In this issue of *IEEE Control Systems Magazine* (*CSM*), we speak with Lalit Mestha, principal scientist at Xerox in Rochester, New York. Lalit's research interests are in systems and control technology related to imaging systems. He has been awarded 82 patents, is a certified black belt in the Design for Lean Six Sigma, and is the author of *Control of Color Imaging Systems*, recently published by CRC Press. He is also the recipient of the 2006 IEEE Control Systems Technology Award.

Next, we speak with Thomas Parisini, of the University of Trieste, Italy, where he holds the Danieli Endowed Chair of Automation Engineering. Thomas's research interests are in fault diagnosis and nonlinear model predictive control with applications to industrial process control. Thomas served as chair of the IEEE Control Systems Society (CSS) Conference Editorial Board from 2005 to 2009 and was recently appointed editor-in-chief of *IEEE Transactions on Control System Technology (TCST)*.

The next interview is with Panos Antsaklis, professor in the departments of electrical engineering and computer science and engineering at the University of Notre Dame in South Bend, Indiana. Panos was in charge of the technical notes for *IEEE Transactions on Automatic Control* (*TAC*) in 2009, and he became the editor-in-chief in January of 2010, succeeding Christos Cassandras who held the position since 1999. Panos's research interests range from networked control systems to hybrid and discrete event to learning and reconfigurable systems. He is the author of the graduate-level textbooks *Linear Systems* and A *Linear Systems Primer*. He is currently president of the Mediterranean Control Association, and he has served the CSS in many capacities, including as its president in 1997. In the interest of full disclosure, Panos was the *CSM* editor-in-chief's first instructor in control.

Finally, we speak with 2011 CSS President Richard (Rick) Middleton. Rick is a full professor at the Hamilton Institute, the National University of Ireland Maynooth, and he has a part-time appointment at the University of Newcastle in Australia. Rick has had extensive involvement in CSS activities, including conference organization, and he recently completed a term as senior editor of *TAC*. His research interests have involved adaptive and robust control with, more recently, biomedical applications.

## PANOS ANTSAKLIS

**Q. How did you develop an interest in control system technology?**

*Panos:* I always liked putting things together (and taking them apart…) and I was really good at it. I was also a very good student—I especially liked physics. Physics is taught in the second-level education system in Greece for several years and elsewhere in the world, as opposed to the United States, and I consider this a huge drawback of the U.S. high school science education. So I decided to study mechanical and electrical engineering at the National Technical University of Athens, which was a highly selective five-year program, although my father and my two brothers were all medical doctors! There, I became interested in the mathematically elegant state-space control-system model formulations. I realized that I could manipulate physical systems based on rigorous mathematical models of their dynamical behavior, and I learned how to look at properties of the mathematical models and check whether they make sense in the physical world, and vice versa, which I believe is at the heart of modern engineering.

I came to the United States supported by a Fulbright scholarship, and I was fortunate to be accepted at Brown University to study under Bill Wolovich, as well as Allan Pearson, Harold Kushner, and Peter Falb. Bill was a pioneer in the decoupling problem and in the polynomial matrix approach to control. I studied LTI multivariable systems by means of polynomial (differential operator) matrix descriptions and transfer function factorization approaches, which led to the appealing parameterizations of all stabilizing controllers and to convenient solution approaches to H-infinity optimal control problems. I continued this work during a year-long visit at Rice University with Boyd Pearson. I then went to Imperial College in London as a lecturer (under David Mayne) and from there, two years later, to the University of Notre Dame, where I am today.

*Digital Object Identifier 10.1109/MCS.2010.938481*

Panos Antsaklis of the University of Notre Dame with Christos Cassandras at the 2005 CDC in Seville, Spain.

**Q. How have your research interests evolved since you received your Ph.D. from Brown University in 1977? By the way, congratulations on receiving the 2006 Brown Engineering Alumni Medal.**

*Panos:* Thank you for your good wishes. I am really proud of the Engineering Alumni Medal. It is a great honor and I was excited going back to receive it during the 2006 commencement weekend. I was there with my wife Melinda (she has a Ph.D. in Russian literature from Brown, we first met there as graduate students, and so it was great for both of us to be back) and with our daughter Lily, who is now a senior in psychology.

After my Ph.D., I continued working with polynomial matrices and factorization descriptions that, by the way, provide wonderfully clear insights in certain cases especially when both external, transfer function descriptions are involved and connections to internal descriptions and dynamics are desirable. The state-space formulation has been the favorite in the United States, but polynomial matrices have been used quite a lot outside the United States, in control design and optimal control.

