

In this issue of *IEEE Control Systems Magazine (CSM)*, we speak with Yutaka Yamamoto, who is the president of the IEEE Control Systems Society (CSS) for 2013. He is professor at the Department of Applied Analysis and Complex Dynamical Systems, Graduate School of Informatics, Kyoto University. He has served as vice president (VP) for Publication Activities (2007–2008), VP for Technical Activities (2005–2006), and as a senior editor for *IEEE Transactions on Automatic Control* (2010–2011). He is the author of over 200 refereed papers and is the recipient of many awards, including the George S. Axelby Outstanding Paper Award (1996), the Commendation for Science and Technology by the Minister of Education, Culture, Sports, and Technology (Japan, 2007), and IEEE CSS Distinguished Member Award (2009). He is an IEEE Fellow.

We also speak with Murat Arcak who is an associate professor at the University of California, Berkeley, in the Electrical Engineering and Computer Sciences Department. He is an IEEE Fellow and has received several awards for his research, including the Donald P. Eckman Award from the American Automatic Control Council and the Control and Systems Theory Prize from the Society for Industrial and Applied

Mathematics. He has coauthored one book and over 150 journal and conference papers.

This column ends with Arthur Krener's acceptance speech for the 2012 Richard E. Bellman Control Heritage Award given in Montréal, Canada, in June 2012. He is a mathematician whose research interests are in developing methods for the control and estimation of nonlinear dynamical systems and stochastic processes. In 1971 he received the Ph.D. in Mathematics from the University of California, Berkeley, and joined the faculty of the University of California, Davis (UCD). He retired from UCD in 2006 as a Distinguished Professor of Mathematics and he currently is a Distinguished Visiting Professor at the Naval Postgraduate School. He has also held visiting positions at Harvard University, Imperial College, NASA Ames Research Center, the University of Paris, the University of Maryland, the University of Padua, North Carolina State University, and the University of California, Berkeley. Honors and awards include Fellow of the Society for Industrial and Applied Mathematics (SIAM), Life Fellow of the IEEE, the W.T. and Idalia Reid Prize in Mathematics from SIAM, the IEEE Control System Society Bode Prize Lecture, and the Richard E. Bellman Control Heritage Award from the American Automatic Control Council.

YUTAKA YAMAMOTO

Q. Congratulations on your new role in the IEEE Control Systems Society (CSS). You have been extremely active in CSS over the years. Which of the numerous roles have you found the most rewarding thus far?

Yutaka: Thank you. First of all, it is a great honor to serve the CSS as president. I joined CSS 30 years ago and have attended more than half of the Conferences on Decision and Control (CDCs) in its 50-year history. The transactions and the CDC have always given me the opportunity of

learning and research, being a source of inspiration and excitement, and simultaneously the sense of belonging to a right community.

I have learned many things from all roles of my CSS experience, including the versatility of our technical fields and how to delegate different technical fields from VP Technical Activities, how our journals are being processed, and how we have to deal with the IEEE headquarters through the role of VP Publications. I have also benefitted from



Yutaka Yamamoto, 2013 President of the CSM, and Professor at Kyoto University.

the role of a senior editor for *IEEE Transactions on Automatic Control*, to learn with renewed views how human factors play a crucial role in improving papers. I may come back to this issue in a forthcoming editorial.

I have also been fortunate enough to be able to develop many precious human relationships in this community worldwide. In a word, CSS has always been my "home ground," and I have been building my career through CSS. The friendship and human relations

I could develop through CSS is one of the most precious treasures, and I am grateful to my predecessors and past volunteers who made this possible. It is now my turn to work for the Society in my capacity, and I will do my best. I am also the first CSS president from Asia, reflecting the internationalization of the IEEE and the CSS. This is in the right direction, and I would like to see how this trend will affect us in our community and culture.



Yutaka visiting Pembroke College, Cambridge, United Kingdom, 2011.

Q. How did your educational background bring you to the systems and control field?

Yutaka: I got my bachelor's and master's degrees in the Department of Applied Mathematics and Physics, Faculty of Engineering, Kyoto University in 1972 and 1974, respectively. I then had the opportunity to study for my Ph.D. at the University of Florida, under the guidance of Professor Rudolph E. Kalman.

It was fortunate that in my undergraduate and master's program I had an opportunity to acquire a serious mathematical and physics background, albeit in an engineering school, while simultaneously being exposed to a rise of computer science. Even today this mixture of theoretical engineering and practice is not very a popular scheme in engineering education, and I could benefit from it in preparing myself for a more theoretical study in systems science.

