In this issue of *IEEE Control Systems Magazine*, we speak with Mathukamalli Vidyasagar (Sagar) who is the Cecil and Ida Green Chair in Systems Biology Science and head of the Bioengineering Department in the Erik Jonsson School of Engineering and Computer Science at the University of Texas at Dallas (UT Dallas). Before moving to UT Dallas, he was the executive vice president of Tata Consultancy Services, where he created the Advanced Technology Center, an industrial R&D laboratory of around 80 engineers, working in areas such as computational biology, quantitative finance, e-security, identity management, and open-source software to support Indian languages. He is recipient of the IEEE Control Systems Society's Hendrik W. Bode Lecture Prize, the IEEE Control Systems Award, and a Fellow of IEEE. He is the author of nearly a dozen textbooks.

Next we speak with Jozsef Bokor who is head of the Systems and Control Laboratory in the Computer and Automation Research Institute at the Hungarian Academy of Sciences (MTA SZTAKI), professor and head of the Control and Transport Automation Department at the Budapest University of Technology and Economics (BME), Hungary. He has coedited six books, coauthored over 500 journal and conference papers, and is a Fellow of IEEE.

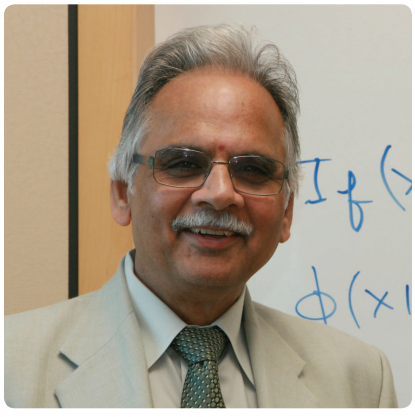
We also speak with Le Yi Wang, who is a professor in the Department of Electrical and Computer Engineering at Wayne State University, Detroit, Michigan. He received his Ph.D. degree in electrical engineering from McGill University, Montreal, in 1990 and has been with Wayne State University since then. He has coauthored one book and written over 180 journal and conference papers, holds six patents, and is a Fellow of IEEE.

We end with Mayuresh V. Kothare, who is the R.L. McCann Professor and chair of the Department of Chemical Engineering at Lehigh University, Bethlehem, Pennsylvania. Mayuresh received his B.S. (1991) from IIT Bombay and his M.S. (1995) and Ph.D. (1997) degrees from the California Institute of Technology, all in chemical engineering, with a minor in control and dynamical systems during his graduate studies. Before joining Lehigh, he held a one-year postdoctoral appointment with Mobil Oil Corporation. He is a Fellow of IEEE and has coauthored a research monograph and over 120 journal papers and conference proceedings.

MATHUKUMALLI VIDYASAGAR

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

Sagar: Well, it was completely by accident that I chose controls as a field. I talked about this during my acceptance speech when I received the IEEE Control Systems (Field) Award. When I was an undergraduate at the University of Wisconsin, I was absolutely fascinated by passive network synthesis, an intellectually beautiful subject that is not taught anymore, unfortunately. So I had no doubt in my mind that my graduate research was going to be in circuit theory. By the time I reached my final undergraduate semester, all I had to do to graduate was to take six elective courses in any topic in electrical engineering. Originally I signed up for six courses that, naturally, met on Mondays, Wednesdays, and Fridays. As a result I had classes solidly from 9:30 am until 3:30 pm and no lunch hour. After the first week of classes, I realized that I had to drop my lunchtime class to survive the semester. So I looked around for a course that met on Tuesdays and Thursdays. The first controls course at Wisconsin had a three-hour lab, with only two hours of lectures on Tuesday and Thursday to make up the three credits. This suited me perfectly, so I signed up for that course. I had no real interest in control theory at that point—in fact, I did not even know what it was! But once I got into control theory, I liked the mathematical elegance of it, which, by the way, was also the main attraction for



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me about circuit theory. People often do not know that back in the 1950s, what today we would call "system theory" was published just as much, if not more, in *IEEE Transactions on Circuit Theory* as in *IEEE Transactions on Automatic Control*.

As for "continuing interest," well, what can I say? Over the years the field of circuit theory came to be dominated first by active (as opposed to passive) network synthesis and then very-large-scale integration (VLSI). As a result, theory fell by the way side during the 1980s, and I would say that to some extent that field has never really recovered its preeminent position in terms of exploring fundamental questions. Until the early 1980s, I used to attend both the IEEE International Symposium on Circuits and Systems (ISCAS) as well as the IEEE Conference on Decision and Control (CDC), but I stopped going to ISCAS about that time. Perhaps with the rise of analog VLSI, there is now greater scope for theory once again in the circuits field. However, I am in no position to know.

I think the main advantage that we as control theorists have is that we know bits and pieces of many branches of mathematics. But unlike "real" mathematicians, we also get a lot of practice in modeling, that is, taking an engineering specification and turning it into a mathematical requirement. This extra dimension is what distinguishes us from "pure" mathematicians.

Another point is that, for whatever reason, the early pioneers of control theory (and I am perhaps old enough by now to be called an old-timer if not exactly a pioneer) were very friendly and open to new ideas. And this tradition continues. Look at the Conference on Decision and Control (CDC), for example. One can propose an invited session on just about any topic, and provided the papers are top-notch, the proposal will get accepted. It almost never happens that someone says, "Oh, *that* is not control theory!"

Profile of Mathukumalli Vidyasagar

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- *Other research positions:* assistant professor, Marquette University, Milwaukee, United States (1969–1970); assistant professor to professor, Concordia University, Montreal, Canada (1970–1980); professor, University of Waterloo, Canada (1980–1989); director, Centre for Artificial Intelligence and Robotics Bangalore, India (1989–2000); executive vice president, Tata Consultancy Services, Hyderabad, India (2000–2009).
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Q. What are some of your past and current research interests?