But no matter how much I enjoyed the neat mathematical formulations of linear ordinary differential equations (ODEs) with constant coefficients I always knew these models, useful as they were, were limited, since there are dynamical processes that are not amenable to linear or even nonlinear ODE descriptions, and we need descriptions involving logical statements and finite automata or Petri nets. The turning point for my research was the summer I spent at the Jet Propulsion Laboratory trying to envision how future spacecraft could become autonomous.

Does it sound futuristic? Maybe. However, the ideas and concepts that were described in the resulting publications, such as control hierarchies and intelligence, the need for fault diagnosis and reconfiguration, learning, and planning to achieve highly autonomous control systems have definitely withstood the test of time. My new interests brought me in contact with researchers interested in intelligent control and discrete event dynamical systems (DES), since in the higher levels of the hierarchical control structures the decision-making can be naturally described by automata or Petri nets. I worked with DES (actually, initially collaborating with Alan Willsky during a sabbatical at MIT), but also with neural networks (teaching topics on neutral networks during a sabbatical at Imperial College). My research on DES focused on Petri nets, and we were able to

come up with a supervisory control approach using Petri nets based on structural place invariants, which has significant advantages. In fact, in the December 2009 issue of *IEEE Computer Magazine* there is an article by HP researchers where they describe an approach to eliminate bugs from commercial grade software that uses that particular supervisory approach. This is very exciting since I think it is important to have methods developed in control that are used by and influenced by other fields. In fact, we are currently working with our DES approach to derive systematic procedures to do concurrent programming, a notoriously challenging topic in the computer world.


Panos and Melinda Antsaklis in Sifnos, Greece.

My interests during that summer at JPL led me also to the study of hybrid systems that combine continuous and discrete processes described by differential equations and automata, for example. Such hybrid systems may appear in autonomous architectures when the higher discrete decision-making levels interact with the lower level continuous controllers—and of course in many other cases, from bouncing balls to train gate openings to gear boxes in automobiles. Hybrid system control significantly broadens the control field, since the models for real applications are more realistic and the mathematics involved is really challenging, which makes it even more attractive to mathematically inclined researchers in our field. Our hybrid control approach uses abstractions to derive DES models from continuous plants in an analogous way, in which we derive discrete-time models from continuous plants taken together with the sample and hold interface. Of course, the realization by the controls community that useful concepts and methodologies may be found in intelligent and autonomous control also opened up the field, which I thought was a healthy thing to happen. By the way, I was guest editor of several issues in *CSM* on neural networks and intelligent, autonomous control, and I had special issues in *TAC* and *Proceedings of the IEEE* on hybrid systems.

More recently I have been interested in cyberphysical systems (CPS) that combine all of my research interests above with networked control; I was guest editor of special issues in *TAC* and *Proceedings of the IEEE* on networked control systems in 2005 and 2007. CPS is a crucial area for future applications, and I am proud that I was involved in high-level U.S. government committees that pointed out this fact to the federal funding agencies. I was a member of the Networking and Information Technology subcommittee of the President's Council of Advisors in Science and Technology (PCAST).

**Q. What do you see as the really challenging problems in our field? Feel free to distinguish between problems that are motivated by real-world applications and problems that you just feel are interesting for their own sake.**

***Panos:*** After a talk I gave at the 2009 ACC, a prominent member of the controls community complimented me on a statement I had made, namely: "Feedback transcends models." I really believe this. We are the experts on feedback, but many times we restrict ourselves to a "safe" mode we understand best, of systems described by neat mathematical models so as to derive elegant solutions to problems we largely define ourselves. Certainly there is value in deriving interesting solutions to problems that may one day be of importance to applications, but in this way we hold ourselves back, I think. I believe that the best and richest in content and potential problems come from real applications and real needs where the mathematical models may be messy, hardly reliable, or hardly existent, and we need to transcend the current boundaries of our field to reach out to understand other disciplines. This is the way to move forward so as to have significant impact, to solve significant problems, and to have others realize and appreciate the importance of our scientific contributions.

