, it is beginning to look a lot like the late 1970s, when reservoir levels were so low that emergency rationing was imposed by local and state governments. That crisis had an upside, though; it gave birth to a host of new water conservation technologies and policies: low-flow showerheads and toilets; super-efficient washing machines; water recycling; xeric gardening; and drip irrigation on farms. Today we take some measure of water efficiency and conservation for granted; it took a drought to make us do so.

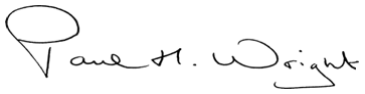
Similarly, the drought of 2014 gives CITRIS incentive to supercharge our water-related projects. The two profiled in this issue of the *CITRIS Signal* demonstrate how technology can be applied both to better understand and to ease the state's water supply crisis. "The Development of a Basin-Scale Water-Balance Instrument Cluster for Hydrologic, Atmospheric and Ecosystem Science," a collaborative project led by teams at Berkeley and Merced, is finding new ways to better track how much water is stored in the Sierra and when it will be available. It is also detecting

important but underappreciated factors like the amount of water absorbed and transpired by the same trees that endanger some California forests with catastrophic fires. It may seem counterintuitive but harvesting some trees in these areas might both constitute environmental restoration (the trees remain due to a century of artificial fire suppression) and a way to wring significantly more water out of the watershed.

The second story, "Elevated Research," focuses on a new member of the CITRIS family, YangQuan Chen, director of the MESA Lab at UC Merced. Several years ago, Professor Chen recognized the potential for a profound research tool in unmanned aerial vehicles, commonly called drones. Not only can they help evaluate water supplies (and water quality) in hard-to-reach regions, but they may also become staples on California farms practicing precision agriculture. Drones can provide affordable real-time data about the moisture and nutritive stress levels of crops on different parts of a farm, so managers can water only those crops that really need it. According to a recent report by the Association of Unmanned Vehicle Systems International, the adoption of drones in California's Great Central Valley will create thousands of jobs and billions of dollars of new industry and agricultural savings in the decades to come. Chen and his UC Merced-based lab will be in the center of this revolution.

As California retools its water use to reflect 21st-century realities, CITRIS is positioned to make key contributions to navigating these troubled waters. And, as was the case after the last drought, the technologies developed and lessons learned in California will help quench the thirst of dryer regions around the world. Stay tuned for details about a symposium planned for late April on new technologies for environmental research and journalism.

Keep up the good work,



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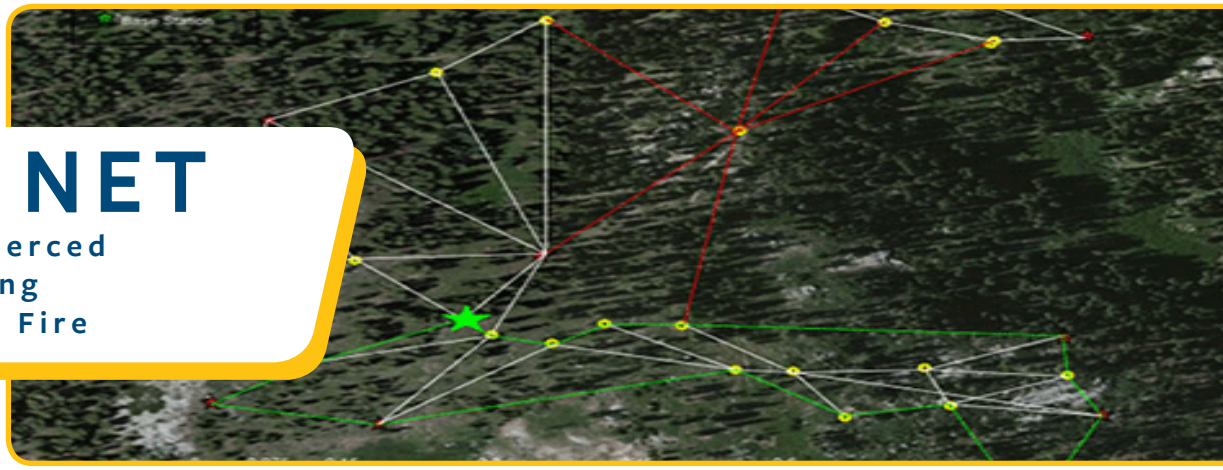
Pictured on front cover: UC Merced graduate student Brendan Smith goes knee deep to demonstrate the capabilities of a water-drone he created. Related story on page 6.



