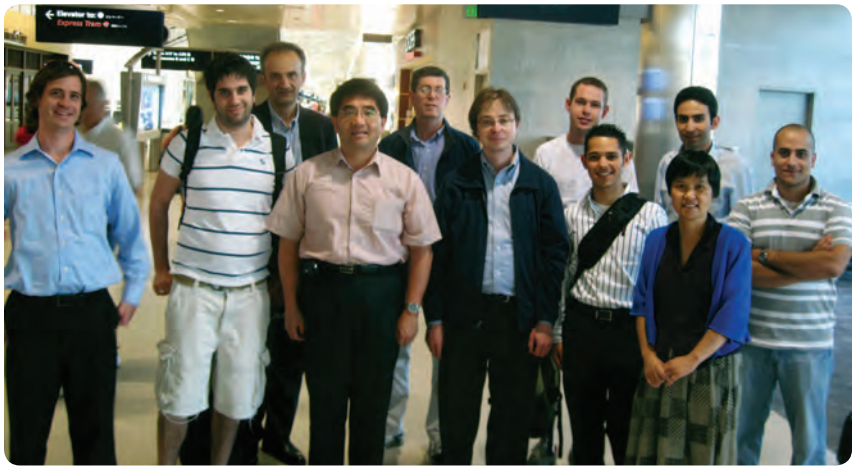
Guessing and Games

PRACTICE, PRACTICE, PRACTICE

Having recently returned from the 2010 American Control Conference (ACC) in Baltimore, I marvel at how thousands of new papers emerge every few months from our research community. Each paper advances the state of the art in systems and control, and the cumulative effect is to move the field forward. Admittedly, not every conference or journal paper has a major impact on the field. But each paper is part of a process of developing and testing new ideas and techniques. Just as a musician practices etudes to build proficiency, each paper and presentation allows us to hone our skills in performing research and in communicating our results to one another.



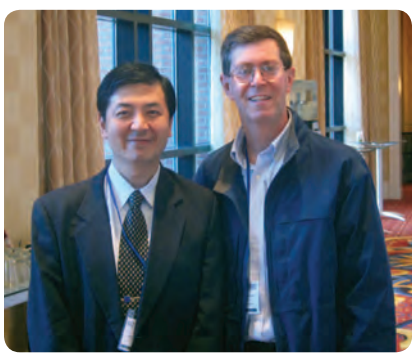
Returning to Michigan from the 2010 ACC in Baltimore (from left): Jesse Hoagg, Dogan Sumer, Mrdjan Jankovic, Huei Peng, Dennis Bernstein, Ilya Kolmanovsky, Alexey Morozov, Scott Moura, Jing Sun, Saeid Bashash, and Tony D'Amato.

ABDUCTIVE REASONING

One of the things we're told in grade school is to think before answering and not guess. Since learning to think is one of the key goals of education, it's hard to disagree with this advice. But one thing I've learned since grade school—and that I suspect most researchers know but rarely admit—is that guessing can be an extremely valuable skill. Guessing generates conjectures, and testing conjectures helps to narrow down the possibilities of what is and isn't true. Unlike deductive reasoning, which moves logically from assumptions to conclusions, guessing may forego the deductive process entirely based on experience, data, and imagination. I'm not suggesting that we teach courses on how to guess well. But guessing can be fun and it often works. And it's hard to argue with success.

YOUR TURN

A chess game is a system that is devoid of uncertainty, observable with perfect measurements, and—at least for our own pieces—controllable. Yet its combinatorics are sufficiently complicated to keep the game from becoming trivial. Problems that are highly combinatoric invite heuristics, and chess moves are typically analyzed in terms of qualitative principles such as "sacrificing material for position." Expert players endlessly examine lines of play, looking for advantageous moves, continuing to discover unexpected variations of well-known sequences. These studies occur offline since the time limit during a match restricts the ability to examine and assess all potentially useful moves. Beyond combinatorics, the game has its clever quirks. For example, the queen trumps all other pieces with the exception of the knight, which has a highly restricted range of travel but threatens the queen due to its unique nonlinear trajectory and unique ability to jump over pieces. The potential of a seemingly weak piece to overcome a strong piece is analogous to the circularity of rock-paper-scissors. What does chess teach us about systems and control? Since we can see only n moves ahead, what can occur after n moves is uncertain.



Li-Chen Fu, editor-in-chief of the *Asian Journal of Control*, and Dennis Bernstein.

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Consequently, while we choose the best move we can think of, our optimization horizon is limited. Of course, the question of what exactly we ought to be minimizing over n moves presents difficulties as well. Hence heuristics rule.

Dennis and his sons Sam (left) and Jason in Glacier National Park.

INACTIVE

Passive control is the black sheep of control engineering. While we envision sophisticated active control systems implemented with sensors and actuators, a passive control system requires no energy source other than what it receives from the plant it is intended to control. In addition, unlike the code needed by an active controller, the logic of a passive controller is embodied in its hardware implementation. The outrigger used to stabilize canoes in the South Pacific (see Danny Abramovitch's 2005 *IEEE Control Systems Magazine* (*CSM*) article) is a perfect example. Despite its passive nature, we can view a passive controller as applying feedback to the plant, although we admit that the direction of the signal arrows is artificial, as explained by behavioral theory (see Jan Willems's 2007 *CSM* article), which views interconnection through ports as a more appropriate modeling paradigm than signal processing. Passive controllers tend to be reliable since they cannot fail due to software errors or power failures, and they tend to be robust since they're specifically suited for the controlled plant. But unlike active controllers, passive controllers are viewed as specialized one-of-a-kind devices, without universal implications. But given their success, perhaps we should give them a little more attention.

Dennis on Lake Erie.

FROM MATH TO STATS

In 2008, *Wired* magazine published an article that essentially argued that the scientific method in the petabyte age is dead, and all that is meaningful is data. I can't accept this thesis since I equate theory with understanding, and an ounce of understanding is worth a mountain of numbers. But while a strength of systems and control is its affinity for rigorous mathematics, its weakness is apathy for data. Analyzing data for model building and health monitoring is where systems and control interacts with the real world. When our field fully embraces the role of data, the theories we develop will reach a new level of usefulness and applicability.

THE DILEMMA

The word "the," as an alternative to "a" or no article at all, is somewhat unique to English. In a nutshell, speakers and writers of English are forced to make a decision on how each noun is to be introduced. The word "the" connotes definiteness, uniqueness, and specificity. If I say "the book" then I am referring to a specific book. If I say "the global minimizer" then I am referring to a unique point. But tricky cases can occur. Instead of saying, "The sensor and the actuator require 5 V," I need only say "The sensor and actuator require 5 V." Since "the" denotes uniqueness, I hesitate to write "The minimal realization (A, B, C)" since minimal realizations are not unique. But in this case the "the" does not indicate that minimal realizations are unique but rather refers to the specific realization whose name is "(A, B, C)." All of this raises an interesting question, namely, is "the" some kind of beneficial feature of English or is it an annoying distraction that other languages have wisely avoided? I honestly don't know, but it's a safe bet that each language has unique capabilities and limitations.

Dennis Bernstein