**Q. You've written two textbooks on linear systems with Tony Michel. What is unique about these texts?**

***Panos:*** The first book was *Linear Systems. The Primer* is really a more student-friendly version. The topic is linear systems theory, which has been the bread and butter of the field since the 1960s. Over the many years and among the thousands of papers on the topic, there is a tremendous number of results out there. So the big question in a linear systems book is what to include, what to emphasize, that is, what are the key concepts. Certainly you do not want a laundry list of results that confuse the reader. Our books emphasize and highlight only those concepts and results we consider fundamental and most important, and we separate them from the less central results or from the results that are beyond the scope of these first-year graduate course books. We include many additional results in the exercises. This is harder to do

than you think! Rigor, of course, is the other characteristic of the book and you know Tony Michel, so this should not come as a surprise. We believe that all the statements in the linear systems book, all the definitions, comments, theorems, and lemmas are correct!

It has been really satisfying to have people from around the world approach me at conferences to tell me that they have the books on their desks as reference or textbooks and have enjoyed reading them. As you know, the publishers do not normally provide such detailed information about the use of books or testimonials from readers and so it is very nice when the people who use it come up to you.

**Q. Please talk a little about the Mediterranean Control Association and their activities.**

***Panos:*** In June 2010 we had the 18th Mediterranean Conference on Control and Automation (MED) in Marrakesh, Morocco, with almost 300 attendees. The first MED conference took place in 1993 in Greece with the objective of bringing together researchers, scientists, and engineers in the control systems and automation areas from the Mediterranean countries, who share more than technical interests, such as culture and history. In 1998 the parent organization Mediterranean Control Association (MCA) was founded to oversee all the MED conferences. I was the founding MCA president, and I have served since the beginning. The MED conferences have filled a need in that part of the world, and a MED conference is a great place to have high-level technical discussions in attractive surroundings. The MED conferences are technically well respected and well established as institutions. We are really happy about it! MED11 will be in Corfu, Greece. Do submit a paper!

**Q. What are some changes that have occurred or that you hope will occur with *TAC*?**

***Panos:*** We implemented a major restructuring in 2009. We introduced a system of senior editors to assign papers to associate editors. Christos Cassandras was a truly great help with this change as he has been with everything else, and his help has made my taking over so much easier. Such change became necessary because the number of papers submitted per year went up substantially. We are at about 1600 papers per year for the past couple of years, and you need more than a few people to oversee all these. Remember that each paper submitted to *TAC* typically goes through several reviewing cycles before it is accepted and published, and so we deal with over 4000 decisions per year—each with correspondence and time-consuming evaluations by the editors, definitely not a simple task. Taking advantage of the restructuring, we were able to consolidate the two editorial offices we had into one at Notre Dame.

I would like to see more emphasis by the authors on putting their results into context. I would like to see more transparent connections between the results in the paper and existing or future applications. For this to be accomplished we will need some changes in the culture in the systems and controls field and so this may take some time. I should mention that I had an editorial piece in the January 2010 issue of *TAC* discussing plans that will help us continue and enhance the excellent reputation of *TAC*.

**Q. What advice do you have for potential authors of *TAC* papers?**

***Panos:*** For a contribution to have measurable impact the results in the paper should be stated clearly and put into context so they can be appreciated by the average reader, their implications made transparent, the connections to real and potential applications if any be explained.

Today there are more papers out there than ever before competing for our attention. What we have in the *TAC* are papers that have gone through a series of rigorous examinations that minimize errors. Can we point out clearly in the paper the full implications, context, and significance of our results? Such change I think will not only make our field better understood by others but also help us shift our emphasis to rich areas that have greater potential impact on current and near future needs.

**Q. Any advice for young researchers in our field?**

***Panos:*** Think beyond your next *Transactions* paper. Work hard and responsibly, be innovative, and be respectful of the work of others. Do the things that feel right to you. Look around you in your field and see how you can explain what you see to others even outside the field, clearly. Use the language of mathematics for rigor and preciseness, but also use the language of physics, of chemistry and biology as well as of psychology or economics. Remember, "Feedback transcends models."

**Q. What are some of your interests outside of research, teaching, and service to the control systems field?**

***Panos:*** I am interested in history: of places, and of people, as well as in the roots and history of disciplines, of fields of study, like ours for example. I have been looking into the history of ancient feedback mechanisms for some time now. Traveling is also fun for me, but most of the travel I do is primarily for business. When I travel to a different country I always try to learn all I can about its history, culture, and its people. But I also have other more specific interests. For example, I have been studying the different calendars and the reasons behind the different dates for Easter Sunday between Eastern and Western churches—check my Web site for an article on that. Also, did you know that I have a collection of old engravings and maps of Greece dating from the 1700s and 1800s?

**Q. Thank you for speaking with *CSM*!**

***Panos:*** Dennis, you're most welcome. It was a pleasure. Thank you for asking me.