SNOW NET

Joint Berkeley-Merced Snowpack Tracking Project's Test by Fire

by Gordy Slack

California is experiencing its third dry winter in a row. Rainfall stands at levels far below normal and some reservoirs are nearly empty, but the real problem registers at higher altitudes in the Sierra Nevada where most of the state's water wealth is stored as snow. The Sierra snowpack is at only about 17 percent of average level for this time of year. That is hard news to swallow for big water users across the state: farmers, town and city governments, hydro-power producers, and wildlife managers.

Worse, says the California Department of Water Resources, new climate models suggest that these dry conditions may be California's new normal. Someday, desalination and other freshwater-generating technologies may provide new alternatives to the precipitation California relies on today, but for now the best that resource managers can do is maximize the efficient use of current water supplies.

Imprecise estimates of how much water the snowpack holds, however, make such efficiency planning difficult from the top of the system down. Currently, in the winter, the most remote Sierra snowpack sites are visited by humans only once a month and measurements taken on these trips are very coarse, providing only approximate data about how much frozen water is accumulating and will flow to reservoirs in the spring and summer.

A joint project between UC Berkeley and UC Merced attempts to radically improve the quality and availability of data about the amount of water stored in mountainous parts of the vast American River Basin, which runs from the Sierra Nevada to Sacramento. The snow at the top of this watershed is one of California's primary freshwater storage sources. The CITRIS-supported project, the Development of a Basin-Scale Water-Balance Instrument Cluster for Hydrologic, Atmospheric and Ecosystem Science, aims to provide real-time, high-resolution data about how much water is stored in and being released from the Sierra snow pack. Armed with that knowledge, water managers can begin to plan allocations for the spring and summer even as the winter snows accumulate.

The project, initially profiled in a 2011 *CITRIS Signal* feature, took a major step forward this summer when a team of faculty members and students traveled into the Sierra high country and installed ten sensor networks, each composed of ten or more stations that measure snow depth, temperature, and humidity.

photo by Zirin Zhang

These NeoMotes, data loggers fitted with transceivers, were attached to sensors in each snow-monitoring station. Designed for this project by Professor Steve Glaser and his former student Branko Kerkez, the motes are now commercially manufactured by Metronome Systems in San Jose.

Several more networks will be installed next summer and other sensors measuring solar radiation, soil moisture, and sap flow will be added. Because the networks are based on super-low-energy, wireless communications technology and can send data back to Berkeley in near real time, they could make high-value data from remote areas both relatively inexpensive and readily available. But for the system to gain widespread acceptance among the famously conservative (aka risk-averse) community of water managers, "it must also prove to be both reliable and robust," says Ziran Zhang, the UC Berkeley graduate student coordinating installation of the instruments.

"Reliable and robust. Those two words are repeated again and again," says Zhang. "Data must be accurate when they come and we have to be able to count on them under all different conditions." The system's stations had been in place for only a couple of months when they underwent trial by fire. The American Fire in August burned nearly 30,000 acres in and adjacent to the area containing two of the networks. Fire crews pulled out all but one of the threatened sensor stations at the Duncan Peak site. The one left behind was destroyed by the fire and another replacement was crushed by a falling tree later in the season.

Curious animals have also been a challenge. Bears are attracted to the wires connecting the sensors to the transmitters and one chewed on a battery after carefully opening the enclosure, says Zhang. In addition to tracking the snowpack, each node on the network also monitors its own health and, as long as only a limited number of nodes malfunction simultaneously, the system can work around a broken network, too. Each site communicates wirelessly with multiple others, so if one connection is lost, data will still find their way home to Berkeley. When a node goes down, that fact is automatically transmitted to the researchers, so they can send someone out to repair it promptly, says Zhang. The rough wilderness terrain raises several challenges for the researchers. Radical altitude changes, rock outcroppings, and irregular vegetative cover all complicate the task of gauging the strength of the wireless signals, says UC Berkeley engineering professor Steven Glaser, co-PI on the project. "The network can be working perfectly in the lab, but when you install something like this in the wild, there will be surprises."

Roger Bales stresses the importance of properly locating each station so that it can both communicate with the others and collect representative data. "We will be taking lessons learned this year back into the field with us next summer," says Bales, co-PI on the project and engineering professor at UC Merced. In addition to addressing basin-scale questions about how much water is stored in the snow and how much it is releasing at any given time, other more locale-specific questions may be answered by the sensor networks as well, says Bales. For example, the project is examining how much water is drawn up

> I suspect there is a high value to the electricity grid of having better forecast information, which is what these sensor networks are all about.
>
> - David E. Rheinheimer, Postdoctoral Scholar at UC Merced & Center for Watershed Sciences at UC Davis

and held by vegetation in different areas. "The trees are like giant pumps that pull water up into their trunks," says Glaser.

