

Another challenge to the GN&C (guidance, navigation, and control) designers is the high variability and uncertainty in the Martian atmosphere. Robustness of the entry, descent, and landing algorithms to environmental uncertainty is essential to overall mission success. There are ways to mitigate many of the difficulties that I just described. However, all of the proposed fixes cost money, and solving the complex guided entry problem within tight budget constraints is, in fact, the principal challenge.

CSM: *You are the “Bishop” in “Dorf and Bishop,” earlier known as just “Dorf,” my very first controls textbook! Can you describe some of the changes to that text over the years?*

Robert: My first course in controls also used Dorf’s *Modern Control Systems*, the second edition! I met Richard Dorf, who is professor of electrical and computer engineering at the University of California, Davis, through a publisher contact, and we originally collaborated on the companion text *Modern Control Systems Analysis and Design Using MATLAB*, which was eventually merged with *Modern Control Systems*. The book is now in its ninth edition, and the tenth edition will appear soon. I have been involved directly as a coauthor since the seventh edition. Initially, my contributions to the book focused on computer-aided design and analysis aspects featuring MATLAB and Simulink. Richard Dorf and I have worked hard to keep an “applied” orientation to the material, while not neglecting the theory. In the tenth edition, I updated the material on state-space design methods and fine-tuned the root locus material. With the advent of effective interactive root locus tools, I think that the level of coverage of hand-sketching root locus can be reduced and replaced with increased emphasis on design and analysis methods. The emphasis on problem solving that has characterized the book since the early days continues in the newest editions. In the tenth edition, I added or changed over 100 problems out of the over 800 problems in the end-of-chapter problem sections. I have always been fascinated with the level of interest that the book generates internationally, having been translated into Chinese, Russian, Portuguese, and Korean, and other international editions as well. I hope to continue to support the international aspects of the book in future editions.

CSM: *At UT you’ve received several teaching awards. Do you feel you have a special style or approach to teaching that has earned you these awards? Please don’t be modest in revealing your teaching secrets!*

Robert: The engineering students who know me will not be surprised when I say that I have no formal teaching philosophy—and no teaching secrets. The simple fact is that I enjoyed being a student, and now I enjoy being with students. The students know and appreciate this. My teaching plan is to be well prepared for each and every lecture, to be accessible to students, and to help guide students

along their path of discovery. Accessibility to students is probably the chief contributor to my teaching success. When I was a student, the first day of class each semester was always a joy for me. So when I began teaching I decided that I would try to make the first class day a joy for my students. The goal is to start with good initial conditions! That’s how my semester starts. The rest just follows.

CSM: *Thank you for talking to CSM, and best of luck in your endeavors, here and on Mars!*

Looking Back



Peter H. Meckl, Mechanical Engineering Department, Purdue University, West Lafayette, IN, meckl@purdue.edu.

CSM: *Congratulations on completing an unprecedented nine years as an associate editor of CSM! During this time you had the opportunity to work with several editors-in-chief (EICs), including Steve Yurkovich, Tariq Samad, and Dennis Bernstein. How would you characterize their approaches to the magazine?*

Peter: It’s hard to believe that so many years have already gone by! It’s been a labor of love, and I thoroughly enjoyed my interactions with each of the EICs.

It was Steve Yurkovich who got me involved in the magazine. I first met Steve at the IEEE Robotics and Automation Conference in the late 1980s. At the time, I was presenting some work on designing shaped input commands for robot motors so that the resulting motion would be free of vibration. The control community had been rather skeptical of this approach, since it is inherently an open-loop approach, but Steve immediately took an interest in it. I appreciated having someone of his stature affirming my work and so we struck up a friendship. We met at subsequent conferences and, since we both had young children, we had lots of stories to share. When Steve helped to organize the first IEEE Conference on Control Applications in 1992, he asked me to serve on the Program Committee. In that role, I came to appreciate his style of management. Steve focused on picking the best, most reliable people he could find to do each job. Then, he would ensure that they had the resources and information to do the job right. Since I knew that Steve depended on me, I tried hard to do the best job that I could. So when he asked me to serve as an associate editor for the magazine in 1994, I knew it would be a pleasure to work with him. Steve provided samples of associate editor reports and letters to the reviewers, and helped in providing names of potential reviewers. Each month, I would look forward to his editorials in the magazine, since they often focused on the exploits of his sons BJ and James.

