

In this issue of *IEEE Control Systems Magazine*, we speak with six IEEE Fellows in the control systems field.

Ben M. Chen is a professor and area director of Control, Intelligent Systems, and Robotics in the Department of Electrical and Computer Engineering at the National University of Singapore (NUS). He also heads the Control Science Group of NUS Temasek Laboratories. He has served on the editorial boards of more than a dozen control-related journals including *Automatica*, *Systems and Control Letters*, and *IEEE Transactions on Automatic Control* and is an editor-in-chief of the journal *Unmanned Systems*. He has coauthored over 300 journal and conference papers and ten monographs in systems and control, unmanned systems, and financial market modeling.

Daizhan Cheng is a professor in the Academy of Mathematics and Systems Science, Chinese Academy of Sciences, and the School of Control Science and Engineering, Shandong University. He has held visiting positions at several universities including the University of Leicester, Chinese University of Hong Kong, City University of Hong Kong, and the Royal Institute of Technology, Sweden. He has been the chair of the Technical Committee on Control Theory in the Chinese Association of Automation since 2003. His research interests are in nonlinear system control, Hamiltonian systems, numerical methods in system analysis and control, and complex systems. He is the author/coauthor of ten books, over 240 journal papers, and 130 conference papers and is a Fellow of International Federation of Automatic Control.

Ratnesh Kumar is a professor in the Department of Electrical and Computer Engineering at Iowa State University. Previously he was on the faculty at the University of Kentucky and has held visiting positions at the University of Maryland, the Applied Research Laboratory at Pennsylvania State University, NASA Ames Research Laboratory, Idaho National Laboratory, and United Technologies Research Center. He received a B.Tech. in electrical engineering from India Institute of Technology Kanpur in 1987 and an M.S. and Ph.D. in electrical and computer engineering from the University of Texas, Austin, in 1989 and 1991, respectively. He serves or has served as an editor of *SIAM Journal on Control and Optimization*, *IEEE Transactions on Robotics*

and *Automation*, *Journal of Discrete Event Dynamical Systems*, *International Journal on Discrete Event Control Systems*, and *IEEE Transactions on Automation Science and Engineering*, and on the program committees of numerous conferences.

Carsten W. Scherer is a professor of mathematical systems theory in the Department of Mathematics and Physics at the University of Stuttgart, Germany. He was formerly a professor at the Delft Center for Systems and Control, Delft University of Technology, The Netherlands. His professional service includes being past chair of the IFAC Technical Committee on Robust Control, associate editor of *IEEE Transactions on Automatic Control*, *Automatica*, *System and Control Letters*, and *European Journal of Control*, and he is one of the current editors-at-large of *European Journal of Control*. He coedited two books, has published over 150 refereed journal and conference papers, and is a Fellow of IEEE.

R. Srikant is the Fredric G. and Elizabeth H. Nearing Endowed Professor in the Department of Electrical and Computer Engineering and a professor in the Coordinated Science Laboratory at the University of Illinois at Urbana-Champaign. He was a member of the technical staff at AT&T Bell Laboratories before becoming a faculty member. He has served on the editorial boards of *IEEE Transactions on Automatic Control*, *IEEE/ACM Transactions on Networking*, *Automatica*, and *Journal of the ACM*. His research interests include distributed algorithms for wireless networks and the Internet, stochastic processes, optimization, game theory, stochastic control, and information theory.

Bo Wahlberg is professor and head of the Department of Automatic Control, School of Electrical Engineering, KTH Royal Institute of Technology in Stockholm, Sweden. His professional service includes being the founding chair of the IFAC Technical Committee on Modeling, Identification, and Signal Processing; program chair for the IFAC Symposium on System Identification; and guest editor of two special issues in *Automatica* in the areas of statistical signal processing and control and data-based modeling and system identification. His research interests include system identification, estimation, and signal processing with applications.

BEN M. CHEN

Q. How did your education and early career lead to your initial and continuing interest in the control field?

Ben: I majored in mathematics and computer science in my undergraduate studies at Xiamen University, China, and was a software engineer in a computer firm in Guangzhou for about three years, working on machine-level programming. I then went to Gonzaga University for my master's program, concentrating on subjects related to communications under the supervision of Prof. Raymond Birgenheier. When I moved to Washington State University (WSU) for my Ph.D. studies in 1988, WSU had no faculty members doing research in communications systems, and I ended up choosing control for my Ph.D. program, under the supervision of Prof. Ali Saberi. My first project was to rewrite a software package in L-A-S (Linear Algebra and Systems, an old high-level programming language similar to Matlab) for the special coordinate basis decomposition of linear systems. I managed to reduce the total number of lines of code from over 20,000 in the original package to about 200 and was formally accepted by my advisor. But what really got me interested in control was my first unintentional discovery. I was asked to simulate some examples on loop transfer recovery (LTR) in the book *Control System Design*, by Bernard Friedland. It was mentioned in the text that under the Doyle-Stein condition for LTR, the link feeding the control input signal to an observer-based control law might be omitted. When I simulated examples without satisfying the Doyle-Stein condition (which can never be met in any physical system, by the way) by removing the link to the observer, to my surprise, the recovery performance turned out to be unbelievably good. When I showed the result to my advisor, I got kicked out of his office, as apparently I had violated the common belief in control systems design—the separation principle. Nevertheless, the discovery eventually led to a new controller structure for the LTR design



Ben M. Chen and his 40-g fully autonomous microaerial vehicle (photograph courtesy of X. Dong).

and a 24-page paper in *Automatica*. This experience meant a lot to a beginner in the field, and I've been hooked on control ever since.