At one experimental site near Shaver Lake, plant transpiration "pulled out" more than half of the water, he says. In the much larger American River Basin study, area research on the influence of vegetation on water availability is still ongoing, says Bales, but preliminary results suggest that trees are trapping a significant amount of water. "Removal of one-third to one-half of the biomass in a forested area may result in a 5 to 15 percent gain in runoff in the long run," says Bales.

Due to decades of fire suppression practices in the watershed, much of its forests are more densely wooded than old-growth would have been hundreds of years ago. The new data may add extra incentive for land managers to reduce vegetation in some parts of the American River Basin. In some areas, fire suppression has resulted in a near doubling of the biomass over the past century, says Bales. The extra trees don't just take water out of circulation; they also constitute dangerous amounts of fuel for infrequent but potentially catastrophic wildfires.

This summer, both the Yosemite Rim Fire and American Fire were so destructive largely because burning had been suppressed in those regions over the past century. There is just too much fuel. Before the forests were managed, small fires would periodically burn through and reduce the amount of younger, smaller vegetation, leaving the big older trees intact. Allowing controlled burns, or thinning the trees, may well both restore the forest ecosystems and boost badly needed water supplies, says Bales.

"We will know a lot more when our instruments have had a full season or two in the field," says Zhang. Right now he and the research team wait impatiently for the snow to fall and the first winter's data to flow. ■

Picture at top of story: An aerial photograph of one of the ten sites installed this summer in the American River Basin. Each red dot represents a sensor station that measures snow depth, temperature, and humidity. Image courtesy of Ziran Zhang.

ELEVATED RESEARCH

Peaceful Apps for a New Generation of Unmanned Aerial Vehicles

by Gordy Slack

Drones may have a sinister reputation, but they are finding a useful niche in academic research in the service of environmental science, resource management, and precision agriculture. Researchers at UC Merced's new Mechatronics, Embedded Systems and Automation (MESA) Lab explore innovative ways to use Unmanned Arial Vehicles (UAVs) to gather data from places too expensive, rugged, or remote to reach by conventional means.

Small, inexpensive UAVs can give ecologists access to remote areas where collecting samples or data has been difficult or impossible. The "data drones" that Professor and MESA Lab director YangQuan Chen has developed for the past five years are small, but their list of capabilities is long. They can collect high-resolution thermal, near infrared (NIR), and red-green-blue (RGB) standard video and imagery; identify plant species along with their nutrient and hydration levels (key measurements for monitoring both forests and crops); collect air quality samples; track pipelines and shale fracking sites for gas leaks; trace birds and other wide-ranging animals fitted with tracking devices; and even monitor biodiversity.

Monitoring aquatic biodiversity is the focus of a new collaboration between Chen and UC Davis's Michael Miller. The team plans to use Chen's drones to conduct surveys of mountain rivers and other hard-to-reach aquatic ecosystems. Chen's part of the job is to develop a UAV that can land on moving water (even in high winds and foul weather) and retrieve a small sample. Miller is honing a procedure that extracts and sorts DNA to identify all the species living in the body of water from which the sample is taken. The method, which separates the environmental DNA (eDNA) from the water, requires far smaller sample sizes than older methods. An Assistant Professor of Population, Quantitative Genetics, and Genomics at UC Davis, Miller believes he can reduce the required volume of sample to less three tablespoons.

Another planned use of the water-drone would be to conduct biological surveys during and after

Professor YangQuan Chen builds unmanned aircraft that could be used to sample biological diversity in remote areas.

disasters, such as floods, chemical spills, or fires. The vehicles will need to be able to fly, land, and maneuver on moving water, and take off from that water, all in wet and windy weather. These control challenges, says Chen, are at the center of his project.

"You do not need to be able to hold the aircraft in exactly the same spot, but you do need to have active maneuvering of the aircraft while it is on the water," says Chen. If you land on water and surrender to the river flow, the drone could be carried into brush or hit a rock.

In addition to exploring the use of drones for environmental monitoring, MESA Lab researchers also focus on drones that can gather data for farmers. Precision agriculture, a hyper-responsive and efficient farm-management approach, tailors watering and fertilization regimens to real-time crop data that can be inexpensively gathered from above.

"In the next 20 years, I believe the San Joaquin Valley and Central Valley will become the 'Data Drone Valley,'" says Chen. "By 2020, Merced should have a world-class drone center to provide agriculture with the aircraft and analysis that the new field needs."