In 1999, Tariq Samad took over as editor-in-chief. I had come to know Tariq from previous discussions at the

American Control Conference (ACC) on the topic of neural networks and control. As associate editor, I really didn't notice much of a transition in going from one EIC to another, but in time, Tariq placed his own stamp of individuality on the magazine. He encouraged us to serve as guest editors to put together special issues that focused on such topics as control systems in agriculture, computer networks, and history of control. He also put more emphasis on the graphics, striving to include photographs and color wherever possible to spice up the text. He also introduced the "On the Lighter Side" to the magazine, with "Control Cryptics" and occasional jokes.

In August 2003, Dennis Bernstein became the new EIC. I felt I already knew Dennis from his numerous "Student's Guides" that explained such topics as frequency response in clear and easily understood language. Dennis also helped put together an interesting issue on the history of control, which demonstrated his passion in describing the important developments and concepts in this field. It's too early to tell where Dennis will take the magazine, but I have no doubt that *CSM* will continue to be the premier control publication for practitioners in the field.

CSM: *Your field is motion and vibration control. During your nine years with CSM, did you observe any trends relating to your field of interest?*

Peter: Early on, the idea of command shaping to reduce vibration in systems that exhibit flexibility was not well received by control people. Usually, they would argue that it was strictly an open-loop approach and therefore suffered from all the drawbacks associated with open-loop control. The main criticism was that command shaping could not handle parameter uncertainties. However, in time, a variety of different approaches were devised to address this problem and good results have been demonstrated for such diverse applications as space satellites, robots, and gantry cranes.

Back in 1993, I organized the first command shaping session for the ACC in San Francisco. At that time, there were still quite a few skeptics out there. Nevertheless, I continued to organize command shaping sessions at subsequent ACCs. Over the years, I noticed that more and more people began attending these sessions. At the 2003 ACC in Denver, I actually had two sessions devoted to command shaping. My list of potential author contacts has grown to almost 40, and some of the major players in control are now convinced that command shaping should be one part of an overall control solution.

One of the important current research topics in this area is the integration of feedback and feedforward control with command shaping. The design of each of these components depends on design choices made for the other components. In general, the use of command shaping relieves the feedback controller from having to do all the work to suppress vibra-

tion, thereby allowing a simpler feedback controller. However, command shaping will work only when the actuator signal does not saturate. Therefore, the total actuator effort from the feedforward part, which depends on choice of feedback controller, and the feedback part, which depends on the size of modeling uncertainty, must be kept below the peak actuator output when using the shaped command. Recently, several papers have suggested a concurrent approach to designing all three of these components with notable success.

CSM: *I understand that you also have an interest in engine control. What are some of the challenges you've encountered in your engine control research? Do you feel that theoretical research has reached its limit on what it can contribute to these problems?*

Peter: I've found engine control to be a great application of control and systems theory. Early on, my students and I worked on some adaptive control ideas to regulate idle speed in diesel engines. Although the proposed approach was successful, our sponsor had us focus on other issues that turned out to be more important. In particular, the tightening emissions regulations required additional sensors and extensive signal processing. Additional government mandates required that the emissions control system diagnose when emissions were out of spec. Solving these problems depends on a thorough understanding of the underlying processes involved in producing engine emissions. Unfortunately, these are highly nonlinear processes that are only partially understood. We were charged with developing virtual sensors that could estimate some of the potential exhaust constituents. This task required generating detailed models from extensive data collected in the experimental engine test cells.

Although we had many system identification approaches to choose from, the main problem we confronted was determining which input signals to use. A typical engine test cell measures dozens of signals. For a virtual sensor to be practical, only a small subset of these signals can be used to create the model. The question is, which ones? In the absence of detailed process knowledge, we needed a way to quantify the importance of each signal in estimating the output exhaust constituents. We eventually found such a metric in "mutual information," a concept originally developed by Shannon in communications theory. We have since developed a software tool that can identify the important input signals from which to create a virtual sensor. We have validated this approach on simple processes for which known models exist. Currently, we are looking at ways to use this metric for diagnostics, to actually determine when something is going wrong in an engine. Certainly, in my mind, this example illustrates how theory can become extremely useful in solving real-world problems.