In my junior year at Kyoto University, I took a reading course of modern engineering. The text was Kalman's seminal paper "On the General Theory of Control Systems" published in the *Proceedings of the First IFAC Congress* in Moscow in 1960. I was literally struck by the depth and beauty of modern systems theory. Until then all I knew was just rudiments of classical control theory, Bode and Nyquist plots, the Routh-Hurwitz stability test, gain and phase margins, lead/lag compensators, etc.

I did not know there could exist such a beauty in control systems that is mathematically elegant yet far-reaching. I was fascinated, and this determined my life-long target and profession.

Little did I know then that there would be yet another lucky incident—I was bound to study under Prof. Kalman himself. I wrote some recollection in an article in this magazine [1], but let me reiterate some of it. I was struck with the entirely different culture in science and education.

Kalman invited many top scientists to give seminars at the Center for Mathematical System Theory, which were very different from what you would imagine. It was a long sequence of lectures, given by world experts, but often interrupted by questions mostly by Kalman himself. Let me quote from the above CSM article:

He often interrupted the speaker and started asking questions. Some questions seemed to take the speakers off track. He would pose a question on whether the theory is based on the correct assumptions or in the right framework, or even the right definitions. [...] In an ordinary seminar, we would naturally take the attitude that a definition is, after all, a definition, and we would hold our breath until we see the outcome. The seminars at

the Center were very different. Rudolf Kalman always tried to see whether the theory is built on a sensible and fruitful definition.

The emphasis was on clear understanding, and well-motivated theoretical study. I had never seen such perfectionism. The questions start from the outset: Why is the problem formulated as such? What is the meaning of that assumption? Is that substantiated enough? Is it not merely for a technical convenience, and so on. It was a truly fascinating and precious learning

process. It was an excellent on-site research training.

I still recall, with lots of fond memory, the golden days in Gainesville, Florida, in the 1970s. Eduardo Sontag was my contemporary at the time, and I learned a lot from him through late-night discussions; Pramod Khar-gonekar and Tryphon Georgiou joined the Center soon after. I was fortunate to spend these days in Florida.

Q. What are your current research interests?

Yutaka: I am currently most interested in applications of control theory to signal processing, particularly that of applying sampled-data control theory to sound and image processing.

I did my work on the modeling of sampled-data control systems in late 1989–1990. The main difficulty of sampled-data systems is that they involve two different time sets—continuous and discrete. The plant works in continuous time while the controller operates in discrete time. This hybrid nature of time sets makes the modeling of sampled-data systems very awkward, and it often results in ignoring their intersample behavior. I came up with an idea of discretizing continuous-time signals as a sequence of function pieces—the idea currently known as lifting. Several other researchers came up with the same idea almost simultaneously, and it had

become clear that we can deal with sampled-data systems almost as an ordinary discrete-time system object, without sacrificing their intersample behavior.

I then noticed that this idea is readily applicable to digital signal processing: Given discretized digital data, the goal is to recover the original analog data that have yielded such digital data. Naturally, the intersample information is lost. According to the popular Shannon paradigm, a perfect band-limiting hypothesis is made, and such lost intersample information corresponds to lost high-frequency components beyond the so-called Nyquist frequency ($= 1/2$ sampling frequency). According to sampled-data control theory, particularly sampled-data H-infinity control, intersample signals can be optimally recovered provided that a linear time-invariant signal generator model is assumed, which is not necessarily an ideal Shannon band-limiting filter.



FIGURE 1 Prototype DA converter based on sampled-data H-infinity control; the device extends the CD range up to 175 kHz.

It became clear that this idea leads to an entirely new digital-analog (DA) converter. Shown in Figure 1 is a prototype of a DA converter that extends the CD audio range of 20 kHz up to 175 kHz. This idea has been implemented into a custom sound-processing LSI by the Sanyo Semiconductor, and has become quite successful; its total production as of December 2011 has reached 30 million chips. The same principle can also be applied to still and moving images. Some examples are given on my Web site [2].

I started my research career with purely theoretical studies of infinite-dimensional systems, particularly, their realization. Over the years I changed topics from delay systems to repetitive control, sampled-data systems, and signal processing, particularly in connection with the application of sampled-data theory to signal processing, I have learned the great potential of systems and control theory. It has been great fun to work on a real application that is directly connected to one's own theoretical work. I also believe that this new control-based paradigm is superior to the conventional Shannon paradigm.

