Waste Not

Water and energy have some interesting common features: Both are essential to humans, and both are in limited supply. To be slightly more precise, I am referring to drinkable fresh water and usable energy. Another especially interesting common feature is the fact that neither water nor energy is consumed. Except for extremely rare cases, energy and water are actually conserved. "Wasting water" does not mean somehow destroying it; all water is eventually recycled and reused. Likewise, "wasted energy" is only heat that isn't readily useful for, say, lighting. As explained in the book *Entropy Crisis* by G. Deutscher, the problem in both cases is an excessive increase in entropy. Entropy minimization is not currently a hot topic in systems and control, but a search does turn up a few items, such as the 2001 book *Entropy in Control Engineering* by George Saridis.

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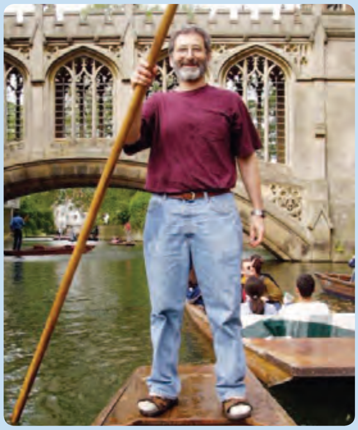
Which brings me to energy efficiency and the current issue of *IEEE Control Systems Magazine* (*CSM*). Efficiency is an optimization problem—doing the most with a fixed resource.

Contributors

Lucy Pao with her husband Leo Radzihovsky and their son Matthew and daughter Sarah at the Chacchoben Mayan Ruins in Mexico.

Steven Peters during a hike to the top of Half Dome in Yosemite National Park.



Gilead Tadmor.

David Arndt hiking on Mount Lamarck.

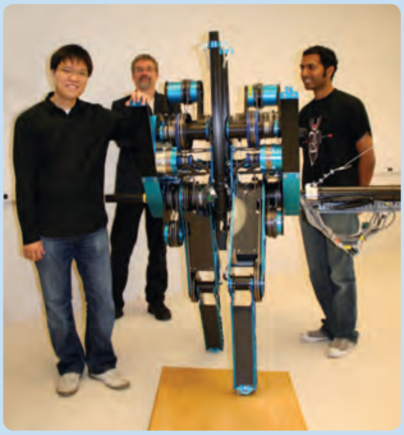
Katie Johnson and husband Curt Stevens in Colorado.

This theme binds the feature articles in this issue of *CSM* The task of a wind turbine is to extract energy from the ambient wind and convert that energy into electricity. The efficiency with which this can be accomplished can make or break the economics of wind turbines. We learn from the feature article by Lucy Pao and Kathryn Johnson that this efficiency is bounded by the Betz limit, which is $16/27 \approx 59\%$. Why so low? The details can be found on the Web, but suffice it to say that this result itself is an upper bound since the derivation assumes numerous idealizations, such as no drag and no hub, that cannot be achieved in practice.

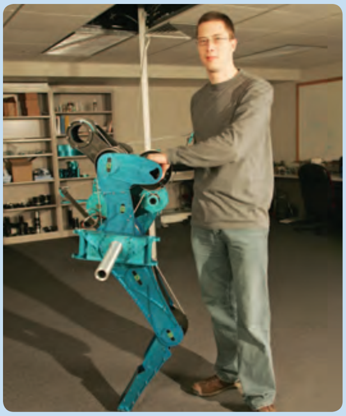
What's amazing about real—not idealized—wind turbines is that a massive steel tower and huge composite blades, not to mention all of the mechanical and electrical components, can be built and operated to extract enough energy to be economically viable. What remains for control systems engineers (that's us) is to develop control strategies that optimize this viability. But optimizing viability is not confined to optimizing the amount of captured energy. Much of the cost of wind turbines is maintenance, and control systems can help maintain the wind turbine, for example, by alleviating loads under severe weather conditions. Fault and failure analysis through signal processing and model-based diagnostics can support this objective.

This feature article on wind turbines provides a tutorial introduction to the subject for control systems engineers. A related article that appeared in the June 2006 issue of this magazine focused on adaptive control techniques. Together, these articles give an overview of the control challenges and goals in this area of technology.

Energy efficiency is also a theme in the feature article by Hae-Won Park, Koushil Sreenath, Jonathan W. Hurst, and J.W. Grizzle, where the focus is on walking bipeds, in other words, getting around on two legs. Most of us take the tasks of standing and walking for granted, but as control systems



Hae-Won Park, Jessy Grizzle, and Koushil Sreenath (from left) with MABEL.