Q. What are some of your research interests?

Ben: My research focus over the years has shifted more toward applications. The foundation that I built in systems and control theory as a young control engineer is truly invaluable in helping me to tackle real-life problems. The theory gives me a much clearer picture of how to solve problems in a more systematic fashion. Moreover, my experiences working on application-oriented topics have forced me to rethink theoretical research. Sometimes, solu-

tions can be much simpler if the problem is tackled from a different angle.

My current research is mainly on topics related to unmanned systems. It is an interesting area, in which it is highly meaningful to push the control system design to peak performance. My specific focuses are on issues related to vision-based navigation and control, navigation and control of unmanned aerial vehicles in indoor and foliage environments, and the development of micro and unconventional aerial vehicles.

I have also been working on the modeling of financial markets for quite some time. My most recent monograph on stock market modeling and forecasting, coauthored with



Ben Chen with his wife, Feng, on camels in a desert in Dunhuang, China.

my former Ph.D. student Xiaolian Zheng, was released by Springer in May 2013. By introducing a feedback adaptation structure with multiple time-scale components (fast and slow dynamics) in the stock market model, we have successfully demonstrated that this new approach has the capability of adapting fast changes in the market and thus yielding good predictive results.

Q. What courses do you teach relating to control? Do you have a favorite course? How would you describe your teaching style?

Ben: I have taught both undergraduate and graduate control classes, including classical feedback control, computer control systems, optimal control, and multivariable control systems. My favorite course is a graduate-level module on multivariable control, in which I need to cover topics ranging from classical techniques, such as LQR control, Kalman filter, LQG, and LTR control methods, to modern control theories, such as H_2 control, robust and H_∞ control, and disturbance decoupling problems. These topics happen to be in line with my research interests. Instead of focusing on mathematical details, I spend considerable time giving students the overall picture and development in the field by highlighting interesting history and milestones behind the theories. My homework assignments are pretty unique too. I challenge my students in the assignments to beat the designs in my monographs. This teaching method forces them to read and learn things beyond the class and textbooks to complete the assignments and familiarizes them with control system design for real and complicated problems. All my teaching materials can be freely accessed from my Web site at <http://uav.ece.nus.edu.sg/~bmchen/>.

Q. What are some of the most promising opportunities in the control field?

Ben: In my opinion, the area of control applications is full of opportunities, to tackle real and meaningful problems



Ben Chen with Feng, Andy, Jamie, and Marie in Pinnawala Elephant Orphanage, Sri Lanka.

and to attract more research funding. Applications also challenge academic researchers to think more realistically. I personally believe that a good control system design should not start from differential equations but should be down to earth and start from the hardware level, including the selection and placement of sensors and actuators.

Q. You are the author of 11 books in the control field. What topics do these books cover?

Ben: I have authored or coauthored ten monographs and one textbook, of which eight are directly related to control theory and application. My earlier monographs were more on systems and control theory, including *Loop Transfer*

Recovery: Analysis and Design (with A. Saberi and P. Sannuti, Springer, 1993), *H_2 Optimal Control* (with A. Saberi and P. Sannuti, Prentice Hall, 1995), *H_∞ Control and Its Applications* (Springer, 1998), *Robust and H_∞ Control* (Springer, 2000), and *Linear Systems Theory: A Structural Decomposition Approach* (with Z. Lin and Y. Shamash, Birkhäuser, 2004). My recent works focus more on control applications, which include *Hard Disk Drive Servo Systems* (first edition with T.H. Lee and V. Venkataramanan, Springer, 2002; second edition with T.H. Lee, K. Peng, and V. Venkataramanan, Springer, 2006) and *Unmanned Rotorcraft Systems* (with G. Cai and T.H. Lee, Springer, 2011). Even though my most recent monograph, *Stock Market*

Profile of Ben M. Chen

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- **IEEE Control Systems Society experience highlights:** associate editor, Conference Editorial Board, 1997–1998; associate editor, *IEEE Transactions on Automatic Control*, 1999–2001; chair, IEEE Singapore Control Systems Chapter, 2002–2003.
- **Notable awards:** University Researcher Award, National University of Singapore, 2000; Prestigious Engineering Achievement Award, Institution of Engineers Singapore, 2001; Best Industrial Control Application Prize, Fifth Asian Control Conference, Melbourne, Australia, 2004; IEEE Fellow, 2007; Best Application Paper Award, 7th Asian Control Conference, Hong Kong, 2009.

Modeling and Forecasting: A System Adaptation Approach (with X. Zheng, Springer, 2013), is not directly related to traditional control topics, its approach is heavily based on a framework in systems theory.

Q. What are some of your interests and activities outside of your professional career?

Ben: I am a frequent trader in stock markets. I like traveling and writing. My hobbies include table tennis, basketball, hiking, and TV sports. I

am a diehard fan of the Washington State Cougars. I am an active member of the Staff Table Tennis Team at the National University of Singapore.

Q. You are an editor-in-chief of a new systems journal. What is its scope?

Ben: I am currently editing, together with Lihua Xie and Siva S. Banda, a new journal titled *Unmanned Systems*. The scope of the journal is all subjects related to the development of automatic machine systems, including advanced technologies in

unmanned aerial, ground, and underwater platforms; unmanned software systems; communications and computer vision systems; navigation and path planning; information fusion; multi-agent systems; mission management; machine intelligence; and innovative application case studies. Interested readers can find more information about the journal at <http://www.worldscientific.com/us/>.

Q. Thank you for your comments.

Ben: You are welcome!