Q. What do you see as some of the priorities for ensuring the future success and impact of control-related technology?

Yutaka: This is a difficult question. If I can say anything, it would not be more than an expression of personal views, which can be well biased. Let me just mention two aspects.

We should broaden our field. Control is ubiquitous, and we have been experiencing this in the past decades. Look at "The Impact of Control Technology" edited by T. Samad and A.M. Annaswamy [3]. We are amazed how versatile control technology is. But I believe we can expand our horizon way beyond, since everything moves and works with control. This is by no means limited to a classical concept of control applications, and we should view our field in a much wider sense, including various disciplines related to systems. Let me randomly list a few keywords that were not considered to be in the mainstream area in the past: embedded systems, quantum control, systems biology, financial engineering, service engineering, nanosystems control, control of networks, smart grids, etc. I would like to dream a day when control and systems theory becomes a guiding discipline in engineering.

I also believe that we can and should be more involved in real applications. In some sense, some part of industry is now in the process of "discovering" control. Although there are sections

within companies for control and systems design, their developments are often guided either by an old principle or by traditional know-how. As is often the case with information exchange and knowledge sharing in different sections, ideas quite common in one field are not necessarily appreciated in another field. Control and systems theory has the advantage of having a solid theoretical structure and hence is potentially applicable to systems in different areas; on the other hand, this universality makes it difficult to be readily appreciable compared to other techniques that are more directly attached to real systems. I believe that we should strive more to make this gap smaller, probably by making more conscious efforts to applying our theory to variety of application areas. Through such efforts, we will be able to develop new classes of problems and disciplines that will open up our future.

Q. How do you see your role as president of the Society, and what are your priorities for the next year? Are you planning any new initiatives?

Yutaka: As my predecessors noted, our Society is in excellent shape, for quite a number of years. The credit goes to the CSS leadership, particularly my predecessors, Christos Cassandras, Rick Middleton, and beyond. Our conferences are very well attended, we publish top journals with many submissions and a large number of citations as well as high impact factors. Our financial status is strong. This trend is excellent, and I believe that we can expect this to be like this. This healthy financial status is due also to our governance system; our Society is operated solely on the volunteer basis, unlike some other IEEE Societies, and this has definitely contributed to our modest expenditures.

There are several issues that our Society has been working on. For example, various outreach programs like the Impact of Control project as noted above and a project for a new journal on networked control.

Now let me here draw your attention to a different angle: Our Society

has grown very much in its 50-plus year history. Thirty years ago when I joined CSS, *IEEE Transactions on Automatic Control* was the only journal we published. We now publish *IEEE Transactions on Control Systems Technology*, and a new journal on the control of networks is being planned. CDC then was large but not excessively. Here are some figures: the total pages of the proceedings (counting only papers) of the CDC was 1,386 in 1982 and 5,198 in 2011, almost four times as much. We cannot expect a somewhat intimate atmosphere where we get together at a conference, chat, and discuss our problems with colleagues or new acquaintances. The conference has grown way too large, or so it seems. People often just rush in to the conference site, just present their papers, and fly back to meet their busy schedule. Or we may still have to keep answering e-mails to keep our heads above water.

Let me pose a question. You may go to a session, not quite in your own area, hoping to learn something in the adjacent field, or what is going on. *How much is the chance that you get lost in the talk?* I did a personal survey. The percentage is quite high. Even when you are attending a session in your own field, the probability is still not that low. *Why?*

As noted above, the situation is now quite much different from what it was 20–30 years ago. The allotted time for presentation is now only 20 min in contrast to 30 min in the 1980s; our field is much more diverse and deals with many different subjects. This means that we cannot assume too much technical background among the audience. Even among experts, it is often difficult to convey the basic idea, due to lack of time.

I believe that we should reconsider the fundamental role model of our conferences. In a short presentation, we can at best convey one simple message. *If you can convey what your problem is, and what the conclusion of your talk is, that is already a success.* Then an audience may come back to you or your paper, and there can be further devel-

opments. On the contrary, if you failed to convey what your problem was, the result will most surely be nil.



Yutaka and Mamiko at Ayasophia, Istanbul, 2011.

I am planning to take an initiative in improving the general quality of conference presentations. You might have received some message on this initiative by the time this issue is in your hand.

Q. The young members in our field—especially students—are the future of CSS. How can we expand their participation and role in CSS?

Yutaka: Yes, young people are the future of our Society. This is clearly true for any professional society. On the other hand, we are confronted with drastic social and economic challenges today whose consequences are not yet entirely clear.

