

World-Class Educators

In this issue of *IEEE Control Systems Magazine (CSM)*, we speak with Maria Elena Valcher of the University of Padova. Prof. Valcher is active in IEEE conference organizing committees, most recently as registration chair of the Conference on Decision and Control (CDC) in The Bahamas in December 2004. CSM speaks with Prof. Valcher about her research and Society activities. We also speak with Jacob Apkarian, chief engineer and founder of Quanser Consulting. Jacob is well known in the educational control community thanks to Quanser's innovative products. In conclusion, we introduce our new corresponding editor, Zongli Lin.

Multidimensional Behavior

CSM: *Thank you for speaking with CSM. Since you served as registration chair for the 2004 Conference on Decision and Control (CDC), many people might know you by sight but not by name. Can you summarize your background, especially those influences that led you to the control field?*

Maria: With pleasure. First let me thank you for this chance to speak with *CSM*, one of my favorite publications! As far as my background is concerned, I have to admit that, although some preliminary decisions in my life were made by tossing a coin, I ended up being so convinced that the following ones came by themselves. I chose the Engineering Faculty almost by chance, but at the second year (out of five years, in Italy) of my master's degree in electronic engineering, I was already sure that I would try to pursue an academic career. When I took a class in system theory in the fourth year, it was just love at first sight, and hence came my interest in research in the control area. This enthusiasm has never left me.

I regard system theory as an extremely interesting and active area, and I am quite proud to be working in this field of research. In particular, I have to say that the control group in my department is active and full of charismatic personalities. (This is not only from a scientific point of view: four deans and one rector came out of our group in the last 20 years!) This type of environment undoubtedly encouraged my interests in the control field.

After the master's degree, I earned a Ph.D. degree in systems engineering. During that time, I also had the chance to visit the Laboratory for Information and Decision Systems of MIT for nine months, which was a fundamental experience for me. My academic career started in Padova as an assistant professor in 1994. I later became an associate professor at the University of Lecce, where I stayed for three academic years, from 1998–2001. After

returning to the University of Padova, I became a full professor at the beginning of this year.

CSM: *It seems that the number of attendees from Italy at CDCs increases from year to year. In fact, Italy has become quite a center of systems and control activity. Do you have some special insight as to how this situation came to be?*

Maria: You are right! Having collected statistics about the number of attendees at the last few CDCs for my registration chair report, I was really surprised to see that what I regarded as a personal feeling was supported by the statistics. At the last two CDCs, there were plenty of Italians. In particular, at CDC'03, Italy was the third country represented (after the United States and Japan), and at CDC'04, we outnumbered the Japanese.

A good explanation can be found in the conference venues of the last few CDCs, which undoubtedly all Italians found rather attractive. However, it must be said that the number of Italians who belong to the various IEEE Control Systems Society (CSS) conference boards, journal editorial boards, the Board of Governors, and the ExCom is also growing. So, it is not solely a matter of nice locations.

My personal explanation is that a few outstanding Italian colleagues (I would surely mention Alberto Isidori, Roberto Tempo, and Antonio Vicino) were first invited to join CSS committees some years ago. Their example, together with their encouragement, stimulated other young researchers. A sort of positive feedback took place. In a sense, until some years ago, the IEEE CSS was perceived more as an American society; now its international character, as well as the fact that everybody can help and contribute to Society growth, are now fully realized, in my opinion.

As far as the status of the control community in Italy, I believe we are presently in very good shape! The presence of some charismatic individuals in the area, who have been and remain active researchers, has led to good recruitment of students. It must be recognized, however, that several Italian Ph.D. students spent long periods in the United States, so we are surely indebted! It's hard, however, to predict whether we will be able to keep this pace.

CSM: *Before we talk about your research papers, I'd like to ask you about your four books, all of which are written in Italian. One of your books, *Segnali e Sistemi*, written with G. Ricci, is in its second edition. What is the nature of this book and how does it relate to your other educational books?*

Maria: Well, three out of the four books are textbooks, which I wrote, together with other colleagues, as reference

texts for the classes we teach. *Segnali e Sistemi* is probably the one of which I am most proud. The book was based on months of discussions between my coauthor and myself, but I believe the effort was worthwhile. The need for such a text may sound strange to an American audience, but the introduction of a signals and systems class in the standard information engineering program was a rather recent event. Until a few years ago, signals and systems was taught by individuals with slightly different backgrounds but dramatically different research interests. As a result, the average student always perceived a sort of gap that this class now surely removes.

At this point, one may wonder why we simply did not choose to adopt one of the classical signals and systems textbooks. The main reason is that the teaching system in Italy is different from the one in the United States. Some of our courses, such as signals and systems, are more theory oriented and often lack a suitable lab activity where the students can “digest” the theoretical concepts. So, American textbooks are usually not suitable for this teaching method.