Jonathan Hurst with Thumper, a monopod version of MABEL.

Jessy Grizzle (far right), U.S. Senator Carl Levin (center), and University of Michigan Dean of Engineering David Munson.

Jim Bobrow near Topaz Lake, California.

Bernd Noack.

engineers we appreciate the fact that the very act of standing is a stabilization problem. Walking is more difficult since a periodic motion rather than an equilibrium must be stabilized. What makes this task difficult is that much of human walking involves configurations that are instantaneously unstable. To get a feel for this point, it's helpful to watch YouTube videos of Asimo ("Asimov" sans "v") and other biped robots walking and running. What's clear from these videos is that mechanical bipeds tend to walk by keeping their center of gravity above their feet, making for a kind of unnatural stilted gait.

MABEL, the biped featured in this issue of *CSM*, is the next-generation version of RABBIT, which was featured in the October 2003 issue. A unique feature of MABEL is its ability to store energy in flexures, thus allowing it to achieve greater walking efficiency than robots without energy regeneration. The goal of this article is to identify MABEL, that is, build empirical models from various tests. The goal is to identify the inertia and stiffness characteristics of MABEL, which involves a combination of input design, signal processing, and judicious reconfiguring of MABEL's pulleys and cables. As in many applications of system identification, the challenging aspect is dealing with difficult-to-model and often unexpected effects such as amplifier bias, friction, and cable stretch.

For "Applications of Control," David Arndt, James E. Bobrow, Steven Peters, Karl Iagnemma, and Steven Dubowsky consider a control problem that is a specialty of the movie industry, namely, driving a car on two same-side wheels. Although the usefulness of this particular driving maneuver is limited to navigating narrow alleyways in spy thrillers, the underlying motivation for this work is to enhance the controllability of a vehicle when two wheels of the car depart from the road surface. This condition often precedes rollover, which is a contributing factor to a substantial number of serious accidents. To study this problem, the authors close feedback loops on a remote-controlled scale-model truck.

Gilead Tadmor and Bernd Noack answer an "Ask the Experts" query on active flow control. In their essay, Gilead and Bernd explain some of the challenges of this interdisciplinary field, ranging from overlapping notation and conflicting terminology to the highly nonlinear and high-dimensional dynamics of fluid motion. This essay is a "must read" for all researchers interested in applications of control that can have a widespread impact on technology.

For "Member Activities," we introduce the 2011 IEEE Control Systems Society (CSS) Fellows Class, those members of CSS who have most recently been elevated to Fellow status. This is a major achievement of CSS members, and we extend our congratulations.

Also in this issue, "People in Control" interviews Magnus Egerstedt and Steve Yurkovich. Magnus, who is the current editor of the Eletter, discusses his research interests in robotics and hybrid control. Steve, a former editor-in-chief of *CSM* and former CSS president, discusses his views on the present and future of control technology.

This issue also brings you the "President's Message," thanks to CSS President Rick Middleton, a report on the 2010 MSC conference, one book review, and numerous book announcements. We sadly publish obituaries of Charlie Desoer and Jerry Marsden. And we close with more offbeat observations on everyday objects.

The next issue—June—will bring us up to ACC time, this year in San Francisco. In the meantime, please send me your letters on any aspect of *CSM* as well as your ideas for future articles on underrepresented topics.

Dennis S. Bernstein

Faux Pop

To many people, the father of the computer is a scientist named John von Neumann, already worshiped in academic circles for his contributions to mathematics and logic before he got involved in the development of Giant Brains. The basic architecture of the computer became known as the "von Neumann architecture," and that term—just like the design it describes—remains in use today.

John von Neumann didn't invent the computer, however. The distinction rightly belongs to two men at the University of Pennsylvania, Presper Eckert and John Mauchly. They built ENIAC, the first digital, general-purpose, electronic computer—the first Giant Brain. ENIAC was a bus-size mousetrap of forty nine-foot-tall cabinets filled with nearly 18,000 vacuum tubes and miles of wiring. It was developed as a weapon of war, a machine that could calculate trajectories for World War II artillery guns. Though unwieldy, ENIAC was wired with enough innovation and genius to provide the spark for computer development. The genealogy of the modern computer begins here, with ENIAC, Eckert, and Mauchly.

—Scott McCartney, *ENIAC, The Triumphs and Tragedies of the World's First Computer*, Berkley Books, New York, 1999, p. 5.