In the old days, when the Internet did not exist or was still in a very early stage, the value of professional societies was judged on the basis of the amount and quality of information we received from them. In fact, this had affected us in the past. We lost a fair number of members in the mid-2000s. Thanks to a rise of interest in the Asian countries, particularly in China and India, we are recovering our membership, and we expect to recover 9,000 in the near future. However, this is not necessarily true for societies in other countries. For example, in Japan, most academic societies are suffering from the decrease of their membership. Some people feel that they do not have to be a member of a Society to obtain necessary infor-

mation. Papers can be downloaded through the Internet or through university libraries, and there is much more.

This is a serious challenge that did not exist 30 years ago.

However, *should the value of a professional society be judged solely on the basis of the benefit of obtaining technical information?* Let's think of an example. Suppose you attend a conference, say CDC. You present a paper and get into discussions with one of the session attendees. You may continue discussions during lunch with him/her. You may even get a hint for a new approach to your problem or a new formulation.

All these can be done of course without being a member of the CSS.

You can submit your paper to CDC as a nonmember and still attend the conference. However, do you not wish to belong to the same society where many others belong to? With the sense of belonging to the same group of people where you share a similar sense of problem, being recognized with your personality and professional interest, you can be more positive in pursuing your career and realization of your life. In a word, you can merit from many benefits by belonging to a *community*. The merits you can enjoy go far beyond the information retrieval from the Internet.

As I said above, the challenge of the Internet era did not exist 30 years ago. We have not quite seriously considered the meaning of becoming a member of our professional societies until very recently. What is more, the total framework of our professional activities is rapidly changing. *What is the true value of a professional society then?*

This brief analysis indicates that it is a human factor. A person can build human relationships through such societies, make friends, and get hints from human interactions. Not only can you benefit in your professional activities from human relations, but you can also lead a more fruitful and enriched life through the relationships acquired by such a community. The ultimate value of our Society, like many others, lies in the fact that it forms a valuable

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- *Notable awards:* G.S. Axelby Outstanding Paper Award, 1996; IEEE Fellow, 1998; SICE Fellow, Japan, 2005; Commendation for Science and Technology by the Minister of Education, Culture, Sports and Technology, 2007; IEEE Control Systems Society Distinguished Member Award, 2009.

community where you can belong through your profession. The Society gives you opportunities and human relations and helps you to build careers.

I think this aspect of professional societies will become more crucial and should be more explicitly recognized. I hope to come back to this issue in a forthcoming editorial.

Q. What are some of your interests and activities outside of your professional career? Please also tell us about your family.

Yutaka: I used to play Shogi (Japanese chess), and also Igo (or “Go”), a

board game played with black and white stones, now played internationally. I am afraid that I was not very good at them. As I became busier in my profession, I came to play less and less, and now almost none. One of the occasions was that I played Igo with Paul Erdős, maybe in 1976 or 1977 when he visited Gainesville, Florida, and unfortunately lost. I do not remember how good he was, but I would like to believe it was a close game.

I also like travelling and visiting museums in various cities, which always gives me an occasion to be

exposed to different cultures and refreshed views about our lives.

Another of my hobbies is high-end audio, which is very closely related to my current research interest. Listening to music is not only relaxing but also often enlightening. Sometimes, we can get more joy out of very old recordings because of deep messages built in such performances. (I am talking about monaural or even SP recordings.) It is a pleasure to improve upon their sound quality, and I occasionally dream of a day when everyone uses my new scheme to play those compressed audio media. I love classical music, particularly Mozart, Beethoven, and Brahms. Wilhelm Furtwängler, who in my view the greatest conductor ever, was and still is my hero.

In the past decade or so, I have been much into wines. I like some French chateaux as well as various Brunello di Montalcinos. My visit to Montalcino in 1998 was an eye-opener, and I thank Alberto Isidori for inviting me to a workshop, held after the MTNS conference in 1998. Although I keep some nice Bordeauxs and Brunellos, the prices of the Bordeaux first growths have sky-rocketed since 2007 and are no longer, regrettably, affordable.

My wife Mamiko often accompanies me when I go to conferences, so some readers may know her well. Our son Sho works in Tokyo as a business consultant, and our daughter Kaoru is studying for a Ph.D. in Cambridge, United Kingdom.

Q. Thank you for your comments. We wish you success as 2013 CSS president, and we look forward to reading your editorials in the magazine.

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Mamiko, Yutaka, and their children Sho and Kaoru on the occasion of New Year’s dinner at a restaurant “Maruyama” in Gion, Kyoto, 2012.