As water for agriculture becomes less abundant in California, and as the world's food demands grow, farmers will need to extract higher yields from fewer acre-feet of water. One important way to do that, says Chen, is to closely monitor real-time crop conditions in all parts of a farm. Drones may be the least expensive and most versatile way to accomplish that. Outfitted with cameras and sensors that can give high-resolution readings of soil moisture, plant evapotranspiration rates, pest invasions, and other crop conditions, the drones can help track both the temporal and spatial differences of various portions of a farm so that farmers can deploy resources only when and where they are really needed.

"Every farm should have a few data drones to tell them precisely what the stress level of their crops is, when they need to fertilize, water, and harvest," says Chen. With the right resolution of data, these practices can be customized for all parts of the farm, saving expense and time over human observers.

To meet that need, Chen and colleagues are proposing to create CIDER (the California Institute of Drone Engineering Research) a UC Merced 2020 Strategic Academic Focusing Initiative proposal.

Meanwhile, it is easy to imagine these data drones facilitating the jobs of researchers in CITRIS labs on all four campuses. To keep the barrier to entry low, both to farmers and environmental researchers of all types, Chen plans to offer his drones at an affordable price. The eDNA-drone prototype his team is developing with Miller will probably cost about $1,000, despite its specialized ability to land on and remain stable in moving water. Simpler drones for precision agriculture may cost as little as $600, Chen says.

"They need to be cheap enough so that if you lose one you do not cry too much," he says. ■

Pictured at top of story: UC Merced graduate student Brendan Smith & Professor YangQuan Chen with their eDNA-drone prototype.

Costas Spanos Appointed New CITRIS Director

CITRIS is pleased to welcome Costas Spanos as its newest director.

As the Andrew S. Grove Professor and Chair of Electrical Engineering and Computer Sciences, Spanos conducts research on the application of statistical analysis in the design and fabrication of integrated circuits, and the development and deployment of novel sensors and computer-aided techniques in semiconductor manufacturing. He is also using statistical data mining techniques for energy efficiency applications, and is the leader of the Singapore-based SinBerBEST project, focusing on energy efficient buildings.

"CITRIS is a unique resource at the University of California and represents a great opportunity to drive flexible, meaningful engagement with today's problems on so many critical fronts," says Spanos. "In the coming years, we will build on the successes that have made CITRIS so well-known worldwide, and seek new challenges at the intersection of technology and societal benefit."

In 1988, Spanos joined the faculty at UC Berkeley, where he has served as chair of Electrical Engineering and Computer Sciences, the Associate Dean for Research, and the CEO of the Berkeley Educational Alliance for Research in Singapore. Spanos received his master's and doctoral degrees in Electrical and Computer Engineering from Carnegie Mellon University in 1981 and 1985, after which he worked for three years at the advanced computer-aided design group of the Digital Equipment Corporation.

Spanos will take over leadership of CITRIS from Paul K. Wright, who has served as director since 2007. Under Wright's direction, the institute has grown to include more than 300 researchers on its four UC campuses: Berkeley, Davis, Santa Cruz, and Merced. In 2009, Wright oversaw the launch of Sutardja Dai Hall, CITRIS's 140,000-square-foot headquarter building, which now also houses the state-of-the art Marvell Nanofabrication Laboratory and the CITRIS Invention Lab, both crucial components of CITRIS's entrepreneurial, multi-disciplinary, high-tech landscape. Wright also fostered significant partnerships with California's governing bodies including the California Energy Commission, and cultivated a state-wide telemedicine system, enabling over 800 remote clinics to connect to doctors and researchers at UC Davis Medical Center and CITRIS.

Wright, the A. Martin Berlin Professor of Mechanical Engineering at UC Berkeley, will continued his efforts to address some of society's most pressing problems as director of the new Berkeley Energy and Climate Institute (BECI), a coordinating hub for all of Berkeley's energy and climate efforts. Since last year, when Wright took over the directorship of BECI, Camille Crittenden has been contributing to the CITRIS leadership team as deputy director.

"Costas and I share a vision of the contributions good technology can make to a hopeful future for California and the world," says Wright. "I look forward to continuing our work on those contributions, especially on the pressing energy challenges that face us."

"I am grateful to Paul for his extraordinary service to CITRIS and its four constituent universities and to the University of California as a whole," says Robert Birgeneau, who stepped down as UC Berkeley's chancellor late last year. "And I am confident Costas will continue to push CITRIS's upward trajectory into great new realms." ■

David Lindeman Appointed Director of CITRIS Health Care Initiative

CITRIS is pleased to announce that Dr. David Lindeman has been appointed Director of the CITRIS Health Care Initiative. In this role he will be responsible for coordinating health care projects among the four CITRIS campuses (Berkeley, Davis, Merced and Santa Cruz). He will facilitate research, education, and development of health care technology solutions related to chronic disease management, patient engagement, and other health care issues. Lindeman will be joined in this effort by Steven DeMello, former Director of Health Care for CITRIS, who is moving into the position of Senior Advisor to CITRIS.