Sagar: I am going to make a truly outrageous comparison, but bear with me. One of the most decisive events in my life was that, about a year after I finished my Ph.D. and was working as an assistant professor, I read the biography *Hilbert* by Constance Reid. It is a really wonderful book, and it is truly amazing how this lady, who was not a mathematician at all, managed to capture the essence of Hilbert the mathematician. Most persons in that situation would have suppressed the mathematics and tried to make the subject of the biography more "human" by dragging in all sorts of extraneous nonsense. But Ms. Reid did not do that at all. What struck me about Hilbert was that he changed areas of research at quite regular intervals, say every three or four years. In this way, over time he became a universal mathematician, perhaps the last one the world has seen. (I may make an exception for Andrei Kolmogorov.)

So after reading this biography, I said to myself that this seemed like a good recipe for success. Now, it should be pretty obvious to anyone that I am no Hilbert. Rather, my point is that there is a little bit of Hilbert in each one of us, and we need to encourage that aspect of (intellectual) risk-taking, as opposed to just carrying on doing the same old thing.

I was also pretty fortunate that during my entire career I never had to worry about "funding." So I could afford to take the time to master a brand-new subject and undertake fundamental research as opposed to "expedient" research.

So with this luxury of being able to work on whatever caught my fancy, over the years I have been all over the place: linear systems, nonlinear systems, robotics, neural networks, statistical learning theory, computational biology, and most recently computational biology with a special emphasis on cancer. I also started doing some interesting work in mathematical finance but made a conscious decision to give it up because at present the entire financial sector appears to me the embodiment of evil, and I do not want to be associated with it in any way!

Right now I am fascinated by what is called "translational medicine," namely, how to take research advances in biology into the clinic. The biologists call this "from bench-side to bedside." I like to think what I am doing can be called "from bits to bedside." So, for instance, my students and I have developed a universal algorithm for identifying a small number of predictors (called "biomarkers" in those circles) that can be used to determine which patients will respond to some sorts of cancer therapy and which patients will not. But this alone is not enough. We also need to know *why* someone will respond and another will not, and we have developed an algorithm for that too! These are called "mechanistic" models in biology. I have been really fortunate to collaborate with a *very patient* biologist who saw the value in educating me about these problems. I feel I am now at a point where I should present my work to biologists who do not know me at all to see whether they take me seriously. *That* will be the acid test.

Q. You are the author of several textbooks. What kinds of topics do these books cover?

Sagar: Again, they are all over the place. I love to write books because I find that I develop a much deeper understanding of a subject that way. Also, by compiling what is already known in a subject, I see the "holes" more clearly and get ideas for my own research.

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

Sagar: One advantage of having written many books is that I probably have a book for whatever course I am asked to teach! Last year I taught two courses: an advanced linear control theory course, basically out of my book *Control System Synthesis: A Factorization Approach* augmented by later work such as state-space solutions for H-infinity control problems, and a biostatistics course, basically out of a book I am finishing up on hidden Markov models. I do not really have a favorite course as such. I enjoy teaching anything that is new to me so that I can learn and educate myself through the teaching process.

My teaching style is definitely the old-fashioned way of talking and writing things on the board. I never use any notes while lecturing. I feel that if I need to keep looking at notes then I do not know the subject well enough to teach it! The board has changed from black to white and chalk has been replaced by markers, but this style is still the best in terms of being highly interactive and highly adaptive to the students' needs. People who "cover" a lot of material by flashing lots of "slides" at students at breakneck speed are simply deluding themselves that they are transmitting useful information. I do not think anyone can learn theory that way.

Q. What do you feel are the most promising research directions for the control field?

Sagar: Well, obviously I am fascinated by the promise of applying all the tools in our arsenal to the problem of cancer, which is why I am working on it. Cancer has a huge mind share in the public at large, but I have been pleasantly surprised by how much we control theorists can contribute, if only we take the trouble to look. To repeat what I said earlier, it is absolutely essential to find some biologists who will hold our hands while we come up to speed.

Aside from this, there are several areas that are potentially transformative, such as robots controlled by brain signals, to cite just one topic. My own "prejudice" is that I prefer topics that are amenable to the identification of some fundamental principles. We may not know what the fundamental principles are today, but we should be working toward finding them. Unfortunately there is a lot of money going to fields that are just a collection of tricks, and some are content to remain that way. I will not name any for fear of offending people. But I think young people who keep chasing dollars by shifting from one hot field to another will find that, after several years have passed, they have not done anything that is of lasting value. When John Keats was about to die, he wished that his tombstone should describe him simply as "Here lies one whose name was writ in water." In some sense all of us are like that, but we can at least *strive* to achieve something of lasting value. Working on theoretical problems gives us that opportunity, but only if we grab it with both hands!

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

Sagar: As a student I played every sport one can think of, except those that involve ice. As time went on, the sports fell by the wayside one by one. So now I just walk briskly (or not so briskly) for exercise. I like listening to classical music, both Indian and Western. I also like to learn languages. In my school days, I learned French and still speak it quasi-fluently. During the 1990s, I learned Japanese and can manage pretty well on my own in Japan. My latest desire is to learn enough ancient Greek to read some of the great dramatists like Aeschylus, Sophocles, or Euripides in the original. Of course I am never going to "understand" them, but with the original text and a good English translation, I hope at least to get a glimpse of what made these people great.

Q. Thank you for your comments.

Sagar: My pleasure. Best wishes to all readers of *IEEE Control Systems Magazine*.