CSM: What advice would you give beginning researchers in the controls field?

Peter: My single most important piece of advice would be to latch on to a company early on and find out what their problems are. Too many times, researchers solve problems that have little relevance to real-world applications. Since, increasingly, funding depends on demonstrating relevance of the research, it's extremely important to find out what the real problems are. Find an application interesting to you, that you perhaps have some background in, and contact the leading companies involved. It may take a while to establish credibility within the organization, but once you do, you will be rewarded with challenging problems and people who care about your ideas. Better yet, you can leverage that connection to obtain more funding from government agencies that value evidence of true technology transfer.

CSM: Now that you won't be receiving communications from the CSM EIC, how do you plan to spend all of your free time?

Peter: To be honest, in the next year I don't think I'll have much "free time." To begin with, I'll be the registration chair for the 2004 ACC in Boston, so the next six months will be quite busy dealing with that. In addition, I will be going on sabbatical to Karlsruhe, Germany, in 2005, so the latter part of this year will be spent preparing to take the family over to Germany for eight months.

Otherwise, I really enjoy reading when I can get some "free" time. In particular, I enjoy books and articles that describe the history of technology and connect technology to society. In Spring 2004, I'll be coteaching a course titled, "Technology and Values," where I will be discussing such books as *The Existential Pleasures of Engineering* by Samuel Florman and *Meaning in Technology* by Arnold Pacey.

Finally, I enjoy spending time with my wife, Marie, and children Paul, Kristina, and Kayla. We thoroughly enjoyed seeing the Rocky Mountains together this past summer and we intend to spend time together in Boston this summer.

CSM: Do you have any last words of advice for the current and future CSM EICs?

Peter: I think the magazine is in excellent shape and doesn't need any fixes. My only recommendation would be to continue to solicit guest issues from practitioners in the field, both academic and industrial. Keep an eye on the major control conferences and see what the emerging topics are. In this way, *IEEE Control Systems Magazine* can be kept fresh and relevant to a new set of readers into the future.

CSM: Thanks for the chance to chat with you. Keep up the good work!

Introducing New Associate Editors

IEEE Control Systems Magazine (CSM) is pleased to introduce six new associate editors for the year 2004 to replace retiring Associate Editors Pertti Makila, Peter Meckl, Karen Rudie, and Yasuo Takagi. We are grateful for the contributions of the retiring associate editors, who have collectively served *CSM* for a total of 17 years.

The new associate editors are Hashem Ashrafiuon, Randal Beard, Pablo Iglesias, Kent Lundberg, Daniel Rivera, and Jan Swevers. Hashem Ashrafiuon is serving as associate editor for Education, while Kent Lundberg serves as associate editor for History.

Hashem Ashrafiuon



Hashem Ashrafiuon has been a faculty member in the Department of Mechanical Engineering at Villanova University since 1988 when he received his Ph.D. from the Mechanical and Aerospace Engineering Department at the State University of New York at Buffalo. He teaches undergraduate courses in dynamics and control and graduate courses in robotic systems and multibody dynamics. He has developed undergraduate control laboratory experiments and graduate and undergraduate control courses for robotics systems. He has published papers in the areas of variable structure control, robotics, human multibody modeling, and optimization. His current research interests include variable structure control applications in robotics, smart material actuators, and underactuated systems.

Randal W. Beard



Randal W. Beard received the B.S. degree in electrical engineering from the University of Utah, Salt Lake City, in 1991 and the M.S. degree in electrical engineering in 1993, the M.S. degree in mathematics in 1994, and the Ph.D. degree in electrical engineering in 1995, all from Rensselaer Polytechnic Institute, Troy, New York. Since 1996 he has been with the Electrical and Computer Engineering Department at Brigham Young University, Provo, Utah, where he is an associate professor. In 1997 and 1998 he was a Summer Faculty Fellow at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena.

His primary research focus is in nonlinear control, autonomous systems, and multiple vehicle coordination and control with emphasis on unmanned air vehicles. He is a Senior Member of the IEEE, a member of AIAA, and is currently a member of the IEEE Control Systems Society Conference Editorial Board and on the program committee for the 2004 American Control Conference. He previously served on the program committee for the 2002 Conference on Control Applications.