Lindeman also serves as Director of the Center for Technology and Aging (CTA), a collaboration of CITRIS and the Public Health Institute (PHI), and Co-Director of the Center for Innovation and Technology in Public Health (CITPH). Lindeman has worked in the field of aging and long-term care for more than 30 years as a health services researcher and administrator, most recently spending five years as director of CTA and CITPH within the Public Health Institute in Oakland.

"We are delighted to have David with us to help direct our growing program in health care as we attempt to address some of the most pressing health care challenges of our day through technology solutions," says Paul Wright, CITRIS Director. "His extensive experience in working with technology, public health, and aging will be a tremendous asset as CITRIS investigators tackle the pressing health care needs of society."

Previously, Lindeman was the founder and director of the Mather LifeWays Institute on Aging in Evanston, IL, where he was responsible for developing and implementing evidence-based applied research, demonstration, education, and dissemination initiatives. He has held positions as Associate Professor of Health Policy at the Rush Institute for Healthy Aging, Rush University Medical Center and Co-Director of the University of California, Davis Alzheimer's Disease Center. Dr. Lindeman received his PhD and MSW in social welfare with an emphasis on health services research and gerontology from UC Berkeley and his BA from the State University of New York, Binghamton. ■

Announcing the California Report Card

To participate, visit: http://californiareportcard.org/mobile

Californians can now use smartphones to grade their state on timely issues.

Developed by the office of Lt. Governor Gavin Newsom with the CITRIS Data and Democracy Initiative at UC Berkeley, the "California Report Card" (CRC) is a pilot project that aims to increase public engagement with political issues and to help leaders at all levels stay informed about the changing opinions and priorities of their constituents.

Anyone can participate by taking a few minutes to assign grades to the state of California on timely issues including healthcare, education, and immigrant rights. Participants are then invited to enter an online "Cafe" to propose issues for future versions of the platform.

UPCOMING EVENTS

For more event details and registration, visit: http://citris.eventbrite.com

CITRIS Mobile App Challenge

January through April

This challenge encourages teams of UC Berkeley students to develop innovative mobile applications for today's most pressing societal needs. Through a rigorous 3-month process, students will design, prototype and pitch their ideas. The challenge will culminate in a selection process with prizes, along with a Demo Day to showcase the student's projects.

http://mobileappchallenge.org/
+
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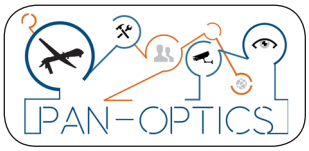

Pan-Optics: Emerging Perspectives on Visual Privacy & Surveillance

March 6, 2014, 10:30a-4:30p

This symposium will bring together scholars and practitioners from a range of disciplines to discuss privacy protections, surveillance methods, and modes of resistance in a digital age. The program will feature two keynote addresses and two panel discussions that will explore emerging surveillance technologies and applications across a range of contexts, and then turn to resistant strategies employed by individuals and organizations in response. Keynote speakers: Rebecca MacKinnon and Trevor Paglen.

Tickets: http://bit.ly/pan-optics2014
General Admission $20 /
Faculty & Staff $10 / Student $5
Banatao Auditorium, Sutardja Dai Hall, UC Berkeley

Research Exchange Seminars

Spring 2014 Schedule
Wednesdays, 12:00p-1:00p

Free and open to the public, the Research Exchange Seminar Series is a weekly roundtable of presentations and discussions that highlights ways to frame and tackle societal-scale research issues. Speakers this semester include Christopher Couper [IBM], Severin Borenstein [Energy Institute at Haas], Tanja Aitamurto [Data & Democracy Initiative], Kamyar Guivetchi [CA Dept of Water Resources] and many more.

12-1pm, Free with Registration
Banatao Auditorium*
Sutardja Dai Hall, UC Berkeley
http://citris-uc.org/news/RE_spring_2014

**Location subject to change.*
http://citris-uc.org/news/RE_spring_2014

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Please visit http://bit.ly/give2citris

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CITRIS's mission, to "shorten the pipeline" between research innovations and their application to real-world problems, requires investment from a range of partners. We receive funding from the University of California, as well as corporations, foundations, and individuals committed to improving the lives of Californians and others around the world. If you would like to support our work in health care, energy, intelligent infrastructures, or data and democracy, please consider making a gift online or contact our Director of Finance, karen@citris-uc.org. Thank you!

CITRIS LINKS

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THE CITRIS SIGNAL

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