The other two books are reference textbooks for an elementary control class (*Lezioni di Controlli Automatici*, with M. Bisiacco) and for an advanced class in polynomial techniques in system modeling and control synthesis (*Metodi e Algoritmi per lo Studio dei Sistemi Multi-variabili*, with E. Fornasini).

CSM: *What do you see as the challenges in systems and control education at the undergraduate level?*

Maria: I’m afraid I can only give an answer that is tailored to my personal experience and, hence, may hold true for the Italian educational system but not necessarily for others. In recent years, there has been a series of major changes in the Italian educational system. The main change is the fact that while traditionally bachelor’s and master’s degrees had completely independent patterns, nowadays students first get the bachelor’s degree and then, if they want, they can begin the master’s program. This significant change has dramatically modified both the size and the content of all courses and, in particular, of all systems and control classes.

Traditionally, our courses were quite long (between 80 and 120 hours per semester) and had a strong theoretical nature. The need to provide shorter classes, with a careful look at applications that may be “useful” for those students who want to get a job after the bachelor degree, somehow conflicts with the ambitious goal of preserving the high level of theory that significantly contributed to the quality of our master and Ph.D. students, as well as to the significant presence of Italians in our international community.



Elena Valcher of the University of Padova. The winged lion is the ubiquitous symbol of the Venetian Republic. Prof. Valcher is currently a member of the CSS BoG and has been a member of several conference organizing committees. Most recently, she served as registration chair of the CDC in The Bahamas in December 2004.

CSM: *The book Modelli Dinamici Multidimensionali seems more research oriented. I’ve noticed that a lot of people in our community (myself included) don’t have a good understanding of what a multidimensional system is. Presumably, multidimensional is something very different from multivariable or MIMO. Could you give a brief description of the meaning of “multidimensional systems”?*

Maria: Okay, I’ll try. A multidimensional system is a system whose describing variables evolve depending on several independent variables, for instance a time and a space coordinate or two space coordinates. These systems have been used frequently in image processing applications, but they also arise from discretizing a partial differential equation that describes phenomena such as river pollution modeling, gas absorption, water stream heating, or the diffusion of a tracer into a blood vessel.

CSM: *What aspects of multidimensional systems are you currently pursuing?*

Maria: Some years ago, I worked on applications of multidimensional systems to physiological and ecological modeling. The mathematical models that arise from discretizing partial differential equations that govern these systems are typically two- or three-dimensional state space models subject to positivity constraints. In fact, all system variables are typically levels of concentration, temperature, pressure, or population level, and hence are intrinsically nonnegative. Therefore, I became interested in positive multidimensional systems. My current research

interests are focused on fault detection in multidimensional systems. The relevance of this problem for image processing applications is rather intuitive, since a corrupted digital image can be regarded as the output of a two-dimensional system affected by a fault. However, I have not yet addressed this issue.

CSM: *Your other area of interest is behavioral systems, which you work on in conjunction with multidimensional systems. How did you develop an interest in behaviors?*

Maria: This is a very long story since my master's thesis was about the behavioral approach to one-dimensional and multidimensional systems modeling. In behavioral system modeling, one does not need to make an often artificial distinction between inputs and outputs, but rather the focus is on the interconnection structure of a system with great flexibility. I have always found this approach extremely elegant and powerful, since it allows one to treat (in a compact and general form) control problems for several different classes of linear, time-invariant systems. For instance, the classical approach to singular systems has always led to an amazing number of conditions and complicated formulas, which can be completely avoided with the behavioral approach. Also, multidimensional systems are more generally and efficiently investigated within the behavioral approach.

CSM: *Turning to the CSS, you clearly devote many volunteer hours to Society activities. What do you enjoy most about these activities?*

Maria: There are several aspects of these activities I personally enjoy. Even though it may sound silly, I like the idea of contributing to a Society that has so many outstanding scientists. I got this strong feeling the first time I had the chance to attend a Board of Governors (BoG) meeting, and it has never changed. I am always surprised at how competent and good natured the BoG members are. Having served as registration chair at CDC'04, I have an exact perception of how much work certain activities require, and it's nice to see how some people always offer their good services to the Society. Of course, in all these activities I appreciate the technical aspects, so I'm typically more attracted to activities that involve topics and paper selection and may require reviewing.

CSM: *When you're not teaching, doing research, or volunteering for the CSS, how do you keep from getting bored?*

Maria: I'm afraid that "getting bored" is a phrase I have not used since I was a child, even though occasionally I would like to. Some (I may also say several) years ago, I had some hobbies and in particular I practiced ballet for many years (almost 20). Lately, apart from reading a lot (novels or history books) and biking, I love cooking. I

believe the results are good. (I may give references!) This sounds very Italian, huh?!

CSM: *Many thanks for taking the time to speak with CSM!*

Questioning the Answers

CSM: *Thank you for speaking with IEEE CSM. Many of us in the control community who have educational laboratories know of Quanser and its wide range of products, but I suspect that not many know about the history of Quanser and your background as founder. So I'd like to start by asking about your educational background.*

Jacob: Thanks, Dennis. It's a pleasure to speak with CSM. I always enjoy receiving the next exciting issue! I believe that teachers play a crucial role in guiding students to help them find their strengths and fulfill their desires. I've been very lucky to have had two superb teachers. The first is my high school physics teacher in Beirut, Lebanon, and the second is Dr. Pierre Belanger, who taught me controls during my undergraduate years at McGill. After graduating with my B.S. degree, I held a couple of junior positions but soon decided to pursue grad school. I received a master's in control and a Ph.D. in biomedical engineering from the University of Toronto.

CSM: *Where did the name Quanser come from? It sounds very space-age-ish. Does it mean something?*

Jacob: During grad school, with a lot of time on my hands, I wrote songs, poems, and short stories. During that period, I also did some consulting work for IBM. At some point, I had to issue an invoice and they required a registered company name. The story I was writing at the time was titled Questions and Answers (existentialist musings about life in general). For lack of a better name and with the title of the story in the foreground of my consciousness, I merged it into one word and submitted an invoice. Little did I know that I would eventually be designing products that deliver questions as well as answers.

CSM: *You spent some time teaching at the University of British Columbia (UBC). Did you enjoy teaching, and did that experience help you in your current work at Quanser?*

Jacob: I very much enjoy teaching. I find it very gratifying to help students develop their skills and discover their potential. While I was a faculty member at UBC, I noted the need for experimental products for teaching control. Simulations were the prevailing mode of teaching control, but with the advent of the PC, the ability to perform control experiments straight from the desktop PC was clearly becoming a tangible reality. I decided to independently pursue the idea of developing experimental systems for teaching control. To maintain a living and to fund the company effort, I took a job as a researcher in a hospital and then as a control engineer at SPAR Aerospace. Eventually,

Quanser became a self-sustaining company, and I focused entirely on its operation.

CSM: *I'd like to know a little more about how Quanser operates. Can you describe what goes on at Quanser in a day-to-day sense? How are new ideas developed, implemented, and supported? What kinds of technical staff do you have?*

Jacob: As in any other company, there are daily activities such as client services management, parts and inventory management, accounting, assembly, testing, and shipping. These activities are handled by specific departments. We have a growing R&D department consisting of eight engineers dedicated to new product development, custom work, and client support. Since control is multidisciplinary, our engineers are well versed in mechanical, electronic, robotic, and software engineering. We keep abreast of the research trends and are continuously listening to our clients. Product ideas are developed either in-house or in conjunction with a university partner. Funding is for the most part "organic." We also offer custom design services, mostly to university researchers seeking assistance in designing and building the systems that they need for their research labs. This activity keeps our work interesting since we are always in touch with leading researchers in the field.

CSM: *As director of R&D at Quanser, what is your role in product development and support?*

Jacob: In the early days, I was involved in every aspect of a project, including conceptual design, prototyping, assembly, and production. I do much less hands-on work now. I'm responsible for setting the general direction and vision of the company's R&D activity. I'm also involved in critical design reviews for all projects, and I serve as team leader for all special projects, such as custom robots, haptic devices, magnetic levitation systems, and unmanned aerial vehicles. I also research new opportunities where we can apply our expertise to industrial applications. As chair of the board, I am also closely involved in all other company-related activities.

CSM: *Since your Ph.D. is in biomedical engineering, I was wondering how you see that field developing.*

Jacob: After graduating, I was interested in the application of robotics as assistive devices for people with disabilities. Alas, funding in this area was very limited and the

technology was not mature enough. Nowadays, I see haptics as a new area of control engineering that can significantly contribute to the medical field. Applications of haptics in medicine range from surgical robots to physical rehabilitation and clinical assessment tools. This exciting area of control requires skills in multiple disciplines. We've started working in this area, and I believe we are well poised to contribute to this field.

CSM: *You once mentioned in casual conversation that your career objective is to be obsolete as soon as possible. Is there some deeper message in that statement? What advice would you have for students contemplating graduate study in control?*

Jacob: That was really just tongue in cheek, in the sense that I want to retire ASAP. Though, I wouldn't know what to do with myself if I did. Seriously, however, I look forward to not being the point man in the company, so I strived to develop a team of highly qualified engineers that has the strength to independently face the new challenges of the future. I believe that the engineers at Quanser are well rounded and have gained tremendous

experience in a variety of disciplines. They are always willing to explore new areas. My advice to graduate students in experimental controls is to expose themselves to all the intricacies involved in their research: right down to the nuts and bolts and wiring diagrams. Control engineering requires an understanding of physical phenomena. I'm a member of the "if you don't understand it, you can't control it" school of control.

CSM: *What trends do you see occurring in control education? What can control educators do more (or less) of? How can we all do a better job increasing student's interest in control?*

Jacob: I can only speak of experimental control education. I see work being done in virtual labs. As a matter of fact, we were the first to commercialize a product called WebLab, which enabled users to control physical experiments remotely with live 3-D animations to visualize system response. However, I still believe that interacting with the physical system is an essential component of the learning process. Students need to touch and feel what they will control to gain a complete understanding of the relevant phenomena.

I also note that some educators are teaching control through mechatronics or project courses. Mechatronics is



Jacob Apkarian at work. Jacob is the founder and R&D director of Quanser Consulting, located in Toronto, Canada. Quanser develops a wide range of control education equipment as well as advanced control solutions for research and industrial purposes.

an important element of system design, except that control fundamentals become secondary. I believe a course that uses a simple plant such as a dc motor is still the most effective introduction to the concepts of modeling, stability margin analysis, robustness, and disturbance rejection. However, to keep a student's interest piqued, one could creatively augment the course content with the latest trends, such as haptics, virtual reality, gaming, and robotics.

CSM: *What do you do when you're not developing new lab experiments, visiting clients with new ideas, or tending to the Quanser booth at conferences?*

Jacob: I have a young daughter and a growing family, so that keeps me pretty busy. I try to find time to mountain bike and snowboard. Unfortunately, my ambition exceeds my ability, and occasionally I hurt myself. The worst accident was when I broke both wrists a couple of summers ago while attempting to take a jump on my mountain bike. Clearly, I did not understand the dynamics involved in landing the bike properly, and even if I did, I doubt I had the control authority!

New CSM Corresponding Editor

CSM seeks to publish reports on conferences and workshops as well as all significant control-related events. The new CSM corresponding editor for conferences is Zongli Lin. Conference organizers are encouraged to contact Prof. Lin (zl5y@virginia.edu) to arrange advance publicity and to plan for the submission of conference reports.

Prof. Lin received his B.S. degree in mathematics and computer science from Xiamen University, Xiamen, China, in 1983, his master of engineering degree in automatic control from the Chinese Academy of Space Technology, Beijing, in 1989, and his Ph.D. degree in electrical and

computer engineering from Washington State University, Pullman, in 1994. He is currently a professor with the Charles L. Brown Department of Electrical and Computer Engineering at the University of Virginia. Previously, he worked as a control engineer at the Chinese Academy of Space Technology and as an assistant professor with the Department of Applied Mathematics and Statistics at the State University of New York at Stony Brook.



Zongli Lin of the University of Virginia.

Prof. Lin is the new IEEE CSM corresponding editor for conferences.

His current research interests include nonlinear control, robust control, and modeling and control of magnetic bearing systems. He has published 250 papers, over 90 of which are in archival journals. He is also the author of *Low Gain Feedback* (Springer-Verlag, 1998), a coauthor (with Tingshu Hu) of *Control Systems with Actuator Saturation: Analysis and Design* (Birkhauser, 2001), and a coauthor (with B.M. Chen and Y. Shamash) of the recently published *Linear Systems Theory: A Structural Decomposition Approach*

(Birkhauser, 2004). For his work on control systems with actuator saturation, he received a U.S. Office of Naval Research Young Investigator Award in 1999.

Prof. Lin was an associate editor of *IEEE Transactions on Automatic Control* from 2001–2003 and has been an associate editor of *Automatica* since 2004. He is a member of the IEEE Control Systems Society's Technical Committee on Nonlinear Systems and Control and heads its Working Group on Control with Constraints.

President's Message

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director represents several Societies, including the CSS, on TAB. Of the roughly 8,000 current CSS members, less than 1,000 routinely vote in these elections. I would like to see a higher level of participation from you, our membership, since your vote is extremely important for selecting the kind of top-quality people we need to represent us at both the Society and the IEEE levels. So please remember to cast your vote when you receive the e-mail notifications from IEEE.

As always, I look forward to receiving your feedback at mspong@uiuc.edu.

Mark W. Spong
President

IEEE Control Systems Society

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